SWISS PROJECTS FOR RADIOACTIVE WASTE DISPOSAL MOVE INTO A NEW PHASE

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ABSTRACT

In Switzerland at the end of the nineteen seventies, continued use of nuclear power was made dependent upon a demonstration that safe disposal of radioactive waste was feasible. The corresponding "Project Gewhr" was submitted to the Swiss authorities in 1985 and the decision of the Swiss Federal Government was published in summer 1988. The government allowed the existing nuclear power plants to continue in operation. The specific points made by the government in its evaluation of Project Gewhr will, however, have a direct influence on Swiss disposal planning in the future.

The Nagra program has, during the years since the submission of Project Gewhr 1985, already been adapted in expectation of a conditionally positive decision. This paper briefly reviews the highlights of the particular project strategies which have resulted from this adaptation. Top priority is allocated to the implementation of the disposal of short-lived L/ILW. Four potential sites have been designated, and field work initiated at three of these. The end-objective is repository operation by 1998. For the HLW/TRU program, the government demands that siting work should include not only investigation of the crystalline host rock option studied in Project Gewhr but also increased emphasis on the study of alternatives in sedimentary rocks. Hence, both the crystalline and sediment options are being evaluated; selection of the option for which detailed site characterization will be undertaken is scheduled for 1993. The earliest date foreseen for HLW/TRU repository operation is 2020.

INTRODUCTION

In Switzerland, continued use of nuclear power was, in 1978/79, made dependent upon a demonstration that safe disposal of all categories of radioactive waste was feasible. The resulting major project (Project Gewhr 1985), which was submitted to the Swiss authorities on January 23, 1985, has been described at previous Tucson meetings. Following a review period which lasted considerably longer than originally anticipated, the decision of the Swiss Federal Government was published on June 3, 1988.

Based on its overall positive review of the Nagra project, the government allowed the existing nuclear power plants to continue in operation. The specific points made by the government in its evaluation of this project will, however, have a direct influence on Swiss disposal planning in the future. The key conclusions of the authorities were that: no problems have been identified with short-lived low- and intermediate-level wastes (L/ILW) and the waste producers should proceed as rapidly as possible with implementation of appropriate facilities also for HLW and for long-lived ILW (essentially TRU), the safety assessment methods used and the data derived from field and laboratory experiments show that safe disposal can be achieved for HLW and TRU, however, further proof is needed that an acceptable site of sufficient extent can be found in Switzerland the subsequent work on siting should include the crystalline host rock option studied in Project Gewhr but should also increase the emphasis on the study of alternatives in sedimentary rock.

The Nagra program has, during the years since the submission of Project Gewhr 1985, already been adapted in expectation of a decision along the above lines. In the adapted program, first priority is allocated to the implementation of the disposal of short-lived L/ILW. In the second main project, the HLW/TRU program, both crystalline and sediment options are being evaluated. The change in the waste classification strategy and both main repository programs will be described in the following chapters.

WASTE CLASSIFICATION STRATEGY

In discussions with the safety authorities, conceptual problems have arisen with the classification of reprocessing wastes with low TRU contents and with their allocation to appropriate disposal facilities. The precise waste sorts to be allocated to individual repository types are to be defined with respect to maximum allowable radionuclide concentrations which are based upon official radiological protection requirements. Analyses of the original Nagra disposal concepts (based on preliminary site-specific safety assessments) indicated that some TRU wastes from reprocessing might be allocatable to either a Type B (L/ILW) or a Type C (HLW) repository. However, the Swiss government accepted only the short-lived L/ILW as being demonstrably disposable with no further problems; accordingly there is now more emphasis on treating all TRU along with HLW.

Nagra has decided that top priority must be allocated to implementing a Type B repository as soon as possible at least for the "problem-free", short-lived wastes. Even if performance assessments continue to indicate that this repository could safely accept TRU waste also, first investigations up to and including licensing will consider only the short-lived L/ILW. The reason is that the short-lived L/ILW represents nearly 90 % of the total waste volume and nearly 100 % of the volume of waste originating at present in Switzerland. The HLW and TRU result from reprocessing abroad, mainly in France, and will return to Switzerland only after 1992. For HLW and TRU, the option of disposing of this waste abroad within the framework of international cooperation is also being kept open.

DISPOSAL OF SHORT-LIVED WASTE

Because of the high population density in Switzerland, no shallow land burial is foreseen for short-lived waste.

Geologic disposal in the so-called Type B repository was selected even for LLW, this being the best way of meeting the requirements of the Federal Law (safety of disposal not dependent upon perpetual supervision of the repository) and assuring the necessary public acceptance. Since short-lived waste - e.g. operational waste from nuclear power plants and waste from medicine, industry and research - already exists in a form suitable for final disposal, the Type B repository is required more urgently than the HLW repository. It is intended to be operational before the end of this century (planning target 1998). The Type B repository will be constructed in Switzerland even if the HLW (and TRU) should be disposed of abroad within the framework of an international cooperative project.

In the Type B repository, the waste is isolated from the biosphere by both natural and engineered safety barriers. Key parameters for the realization of the general multiple safety barrier concept are the choice of the host rock (e.g. clay, marl, anhydrite, crystalline or others), the engineering design of the repository and the specification of the waste categories to be accepted for emplacement in the repository. A mined cavern system with access through a horizontal tunnel was selected for the Type B repository. Such a system in an alpine formation of Valanginian marl has also been used as the reference repository concept for Project Gewhr. The safety analyses were performed for a model-site based on the present knowledge of one of the potential repository sites (Oberbauenstock). In the reference repository there was provision for disposing of 200'000 cube metres of waste, corresponding to 40 years of operation of twice the present NPP power output. The repository to be actually realized will be somewhat smaller.

The site selection for the Type B repository proceeded in several stages. First of all, Nagra selected possible host rocks according to hydrogeological and geological criteria and evaluated a total of 100 potential sites in the years 1978 - 81. The results led to a narrowing-down of the number of potential sites to finally three - Bois de la Glaive (anhydrite), Oberbauenstock (Valanginian marl) and Piz Pian Grand (crystalline) - for which Nagra prepared relevant applications for exploratory boreholes and tunnels; these were submitted to the Federal Government at the end of 1983.

The necessary licenses were granted in 1985; however, the decision on the construction of exploratory tunnels has been postponed until the results of some boreholes and geophysical investigations have been presented. In the years 1986 - 87, Nagra performed such investigations at Oberbauenstock and at Piz Pian Grand. No licensed work has been done at Bois de la Glaive due to severe political obstruction at this site. The reports on results of the first investigation phase and the applications for exploratory tunnels at all three sites (to be constructed only in so far as necessary) were submitted to the Federal Government at the end of 1988.

In addition to the three sites mentioned, a fourth has been selected at Wellenberg in Canton Nidwalden, where the geometry of the Valanginian marl would allow the construction of a horizontally accessible repository for short-lived waste combined with a repository cavern for TRU at a depth of 300 m (or so) at the same site. The Federal Government authorized Nagra to perform the necessary investigations, including an exploratory tunnel some about 2'000 m in length and an underground rock laboratory which should allow Nagra to perform marl-specific underground experiments. The licence of August 1988, however, applies only to the horizontally accessible repository part and hence to short-lived waste. Local planning permits are now being obtained and the detailed field work is planned to begin in 1989. The time-table is somewhat open due to regional political opposition.

HIGH- LEVEL WASTE REPOSITORY PROGRAM

The Crystalline Program

A first regional geological exploration phase is drawing to a close. A network of reflection and refraction surveys, extensive regional hydrologic investigations and 7 deep drill holes have served to give a first picture of the 1200 kmFD investigation area in Northern Switzerland. The drill holes have penetrated through between 300 and 2000 m of sediments and up to 1200 m into the underlying crystalline basement. The investigations revealed the existence of a previously unknown major permocarboniferous trough, the extent of which leads to a drastic reduction in potential siting areas for a crystalline deep repository. Following completion of the last drill hole (currently over 1000 m deep) an evaluation of all results will take place within the scope of a regional synthesis. The objective is to judge whether the remaining potential siting areas are sufficiently promising to justify the investment of effort needed for full site characterization. This synthesis is expected to be completed in 1991/92.

The Sedimentary Program

Even before 1980, sedimentary options for HLW disposal were considered in Switzerland. Specific design studies were performed at that time for an 800 m deep repository in opalinus clay. For Project Gewhr 1985 emphasis was placed on crystalline rocks, although interesting formations in the overlying sedimentary layers were also geologically and hydraulically tested during the drilling work. The reduced siting possibilities in crystalline (because of the findings mentioned above) and the recommendations of Project Gewhr reviewers led to intensification of work on sediments in 1987. A single sedimentary program was implemented, covering authority requirements to expand siting options for both HLW and TRU.

The program is divided into several phases. The first of these has involved selection of the large-scale regions most promising for sedimentary studies, evaluation of the potentially suitable formations therein and selection of candidate host rocks and areas for further study. All of this work has been based upon existing geological data from Nagra seismic and borehole investigations and also from oil-industry field work. The results have been documented in the Nagra Technical Report NTB 88-25 (1).

The first step in the sediment study involved the identification of most promising investigation regions. Tectoni-

cally quiet regions with the simplest possible structural geology in the sediments were sought; this led to selection of a large region in the north and north-east of Switzerland. An attempt was then made to use large-scale modelling in order to identify suitable hydrogeologic situations for repository siting. However, the sparseness of reliable data prevented this approach from making a positive contribution to the selection process at this stage.

Accordingly, in the large investigation region potential host rocks were sought, the criteria being appropriate depth and thickness, simple structure and low hydraulic permeability. Seven formations were identified and their safety-relevant, hydrological and rock-mechanical characteristics evaluated in more detail. This led to the selection of two options for further study, namely lower freshwater molasse and opalinus clay.

These two variants were evaluated in more detail, including also the performance of first semi-quantitative safety analyses involving extensive parameter variations. For the two potential host rocks, more localized potential siting areas were also identified based on finer differentiation of the geological settings. A final step in the first phase of the sediment study consisted then of selecting for each potential host-rock option the localized areas for which possible field studies are to be planned in more detail.

A second study phase is now in progress with the aim of choosing the single first priority option which will be investigated in a dedicated field program. The advantages and disadvantages of the two possible formations are very divergent so that an intercomparison is difficult. The opalinus clay has very attractive hydrological and nuclide transport properties but is of limited thickness (100 m). A further issue to be cleared up is the probability and the consequences of significant faulting in the clay layer. The molasse is of great thickness (2000 m) and can be of low permeability; however, it is heterogeneous on a scale which may be difficult to characterize. In particular, the relatively impermeable clay-rich parts of the molasse can be interrupted by more transmissive sand-channels and it may be difficult to characterize the degree of inter-connectedness of these channels.

In the current evaluation of the most promising option, much weight is being put upon attempting to quantify the exploration effort needed to adequately characterize the alternative options. The extremely complex and lengthy licensing procedures needed for field work in Switzerland play an important rle in determining strategy here. The special legislation enacted for permitting field work within radioactive waste disposal projects requires a fairly detailed specification of the field program and can involve long delays (in one specific case a delay of 6 years resulted from legal objections). Current plans are to submit a formal application for geological investigations in 1990. Optimistic planning would then imply that an evaluation of the field work and identification of potential sedimentary region(s) for full site characterization could be completed at the earliest by 1993.

TECHNICAL PROGRAMS

Although some of the technical programs supporting the waste disposal projects are waste-type and/or site-specific, others are more generic. Into the former class fall, for example, studies of waste form degradation and radionuclide sorption onto host rocks while the latter includes more fundamental studies on topics such as colloid stability and mobility into the geosphere and model validation by use of natural analogues.

Much effort in waste-package characterization has focussed on L/ILW in a cementatious environment. Experimental facilities have been improved in order to allow work to be carried out under a controlled atmosphere which greatly increases the relevance of data produced. A joint Japan-Sweden-Switzerland (JSS) study of HLW glass leaching, which involved extensive work on COGEMA glass, has also recently been completed. Follow up studies on BNFL glass are currently underway.

Gas production from anaerobic corrosion of metals has been identified as a topic requiring specific further study for both L/ILW and HLW packages. Both direct measurements of hydrogen evolution and evaluation of the literature indicate that the production rates assumed in current models may represent very conservative overestimates of true probable production rates. Experimental data on the engineered barriers are requirements for models which consider the constraints on radionuclide release and transport in the near field. Main areas of recent development here include expansion of thermodynamic databases for specific radionuclides and for minerals formed during the hydration of cement.

Effort has also been focussed on problem areas which have not been treated quantitatively in past models of near-field release and transport through the geosphere - namely colloids, organics and microbes. A first stage of field studies of natural concentrations of colloids and microorganisms in relevant environments has been followed by laboratory studies of colloid interaction with radionuclides and the growth of microbes with production of organic compounds and colloids in a simulation of the L/ILW near field. A quantitative approach to modelling microbial activity has been developed and a major aim for the future is the formulation of a colloid transport model.

In terms of far-field transport, a major aim has been the validation of the codes/databases used. In this regard, the underground test site at Grimsel is particularly valuable, since it not only provides scope for extensive evaluation of hydrological, geophysical and rock mechanical characterization techniques but also is the location of a major migration experiment. Migration experiments with non-sorbing tracers (both stable and radioactive) were completed last year and the first phase of experiments with sorbing radiotracers will commence in early summer.

For use in both quantitative performance assessment and in a more qualitative public discussions, natural

analogue studies are considered to be important in the Swiss program. In addition to participation in the international Poos de Caldas project, natural analogue studies focussed on sites in Switzerland and in the southern Black Forest are also continuing.

Finally, it can be mentioned that the formulation of Swiss regulations in terms of dose criteria necessitates biosphere transport and dose to man models. The models and associated databases are continuously updated and tested through participation in the BIOMOVS program.

REFERENCES

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