THE OPLA-RESEARCH PROGRAM ON THE FINAL DISPOSAL OF RADIOACTIVE WASTE IN GEOLOGICAL FORMATIONS (SALT) IN THE NETHERLANDS

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ABSTRACT

The OPLA-program is the Dutch national research work on the final disposal, focussed on rocksalt formatrons, of all categories of solid radioactive waste that will arise from nuclear powerplants, hospitals and laboratories. The activities are split up in three stages: 1, 2 and 3. In the fall of 1987, stage 1, in which a comparison is made between disposal concepts, has to be finished. Before entering stage 2, existing of field work focussed on geological and geohydrological comparison of sites, a positive decision of the Dutch government is needed. In the technological and scientific activities of the OPLA-program, there is an extensive and fruitful cooperation between ECN and GSF (IFT) in the FRG (see also XI-1).

INTRODUCTION

In this paper, information will be given on the OPLA-program. The OPLA-program is the Dutch research work in the field of geological disposal of radioactive waste. This research program has been compiled by the Onshore Disposal Study Committee (OPLA) at the request of the Integrated National Research Program-Nuclear Waste (ILONA) Policy Committee. In accordance with its terms of reference, the proposed program identifies "(matters) requiring further study on the basis of which a possible decision can be taken on geological disposal in the Netherlands."

Before discussion of the contents of the OPLA-program, some remarks are made towards the handling of radioactive waste in the Netherlands in the past and the future. Up to 1982, the Netherlands participated in the sea-dumping operation organized, since 1967, by (E)NEA. The dumping LLW and MLW was executed in the Atlantic Ocean at a depth of more than 5,000 meters. The quite sudden decision to stop the sea-dumping operation by the Dutch government for non-technical reasons, made it necessary to erect temporary interim storage facilities in a very short time span. This facility, located in Petten, is only licensed for a period of about 10 years and is unable to handle high-level vitrified waste or used fuel elements, which is expected from the French reprocessing plant of "Cogema" early in the nineties. Based on the positive advice of the "MINSK" Committee, a site selection procedure has been carried out for a facility which can handle <u>all</u> kinds of solid radioactive waste (see XI, 2). Before going back to the OPLA-program, it is worthwhile to note that already in 1979 a report was published by the Dutch government concerning the possibilities of geological disposal, on Dutch territory of all types, of solid radioactive waste. This report gave positive advice on the above-mentioned problem. Due to internal political circumstances, no follow-up was given of the indicated research mentioned in the report. The OPLA-report of 1984 can be seen as a second attempt in this respect, but on the other hand, it has a more definite character. In fact, a complete program is presented which can lead to a final disposal method of radioactive waste.

In the introduction of the report, it is stated: "The committee considers that national and international research programs already completed provide sufficient knowledge and insight to arrive at a justified choice of host rock. Indeed, the committee feels that such a choice is desirable in order to assist the progress and efficiency of the research that is still to be performed. With a view to the other opinions and the above-mentioned ultimate assessment of a site explored, the research program has been divided into three stages:

1. inventory and comparison of potential disposal concepts and sites;
2. preliminary field research near selected sites;
3. above-ground field research exploration of a chosen site.

Each of the first two stages leads to a choice in principle from among the options investigated in that stage. The following stage is in principle confined to further study of those selected options. If this further study should reveal that insuperable problems are associated with the opinions investigated, other options will have to be subjected to further study. These choices will therefore become definitive only if they are confirmed at the further-study stage; they have the status of choices in principle. The final stage leads to a definitive appraisal of the suitability of the site explored in that stage for disposal of (high-level) radioactive waste. It is this work, outlined in the OPLA report, that will dominate the work done in the Netherlands for the coming years on final disposal. Furthermore, it is worthwhile to mention that the safety assessment work and the insitu-research in the ASSE salt mine is done in close cooperation with the owner of the mine, the GSF in Munich. The main emphasis of the insitu experiments is focussed on the ECN participation in the HAW pilot facility of the GSF.

Finally, it has to be mentioned that the OPLA work is internationally linked by participation in the third 5-year R and D program on disposal of radioactive waste of the European Community and partly subsidized by this organization.

RADIOACTIVE WASTE FLOWS IN THE NETHERLANDS

In order to establish the total amount of nuclear waste, the following basic assumptions have been made:

- the nuclear power stations "Borsele" (~ 450 MWe) and "Dodewaard" (60 MWe) will remain operational; total life time about 30 years;
- additional nuclear power of 3,000 MWe will become operational in the mid-nineties.

Three sources of radioactive waste can be identified:

1. the French reprocessing plant of the firm Cogema;
2. the operational waste of the power stations, hospitals and laboratories;
3. the decommissioning waste of the power stations.

The first category can be expected for the "Dodewaard" and "Borsele" station, in the early nineties; the second category will sharply increase when the "3,000 MWe" becomes operational. The last category will probably appear peakwise.

FINAL DISPOSAL (POSSIBILITIES IN THE NETHERLANDS)

There are several types of rock potentially suitable for geological disposal of radioactive waste. On the basis of the knowledge of the Dutch subsurface currently available, it may be stated that in the Netherlands and below the Dutch sector of the Continental Shelf, the following types of rock qualify in principle for further consideration:

- salt;
- clay;
- metamorphic rock.

Salt

The rock salt formations potentially suitable in the Netherlands were initially deposited as bedded salt in the Zechstein (200-220 million years ago) by evaporation of sea water. They are present in the form of bedded salt, salt pillows, and salt domes. The pillows and domes are locally raised structures which were formed out of the original bedded salt. As regards to the sizes of these structures, in the case of salt domes, they extend several kilometers both horizontally and vertically; salt pillows both horizontally and vertically; salt pillows measure several hundred meters in the vertical.

Clay

The Dutch subsurface has a large number of clay structures, generally with a large lateral extent. In some cases, they are several hundred meters thick. The clay contains mud in varying degrees, and intercalated layers of mud and sand also occur in varying degrees. To what extent mining would be feasible in these structures would still have to be established. In terms of depth, mining would often be possible.

Metamorphic Rock

No statements can be made at this juncture regarding the safety of disposal in metamorphic Cambrian rock in the Netherlands, because the necessary data would cost much time and money. Furthermore, comparable foreign studies on the rock are lacking, in contrast to salt and, to a lesser extent, clay.

Priorities for Research

On the basis of the above, the following sequence of priorities for subsequent research into geological disposal of radioactive waste in the Netherlands has been selected:

1. salt, as the rock which according to present knowledge has by far the best prospects, and on which the Netherlands indeed possesses far more know-how and understanding by comparison with clay and metamorphic Cambrian rock;
2. clay as a possible second choice;
3. metamorphic Cambrian rock as a purely hypothetical third possibility.

STATE OF THE ART

The following pages set out the state of the art and the proposed research program, including an estimate of the time and expenditure required. The time schedule mentioned here, has been compiled on the basis of technical considerations relating to the quality and continuity of the research program in addition to coordination with international programs. This time schedule does not provide for any additional time that might be required if the relevant administrative and political decision-making process cannot be fitted into the schedule. If such factors were to lead to substantial anomalies in the time schedule, this research program would have to be critically examined for its integrability in the resultant new situation.

Stage 0 ended and comprised a general comparison of potential host rocks, and a choice in principle from amonst them. For the Netherlands the main options are rock salt and clay. Metamorphic rock should also be mentioned for the sake of completeness. However, this rock offers too few prospects for further consideration. Dutch research into the geological disposal of radioactive waste has focussed principally on salt as potential host rock. Belgium is conducting a comprehensive research program aimed at clay as host rock. The committee concluded, on the basis of the available technical and geological information, that it was feasible to make a choice in favor of rock salt as a host rock. The committee also considered this choice to be desirable with a view to ensuring the effectiveness and progress of the further research effort. This conclusion was based mainly on the following considerations:

- the general and specific safety studies performed so far with regard to disposal in salt and in clay warrant the conclusion that in both rocks, safe disposal is possible in principle. The results of the Dutch studies and investigations relating to disposal in salt appear to justify the expectation that safe disposal will also be possible in Dutch salt. In view of the conclusions drawn from Belgium, safety studies on disposal in the "Boom" clay formation, which extends into the Netherlands, it may be expected that the same conclusions will apply to the Dutch part of that formation;
- in view of the experience accumulated in salt mining, which is also relevant to disposal mining, no insuperable problems are anticipated regarding the engineering feasibility of dis-

posal in salt. The engineering design of a repository in clay requires further elaboration, and Belgian development work is directed at this.

In Stage 1, which is well under way now, a comparison is made of the techniques applicable in the host rock chosen in relation to the formation types of that rock occurring in the Netherlands or below the Dutch sector of the Continental Shelf. These further studies and research may show that there are compelling technical reasons to choose a different host rock. Up to now, no indication has been found that this will be the case. Stage 1 leads to a choice of one of the potential combinations of a technique and a type of formation. The proposal for Stage 1 envisages rock salt as the host rock. It considers three types of formation: Salt domes and salt pillows, and bedded salt. The disposal techniques considered are conventional mines, bore holes drilled from the surface, and various types of caverns. Table 1 gives a review of potential disposal techniques in salt which should at any rate be included in the research during this stage. The proposed research program includes among other areas of interest:

- further development of preliminary designs for the various combinations of disposal technique and formation type;
- hydrologic transport and subrosion calculations;
- preliminary study of the internal mappability of salt structures using existing techniques;
- general geological evaluation of the Dutch salt deposits on the basis of existing data. This evaluation would include the design of three-dimensional models of the deep subsurface of the North-Eastern Netherlands (including the salt lithology) and the intermediate subsurface near a number of potentially suitable salt structures, reconstruction of the history of the salt structures and forecasting their stability;
- comparative safety study for a number of disposal concepts in salt;
- comparison of these disposal concepts in terms of technical feasibility, cost, etc.

On the basis of non-site specific information, a feasibility study for the several formation types and disposal techniques (Fig. 1 and 2) has been carried out. All but one disposal option, i.e. the deep-lying dry cavern because of expected stability problems, were found to be feasible.

It was observed that the experience with loading deep bore holes and caverns with radwaste was not available and consequently not demonstrated. Furthermore, the monitoring of the disposal process and the quality assurances of the important closing operation of the disposal facility was identified as being of a lower quality than in case of the mine. The result of this engineering study serves as an input for the safety analysis. For a substantial part of all the options, extensive thermomechanical calculations were made in order to assess the stability of the salt formation involved.

For nearly all the disposal concept, the main accident scenario is a flooding of the repository followed by squeezing the contaminated brine out of the salt formation. This phenomenon is strongly influenced by converging processes of the salt. Therefore, studies on this phenomenon play an important role in the OPLA activities both by a theoretical observation (5,XXI) and by insitu experiments (21,XV). The flooding of the repositories and the squeezing out of the brine will be calculated with the EMOS program of the GSF. On the boundary of the salt formation the METROPOL program will be used to calculate the radionuclide transport to the biosphere. The METROPOL program, based on finite element techniques, has some advanced features. For instance, the effect of density variations are taken into account (36,XXVIII).

A part of the above-mentioned main line of the OPLA research program, a substantial supporting program is executed, running from fundamental research on creep phenomena in salt, radiation damage in rocksalt, to the study on the stability of salt formation loader with radwaste comprising large hetrogenities.

Stage 2 follows the first stage, comprising a largely geological and geohydrological comparison of a number of sites, selected for further study partly on the basis of information obtained in Stage 1, and a further development of the preliminary design with a concomitant safety study. It is proposed that this preliminary survey should be conducted at two sites, using three-dimensional seismic exploration in combination with between 5 and 10 medium-deep bore holes (to a maximum of 500 meters), stopping short of the salt. On the one hand, these borings will provide support for the seismic exploration, while on the other hand, they will supply the hydrologic data required for verification of the hydrologic models and for the hydrologic subrosion and transport calculations. On the basis of the resultant data on the rocks above and around the two salt structures and the movement of the groundwater in these rocks, it will then be possible to decide on the location for the definitive surface and underground exploratory study of Stage 3.

Stage 3 will consist of the definitive surface and subsurface survey of the site chosen. The nature and scale of this survey will be very largely dependent on the type of formation concerned. Nevertheless, the survey will certainly comprise the following elements:

- geohydrological borings into the rocks overlying and, if relevant, around the disposal formation considered (but not into the salt). Approximately one hundred of these borings are expected to be necessary;
- seismic surveying to establish the geometry of the salt structure;
- boring drilled marginally into the salt structure in order to establish its flanks;
- exploratory borings into the slat, preferably at the planned shaft sites.

With regard to the exploratory borings into the caprock and marginally into the underlying salt, borings which can only be relevant if a salt dome is being explored, it may be noted that the number of borings needed will depend on the data that is already available when the exploratory drilling program begins. In addition, the desire not to adversely effect the isolation capability of the salt structure as a direct result of the investigation may tend to limit as far as possible the number of borings of this type drilled. The same factor is also involved in keeping to a minimum the number of borings, and especially the manner in which they are drilled, around a dome and marginally into the salt, in order to determine the the geometry of the structure.

The data produced by the above-mentioned investigation and the subsequent surface and subsurface exploration will be evaluated in a definitive safety study, designed to form the technical basis for a decision on actual disposal.

TABLE I

Review of Potential Disposal Techniques in Salt

REVIEW		BRIEF DESCRIPTION OF THE TECHNIQUE	REVIEW		BRIEF DESCRIPTION OF THE TECHNIQUE
A	CONVENTIONAL MINE	TWO VERTICAL SHAFTS (TRANSPORT AND VENTILATION); GALLERIES AT ONE OR MORE LEVELS; CAVERNS FOR LOW- AND MEDIUM-LEVEL WASTE; BORE HOLES (DRY-DRILLED) SEVERAL HUNDRED METRES LONG FROM AROUND 900 M LEVEL, FOR NUCLEAR FISSION WASTE	D	CAVERN WITH WIDE SHAFT, DRILLED AND OPERATED DRY	CAVERN CONSTRUCTED BY DAILLING AND SHOOTING, REMAINING DRY AFTER CONSTRUCTION. WASTE IS ENPLACED IN THE CAVERN IN A CONTROLLED WAY
B	PHASED CONSTRUCTION CAVERN AND MINE COMBINATION	FIRST PHASE COMPRISES THE CONSTRUCTION OF A CAVERN AS IN D, LARGE ENOUGH FOR SAY 25 YEARS, THEN CONSTRUCTION OF SECOND SHAFT, SEALING OF CAVERN, AND EXPLORATION FOR ENLARGEMENT FROM THE TWO CAVERNS TO FORM A COMPLETE MINE	E	SOLUTION CAVERN WITH WIDE SHAFT OPERATED DRY	CAVERN CREATED BY SOLUTION MINING AND PUMPED EMPTY AFTER COMPLETION. WASTE IS EMPLACED IN THE CAVERN IN A CONTROLLED WAY
C	BORE HOLES FROM THE SURFACE	FROM THE SURFACE, WET-DRILLED HOLES DEEP INTO THE SALT, WHICH AFTER CHARGING WITH CANISTERS OF NUCLEAR FISSION WASTE ARE FILLED IN, CEMENTED, COMPLETED AND SEALED	F	FLUID-FILLED CAVERN, OPERATED WET	CONTINUING TO CONTAIN BRINE DURING OPERATION IN ORDER TO KEEP THE CAVERN OPEN. WASTE IS SUNK INTO THE CAVERN. AT GREATER DEPTH THE BRINE REQUIRES PRESSURIZATION.

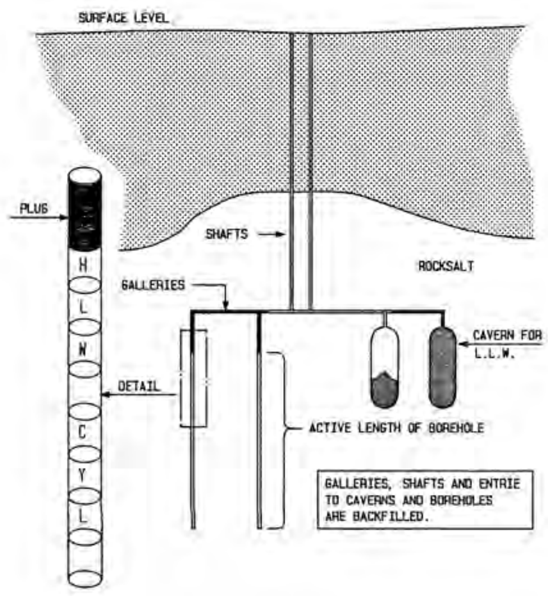

Fig. 1. Lay-Out of Mine Design.

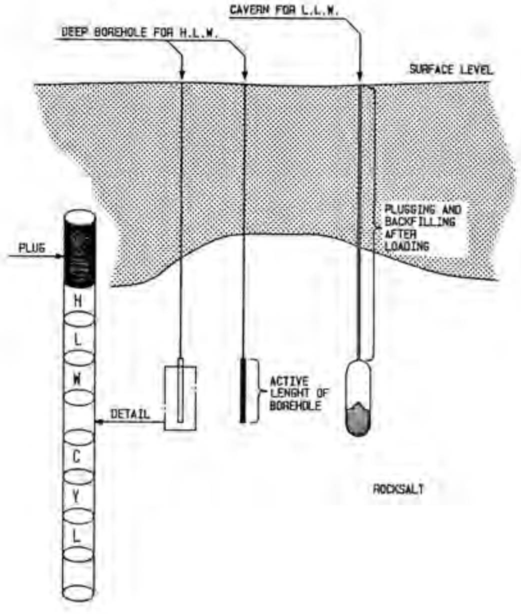

Fig. 2. Lay-Out of Deep Borehole and Cavern Concept.