SRP REPRESENTATIVE TO THE FEDERAL REPUBLIC OF GERMANY (FRG)

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Monthly Report for May 1987

Summary

This was a particularly busy period in the FRG as there were several important meetings and U.S. visitors to the FRG. The underground laboratory in a clay formation and vitrification facility (PAMELLA) in Mol, Belgium are discussed. Highlights from the CEC meeting on natural analogues are presented. A U.S./FRG workshop on geotechnical instrumentation was held near Braunschweig, FRG at the Asse Salt Mine. An IAEA meeting on the back-end of the fuel cycle and a Bavarian government-sponsored symposium of the same title were attended. Mr. Ben Rusche, Director of the Office of Civilian Radioactive Waste Management, addressed the Bavarian symposium and visited the candidate Gorleben salt repository.

On May 12, 1987, an unfortunate construction accident occurred in Shaft #1 at Gorleben. A steel reinforcement ring broke and fell a distance of about five meters to the bottom of the shaft. Several workers were struck by the falling steel ring, and one worker later died as a result of the accident. An investigation is underway to determine the cause of the accident, and a recovery plan is being developed for the further excavation of this shaft. In the meantime, until the investigation and other response activities are completed, there will be a delay in the shaft-sinking operations at Gorleben.

Introduction

Beginning in early 1987, the long-term assignment of a representative of the Salt Repository Project (SRP) to the nuclear waste disposal program in the Federal Republic of Germany (FRG) was established as part of the ongoing interactions between the two countries under the U.S./FRG Bilateral Agreement (Waste Management). Through day-to-day contacts and close association of a technically cognizant SRP representative with key aspects of the FRG program, the objective of having a systematic exchange of pertinent programmatic information and data on the nuclear waste

disposal programs of both countries is being realized. During this reporting period, additional valuable contacts with key FRG personnel were established and direct communication with SRP management was maintained.

The construction accident at Gorleben was quite unexpected. Early information on this accident was received during attendance at the IAEA meeting and was relayed to the U.S.A. Copies of the official press releases are included in this report.

Underground Laboratory in Boom Clay Formation, Mol, Belgium

An informative visit was made to the underground laboratory in a Boom clay formation operated by the Belgian nuclear research establishment (SCK/CEN) near Mol, Belgium. In the 1970's, it became apparent that Belgium would have to find a disposal solution within its borders for high-level waste. Clay seemed to be a good choice, given the limited availability of potential sites in this small country and the location of the nuclear establishment at Mol over Boom clay beds. Thus, the project for underground exploration and construction of the HADES (High Activity Disposal Experimental Site) laboratory for in-situ testing began to take shape in 1974. In this underground facility, which is located about 220 meters below the surface, research and in-situ tests are being carried out in the following areas: rock and soil mechanics; physico-chemistry of deep clay; mechanical stability of underground structures; corrosion resistance of potential materials; heat tranfer; nuclear technology; deep hydrology; etc.

Attachment 1 is a recent publication describing this project and Attachment 2 is a list of relevant publications by SCK/CEN workers.

Of particular interest in regard to this facility is the underground testing experience that is being acquired there. However, the particular features of a site for disposing of nuclear wastes in clay are much different from other formations such as salt.

Work has begun on the second phase excavation of a 200 meter gallery. This is being done without benefit of freezing. Previous experience has shown that the wall movement of the clay is small following the initial expansion (which is relatively large) as tunnels are being excavated.

PAMELA Vitrification Pilot Plant, Mol, Belgium

A visit was made to the PAMELA vitrification pilot plant located near Mol, Belgium. This pilot plant was originally intended for the vitrification of about 50 cubic meters of waste from EUROCHEMIC commercial reprocessing of nuclear fuels in the 1970's. The plant features a liquid-fed ceramic melter with a 0.72 square meter surface area. It can produce three canisters per day of vitrified waste (150 kg/canister). DWK (German Fuel Reprocessing Company) workers at the PAMELA plant are providing technology transfer to the current plant owner, BELGOPROCESS. The vitrification process was developed by the Karlsruhe Nuclear Research Center (KfK).

The plant tour was impressive. It is a clean and very efficient facility. Currently, a campaign is underway to vitrify a large volume of reprocessing waste from high-enriched (93% U-235) fuel. Special modifications were required in 1986 to accomodate this waste. Once the ceramic melter is heated up, the process runs continuously; from October 1986 to May 1987, over 240 canisters of vitrified product were produced. In all, a production total of about 800 canisters is planned.

CEC Meeting on Natural Analogues

A meeting sponsored by the Commission of the European Communities (CEC) on Natural Analogues in Radioactive Waste Disposal was attended in late April. The program is shown in Attachment 3. It turned out to be a good meeting for persons who have not been following the field closely, with lots of information about what is being done worldwide in the way of natural analogue studies geared to solving the nuclear waste disposal problem. However, it was attended almost totally by workers in the field who all seemed to agree that what was needed was more financial support, further studies, exhaustive searching for more natural analogues, and generally very ambitious research efforts. Much of the research appears to be open-ended and, unfortunately, there were few program managers or regulatory representatives at the meeting to provide a needed balance or help to answer the questions "what is needed?" and "what is enough?" One can understand the enthusiasm of workers in the field, but it seems certain that the subject is being greatly oversold. For one thing, there appears to be such a large number of natural analogues to a nuclear waste repository, including colloids; sunken ships (bronze cannons, to be exact); all sorts of sediments and deposits in which leaching, precipitation, and other chemical processes have influenced

elemental distributions; and natural waters and mineral bodies exhibiting all kinds of scientifically interesting behavior. The problem is to link the characteristics of a natural system to conditions that would prevail in a repository in such a way that reasonable predictions or conclusions could be made.

In spite of the above comments, some good scientific studies were discussed at the meeting, and lively, useful discussions took place. A couple of the natural analogue studies that were discussed appear to have real potential for allaying fears that radionuclides cannot be adequately contained. The Cigar Lake uranium deposit in Canada is important in that there is no surface signature for this massive ore body which lies at a depth of about 440 meters. This deposit has survived without any significant groundwater dispersion for over one billion years. There was also a good paper and discussion about the Oklo natural fission reactors in the African Republic of Gabon, and it was interesting to learn that there is still some useful information coming from that well-studied ore body.

Professor W. A. Elders gave a paper on his SRP-supported Salton Sea work entitled "A Natural Analogue for Near-Field Behavior in a High Level Radioactive Waste Repository in Salt: The Salton Sea Geothermal Field, California, USA". Apparently, it was his first opportunity to discuss the Salton Sea analogue work before a group like this containing many persons who are well versed in this type of approach to the analogue problem. His paper was well received and seemed to fit in nicely with the other papers at this symposium. A preprint of Elders' paper is included as Attachment 4.

Nuclear Fuel Cycle Division at the CEC

While in Brussels, a visit was made to CEC headquarters and discussions held with staff of the Nuclear Fuel Cycle Division. The CEC funds R&D programs directly with funds obtained from Member States by a tax that is levied against them; also, CEC partly funds work under cost-sharing contracts (typically, at a 50% level) that is conducted at research centers in the Member States. Some of this work has direct application for salt repositories and thus is of potential importance to the SRP.

The CEC puts out a periodic newsletter on their activities (a copy is included as Attachment 5). There is a cooperative umbrella agreement with the U.S. for waste management exchange and DOE receives copies of publications as they are issued. A recent compilation of CEC publications concerning the R&D

program on Radioactive Waste and Storage has been issued as report EUR 10745. Important waste management programs sponsored by CEC are in the following areas: MIGRATION of RADIONUCLIDES in the GEOSPHERE (MIRAGE); Performance Assessment of Geological Isolation Systems (PAGIS); corrosion/waste package; geologic interactions; sealing/backfilling; and buffer materials.

U.S./FRG Workshop on Geotechnical Instrumentation

The U.S./FRG Workshop on Geotechnical Instrumentation was held at the Asse Salt Mine, near Braunschweig, FRG over the period of May 4-7, 1987. An agenda and list of participants are given in Attachment 6. The U.S. attendees included Donald Clark and Hemi Nalia from Battelle's Office of Nuclear Waste Isolation (ONWI), Gordon Green and Frank Shuri from Shannon & Wilson/Golder Associates, and Daryl Munson from Sandia National Laboratories (SNL).

A workshop report will be issued and travel reports have been written by the U.S. participants of this workshop. Therefore, only an outline of the group's activities will be given here. Formal presentations were given on the first day (May 4), and in the late afternoon the group departed for Gorleben. The second day included a tour of the Gorleben site and discussions of instrumentation to be used there during the exploratory phase. The group then returned to Braunschweig and another day of presentations and discussions at the Asse Salt Mine site. On the fourth day (May 7), the group toured the Asse Salt Mine in the morning and then visited the Bundesanstalt fuer Goewissenschaften und Rohstoffe (BGR) laboratories in the afternoon. The BGR, Federal Institute for Geosciences and Natural Resources, is located in Hannover, FRG. This institution is comparable to the U.S. Geological Survey and has an important role in the German repository exploration and characterization program. Finally, a small group of the participants left for Ettlingen (near Karlsruhe, in the southwestern part of the country), from where a visit was made to the facilities of Gloetzl-Baumesstechnik on the final day (May 8).

In all, it was a productive workshop and an informative exposure to the in-situ and rock mechanics testing programs of the FRG for the U.S. visitors.

IAEA Meeting on Back-End of the Fuel Cycle

The IAEA Meeting on Back-End of the Fuel Cycle was held in Vienna, Austria on the dates of May 11-15, 1987. A copy of the program for this meeting is included as Attachment 7. It was a very good meeting, well attended and providing an excellent overview of the programs of many countries for management of high-level wastes and spent fuel. Several countries are moving ahead with fairly ambitious programs for the reprocessing of nuclear fuel, including the FRG, China, France, the United Kingdom (UK), Japan, and the USSR. These countries plan to recycle the recovered plutonium in thermal power reactors and later also in fast-breeder reactors. Other countries (e.g., Finland, Italy, Spain, Canada, and Sweden) are pursuing the option of long-term storage of spent fuel prior to direct disposal or possible reprocessing and vitrification. The U.S. plans, as contained in the Mission Plan and its Amendment submitted to Congress, include the characterization of three candidate sites and the Monitored Retrievable Storage (MRS) option.

A contrast was evident between small countries whose plans for final disposal are well into the future and the larger nuclear states such the USA and FRG whose plans are to proceed with all due speed in developing acceptable, licensable geologic repositories. Several good papers were presented on the strategies adopted by the different countries and the facilities now in use or planned to be used in the future. The reprocessing plants being built all appear to be using advanced, state-of-the-art designs. And good coverage was given the storage facilities, both wet and dry, for spent fuel that exist or are under development.

One new development announced at the meeting was the UK decision to provide for deep disposal of low-level waste (LLW). While the decision might have been politically inspired, it presumably reflected the conclusion that combining LLW with intermediate-level waste (ILW), and disposing of them in a deep multi-purpose facility would be cost effective. Such an approach should have much greater chance of winning public acceptance than shallow land burial, particularly if the costs are not greatly different. The Germans were elated by this development as it lends additional support to their plans for disposal of non-heat producing wastes in the Konrad iron ore mine.

Bavarian Symposium on the Back-End of the Fuel Cycle

The Bavarian Government (State Ministry for Land Development

and Environmental Questions, BStMLU) sponsored a symposium on the back-end of the fuel cycle in Munich, May 18-21, 1987. A copy of the program for this meeting is included as Attachment 8. This meeting was intended to present opportunity for a debate on the status of the science and technology of managing the wastes from light water reactors. The Bavarian government favors construction of a reprocessing plant at Wackersdorf and the debate primarily centered on the rationale for this decision, the positive benefits of closing the fuel cycle, etc. Thus, the meeting was decidedly upbeat and concluded with general consensus that the direction of the German program is warranted by consideration of national interests, economic factors, and the generally advanced state of the technology.

Some excellent review papers were presented at the meeting on the German program. Professor Streffer from Essen gave a good paper on the preferred approach of considering individual, rather than collective, doses in performance assessment calculations. Of course, the design of the Wackersdorf plant was covered rather thoroughly. And, on the final day, there were several important papers on the nuclear waste disposal programs of other countries. Mr. Ben Rusche presented a well-received paper on the U.S. civilian waste disposal program. Afterwards, there was a panel discussion that included many questions and comments from the audience.

Dr. Toepfer, the new Federal Minister of the Environment, Nature Conservation and Nuclear Safety (BMU), delivered an important address on the Federal government's position on nuclear power in the FRG. Unlike the U.S., most discussions in the FRG that concern nuclear waste disposal also include the subject of nuclear power generation, its pros and cons, etc. At any rate, there seems little doubt that the new Minister intends to take an active part in the debate occurring in his country.

Construction Accident at Gorleben

On May 12, 1987, an unfortunate construction accident occurred in Shaft #1 at the Gorleben candidate repository. The initial press release by the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern fuer Abfallstoffe (German Company for Planning, Construction and Operation of Repositories, DBE) is included as Attachment 9.

Seven miners were at the bottom of the shaft, aproximately 239 meters (740 feet) below the surface, at the time of the accident. A steel support ring which had been placed over the prelimary liner about 5 meters from the shaft bottom unexpectedly broke and fell down striking six of the miners. One of the miners was seriously injured and died two days later.

Steel support rings had been placed over the preliminary liner in the lower region of the shaft where unexpectedly high non-uniform ground pressure was observed in a clay layer just above the caprock covering the salt dome. After the accident, it was noted that the rock was continuing to exert pressure on the remaining support rings and it was decided that the situation could best be stabilized by filling the affected part of the shaft (lower 14 meters) with a lean concrete plug. A joint press release from DBE and the Physikalisch-Technische Bundesanstalt (Federal Institute of Physics and Technology, PTB) was then issued on this development (see Attachment 10).

The early press coverage of this accident was fairly factual and did not attempt to link it with the nuclear mission intended for the Gorleben salt dome. However, it can be expected that some of the later press treatments will be more critical and contain an anti-nuclear slant. An investigation as to the cause of the accident was undertaken immediately. Also, there will be a technical assessment of the conditions leading to this unfortunate event and a recovery plan for further shaft sinking will be prepared. In the meantime, some delay is inevitable so far as the shaft sinking operations at Gorleben are concerned.

Activities Planned for June 1987

A major objective will be to stay in close touch with the situation at Gorleben. A number of U.S. visitors will be in the area for meetings and tours of the German facilities. A visit will be made to the Karlsruhe Nuclear Center (KfK) to discuss field testing planned in connection with the program for direct disposal of spent fuel.

Attachments

1. Publication "The HADES Demonstration Project for Radwaste Disposal in Deep Clay"
2. List of Publications by SCK/CEN Workers on Disposal of Radioactive Wastes into Geological Formations
3. Program for CEC Meeting on Natural Analogues
4. Paper on Salt Sea Geothermal Field by W. A. Elders and Presented at CEC Meeting on Natural Analogues
5. Copy of The Periodic Newsletter on Radioactive Waste That is Published by the CEC
6. Agenda for US/FRG Workshop on Geotechnical Instrumentation

7. Program for IAEA Meeting on Back-End of Nuclear Fuel Cycle
8. Program for Bavarian Symposium on Back-End of the Nuclear Fuel Cycle
9. First Press Release on Gorleben Accident
10. Second Press Release on Gorleben Accident

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ATTACHMENT 1

STUDIECENTRUM VOOR KERNENERGIE

CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

THE HADES DEMONSTRATION PROJECT FOR RADWASTE DISPOSAL IN DEEP CLAY

L.H. Baetslé, A. Bonne, P. Dejonghe

International Conference on Radioactive Waste Management
Winnipeg, Sept. 7-11, 1986

THE HADES DEMONSTRATION PROJECT FOR RADWASTE DISPOSAL IN DEEP CLAY

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ABSTRACT

The underground laboratory constructed on the site of the belgian nuclear research establishment at mol in the framework of the hades-project (high activity disposal experimental site) permitted to carry out specific in situ investigations in the field of corrosion behaviour of various candidate materials, geotechnics, hydrology, physico-chemistry, heat transfer and radionuclide migration.The results of these investigations are very encouraging and the decision has been taken to extend the underground facility towards a pilot size unit.

INTRODUCTION

The underground laboratory constructed on the site of the belgian nuclear research establishment (S.C.K/ C.E.N.) at Mol, Belgium has been the starting point of an extensive in situ research programme in deep clay. Specific in situ investigations in the field of corrosion behaviour of various structural materials and waste forms are being carried out in representative conditions. Important contributions have been brought to the hydrology in the clay body and the adjacent layers, to the geotechnical aspects of building galleries in clay and to the radionuclide migration.

The result of all these investigations are very encouraging and the decision was taken to extend the underground laboratory towards a pilot size demonstration facility. The H(igh) A(ctivity) D(isposal) E(xperimental) S(ite) project is performed in the framework of the european atomic energy community's costsharing research programme on radioactive waste management and disposal.

For reasons of technical convenience the project has been split up in two phases
- in first phase from (1986-1992) the upscaling of construction capability in non frozen clay coupled to pilot size experiments on heat transfer, radiolysis and gamma source handling ;
- in a second phase starting in 1988 and extending to 1994 the construction of a second shaft with connection tunnels to the existing laboratory. This phase will be started after approval by the National Waste Management authority (NIRAS-ONDRAF).

The full scale underground demonstration gallery will allow to perform mock-up tests on real scale first and retrievable disposal of different waste forms at a later stage.

THE UNDERGROUND LABORATORY

The underground laboratory situated on the nuclear site of Mol is located in the vicinity of the other nuclear installations. Its construction started in 1978 and was finished in 1984. It was commissioned for in situ experiments with radioactive substances. A schematic view of the present underground construction is shown on figure 1. The shaft has a depth of 225 m equipped with a lift; at the bottom an horizontal gallery of 35 m length with 3.5 m Ø has been constructed. The gallery (Fig. 2) is lined with galvanized cast iron vaults in which numerous ports have been installed. At the end of the gallery a 25 m deep shaft (1.5 m Ø) has been dug into non frozen clay and lined with concrete blocks. Finally a 7 m horizontal drift at 250 m depth ends up in a open clay wall.

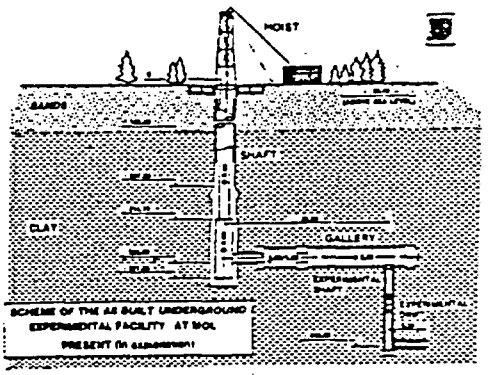

FIGURE 1: SCHEMATICAL VIEW OF THE AS BUILT UNDERGROUND LABORATORY

At the beginning of the operational phase important water leaks occurred in the concrete walls of the shaft but by an appropriate polyurethane injection treatment the amount of inleaking water has been reduced to 3 l/h.

FIGURE 2: VIEW OF THE UNDERGROUND LABORATORY BEFORE MOUNTING OF EQUIPMENT

The most important geotechnical conclusion resulting from the construction phase was the possibility to dig galleries in non frozen clay at 250 m depth. Moreover it was shown that after an initial expansion the clay body remains unaltered for a very long period of time. Figure 3 shows the wall movements as a function of time at different distances from the small drift. It may be anticipated that construction of large diameter galleries (4 to 6 Ø) without freezing is technically feasible.

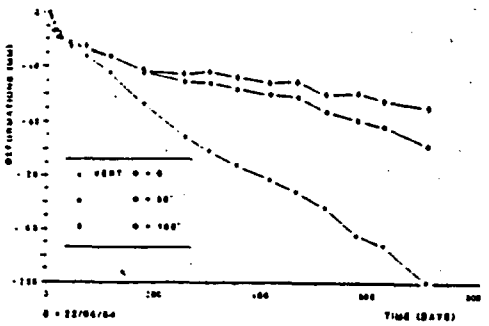

FIGURE 3: DEFORMATIONS OF CLAY WALL AS A FUNCTION OF MEASUREMENT ANGLE

Corrosion and material test experiments

In preparation of a series of in situ tests a so called "overcoring" test took place : it aims at recovering a test loop without damaging the interface between the loop and the surrounding clay.

A mock-up corrosion loop 6 m long and 102 mm Ø was emplaced horizontally in the clay formation and kept into position till it was completely caught by the plastic deformation of the clay formation. The recovery procedure is schematically shown in Fig. 4. By pushing a 40 cm Ø tube into the medium, a 1.5 m long section containing the mock-up has been retrieved in "non-disturbed" condition. Based on that experience a series of instrumented corrosion and heat transfer loops have been introduced.

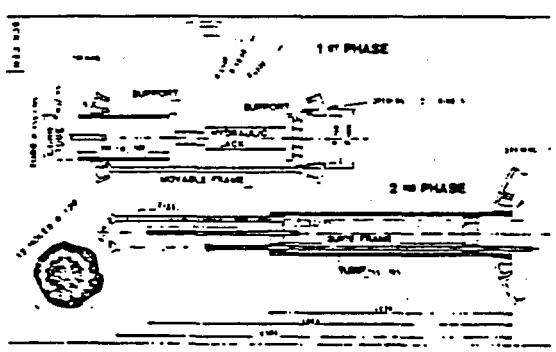

FIGURE 4: SCHEMATIC VIEW OF THE OVERCORING EXPERIMENT TO RECOVER EXPERIMENTAL RIGS

Two types of material test loops have been constructed and installed in the underground laboratory : one type with direct contact between clay and test samples and a second type where a carrier gas leaches the clay surface and the resulting "vapours" attack the displayed material samples ; each loop has a length of 5.3 m.

A number of structural materials (Titanium, Hastelloy, Stainless steel, Cast iron...) and waste materials (Am and Pu traced borosilicate, ironsilicate, concrete,...) samples are attached at the inner tube of the loop. Four loops of the "direct contact" type have already been installed : one loop will remain at ambient temperature, two at 90°C and one at 170°C. The first loop to be retrieved after 2 years is that kept at 90°C. Figure 5 shows a picture of the installed loops in the underground.

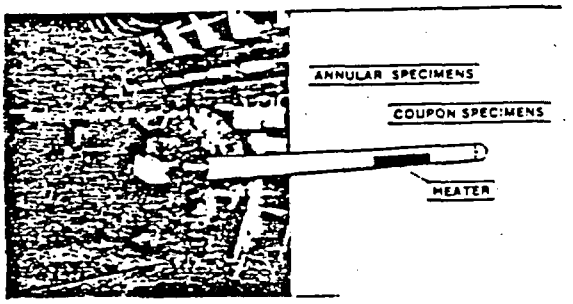

FIGURE 5: CORROSION LOOPS AS MOUNTED IN THE LABORATORY WALL WITH PERSPECTIVE VIEW OF THE TUBE INSERTION IN THE CLAY BODY

The four "clay atmosphere" loops are to be installed in the course of this year. The tubes have a porous plug and have heating elements and test specimens inside. Argon is used as purge gas to take up corrosive products penetrating the plug and to circulate these over the test samples. The outcoming flow is finally collected and continuously monitored for its dew point. The chemical monitoring equipment (pH, Eh, gases,...) is already available (see Fig 6).

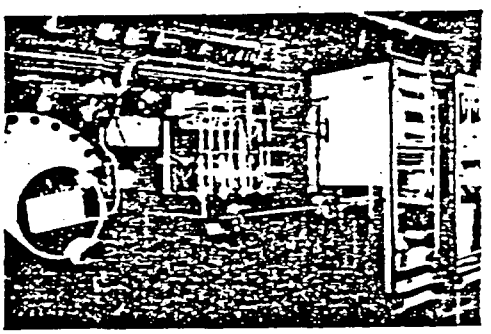

FIGURE 6: CHEMICAL MONITORING EQUIPMENT OF CORROSION LOOPS IN CLAY

Additionally direct corrosion rate instrumentation has been installed
- corrator measurements (linear polarization resistance) ;
- corrosometers (electric resistance measurement).

Those corrosion monitors are specially suited to measure very slow corrosion rates e.g. on titanium, hastelloy, etc. which are candidate overpack materials.

All data produced in the underground laboratory are collected by an IBM-TX computer and transferred by an optical fiber communication network to the laboratory computer systems. By means of these sophisticated equipment it is expected to continue all measurements during several years notwithstanding the heavy civil engineering and mining operations scheduled from early next year.

Geological experiments

A large scale geotechnical experiment has been carried out during the excavation of the small shaft and the adjacent drift.

Before the digging of the small shaft and the adjacent drift an electrical extensometer (DISTOFOR) has been introduced in the clay from the bottom end of

the main gallery down to the end of the small shaft just above the drift (Fig. 7). The apparatus permitted to record the movements inside the clay up to distances of 5 m from the roof of the excavated drift. After an initial sudden expansion the clay-wall, the movement decreased till almost negligeable displacements as shown on Fig. 8.

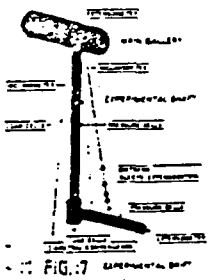

FIG.:7

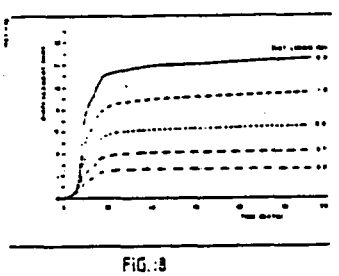

FIG.:8

FIGURE 7: DISTOFOR EXPERIMENTAL DEVICE TO MEASURE MOVEMENTS IN CLAY DURING EXCAVATION TESTS

FIGURE 8: DISPLACEMENTS MEASURED INSIDE CLAY BODY

Additional rheological studies on clay have been continued by experimentally investigating the "convergence-confinement" modelling. A special measuring device (15 m long) has been implanted in a horizontal borehole. Its working principle is the measurement by inductance variation probes of the steel tubing deformation as a result of the pressure buildup.

As a conclusion to the geotechnical investigations it is now technically accepted that concrete wall thicknesses of about 0.6 m are sufficient to sustain the lithological and hydrologic pressure of 40 bars from the clay formation over a sufficient long time span.

Hydrologic behaviour of Boom clay

In order to have a precise picture of the hydraulic pattern in the Boom clay surrounding the underground facility, a number of piezometers and pressure cells have been installed in the vicinity of the gallery during the construction and the completion of the underground facility.

The piezometers consist of a stainless fritted steel screen and a stainless steel extension pipe, emplaced at various depths and along varying inclinations. Those piezometers are mainly used to collect pore water samples under strict anaerobic conditions for accurate chemical analyses, ^{14}C-dating and U/Th isotopic ratio determination.

The piezometer network allows to trace the in situ pore water pressure evolution and to measure experimentally the clay permeability at different horizons.

The following preliminary conclusions stem from the ongoing pressure measurements :

<i> at a depth of 250 m pore water pressure stabilizes at 19.5 bars, while in the vicinity of the gallery a pressure of 8 bar (223 m depth) is found. As the static water level should give pressures in the range of 23 to 25 bars, this clearly indicates a drainage of the clay by the experimental laboratory. The water seeping through the walls of the construction is swept by ventilation ;

<ii> flow rates, measured in a piezometer located at the bottom of the small shaft amount to 940 ml/day, allowing the collection of sufficient water for chemical analyses and in situ determination of the clay permeability ; the in situ permeability amounts to 0.1 l/m^2/day-bar with a local gradient of 2 bars ;

<iii> appropriately designed instrumentation equilibrates quickly with the formation. The pressure build-up and the hydraulic gradient measured in a multiple piezometer installed along a 10 m deep borehole are shown in Figure 9.

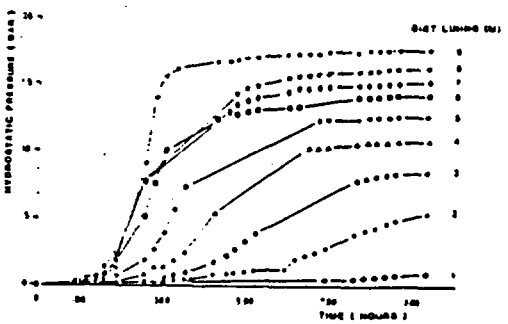

FIGURE 9: PIEZOMETRIC WATERPRESSURE AS A FUNCTION OF DISTANCE FROM CLAY WALL AND ELAPSED TIME

An essential parameter governing the mass transfer concerns the porosity of the medium involved, as the porosity determines both the interstitial groundwater velocity and the interactions of the nuclides with the geological medium. Laboratory tests on molecular difusion deal essentially with total porosity, while in the underground facility advantage is taken of the extremely high hydraulic gradient occurring in the clay wall of the underground laboratory.

By imposing a counter pressure a very large range of hydraulic conductivities can be tested under in situ conditions.

Migration experiments

In situ experiments are being conducted in the underground laboratory in order to determine the diffusion parameters ruling the radionuclide migration in deep compact clay.

A typical experiment consist of a labelled clay plug pushed inside a metal tube whose orifice is in direct contact with the formation. Based on the high retardation factor for ^{152}Eu, ^{241}Am, ^{238}Pu as determined in the laboratory and on the increased wastes movement through the clay boundary experiments can be performed within a reasonable time period. However their significance is only limited since the migration direction is monodimensional and directed towards the gallery wall (Fig.10).

Under 8 - 10 bar hydraulic pressure water percolates through the plugs at a rate of 1 to 2 drops per day i.e. about 500 times faster than the natural flow rate. By applying a counter pressure the percolation flow rate can be varied over a very wide range.

However if the counter pressure approaches the pore water pressure of the formation practically no convection occurs and longe range experiments can be performed. If the counter pressure equals the pore water pressure no movement whatsoever is to be observed and pure diffusional transport is observed.

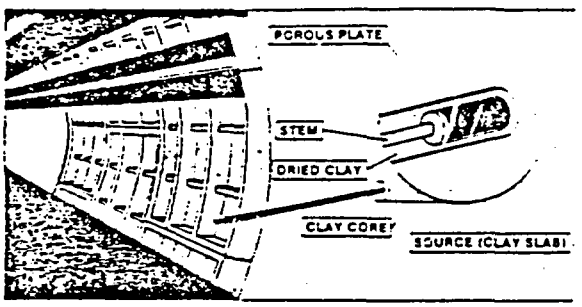

FIGURE 10: EXPERIMENTAL DEVICE TO MEASURE RADIONUCLIDE MIGRATION UNDER IN SITU CONDITIONS AROUND THE UNDERGROUND LABORATORY

PILOT AND DEMONSTRATION FACILITY

The first phase of the HADES pilot and demonstration project consists of the digging in unfrozen clay bf a 25 to 30 m long gallery connected with the presently existing shaft. The new gallery will be opposite to the underground laboratory and be used for radiolysis experiments, large scale heater tests and emplacement operations of radioactive sources into the formation.

The design has been started about the middle of 1985. The following factors had to be taken into account when defining the constructional requirements of the test drift.

- the new drift will be lined with concrete and connected to the existing underground laboratory ;
- the investments for the construction of phase 1 are limited but sufficient to perform a mine-by experiment ;
- the drift must be equipped for performing tests with significant radioactive sources.

Fig. 11 shows the concept of the test drift and its situation with regard to the present underground laboratory. The works around the crossing chamber should not compromise the geotechnical stability and interfere as little as possible with the exploitation and accessibility of the underground laboratory.

The present status of the design can be summarized in the following characteristics :

1. The drift will have a length of 25 m, a useful internal diameter of 3.5 m and a concrete lining of 0.60 m thickness. This lining thickness implies an excavation diameter of 4.7 m.

2. The concrete quality of the lining blocks will have to exceed normal standards because of the high working stresses, low water/cement ratio and very high density. Each block has a trapezoidal shape separated from its neighbour by linex panels.
3. Three types of holes are presently foreseen (0.2, 0.4 and 0.76 m Ø). The small holes will be precasted in the concrete blocks.

The excavation and construction of the phase I facility will take place in 1987.

A serie of tests are planned in the drift.
1. Mine-by-test (geotechnical follow up).
2. Heater test (5 - 12 KW).
3. Radiation test ($\geq$ 1000 Ci γ source).
4. Emplacement - retrieval test (dummy HLW container).
5. Migration test (representative HLW glass composition).

The second phase will follow with a certain delay the experimental programme scheduled for the period 1987-1992. Fig. 12 shows an artist view of the full scale HADES facility. It is composed of a 200 m gallery connected to a second shaft.

The following activities are planned :
- construction of a new access shaft with a diameter of 4.5 m ;
- excavation of a 200 m gallery connecting the phase I drift to the new shaft. The excavation is scheduled to take place by mechanized tunneling using a tunneling machine ;
- construction of other underground structures eg. a connecting chamber and disposal holes ;
- placement of the mechanical and handling equipment ;
- emplacement of monitoring and instrumentation system.

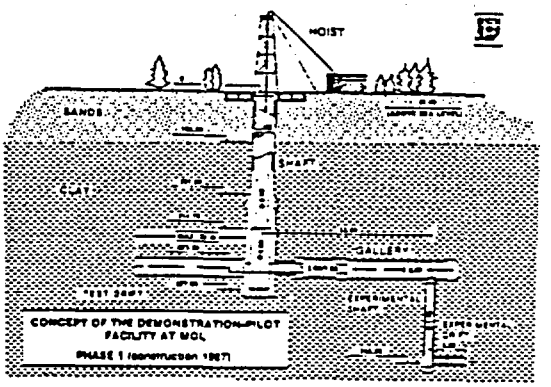

FIGURE 11: CONCEPT OF THE DEMONSTRATION TEST DRIFT AS IT WILL BE CONSTRUCTED IN THE VICINITY OF THE UNDERGROUND LABORATORY

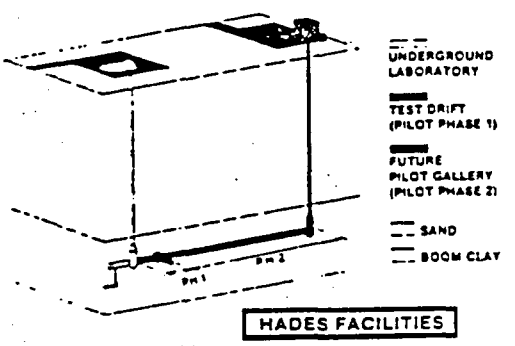

FIGURE 12: SCHEMATIC VIEW OF THE HADES FACILITY AS IT IS PLANNED TO BE CONSTRUCTED AND OPERATED IN THE NEXT 10 YEARS

A series of experimental test programmes are scheduled :
- Tests on handling, emplacement, backfilling and retrieval of dummy containers. Comparative evaluation of emplacement concepts in separate disposal holes or in full gallery section.
- Radioactive tests with actual waste forms : handling and emplacement of real waste containers ; backfilling in disposal holes and in parts of the gallery ; radioactive monitoring of the overall structure and the surrounding clay formation.

- Study of the clay and material behaviour with special emphasis on the long-term effects of ventilation, thermomechanical behaviour impact on the pore moisture content of the clay.

A principle agreement has been signed between SCK/CEN and the Commission of the European Community to carry out the programme over the next 10 years. However each programme phase is connected to a budgetary frame which covers successively the phase I (1985-1987) with its associated experimental test programme (1988-1992) and the phase II which is only decided in principle.

Discussions are taking place with the National Institute for Radioactive Waste Management (NIRAS/ONDRAF) to establish a proper timing for the realization of the pilot facility. If sufficient support and international collaboration is found the construction of the second phase could start in 1989 and be operated with real waste forms from 1995 on. Fig. 13 shows the time schedule.

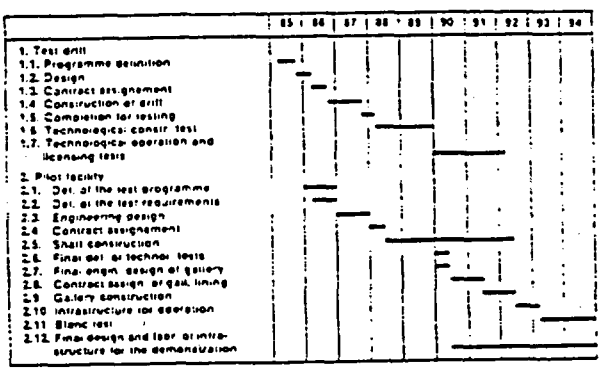

FIGURE 13: TIME SCHEDULE OF THE HADES FACILITY CONSTRUCTION

At the present time a formal agreement exist between the french ANDRA and SCK/CEN in order to cover certain aspects of the R&D programme and to collaborate in the phase I pilot facility. Other parties have been contacted in order to establish a fully international programme capable of demonstrating the clay option as a fully mature technology in comparison with other formations.

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From 1983 on the running R&D programme has been included into the overall Waste Manage- ment Strategy of the National Institute for Radioactive Waste Management (NIRAS-ONDRAF) which supported financially the research activities of our institute and the associated university laboratories in this area.

Bilateral co-operation between the french Agence Nationale des Déchets Radioactifs (ANDRA) and SCK/CEN led to an amplification of the in situ research activities.

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ATTACHMENT 2

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June 1986

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A. BONNE, J. BLACK, F. GERA, F. GONZE, E. TASSONI, J.F. THIMUS
Characterization and behaviour of argillaceous rocks.
Second European Community Conference on "Radioactive waste management and disposal"
Luxembourg, April 22-26, 1985

H.J. CLARK, A. BONNE, F. VAN KOTE, H. STELTE
Application of the Pagis Methodology to clay, salt, granite and sub-seabed repositories.
Second European Community Conference on "Radioactive waste management and disposal"
Luxembourg, April 22-26, 1985

J.F. OUVRY*
Results of triaxial compression tests and triaxial creep tests on a artificially frozen stiff clay.
Sapparo, Aug. 1985
*BRGM, Orléans, France

P. DEJONGHE, E. DETILLEUX, A. BONNE, G. COLLARD
Status of the nuclear waste disposal program in Belgium.
Proceedings ANS symposium,
Pasco, 24-26 Sept. 1985

G. ROUSSET, J.C. FERNIQUE, R. ANDRE-JEHAN, A. BONNE
Mechanical behavior of galleries in deep clay. Study of an experimental case (experimental drift at Mol, Belgium).
Proceedings ANS symposium,
Pasco, 24-26 Sept. 1985

A. BONNE, J. MARIVOET
Safety analyses of a HLW-repository in a clay formation.
Proceedings ANS symposium,
Pasco, 24-26 Sept. 1985

P. MANFROY, R. HEREMANS, A. BONNE
Ten years of site specific research and its relevance to the concept of a waste disposal system in clay.
Proceedings ANS symposium,
Pasco, 24-26 Sept. 1985

J. DE CONINCK*
Microfossiles à paroi organique dans les sables de Lede (Eocène moyen) du sondage de Mol (Belgique).
Publ. : Bull. Belg. Ver. Geologie/Bull. Soc. Belg. Géologie, V94/1, pp. 65-78, 1985
* Laboratorium voor Paleontologie (Geol. Inst.) R.U. Gent

P. HENRION, M. MONSECOUR, A. FONTEYNE
Application of sorption data to the evaluation of radioelement migration in the Boom clay formation.
Proceedings of the "Scientific seminar on the application of distribution coefficients to radiological assessment models"
C.E.C., Louvain-la-Neuve, 7-11 October 1985

A. BONNE, P. MANFROY, R. HEREMANS
Site investigation and geo-planning concerning the final disposal of conditioned high-level and alpha-bearing wastes in a deep clay formation at Mol.
Proceedings of the "Nationaal Colloquium - Ingenieursgeologische problemen in verband met afvalberging/Colloque national - Problèmes de géologie de l'Ingénieur en relation avec le stockage des déchets"
Org. BCIG/CBGI, pp. 4.1.
Liège, Sart-Tilman, oct. 22-24, 1985

B. NEERDAEL, P. MANFROY, A. BONNE
Investigations et acquisition des paramètres nécessaires pour la conception et la construction d'une installation souterraine pour l'enfouissement de déchets hautement radioactifs dans une formation argileuse profonde.
Proceedings of the "Nationaal Colloquium - Ingenieursgeologische problemen in verband met afvalberging/Colloque National - Problèmes de géologie de l'Ingénieur en relation avec le stockage des déchets"
Org. BCIG/CBGI, pp. 4.48
Liège, Sart-Tilman, oct. 22-24, 1985

J.F. THIMUS, M. LEJEUNE, B. SINE, M. BUYENS, B. NEERDAEL
Auscultation gécmécanique du puits d'accès au laboratoire souterrain.
Proceedings of the "Nationaal Colloquium - Ingenieursgeologische problemen in verband met afvalberging/Colloque National - Problèmes de géologie de l'Ingénieur en relation avec le stockage des déchets"
Org. BCIG/CBIG, pp. 4.63
Liège, Sart-Tilman, oct. 22-24, 1985

P. DEJONGHE, E. DETILLEUX, G. COLLARD, N. VAN DE VOORDE, A. BONNE
Status of the radioactive waste management program in Belgium.
Proceedings of the "Symposium on Radioactive waste management"
Tucson, 3-6 Feb. 1986

P. DEJONGHE, A. BONNE, N. VAN DE VOORDE, E. DETILLEUX
Low and medium level radioactive waste management in Belgium.
Proceedings of the "International Symposium on alternative low-level Waste technologies"
Chicago, 27 Feb. - 1 March 1986

A. BONNE, P. MANFROY
Factors and elements involving adaption and actualisation of the design and the concept of a HLW, ILW, and alpha-bearing waste repository in a deep stratiform clay formation on the continent - The case of the Mol-site (Belgium).
Proceedings of the "International symposium on the siting, design and construction of underground repositories for radioactive wastes"
IAEA-SM-289/38
Hanover, March 3-7, 1986

P. MANFROY, R. HEREMANS, P. KOCKEROLS, Th. ZEEVAERT
Etude préliminaire sur les possibilités d'enfouissement terrestre des déchets conditionnés de faible radioactivité en Belgique.
Proceedings of the "International symposium on the siting, design and construction of underground repositories for radioactive wastes"
IAEA-SM-289/38
Hanover, March 3-7, 1986

D. DE BRUYN, B. NEERDAEL, P. GONZE, J.P. ROSSION, G. ROUSSET
Contribution to the study of the time dependent behaviour of clay at great depth. Application in view of the construction of a waste disposal facility in the Boom clay formation.
Proceedings of the second International Symposium on "Numerical Models in Geomechanics"
Gent, March 31 - April 4, 1986

P. VAN ISEGHEM, W. TIMMERMANS, W. DEBRUYN, J. DRESSELAERS, B. NEERDAEL
In situ testing of nuclear waste forms in an underground laboratory in clay
Proceedings : "Ceramics in nuclear waste management"
Chicago, April 28 - June 1, 1986

A. BONNE, B. NEERDAEL
Disposal of radwaste in clay : the experience gained in Belgium.
Proceedings : Transactions ENC '86, Genève, 2-6 June 1986

A. BONNE, R. HEREMANS, P. MANFROY, R. VAN HAELEWIJN
Construction of an underground facility for "in-situ" experimentation in the Boom clay.
EUR 10177 EN, 1986

ATTACHMENT 3

COMMISSION
OF THE
EUROPEAN COMMUNITIES

DIRECTORATE-GENERAL
FOR SCIENCE RESEARCH
AND DEVELOPMENT
JOINT RESEARCH CENTRE

XII-D-2

NATURAL ANALOGUES IN RADIOACTIVE WASTE DISPOSAL
A Symposium organised by the Commission of the European Communities
Brussels, 28-30 April 1987

PROGRAMME

28 April, 1987

8.30 - 9.00	Check-in
9.00 - 9.30	Welcoming Address and Introduction S. ORLOWSKI, Head, Radioactive Waste and Fuel Cycle Division, CEC
9.30 - 12.30	SESSION I: WHY NATURAL ANALOGUES (RATIONALE AND KEY AREAS OF NEEDS) Chairman: N.A. CHAPMAN, British Geological Survey (UK) Co-Chairman: M. D'ALESSANDRO, JRC Ispra
9.30 - 10.00	"Natural analogues and performance assessments: a point of view based on the PAGIS experience" N. CADELLI, CEC
10.00 - 10.30	"The role of natural analogues as seen from the safety assessment and acceptability point of view" T. PAPP, SKB (S)
10.30 - 11.00	COFFEE BREAK
11.00 - 11.30	"Natural analogues and radionuclide transport model validation" D.A. LEVER, UKAEA (UK)
11.30 - 12.00	"Applicability of natural analogues studies to the long-term prediction of the far-field migration at repository sites" P.L. AIREY, IAEA
12.00 - 12.30	"Natural and archaeological analogues: a review" D.G. BROOKINS, University of New Mexico (USA)
12.30 - 14.00	LUNCH

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14.00 - 17.20 SESSION II: MAJOR ANALOGUE SITE STUDIES

Chairman: I. MC KINLEY, EIR (CH)
Co-Chairman: S. CARLYLE, OECD-NEA

14.00 - 14.25 "Near-field analogue features from the Cigar Lake uranium deposit"
J. CRAMER, AECL (CANADA)

14.25 - 14.50 "Sandstone uranium deposits: analogues for SURF disposal in some sedimentary rocks"
D. BROOKINS, University of New Mexico (USA)

14.50 - 15.15 "Radionuclide migration around uranium ore bodies in the Alligator Rivers region of Australia - Review of research and its implication for model validation"
P. DUERDEN, C. HARDY, Australian Atomic Energy Commission (AUSTRALIA)

15.15 - 15.40 "Uranium in selected endorheic basins as partial analogue for spent fuel disposal in salt"
A. VAN LUIK, Battelle PNL (USA)

15.40 - 16.05 COFFEE BREAK

16.05 - 16.30 "Natural analogues of radionuclide migration in sediments in Britain"
P. HOOKER, British Geological Survey (UK)

16.30 - 16.55 "Biogechemical studies of the Ra, U, Th and REE deposit at Morro do Ferro: a qualitative application to improve confidence in radionuclide immobilisation processes"
P. LINSALATA, New York University (USA)

16.55 - 17.20 "The Poços de Caldas natural analogue project"
J. SMELLIE, Swedish Geological (S)

17.20 - 18.00 POSTERS AND DISPLAYS

18.00 - Cocktail offered by the CEC

29 April, 1987

9.00 - 10.40 SESSION III: ANALOGUES FOR WASTE FORMS AND ENGINEERED BARRIERS

Chairman: F.P. SARGENT, AECL (CANADA)
Co-Chairman: P.L. AIREY, IAEA

9.00 - 9.25 "A 17th Century bronze cannon as analogue for radioactive waste disposal"
R. HALLBERG, University of Stockholm (S)

9.25 - 9.50 "Geochemical controls on the retention of fission products at the Oklo natural fission reactors"
D. CURTIS, Los Alamos National Laboratory (USA)

9.50 - 10.15 "The use of natural analogues in the long-term extrapolation of glass corrosion processes"
W. LUTZE, Hahn-Meitner Institute, Berlin (D)

10.15 - 10.40 "Glass stability in the marine environment"
Z.H. ZHOU, University of Western Ontario (CANADA)

10.40 - 11.00 COFFEE BREAK

11.00 - 12.30 POSTERS AND DISPLAYS

12.30 - 14.00 LUNCH

14.00 - 18.00 SESSION IV: ANALOGUES OF PROCESSES AFFECTING RADIONUCLIDE MIGRATION - PART I

Chairman: I. NERETNIEKS, RIT (S)
Co-Chairman: B. SKYTTE-JENSEN, RISØ NL (DK)

14.00 - 14.25 "Testing geochemical models in a hyperalkaline environment"
I. MC KINLEY, EIR, Würenlingen (CH)

14.25 - 14.50 "Simulation of solubility and transport phenomena at the Cigar Lake uranium deposit"
D. MC CONNELL, AECL (CANADA)

14.50 - 15.15 "Hydrothermal alteration systems as analogues of nuclear waste repositories in granitic rocks"
J.F. SUREAU, BRGM (F)

15.15 - 15.40 "Some geochemical and mineralogical peculiarities of the deposits of radioactive material as an evidence for radiolysis in Nature"
I.F. VOVK, IAEA

15.40 - 16.00 COFFEE BREAK

16.00 - 16.25 "Evidence of fossil and recent diffusive element migration in reduction haloes from Permian red-beds of Northern Switzerland and UK"
B. HOFFMAN, University of Bern (CH)
J.P. DEARLOVE, CCAT, Cambridge (UK)

16.25 - 16.50 "Modelling isotope distributions in borecores"
F. HERZOG, EIR, Würenlingen (CH)

16.50 - 17.10 "Long-term diffusion into rock below sea-water"
N. JEFFERIES, UKAEA Harwell (UK)

17.10 - 17.35 "Element distribution across veins in the East Bull Lake Gabbro anorthosite layered intrusion, Algoma district, Ontario - an evaluation of matrix diffusion"
P. PINTO COELHO, The University of Western Ontario (CANADA)

17.35 - 18.00 "Marysvale natural analogue study: feasilibity phase results"
M. SHEA, OCRD (USA)

30 April, 1987

8.45 - 12.45 SESSION IV (CONT'D): ANALOGUES OF PROCESSES AFFECTING RADIONUCLIDE MIGRATION - PART II

Chairman: D. BROOKINS, The University of New Mexico (USA)
Co-Chairman: G. DE MARSILY, Ecole des Mines (F)

8.45 - 9.10 "Natural colloids and generation of actinide pseudo-colloids in groundwaters"
J.I. KIM, Technical University Munich (D)

9.10 - 9.35 "A study of the role of colloids in the subsurface transport of radionuclides in the hydrogeological system of the Koongarra uranium deposit, N.T. Australia"
M. IVANOVICH, UKAEA Harwell (UK)

9.35 - 9.55 "CEC colloid benchmark: presentation and preliminary results"
C. ROSS, British Geological Survey (UK)

9.55 - 10.20 "Matrix diffusion and mobility of uranium in the Alligator Rivers Natural Analogue"
(speaker to be specified by the Australian Atomic Energy Commission)

10.20 - 10.45 "A natural analogue for near-field behaviour in a high-level radioactive waste repository in salt: the Salton Sea geothermal field, California (USA)
W. ELDERS, University of California (USA)

10.45 - 11.05 COFFEE BREAK

11.05 - 11.30 "The geochemistry of natural technetium and plutonium"
D. CURTIS, Los Alamos National Laboratory (USA)

11.30 - 11.55 "The use of uranium series disequilibrium for site characterisation as an analogue for actinide migration"
M. GASCOYNE, AECL (CANADA)

11.55 - 12.20 "Redistribution of natural Iodine 129 among mineral phases and groundwaters in the Koongarra uranium ore deposit. N.T. Australia"
J. FABRYKA-MARTIN, University of Arizona (USA)

12.20 - 12.45 "Mechanisms and quantitative evaluations of radionuclide fixation in rocks and sediments"
H. NAKAMURA, JAERI (JAPAN)

12.45 - 14.15 LUNCH

14.15 - 16.00 SESSION V: PANEL: "HOW FAR ARE WE WITH NATURAL ANALOGUES?"

Chairman: F. GIRARDI, JRC Ispra
Co-Chairman: T. PAPP, SKB (S)
Panel members: D. BROOKINS
N. CHAPMAN
I. MC KINLEY
I. NERETNIEKS
F.P. SARGENT

16.00 CLOSE AND DISPERSE

POSTERS

C. DEGUELDRE, EIR (CH)
"In-laboratory, on-site and in-situ sampling and characterization of the GRIMSEL colloids - Phase I".

P. GLASBERGEN, RIVM (NL)
"Hydrological studies and natural isotope data as indication for groundwater flow in deep sedimentary basins"

D.C. GREEN, Cambridge College of Arts and Technology (UK)
"Natural mineral analogues from a hydrothermally altered granite, Australia"

M. JEBRAK, BRGM, et al. (F)
"A quantitative approach to exchange phenomena between low temperature hydrothermal solutions and granite rocks: methodology and preliminary studies in the Entraygues granite"

J. PATIJN, CEN/SCK, Mol (B)
"Environmental tracers for validating predictive models"

J.C. PETIT et al. CEA (F)
"Hydrothermal alteration in the AURIAT granite, Massif Central"

C. SATO, PNC (JAPAN)
"Natural analogue study of TONO sandstone type uranium deposit in Japan"

R.D. SCOTT, SURRC (UK), et al.
"Natural analogue studies at GRIMSEL"

DISPLAYS

Alligator Rivers, Australia (AAEC)

Pocos de Caldas, Morro do Ferro, Brazil

Loch Lomond and other British sites (BGS)

US natural analogue sites (Co-ordinator: D. BROOKINS)

Fractures and faults in Italian clays (ENEA)

Investigations at the Mol site (CEN/SCK)

Cigar Lake, Saskatchewan, Canada (AECL)

ATTACHMENT 4

A NATURAL ANALOGUE FOR NEAR-FIELD BEHAVIOUR IN A HIGH LEVEL RADIOACTIVE WASTE REPOSITORY IN SALT: THE SALTON SEA GEOTHERMAL FIELD, CALIFORNIA, USA

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Institute of Geophysics and Planetary Physics
University of California
Riverside, California, 92521, USA

Summary

In the Salton Sea Geothermal Field (SSGF), in the sediments of the delta of the Colorado River, we are developing a three-dimensional picture of active water/rock reactions at temperatures of < 300°C and salinities of 7 to 25 weight percent to produce quantitative data on mineral stabilities and mobilities of naturally-occurring radionuclides. The aim is to produce data to validate geochemical computer codes being developed to assess the performance of a Commercial High-Level Waste (CHLW) repository in salt. Among the findings to date are: (1) greenschist facies metamorphism is occurring; (2) brine compositions are fairly similar to those expected in candidate salt repository sites; (3) U and Th concentrations in the rocks are typical for sedimentary rocks; (4) the brines are enriched in Na, Mn, Zn, Sr, Ra, Po and strongly depleted in U and Th relative to the rocks; (5) significant radioactive disequilibria exist in brines and solid phrases of the SSGF. The disequilibria in the actinide series allow estimation of the rates of brine-rock interaction and understanding of hydrologic processes and radionuclide behaviour. Work is continuing emphasizing the reactions of authigenic clay minerals, epidotes, feldspars, chlorites and sulphates. So far, adapting geochemical codes to the necessary combination of high salinity and high temperature has lagged behind the natural analogue study of the SSGF so that validation is still in progress. In the future our data can be also used in validating performance assessment codes which couple geochemistry and transport processes, and in design of waste packages and back fill compositions.

1.0 Introduction

For some thirty years, when discussions first began in the U.S.A. on the concept of mined geological repositories for CHLW, salt has been one of the leading candidates for a host rock (1). However prediction of the performance of a repository in salt, or in any other rock type, requires

ability to model the long-term performance of the specific site and the engineered barrier system. Such performance assessment can only be partially satisfied by laboratory measurements and field tests, which must then be extrapolated to the larger scales, longer times, and higher degrees of complexity likely in a high-level nuclear waste repository. Acceptance of the predictions of the hydrological, transport and geochemical behaviour made by such mathematical modeling requires validating the necessary computational codes against quantitative results derived from real data and known processes, which have operated over long time spans under conditions similar to those anticipated in a salt repository, i.e. to study natural analogues. The methodology for model verification and validation for near-field performance assessment for a salt waste repository is described elsewhere (2).

The geological record provides numerous examples of long-lived natural laboratories where processes relevant to possible behaviour in CHLW repositories have occurred, some of which are the subject of presentations at this conference (3). However most natural analogues studied involve processes which are long since ended, so that it is necessary to make numerous assumptions in modeling the conditions responsible for their occurrence. On the other hand, active geothermal systems offer substantial advantages over "fossil" hydrothermal systems as natural analogues, in that we can study, not only the effects of water/rock interactions at elevated temperatures, but the processes themselves. In an active geothermal system, being drilled to produce steam for electric power, we can make direct observations of the temperature, depth and fluid pressure at which hydrothermal alteration occurs, and sample the fluid and rock chemistry directly. Similarly, we can make direct observations of the parameters such as porosity and permeability which control mass and energy transfer. Furthermore, we are much better able to estimate the age and duration of heating and water/rock reactions (4). Such direct field observations and measurements of natural hydrothermal processes can result in critical input to the development and validation of computer models. However it is clear that data used to develop a computer model must be kept distinct from data used to validate it. In 1982 my colleagues and I began the search for a suitable geothermal field in which to acquire data for geochemical model validation of a salt repository as part of a programme funded by the Office of Nuclear Waste Isolation.

2.0 Choice of the SSGF

Unfortunately we know of no instances of salt domes or salt beds with temperatures at economically drillable depth comparable to peak temperatures estimated to be likely in a high-level waste repository (5). Development of high temperature hydrothermal systems is inimical to the survival of salt. However, the Salton Sea Geothermal Field (SSGF), on the delta of the Colorado River, in the Imperial Valley of Southern California, offers an attractive target for study for a number of reasons. It is the largest and hottest known hot brine hydrothermal system in North America. The SSGF is only one of a number of geothermal fields currently undergoing commercial development as sources of electric power in the Salton Trough of Southern California and Northern Mexico (Figure 1). The Salton Trough is a structural depression at the head of the Gulf of California, which has been partially filled with the Late Miocene to recent detritus of the Colorado River (6). The depression is an active

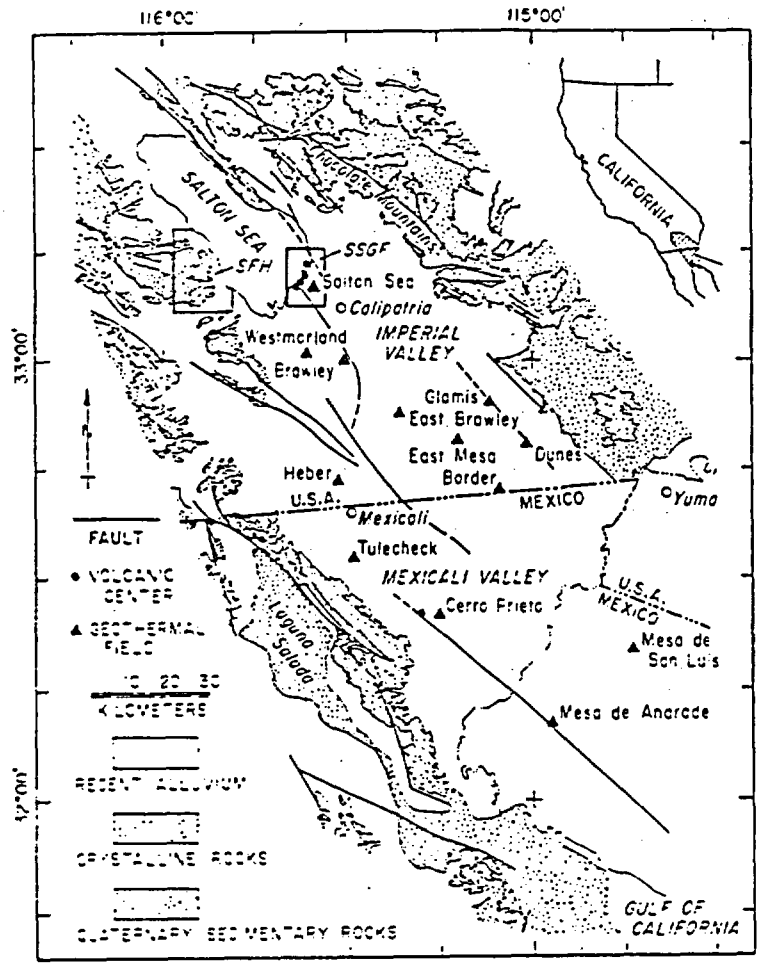


Figure 1.

Map of the geothermal fields and volcanic centers in the Salton Trough of southern California and northern Mexico (SSGF = Salton Sea Geothermal Field; SFH = San Felipe Hills where rocks stratigraphically equivalent to those of the SSGF at crop out).

rift zone at the transition between the divergent tectonics of the East Pacific Rise, to the south, and the transform fault tectonics of the San Andreas Fault system to the north. The tectonics of the Trough is dominated by "leaky" transform faults, producing tensional zones in which intrusion of basaltic and rhyolitic magmas occurs periodically. These intrusions are the heat sources of the high temperature geothermal systems. The progressive growth of the delta of the Colorado River has effectively isolated the Salton Trough from the Gulf of California to the south. Water entering this closed basin can only escape by evaporation. The depression has consequently undergone cycles of flooding and dessication as the Colorado River changed its course, alternately flowing south to the Gulf or north into the closed basin (7, 8).

Although bedded salt or salt domes have not yet been penetrated by drilling, the SSGF was chosen as a natural analogue of a salt repository for the following reasons: (a) It is a well-known hydrothermal system under commercial development with wells, subsurface data and samples available for study. (b) Temperatures within it exceed 300°C and thus span the range expected in a salt repository. (c) It is the most saline system in the Salton Trough with groundwater salinities (70,000 to 250,000 mg/kg TDS) spanning the range of brine compositions expected in and around a salt repository. (d) The sedimentary section is similar to that surrounding potential salt host rock horizons. (e) The geothermal system has been active for more than 25,000 years, a time scale of interest for a CHLW repository (9).

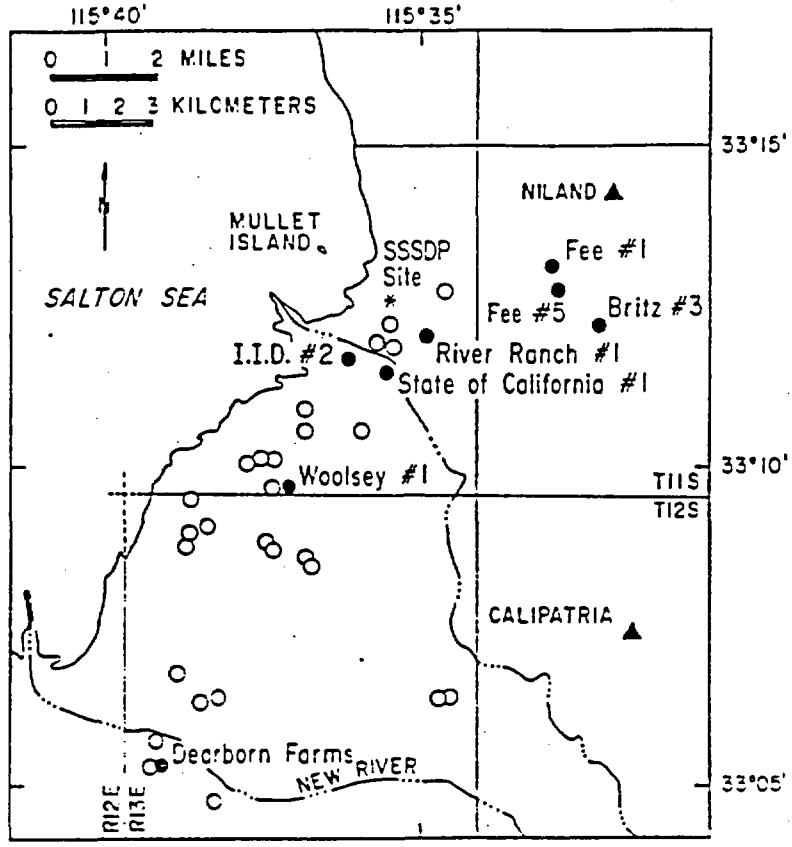


Figure 2. Location of deep geothermal wells and the Salton Sea Scientific Drilling Project research well in the SSGF: filled circles = wells studied for this report; open circles = other wells; asterisk = SSSDP well.

During this analogue study we have acquired samples and data from about two-thirds of the almost 50 geothermal boreholes, ranging from 1.5 to 3.3 km deep, which were drilled in the SSGF. Some of these wells currently supply steam to two operating electrical power plants and more plants are planned for construction in the next two years. Between October 1985 and April 1986 a research borehole, the Salton Sea Scientific Drilling Project, was drilled on the east side of the field to a depth of 3.2 km where a temperature of 355°C was measured. This well released to the public domain a wealth of data and samples from the SSGF including brine samples from two different depths, and 225 m of rock cores demonstrating a transition from unconsolidated lake and deltaic sediments into hornfels with greenschist facies mineralogy (10).

3.0 Geology and Geochemistry of the SSGF

The strata containing the geothermal brines consist of deltaic mudstones with interbedded quartzo-feldspathic siltstones and sandstones with clay or carbonate cements. Detrital phyllosilicates are chiefly smectite, illite, and kaolinite, with lesser amounts of biotite, chlorite and muscovite (11). In response to the temperatures exceeding 300°C at depths of 3 km, or less, over an area considerably more than 100 km^2 (Figure 2) active greenschist facies metamorphism is occurring (12). The

gross stratigraphy in the drilled part of the field consists of an upper clay-silt-evaporite lacustrine sequence, up to 400 m thick in the centre of the field, and a lower interbedded mudstone-sandstone deltaic sequence (9).

The SSGF brines are concentrated Na, Ca, K chloride solutions containing low amounts of SO_4^{-2}, H_2S and HCO_3^-. They range between 7 and 28% by weight of total dissolved solids, depending on depth and location, with concentrations highly stratified with depth. Typical values of dissolved components in the more saline boreholes near the centre of the field (in mg/kg) are:

Cl	83,000	- 155,000	Na	40,000	- 59,000	
Ca	13,000	- 59,000	K	7,000	- 15,000	
Fe	200	- 1,200	Mn	500	- 1,100	
Zn	300	- 800	Li	90	- 290	
SiO_2	180	- 400	Pb	40	- 100	
Cu	0.5	- 8	Ag	0.8	- 1.4	(9)

The very high concentrations of dissolved components are now believed to be derived from dissolution of non-marine Plio-Pleistocene evaporites associated with lacustrine sediments containing bedded anhydrites (after gypsum). Fluid inclusions in these anhydrites contain halite crystals (13). Active base-metal ore deposition is going on in this system (14).

Figure 3 compares the brine chemistry from the IID No. 2 well, which lies near the centre of the field and attained a temperature of about 315°C at approximately the 1,700 m sample depth, with brine chemistry from Fee No. 5 well from near the eastern margin of the field where a temperature of 290°C was reached at about 3,000 m (4). In spite of the marked difference in temperature gradients, the brine analyses are essentially identical. For comparison, the compositions of fluid inclusions in salts and a range compositions of fluids which might intrude a nuclear waste repository in salt in the Permian Basin of Texas are shown (15). The SSGF brines are rather similar to the brines likely to be encountered in CHLW repositories in salt in the USA especially for the elements, Cl, Na, Ca, and K. However, the SSGF brines differ from them in having a lower Mg content as they are not derived from marine evaporites and because above 225°C they precipitate Mg-rich chlorite. Furthermore, the SSGF brines are enriched in Fe, Mn, Zn, Sr, B, Ba, Li, Si, and Pb relative to the brines from the proposed CHLW repository site in Texas, because these elements are leached from the sediments at elevated temperatures. Eh and pH conditions for the SSGF brines are difficult to determine directly due to differences in sampling conditions and reservoir conditions. However, measured Eh values ranging from 0.17-0.25 volts and pH estimates of 4-6 are consistent with the observed mineral assemblages (16).

4.0 Analog Studies of the SSGF

We are using a combination of mineralogical and geochemical methods to develop a three-dimensional picture of temperature, salinity, lithology, mineralogy, and the chemistry of interactions between reservoir rocks and the hot brines. The techniques employed include optical microscopy and quantitative x-ray diffraction for mineralogical modal analysis, x-ray fluorescence and induced neutron activation for rock analysis, electron microbeam analysis for mineral analysis, fission track

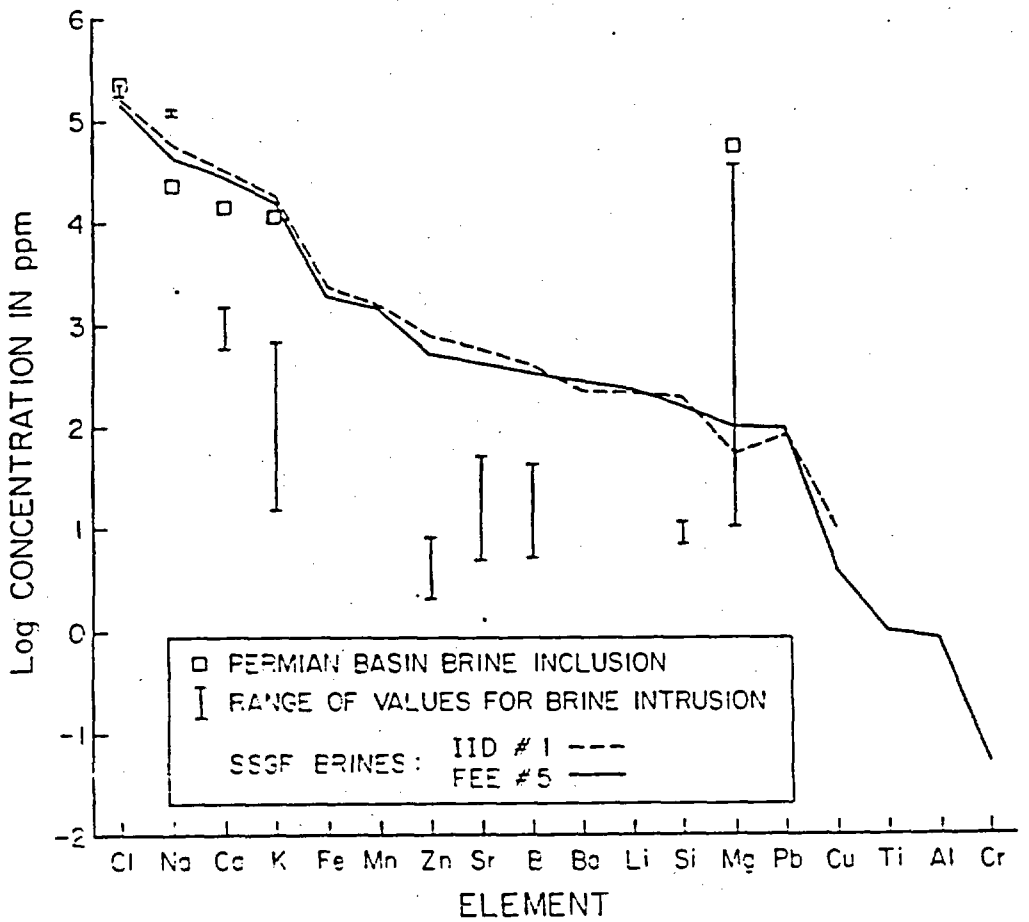


Figure 3. Analyses of brines from a central well (IID No. 2) and a marginal well (Fee No. 5) in the SSGF. For comparison, an analysis of brines in inclusions in Permian salts from a possible salt repository site in Texas, and the range of values which has been suggested for brines which could intrude these salt deposits is included [Permian salt brine data are from (15)].

radiography for ^{235}U analyses, mass spectrometry for hydrogen, oxygen, carbon and sulphur isotopic ratios, fluid inclusion analyses using heating and freezing microscope stages, analysis of U and Th decay chains using α and γ spectrometry and β counting, and fluid analysis by atomic absorption and inductively coupled plasma techniques.

4.1 Mineral Reactions

With increasing temperature and depth four progressive zones of hydrothermal alteration may be distinguished (11, 17). These are (1) at < 190°C a dolomite/ankerite zone with mixed layer smectite/illites; (2) 190-325°C, a calcite/chlorite zone with illite/phengite; (3) 325-360°C a biotite zone with actinolite, albite and epidote; and (4) above 360°C a garnet zone with biotite and actinolite. These mineralogical changes are accompanied by progressive recrystallizations leading to porosity reductions and formation of hornfelsic textures.

4.2 Geochemical Computer Code Validation

An important aspect of this study is validation of computer codes for geochemical interactions in aqueous systems which are being developed for application to the Civilian Radioactive Waste Management Program of the U.S. Department of Energy. In this study the codes being tested consist of the EQ3/6 software package, a thermodynamic equilibrium code with kinetic capability (18, 19). It models water-mineral interactions as a function of temperature and pressure. The EQ3NR speciation-solubility code calculates aqueous speciation and mineral saturation indices from water analyses. EQ6 is a reaction path code which can be used to simulate mineral/water interactions at temperatures up to 300°C and over long times. There is an option to use Pitzer's equations to calculate activity coefficients in aqueous solutions and EQ6 has been upgraded to model open flow-through systems.

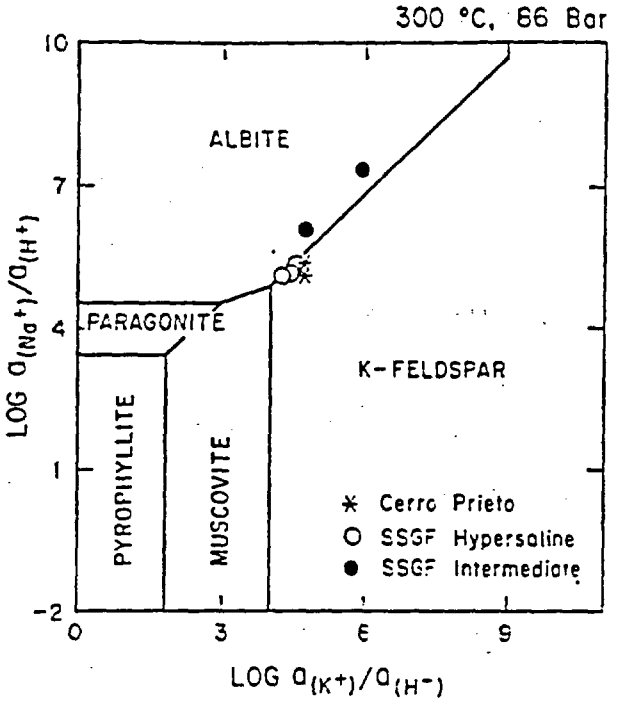
We have analyzed brines and assemblages of authigenic minerals apparently in equilibrium with them for about 12 wells in the field. Figures 4A and 4B show some typical results of using EQ3 to calculate the activity ratios of brines, and then plotting the data for a wide range of compositions on activity diagrams, calculated by the methods of reference (20). The two wells from Cerro Prieto (see Figure 1) produce fluids with approximately 20,000 mg/kg of total dissolved solids, the intermediate brines from the SSGF contain 70,000-100,000 mg/km of total dissolved solids, whereas the hypersaline brines contain 23 to 25 weight per cent of dissolved solids. At quartz saturation, at 300°C and 86 bars of fluid pressure, these brines, ranging over an order of magnitude in concentration, plot as a coherent group. This is consistent with the similarity in hydrothermal minerals observed at Cerro Prieto and in the Salton Sea Geothermal Field over a wide range of salinity.

Although for these components the code predicts mineral assemblages similar to those which are observed to occur, this is in general not true for other dissolved species. Thus so far, further development of the code to work at high temperatures and high salinity simultaneously is proving difficult, consequently validation of the computer codes is an on-going activity.

4.3 Fission Track Radiography

Among the studies of the migration and retardation of elements of interest in CHLW, perhaps the easiest to analyze is U because its distribution can be deduced from fission tracks induced by spontaneous decay of ^{235}U in its host minerals. We used a combination of INAA to determine total concentration of U and fission tracks to determine its location in the rock. We then compared U concentrations in subsurface mudstones and sandstones, over a range of temperature of 325°C with those seen in stratigraphically equivalent, but unaltered, rocks at outcrop in the San Felipe Hills (Fig. 1).

A relatively uniform concentration of U is observed throughout the field, independent of depth, temperature, or salinity (Fig. 5), particularly in mudstones and siltstones. Sandstones are slightly more variable showing their highest U concentration in detrital zircon, epidote or sphene. The U distribution in the San Felipe Hills is similar. In both the Salton Sea Geothermal Field and the San Felipe Hills the sediments contain between 0.2 to 7 mg/kg of U.



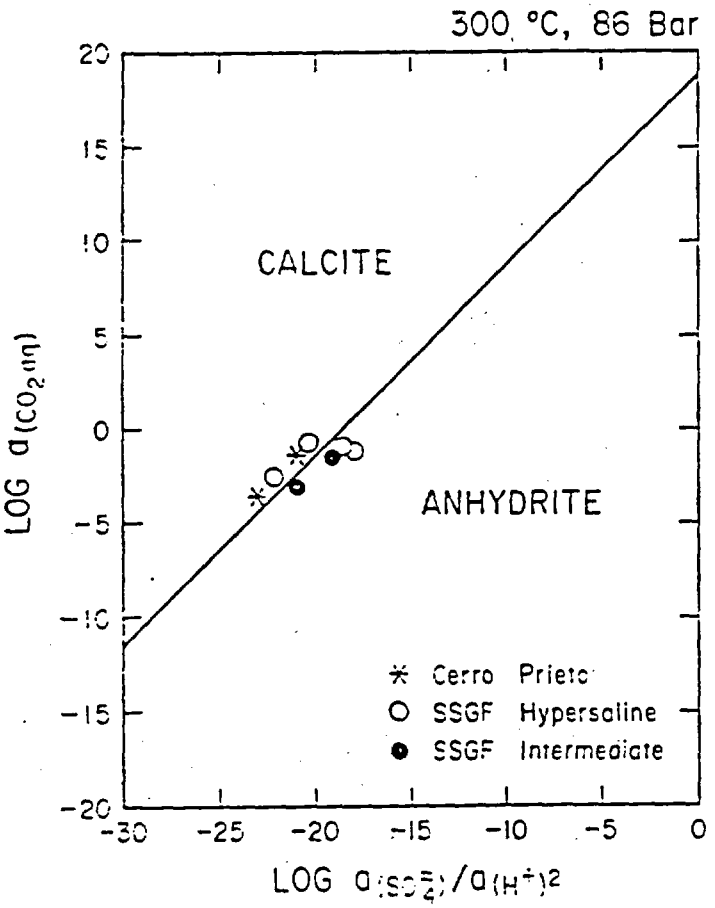


Figure 4. Examples of activity ratio mineral phase diagrams for geothermal fluids in the Salton Trough. The activity ratios are calculated for three types of brines ranging from 7-25% wt of total dissolved solids using EQ3 (19). When plotted on the activity diagrams they predict mineral assembles similar to those observed (20).

A

Upper diagram: Sodium and potassium activities and stability fields of alkali feldspars.

Lower diagram: Carbonate and sulphate activities and stability fields of calcite and anhydrite.

B

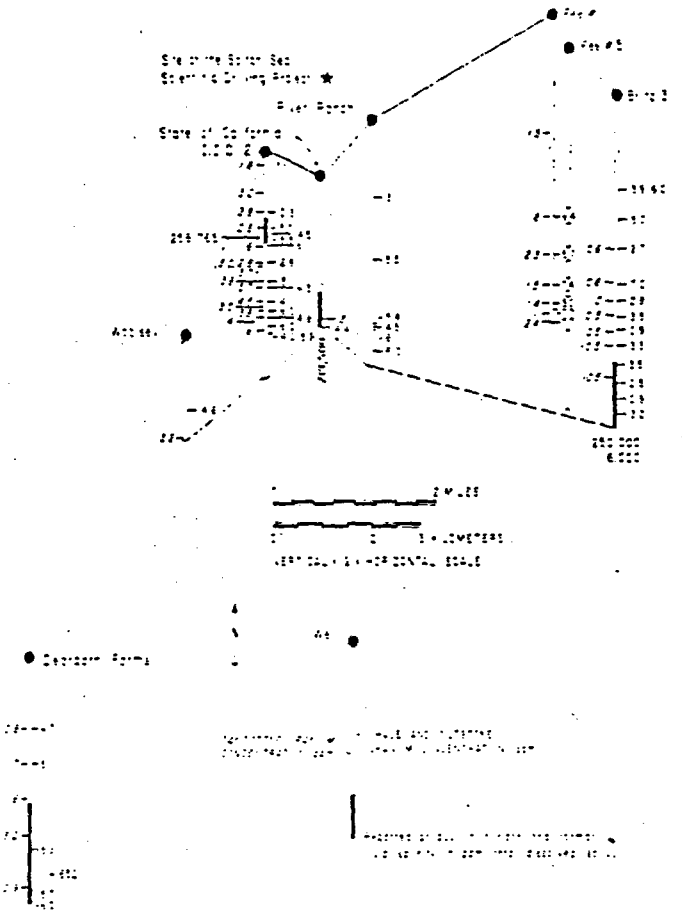


Figure 5. A "fence" diagram showing concentrations of Uranium in shales and sandstones from the SSGF. Well locations are as shown in Figure 2. Brines in Britz No. 3 well come from two separate horizons. Salinity data are from (4).

Table 1 shows that these rocks and a sample of a Holocene lake bed have very similar U and Th concentrations. These similarities suggest that the distribution of these elements is due to detrital processes rather than diagenetic or hydrothermal reactions. A minor exception to this suggested immobility of these elements is seen in the deepest and hottest part of the SSGF where certain samples are slightly enriched in U. Fission track analysis shows that the enriched amount of U is concentrated in locally developed authigenic epidote. This retention of U in epidote above 300°C suggests that U can be mobilized on a microscopic scale, but it is retarded if epidote is forming.

4.4 U-Th Decay Chains

Determination of Rc, the rock/brine concentration ratios, [where $R_c = (dpm/g)_{rock}/(dpm/g)_{brine}$] for the naturally-occurring U and Th series radionuclides in the SSGF vary from 1 for isotopes of Ra, Pb, and Rn, to

TABLE 1. RANGE AND AVERAGE U AND Th AMOUNTS IN SANDSTONES, SHALES, AND MUDSTONES FROM THE SALTON SEA GEOTHERMAL FIELD (SSGF) AND SAN FELIPE HILLS AREA (SFH), IN PPM.

	SSGF SANDSTONES	SSGF SHALES	SFH SANDSTONES	SFH MUDSTONES	HOLOCENE LAKE CAHUILLA MUDSTONE
No. of analyses	30	42	5	5	1
U:Range ppm.	<0.5 to 5.7 ± 0.3	2.5 ± 0.6 to 7.2 ± 0.5	0.5 ± 0.3 to 3.7 ± 0.3	2.3 ± 0.4 to 4.2 ± 0.3	--
Average U	2.2	4.6	2.4	3.3	2.3 ± 0.4
No. of analyses	6	11	5	5	1
Th:Range ppm.	2.4 ± 0.07 to 13.2 ± 0.2	8.3 ± 0.2 to 20.0 ± 0.3	2.9 ± 0.2 to 7.4 ± 0.3	10.7 ± 0.4 to 13.4 ± 0.4	--
Average Th	6.6	14.0	4.2	11.7	11.8 ± 0.4

$5x10^{4}$ for ^{238}U and ^{234}U, and $5x10^{5}$ for ^{232}Th (21, 22). The high sorptivity of ^{238}U and ^{234}U suggests uranium is retained in the +4 oxidation state in these reducing conditions. On the other hand the relatively high solubility of lead and radium appears to be due to chloride complexing (22).

Comparison of $^{228}Ra/^{226}Ra$ ratios in the brine with those of their parents $^{232}Th/^{230}Th$ in the rocks indicates that radium equilibration is achieved within the mean life of ^{228}Ra (8.3 yrs), in brine samples from some wells but not in others. This suggests different rates of water/rock reaction in different wells. These differences are supported by different ^{224}Ra, ^{210}Pb and ^{222}Rn concentrations and also by material balance calculations for $^{228}Ac/^{228}Ra$. A material balance calculation for ^{230}Th and ^{226}Ra, assuming steady state, yields fluid residence time in the SSGF of 10^{2}–10^{3} years, and suggests water/rock mass ratios of 0.7. This suggests the system formed 2–$4x10^{4}$ years ago (22).

5.0 Current and Future Work

Work is continuing to obtain data to validate the equilibrium geochemical computer code and to study radionuclide partitioning between minerals and brine over a range of temperature, salinity and lithology. Special emphasis is being given to clay mineral reactions, the influence of solid solution on the stability of authigenic epidote, feldspars, chlorites, sulphates and smectites, determination of reaction paths from mineral paragenesis and mineral vein sequences, and radionuclide retardation and diffusion. As the geochemical code develops we will continue attempts at validation. We believe that the next step will be to couple these geochemical codes with mass and heat transfer codes. The data from the SSGF natural analogue are equally applicable to such transport models.

6.0 Acknowledgments

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ATTACHMENT 5

RADIOACTIVE WASTE
EC FOCUS

SP-I.87.16 Number 7 April 1987

Programme Management

Implementation of the 3rd cost-sharing R&D programme has continued in 1986 with a second and final call for research proposals in part A "Waste management studies and associated R&D actions". This request, with 31 October 1986 as the deadline for submitting proposals, covered Task 1 "System studies" for the first time, and additional research in Task 2 "Radioactive waste treatment and conditioning", Task 3 "Assessment of waste forms and engineered barriers" and Task 4 "Development of waste disposal facilities".

The level of Community participation sought was 28 million ECU, but available funds only amounted to 8.3 million ECU. Of the 153 proposals received, 44% corresponded to Task 4, 25% to Task 1, 23% to Task 3 and 8% to Task 2. The selection procedures already started, and will eventually lead to negotiations with potential contractors.

The majority of the research contracts have been selected from the first phase of the programme (see EC-FOCUS 6), and have been either concluded or are at an advanced state of negotiation. In the following chapters, some particular projects are highlighted.

RSST Project (Repository System Simulation Test)

This co-ordinated project in Task 3 of the programme concerns the establishment, at international level, of equipment and a test procedure for evaluating the retention properties of the glass matrix in which high-activity waste will be placed (in conditions representative of the near field under disposal conditions), and the assessment of the interactions between the matrix and its environment.

The intercomparison tests will begin in May 1987 and will end a year later. About 15 laboratories will be involved in this project, four of which are from third countries (CH, CDN, USA, J). The Commission will put the test materials at the participants' disposal as well as the reference containers. A consultant will subsequently be called in to assess the results obtained and to present the conclusions of the exercise.

Project COMPAS (Container Mechanical Performance Assessment)

The COMPAS project is to be carried out in the framework of Task 4. Its objective is to assess the medium-term structural resistance of the overpacks of vitrified waste submitted to constraints of deep geological disposal. It will include two intercomparison exercises of structure codes. Various organisations will participate in this project (CEA, STEAG, CEN/SCK, NAGRA, AECL), which will be co-ordinated on behalf of the Commission by the British company OVE ARUP.

Underground pilot facilities

Two projects are at present in progress in the framework of the Community action: the HAW project (ASSE salt mine in the FRG, carried out by the GSF, 8.5 million ECU of Community participation) and the HADES project (Mol clay formation in Belgium, carried out by the SCK/CEN, 6.6 million ECU). A third project is, in conformity with the Council decision, foreseen in France.
For each of the projects, the present situation is as follows:

- HAW Project
  The project is developing satisfactorily, however a slight delay was experienced due to difficulties encountered during the manufacture of radioactive vitrified blocks and their transport.
- HADES Project
  The preparatory work in relation to the test galleries (Test drift) is completed and digging of this gallery should start in 1987. A part of the work, including construction of a second access shaft, which had originally been planned for 1989, has been postponed.

Progress and Achievements of Research

Shared cost action programme

Project COSA

The first phase of the Community project COSA (Intercomparison exercise for rock-mechanics computer codes for salt) was recently completed. The project put together the efforts of twelve rock mechanic calculation teams in the Member States, under the technical co-ordination of the engineering firm ATKINS R&D (UK). The initial step of the exercise covered the verification of computer codes on a simple, theoretical problem with semi-analytical solution: concordance was found between the various solutions. The second step was an attempt to validate the computer programmes against the results of a well-documented, medium-scale laboratory test, representative of a disposal situation. A 300 mm edge salt cube with a 66 mm diameter central hole, was subjected to the pressure of a hydraulic press and to the heat flux of a heater inserted in the hole. Temperature at the borehole wall increased up to 260°C and the creep radial convergence was about 3 mm. Predictions by the codes tallied very well with

Periodic information leaflet on the activities of the European Community in the field of radioactive waste management

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DG XII - SCIENCE, RESEARCH AND DEVELOPMENT - JOINT RESEARCH CENTRE

the measurements as regards temperature distributions, convergence predictions, on the other hand, showed more dispersion, reasonable agreement was however obtained between predictions and experiment. The second phase of the project is scheduled for 1986-1988 and will deal with the comparison of code results concerning a large-scale, long-duration heating test in salt.

Historic Concrete Research

Durability is one of the main concerns when it comes to assessing the potential of concrete as backfilling material for deep radioactive waste repositories. This problem was addressed by a cost-shared contract with Taylor-Woodrow Construction Ltd. A study of the physical and chemical characteristics of ancient and old concretes was initiated. The aim was to identify those properties which have enabled a concrete to survive in its environment and relate these to the modern materials. Samples from c.a. portland cement-based materials were obtained from Weaver's Mill (1897) and Woolston Quay (1899), both in the U.K. These reinforced concrete structures had survived in very good condition, and the explanation is thought to lie in their high cement content compared to present compositions. Ancient mortars and concretes from Kamiros (Greece), Reading Abbey and Hadrian's Wall (UK) showed that these materials could survive for thousands of years.

The preliminary study has therefore shown that the durability of concretes can be very long. Attention should be paid, in the future, to sampling in structures whose conditions are close to disposal situations as regards e.g. depth, presence of water table, etc.

Further research on this topic is planned, and groups or researchers interested in co-operation and information exchange should contact the CEC.

Economic evaluation of various management strategies for alcaline solvent wash waste (ASWW)

A study on the impact of three principal management strategies for Alcaline Solvent Wash Waste on the total management cost of the whole Low and Medium Level Liquid Wastes (L&MLLW) arising from reprocessing operations was carried out. This study, performed with the assistance of several consultants, was based on experience gained in France, Belgium, Germany and the UK. Typical waste compositions and radionuclide inventories were defined, supposing a 20 GWe reactor park.

The study assessed the total management cost for L&MLLW from its origin to the final disposal, i.e. including treatment, conditioning, packaging and transport steps. Depending on the specific activities of the resulting waste products, different disposal modes were considered (deep geological formations, sea-dumping, shallow land burial). Since discharge limits associated with a site may affect the treatment flow-sheet, two different sites (coastal and inland) were considered for the location of the reprocessing plant.

In a first step of the study, a reference management strategy for the whole L&MLLW generated in the plant was drawn up. This involved treatment by chemical precipitation possibly combined with ion-exchange and evaporation, conditioning into bitumen, packaging into type A or B containers and transportation by rail or road of the packaged waste to the three disposal sites considered.

Within this reference management strategy, three basic options were considered for the ASWW management.

Route No. 1: Common treatment of the ASWW along with MLWW.

Route No. 2: Splitting at source of the ASWW into a high level fraction added to the High Level Liquid Waste (HLLW) stream for vitrification and treatment of the low-level fraction as LLLW.

Route No. 3: Actinide recovery from ASWW possibly combined with interim storage for decay before treatment as L or MLLW

On the basis of present day technology, treatment and conditioning flow-sheets and engineered flow-diagrams were drawn up. This led to the quantification of volumes of waste products as well as discharges of liquid effluents for each principal route considered. Typical figures for waste arisings and radioactivity discharges are quoted in Tables 1 and 2 respectively.

Table 1: Amounts of bituminised waste products produced in the three ASWW management routes for 30 years operation.

ASWW route	Bituminised waste (220 l drums)			
	Geological disposal		Shallow land burial or sea dumping	
	Total	ASWW contribution	Total	ASWW contribution
1 (coastal site)	43950	6510	—	—
1 (inland site)	43950	6510	189480	7062
2 (coastal site)	25170	1316	—	—
2 (inland site)	25170	1316	182880	6978
3 (coastal site)	25607	890	—	—
3 (inland site)	25607	890	169294	6433

Table 2: Annual discharges of liquid effluents into environment for the three ASWW management routes

ASWW route	Liquid waste discharges	
	[illegible] a	[illegible] a
1 (coastal site)	7.6	3040
1 (inland site)	10^{-4}	$5 \cdot 10^{-4}$
2 (coastal site)	7.5	1500
2 (inland site)	10^{-4}	$2 \cdot 10^{-4}$
3 (coastal site)	4.8	1500
3 (coastal site)	10^{-4}	$2 \cdot 10^{-4}$

Economic assessment took into account the capital and the operating costs itemised according to each intermediate management step. Actualisation of the cost components was made according to the net present value method. This assessment resulted in the drawing up of diagrams as the one reported in Fig. 1.

In the second step of the study, sensitivity analysis was carried out for the main parameters: discharge limits, actinide losses in the ASWW, disposal concepts and criteria, decontamination performance and size of the nuclear park. This enabled the identification and costing of nearly 100 management variants for L&MLLW. Advantages and disadvantages of each main management option in relation to a given set of basic parameters could

then be highlighted and weighted mainly in terms of cost, but also with respect to their radiological impact resulting from liquid discharges.
A detailed report is being prepared, and will be published in the EUR-series.

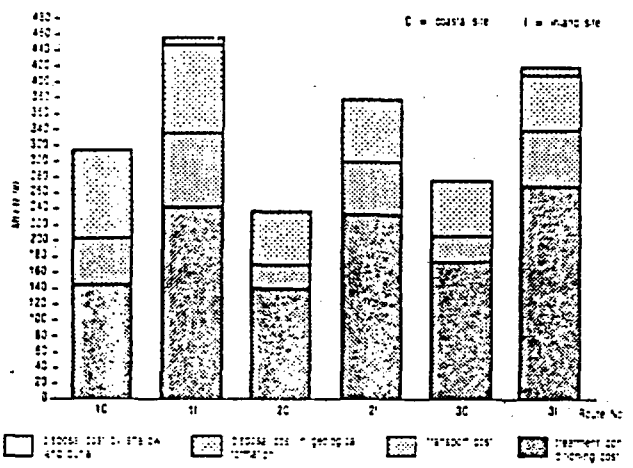


Fig. 1 Total management cost for L & MLLW (30 y. operation)

Joint Research Centre

The role of colloids in radionuclide migration

As previously reported (see EC FOCUS 4), the geochemistry of radionuclides in an aquatic environment may involve changes from the ionic to the colloidal state. This process can occur by nucleation and aggregation (real colloids) or by interaction of the radionuclides with colloidal particles either generated by the conditioning waste matrix or existing in the environment (pseudocolloids). As these processes cannot be described in terms of equilibrium conditions, the reaction pathway of radionuclides in groundwater may be significantly altered by the generation of colloids which can migrate in conditions in which soluble species are retained.
A study has been initiated at JRC Ispra to get a better understanding of these phenomena; it comprises:

- characterisation of natural colloids and laboratory migration experiments of radionuclides in colloidal form;
- identification of the physico-chemical parameters influencing the formation of pseudocolloids of actinide elements (study contracts with the Milan University);
- collaboration with European laboratories involved in the CEC coordinated project MIRAGE (Migration of Radionuclides in the Geosphere) and with AECL-Canada.

The colloid formation has been found to depend on the actinide valence state, and on the pH and ionic strength of the medium. In salt brines, the colloidal fraction of americium is negligible when compared with fresh groundwater, where more than 80% of americium is retained by a 30 nm pore size filtering membrane. Accordingly, the migration of Am (III) in saline aquifers can be described by a solute transport model, whereas a model including filtration of polydispersed colloids is required for Am (III) behaviour in fresh water. Because of the ionic strength effect, a smaller concentration of Am (III) colloidal particles was measured in sea water traced with Am-241. The percentage of soluble Am (78%, filter porosity 50 nm) was found to decrease with ageing of the solution, attaining 68% after 35 days.

For Np-237, no colloids were identified in oxidising conditions. Studies of the leachates of glasses with Am-241, Np-237 and Pu-238 as tracers, performed under anoxic conditions, showed however a colloidal behaviour of the radionuclides different from that observed when leaching occurs in oxidising environment. A special effort has therefore been made to set up anaerobic chambers with a controlled CO_2 partial pressure simulating reducing conditions found in deep aquifers. In the following photograph, a view is given of the flow-through columns installed in the anoxic boxes.

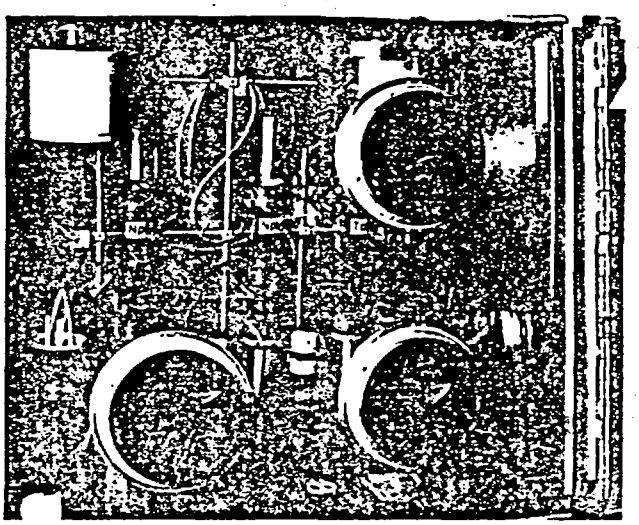


Figure 1. View of the flow-through columns for colloid studies.

Leaching of cement-conditioned waste: its modelling

Leach tests are being performed at JRC Ispra, on cement-conditioned waste samples, under static and dynamic water conditions.
Concrete degradation involves the hydrolysis of tricalcium silicate, which is accompanied by $Ca(OH)_2$ release, and the establishment of a very high pH (about 12.5), at which most of the elements are highly insoluble. For this reason, the lifetime of the concrete matrix is the critical parameter in the system. The reaction proceeds at a constant pH up to the total degradation of tricalcium silicate. Afterwards, the hydrated calcium silicate also begins to degrade, loosing $Ca(OH)_2$ and stabilising pH at the lower value of about 10.5. Finally, when only silica gel is present, the pH decreases to its initial value.
The duration of the various phases can be calculated, so that the solubilities and retention factors of different radionuclides can be evaluated as a function of time.
On these bases, the radionuclide release rate from the matrix can be quantified.
On the basis of a few preliminary results, a mathematical model, describing the cement degradation and radionuclide release has been developed, which will be used for the performance assessment of the disposal of alpha-bearing wastes.
Concrete is treated as a porous medium, whose characteristics deteriorate progressively, while maintaining a porous skeleton.

Assembling PETRA

Installation of the facility PETRA, intended for studying treatment and solidification processes of wastes from PUREX reprocessing, began in November 1986. Its main components had already

been constructed and are at present being assembled in three hot cells within the ESSOR reactor complex. The whole facility is expected to enter the cold commissioning phase in 1987 and to become fully operational by the end of the year.
In this context, a "Users' Group" has been created, with participation of experts from a number of Member Countries. Their aim is to define a detailed working programme for PETRA. The group has already held two meetings, at which a set of preliminary proposals were examined.

Meetings, Seminars, Conferences

- Workshop on **"Melting and recycling of radioactive metals from decommissioning of nuclear installations"**, Karlsruhe (Germany), 27-28 May 1986.

The Workshop was organised by the Commission in collaboration with the Kernforschungszentrum Karlsruhe, in the frame of the Community cost-sharing research programme on the Decommissioning of Nuclear Installations. Invited participants from five Member States (France, Germany, Italy, the Netherlands, United Kingdom), Switzerland and Sweden attended the workshop which was aimed at presenting the results achieved by contractors of the CEC programme.
Two different methods of treatment of radioactive scrap metal from decommissioning are currently being assessed:

- the dilution of a small quantity of radioactive scrap metal in a large quantity of normal scrap metal in order to reach the limit for unrestricted release (research by British Steel);
- the melting of scrap in a special melting facility to reduce the volume and to obtain cast ingots easy to handle and store, with the radionuclides homogeneously distributed and immobilised; this treatment is applied mainly in Germany (Siemens-Kamp Giesserei, GNS, Noell) and France (Edf, STMI), but also in Switzerland, Sweden and the U.S.A.

German industry implements recycling of contaminated steel by fabricating items used in nuclear industry, such as radioactive waste containers and shielding elements. Scrap with activities up to 74 Bq/g can be recycled. Future plans for large-scale operations of melting of contaminated steel exist for components arising from full or partial dismantling of the KKN-Niederaichbach reactor (F.R. Germany), the KRB-A reactor at Gundremmingen (F.R. Germany) and the Garigliano BWR (Italy).

- CEC Workshop on **"Natural Analogues"**, Interlaken (CH), 17-19 June 1986.

A Natural Analogue Working Group was set up in 1985 by the Commission of the European Communities. This group aims at bringing together experimentalists and modellers so that maximum benefit can be obtained from studies of natural geological migration systems, the so-called natural analogues, with a view to safe disposal of radioactive waste. The Group is felt to be playing a useful role of forum for exchange of information, and for identifying the most appropriate ways of using natural analogues for backing-up safety assessment studies of geological disposal concepts.

The second meeting of this group was organised in collaboration with the Swiss NAGRA as part of the co-operative agreement between EURATOM and NAGRA in the field of radioactive waste. Representatives from the Member States of the European Community and from Australia, Canada, Sweden, Switzerland and the USA reviewed the recent progress made in the various national and international research programmes.

Evidence that some natural uranium deposits have remained in place for hundreds of millions of years (e.g. Cigar Lake body in Canada) must be considered as an encouraging step towards the viability and public acceptance of underground disposal of radioactive waste. The proceedings of the meeting will be published in the EUR series as EUR 10671.

- CEC/BNL International Workshop on **"Leaching of Low and Medium Level Waste Packages under Disposal Conditions"**, Upton, N.Y. (U.S.A.), 13-16 October 1986.

The workshop, decided by the co-ordinators of the CEC/US DoE information exchange agreement, co-sponsored by the Brookhaven National Laboratory and the CEC, aimed at reviewing the state of advancement and at identifying the needs regarding future research in the field of the assessment of radioactive release from low and medium level waste packages under disposal conditions. The workshop overall objectives were focused on two major questions:

- "How to obtain realistic source-term models for the post-closure performance assessment of waste packages in aqueous repository environment?"
  and
- "How to ensure that the waste packages and engineered barriers will, in reality, perform as models predict?"

In addition some consideration was given to the pre-closure accidental scenarios (release due to mechanical impact, fire, etc.).

The sessions covered:

- Regulatory requirements and guidelines
- Review of release models presently applied or under development for performance analysis
- Research to provide data and identify mechanisms
- Validation of release models and simulation experiments
- Quality assurance.

The overall conclusions are that:

- sensitivity analysis is not systematically performed to determine range and priority of migration near-field parameters,
- further effort in waste characterisation should concentrate on heterogeneous waste,
- near-field models must accomodate more site-specific features.

Coming Events

- CEC-Symposium on **"Natural Analogues in Radioactive Waste Disposal"**, Brussels (B), 28-30 April 1987.

The Commission of the European Communities has been involved in specific work on natural analogues in the framework of its activities on radioactive waste management, principally within the MIRAGE project which concerns migration of radionuclides in the geosphere. A group, the Natural Analogue Working Group (NAWG) has been set up, where modellers requirements and the results of field research are exchanged at regular intervals. A number of wide-ranging investigation programmes, both on national and international scales, are currently under way or being initiated, and several of these have been discussed recently at the NAWG. Owing to the considerable upsurge in interest of the topic, not least from the regulatory bodies who seek to use analogues to validate assessment codes and their results, it seems appropriate to present the results of these many research programmes to a wider audience.

The Symposium will mainly comprise oral presentations about research programmes, complemented by some poster presentations. In addition, visual displays will be exhibited about the major natural analogue sites throughout the world. The programme and registration form are available.

- International Conference on **"Chemistry and Migration Behaviour of Actinides and Fission Products in the Geosphere"**, München (F.R. Germany), 14-18 September 1987.

The conference, organised by the Institut für Radiochemie, Technische Universität München, and sponsored by the CEC, will focus on recent developments in three key areas, namely, the primary phenomena in nuclear geochemistry, the migration behaviour in geologic media and the modelling process. They are divided into the following topics:

Chemistry of actinides and fission products in natural aquifer systems (near and far field)
- solubility and dissolution processes
- hydrolysis reactions
- complexation with natural inorganic and organic ligands
- redox reactions
- colloid generation
- speciation and detection methods

Geochemical interactions and migration (near and far field)
- sampling, sample handling and experimental techniques
- effects of individual geochemical parameters
- multi-component concurrent reactions
- influence of natural analogous elements
- sorption desorption phenomena and equilibria

Data acquisition and modelling
- data evaluation and interpretation
- data selection and modelling
- validation of results.

A "Call for papers" including a registration form is available. The deadline to submit an abstract is 31 March 1987 for participants intending to present a paper.

Edited by: K.H. Schaller and G. Bertozzi

For more information write to:

COMMISSION OF THE EUROPEAN COMMUNITIES
DG XII-D-2
Rue de la Loi 200
B-1049 Brussels

Publications

An updated list of scientific reports published in the Euroffice series "Nuclear Science and Technology" is now available (Community R&D Programme on Radioactive Waste Management and Storage. Scientific Reports - 2nd Edition. EUR 10745). Reports for the time to December 1985 are grouped by research activity. The cost-sharing research programme on "Decommissioning of Nuclear Installations" produces a regularly updated "List of Publications" (DEC-84/26 revised). Further information may be found in regularly published annual progress reports ("The Community's Research and Development Programme on Decommissioning of Nuclear Installations - First Annual Progress Report (Year 1985)". EUR 10740. (1986) Euroffice).
The following list includes reports published since December 1985; the list is limited to primary research reports: contributions of contractors are mentioned only, when original research not reported in the EUR-series is communicated.

B. COME
"Engineering aspects of backfilling and sealing of radioactive waste repositories" - EUR 9283 - (1984) Euroffice

A. FONTAINE, R. GRAGNANI, C. MIGNUZZI, G. SPAT
"Determinazione delle caratteristiche geochemiche delle acque interstiziali di argille plio-pleistoceniche italiane" - EUR 10008 (1986) Euroffice

B. SKYTTE-JENSEN, H. JENSEN, O.J. NIELSEN
"Geochemical modelling WHATIF-AQ, a computer programme for speciation calculations" - EUR 10119 (1986) Euroffice

O.J. NIELSEN, L. CARLSEN, P. BO
"Geochemical modelling COLUMN 2, a computer program for simulation of migration" - EUR 10120 (1986) Euroffice

OVE ARUP & PARTNERS
"Ocean disposal of radioactive waste by penetrator emplacement" - EUR 10170 (1986) Graham & Trotman Ltd

A. BONNE, R. HEREMANS, P. MANFROY, R. VAN HALEWIJN
"Construction of an underground facility for "in-situ" experimentation in the Boom clay" - EUR 10177 (1986) Euroffice

D. LE MASNE
"Poursuite du développement d'une méthodologie géophysique à partir des forages pour l'étude des sites de stockage en formation granitique" - EUR 10198 (1986) Euroffice

C. POLIZZANO, L. SENSI, L. LEONI, F. SARTORI
"Effetti del riscaldamento naturale nelle formazioni argillose" - EUR 10200 (1986) Euroffice

A.W. HERBERT, D.P. HODGKINSON, D.A. LEVER, P.C. ROBINSON, J. REE
"Mathematical modelling of fracture hydrology" - EUR 10215 (1986) Euroffice

A. PERSTEIN-COUDRAIN
"Etude du couplage des modèles géochimiques basés sur les équilibres thermodynamiques avec les modèles de transport d'éléments en solution dans les milieux poreux ou fissurés" - EUR 10226 (1986) Euroffice

D.G. NOY
"Coupling of transport and geochemical models" - EUR 10227 (1986) Euroffice

T.W. BROYD, M. MCD. CRANT, J.E. CROSS
"A report on intercomparison studies of computer programmes which respectively model:
- radionuclide migration
- equilibrium chemistry of groundwater" - EUR 10231 (1986) Euroffice

G. ALBERS, E. BIURRAN, C. EHLERT, K. SCHIPPERS, M. SCHLICH
"Thermomechanische Belastungen eines Salzstocks im Umfeld von Endlagerungszonen bzw Versuchsanordnungen" - EUR 10314 (1986) Euroffice

A. PUDEWILLS, E. KORTHAUS, G. ALBERS, E. BIURRAN, K. SCHIPPERS
"Entwicklung von Rechenverfahren und Durchführung von Modellrechnungen zur thermomechanischen Wechselwirkung des Steinsalzes mit der Bohrlochauskleidung bzw. mit eingelagerten HAW-Abfallgebinden" - EUR 10342 (1986) Euroffice

J.L. BLES, R. BLANCHIN
"Fracturation profonde des massifs rocheux granitiques" - EUR 10378 (1986) Euroffice

B. HAIJTINK (ED.)
"Corrosion behaviour of container materials for geological disposal of high level waste - Annual progress report 1984 - EUR 10398 (1986) Euroffice

C.J. SPIERS, J.L. URAI, G.S. LISTER, H.J. ZWART, J.N. BOLAND
"The influence of fluid-rock interaction on the rheology of salt-rock" - EUR 10399 (1986) Euroffice

E. SMAILOS, W. SCHWARZKOPF, R. KÖSTER
"Corrosion behaviour of container materials for the disposal of high level wastes in rock salt formations" - EUR 10400 (1986) Euroffice

J.M. WEST, N. CHRISTOFI, J.C. PHILIPS, S.C. ARME
"Investigations on the populations of introduced and resident micro-organisms in deep repositories and their effects on containment of radioactive wastes" - EUR 10405 (1986) Euroffice

G.P. MARSH, I.D. BLAND, K.J. TAYLOR, S. SHARLAND, P. TASCHER
"An assessment of carbon steel overpacks for radioactive waste disposal" - EUR 10437 (1986) Euroffice

A. BILLON, M.-TH. GANDEZ
"Mesures des traces d'éléments transuraniens en solution, étude bibliographique" - EUR 10441 (1986) Euroffice

J.I. KIM et al.
"Chemisches Verhalten von Np, Pu und Am in verschiedenen Salzlösungen" - EUR 10444 (1986) Euroffice

R. STUMPE, J.I. KIM
"Laser-induzierte photoakustische Spektroskopie zum oxidationsstufenspezifischen Nachweis von Aktiniden in Lösungen" - EUR 10445 (1986) Euroffice

TAYLOR WOODROW
"Performance of concrete backfilling materials for shafts and tunnels in rock formations - Volume I: Concrete selection and properties: Volume II: Mathematical modelling" - EUR 10383 (1986) Euroffice

T. ROTHFUCHS
"Untersuchung der thermisch induzierten Wasserfreisetzung aus polyhalitischem Steinsalz unter in-situ Bedingungen. Temperaturversuch 5 im Salzbergwerk Asse" - EUR 10392 (1986) Euroffice

B. SKYTTE-JENSEN, H. JENSEN
"Basic *retention mechanisms* Multielement ion-exchange" - EUR 10423 (1986) Eur. Applied Res. Rep. 7(4) 481-538

L. CARLSEN, D. PLATZ
"Retention of radionuclides in halite and anhydrite" - EUR 10442 (1986) Eur. Applied Res. Rep. 7(4) 539-575

P. VITORGE, A. BILLON et al.
"Etude du comportement physico-chimique des éléments transuraniens dans les stockages de déchets radioactifs" - EUR 10446 (1986) Euroffice

GSF
"Versuchse lagerung nochradioaktiver Abfalle im Salzbergwerk Asse" - EUR 10489 (1986) Euroffice

D. RANCON, P. MIARA, J.M. VINSON, J.C. PETRONIN, J.F. DOZOL
"Mécanismes de rétention et de migration des radioéléments dans l'environnement géologique d'un stockage de déchets en formation cristalline" - EUR 10490 (1986) Euroffice

T.J. FREEMAN, J.R.F. BURDETT
"Deep ocean model penetrator experiments" - EUR 10502 (1986) Euroffice

P. GOBLET
"Simulation de la vie d'un site d'évacuation de déchets radioactifs à différents stades de son évolution. Vol. I: Hydraulique avant, pendant et après creusement" - EUR 10509 (1986) Euroffice

M.M. SARSHAR
"Reliability of sub-seabed disposal operations for high level waste" - EUR 10542 (1986) Graham & Trotman Ltd. (London)

C. POLIZZANO, F. BENNEGNU, G. GIANNOTTI, U. BRANDIMARTI
"Effetti del riscaldamento naturale sulle formazioni argillose ed individuazione del passaggio e degli effetti dei fluidi geotermici" - EUR 10555 (1986) Euroffice

F.T. EWART, R.M. HOWSE, B.M. SHARPE et al.
"Integral migration and source-term experiments on cement and bitumen waste forms" - EUR 10587 (1986) Euroffice

MOTT, HAY & ANDERSON
"Design solutions to interface flow problems - 2 volumes" - EUR 10589 (1986) Euroffice

THE DORA PARTNERS
"Geotechnical deep ocean research apparatus (DORA)" - EUR 10601 (1986) Euroffice

M.H. BRADBURY, A. GREEN
"Retardation of radionuclide transport by fracture flow in granite and argillaceous rocks" - EUR 10619 (1986) Euroffice

ENEA/ISMES
"Studi sulla propagazione delle dislocazioni tettoniche nelle argille" - EUR 10620 (1986) Euroffice

M. SCHLICH
"Simulation der Bewegung von im natürlichen Steinsalz enthaltener Feuchte im Temperaturfeld" - EUR 10672 (1986) Euroffice

P.H. MESSAH, R. CAYE, M. RECAM
"Développement d'une sonde de mesure des contraintes en forage utilisant le principe de la photoélectricité" - EUR 10695 (1986) Euroffice

J. PRIJ et al.
"Measurements in the 300 metre dry-drilled borehole and feasibility study on the dry-drilling of a 600 metre deep borehole in the Asse II salt mine" - EUR 10737 (1986) Euroffice

J. MARIVOET, A. SALTELLI, N. CADELLI
"Uncertainty analysis techniques" - EUR 10934 (1987) Euroffice

A. SALTELLI, J. MARIVOET
"Performances of non-parametric statistics in sensitivity analysis and parameter ranking" - EUR 10851 (1987) Euroffice

G. E. DOGLIO, A. DE PLANO
"Neptunium Migration in Salt Brine Aquifers" - Nuclear Technology, 74, 307-316 (1986)

G. E. DOGLIO, A. AVOGADRO, A. DE PLANO
"Influence of redox environments on the geochemical behaviour of radionuclides" - Material Res. Soc. Symp. Proceedings, Vol. 50, pp. 709-716 (1985)

H. DWORSCHAK, B.A. HUNT
"Alpha-waste minimisation by separation processes: limitations and solutions" - EUR 9725 (1985) Euroffice

W. HAGE, K. CARUSO
"An analysis method for the neutron autocorrelation with multiplying samples" - EUR 9792 (1985) Euroffice

F. LANZA, C. RONSECCO
"Corrosion of low-carbon steel in clay and sea sediments" - EUR 10522 (1986) Euroffice

B.A. HUNT, H. DWORSCHAK, F. MOUSTY
"Study of waste management strategies which minimise the long-term risk: waste streams merging" - Proceedings of the Int. Topical Meeting on Fuel Reprocessing and Waste Management, ANS, Jackson Hole (USA), August 1986 - Vol. 2, pp. 152 (1986)

A. MANARA, F. LANZA, B. CECCONE, G. DELLA MEA, G. SALVAGNO
"Application of XPS and nuclear technique at the study of the gel layers formed under different redox conditions on leached glasses" - in Scientific Basis for Nuclear Waste Management VIII, Vol. 44, p. 63 (1985)

C.N. MURRAY, R. DUJARDIN, T. FREEMAN
"Data transmission from instrumentation emplaced in deep ocean sedimentary formations: an assessment of preliminary tests in the North Atlantic" - First Meteosat Data Collection System Users' conference, Lisbon (Portugal), 8-9 January 1986

D.A. STANNERS, A. DE PLANO
"Uptake Kd studies of Np and Am by seabed sediments under normal and anoxic atmospheres" - Radwaste Management and the Nuclear Fuel Cycle, Vol. 7, (1), pp. 1-11, March 1986

M. SACCHI, M. ANTONINI, S.N. BUCKLEY, A. MANARA
"Alkali effects on bubble formation in irradiated borosilicate glasses" - Mat. Res. Letters (1986)

E. ZAMORANI, G. SERRINI, H. BLANCHARD
"Calcium Release from cement samples of different size" - Cement and Concrete Research Journal, Vol. 16, pp. 394-398 (1986)

E. ZAMORANI, G. SERRINI, H. BLANCHARD
"Static leach tests of simulated MLW conditioned in cement" - Radwaste Management and the Nuclear Fuel Cycle, Vol. 7 (1), pp. 35-52 (1985)

ATTACHMENT 6

Jr. Clark

~~Attachment 1~~

Agenda for the Joint U.S. DOE and FRG
Workshop on Geotechnical Instrumentation
May 4-8, 1987
Asse Mine, Near Braunschweig, FRG

Monday, May 4, 1987

7.30	Pick up at Frühlingshotel
8.30	General Protocol and Introductions (Purpose and Objectives, etc.)
9.00	Current Status of Salt Repository Testing Program for Characterization of the ESF (Kalia)
9.45	Instrumentation and Testing at WIPP (Munson)
10.45	Break
11.00	Instrumentation for the Measurement of Deformations and perceived Difficulties (Green)
11.45	Instrumentation for absolute Stress Measurements and Temperatures and perceived Difficulties (Shuri)
12.30	Lunch
1.15	The Operation of the Tiltmeter Array in an Iron Ore Mine in Order to Detect aperiodic and episodic Rock Movements (Flach)
2.00	A Microseismic Monitoring Array in Combination with Flooding a Salt Mine (Heick)
2.15	Short Coffee Break
2.25	In situ low Pressure Permeability Measurement Techniques (Wieczorek)
3.10	Technical Instrumentation for the in situ Measurement on Gas Liberation and Generation in the HAW-Test Field at Asse (Jockwer)
3.50	General Discussion
4.30	Depart for Gorleben
7.00	Arrival at Hotel Wendland - Gartow

Tuesday, May 5, 1987

8.30	Welcome address (Grübler)
8.45	Disposal of Radioactive Waste in the Federal Republic of Germany (Schneider)
9.30	Current Status of Shaft Sinking (Grübler)
10.15	Coffee Break
10.30	SRP Plans to monitor and test ESF Shafts
11.30	General Discussion
12.00	Lunch
1.00	Visit the Gorleben Site
4.30	Depart for Braunschweig

Wednesday, May 6, 1987

7.45	Pick up at Frühlingshotel
8.30	Stress measuring instrumentation at Asse (Feddersen) ESF
9.15	Evaluation of Stress Measurements in the Asse Salt Mine (Heusermann) BGR
9.45	Observation of the Spreading of a Fracture during and after Hydraulic Fracturing Tests (Fischle) GSF
10.30	Coffee Break
10.45	In Situ Deformation Experiments on a Rock Salt Pillar in the Asse Mine (Hunsche) BGR
11.30	Instrumentation and Results of Deformation Measurements in the HAW-Field at the Asse Mine (Staupendahl)
12.15	Lunch
1.00	Geotechnical Monitoring in the MAW-field at Asse (Wieczorek)
1.45	Multi Heater Experiment in the Asse Mine (Jakob)
2.30	Coffee Break
2.45	General Discussion
3.45	Concluding Discussion and Remarks including Release of the Workshop Report and Future Thoughts and Plans for a Follow-up Workshop
5.00	Depart for Wolfenbüttel - Sightseeing Old Wolfenbüttel

7.30 - 7.45 Schluss Leibniz Haus Schlossplatz 5/6

Thursday, May 7, 1987

7.00	Pick up at Frühlingshotel
~~8.00~~ - 11.00	Asse Mine Tour
11.00	Lunch
12.00	Depart for Hannover
1.30 - 3.30	Meet at BGR and visit BGR-Labs
3.30	Transfer to Main Train Station
4.20	Depart for Karlsruhe by Train
8.59	Arrival in Karlsruhe
9.00	Pick up by Mr. F. Glötzl and Transfer to Hotel Erbprinz in Ettlingen

Friday, 8, 1987

8.30	Visit the facilities of "Glötzl-Baumeßtechnik", at Rheinstetten
	End of Visit in the early Afternoon and Return as individually planned (e.g., Frankfurt Airport)

List of Participants

Joint U.S. DOE/FRG Workshop on
Geotechnical Instrumentation
May 4-8, 1987
FRG

U.S. Participants:	Dr. Kalia	(BMI-ONWI)	4 5 6 7 8
	Dr. Clark	(BMI-ONWI)	4 5 6 7
	Dr. Munson	(SNL)	4 5 6 7 8
	Dr. Green	(Shannon Wilson/Golder)	4 5 6 7 8
	Dr. Shuri	(Shannon Wilson/Golder)	4 5 6 7 8
FRG Participants:	Prof. Dr. Schneider	(PTB)	5
	Dr. Preuss	(PTB)	6 7
	Grübler	(DBE)	5
	Dr. Schrimpf	(DBE)	4 5 6 7
	Dr. Heusermann	(BGR)	4 6
	Dr. Hunsche	(BGR)	4 6
	Jakob	(BGR)	4 6
	Heick	(KBB)	4
	Dr. Brückner	(KFK)	4 5 6 8
	Feddersen	(IfT)	4 6 7
	Fischle	(IfT)	4 6
	Dr. Flach	(IfT)	4
	Dr. Jockwer	(IfT)	4 5 6 7
	Rothfuchs	(IfT)	4 5 6 7
	Staupendahl	(IfT)	4 5 6 7 8
	Wieczorek	(IfT)	4 6 7 8

ATTACHMENT 7

IAEA-SM-294

INTERNATIONAL ATOMIC ENERGY AGENCY
OECD NUCLEAR ENERGY AGENCY

International Symposium on the Back-End of the Nuclear Fuel Cycle - Strategies and Options

11 - 15 May 1987

Vienna, Austria

PROVISIONAL PROGRAMME

MONDAY, 11 May 1987

08.00-09.30		Registration
09.30-10.00		Opening of the Symposium
10.00-12.30	Session I	National Approaches to the Back-End of the Nuclear Fuel Cycle
14.00-17.00	Session II	National Approaches to the Back-End of the Nuclear Fuel Cycle (cont.)

TUESDAY, 12 May 1987

09.00-12.00	Session III (a)	Options and Strategies for the Back-End of the Nuclear Fuel Cycle
14.00-15.00	Session III (b)	Options and Strategies for the Back-End of the Nuclear Fuel Cycle (cont.)
15.00-17.00	Session IV	Transportation of Spent Fuel and Radioactive Wastes
13.30-14.00 and 17.30	Poster Session I	Transportation

WEDNESDAY, 13 May 1987

09.00-12.00	Session V	Handling, Conditioning and Storage of Spent Fuel and High-Level Wastes (HLW)
12.00	Poster Session II	Handling, Conditioning and Storage of Spent Fuel and HLW

THURSDAY, 14 May 1987

09.00-11.30	Session VI	Development Programmes for Reprocessing Facilities
11.30	Poster Session III	Development Programmes for Reprocessing Facilities
14.00-17.00	Session VII	Utilization of Materials Recovered by Reprocessing
17.00	Poster Session IV	Utilization of Materials Recovered by Reprocessing and Disposal of Spent Fuel and HLW

FRIDAY, 15 May 1987

08.30-09.00	Poster Session IV	Utilization of Materials Recovered by Reprocessing and Disposal of Spent Fuel and HLW (cont.)
09.00-11.30	Session VIII	Disposal of Spent Fuel and HLW
11.30-12.00		Closing of the Symposium

MONDAY, 11 May 1987

09.00-09.30 Registration

09.30-10.00 Opening of the Symposium

10.00-12.30 Session I - National Approaches to the Back-End of the Nuclear Fuel Cycle

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
28	B. Lenail J.C. Guais G. Benistan T. Blanchon	France	Le programme français concernant la partie terminale du cycle du combustible nucléaire
81	W.T. Hancox J. Howieson H.N. Isaac	Canada	Status of the Canadian nuclear fuel waste management program
69	W.L. Wilkinson P.M. Billam	United Kingdom	Spent fuel management strategy in the UK
48	J.D. Saltzman	United States of America	The national programme of the United States related to the back-end of the nuclear fuel cycle
15	D.X. Wang	China	Some aspects of the back-end of the nuclear fuel cycle in China

MONDAY, 11 May 1987

14.00-17.00 Session II - National Approaches to the Back-End of the Nuclear Fuel Cycle (cont.)

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
14	V.H. Ryhänen E.K. Peltonen I.T.H. Mikkola	Finland	Strategy for spent fuel management in a small nuclear power programme
38	M.H. Blosser	Germany, Federal Republic of	Back-end of the nuclear fuel cycle in the Federal Republic of Germany - strategy and current status
4	P.-E. Ahlström	Sweden	Once-through fuel cycle today and with a view of future trends (invited)
3	V.I. Vlasov et al.	Union of Soviet Socialist Republics	Radioactive waste management under closed fuel cycle (invited)
76	O. Lendvai et al.	Hungary	Long-term nuclear power development in Hungary with regard to nuclear fuel cycle
43	G. Rolandi P. Venditti	Italy	The "back-end" of the nuclear cycle: Italian policy and programs

TUESDAY, 12 May 1987

09.00-12.00 Session III (a) - Options and Strategies for the Back-End of the Nuclear Fuel Cycle

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
11	P.L. Kunsch Th. van Steenberghe A. Decressin	Belgium/CEC	A multicriteria study on LWR fuel management in the European Community
12	J. Niemi P. Silvennoinen T. Vieno	Finland	Back-end options in the face of uncertainty
59	K. P. Messer H. Schmale E. Merz	Germany, Federal Republic of	The alternatives of the back-end of the nuclear fuel cycle - A comprehensive analysis under the long-term aspects of economy, ecology and risk with the potential for improvements by multinational solutions
91	V.V. Shatalov et al.	Union of Soviet Socialist Republics	Development of safety assessment criteria for the back-end of the nuclear fuel cycle
46	R.P. Bush R.H. Flowers R.C. Webster	United Kingdom	Selection of strategies for the back-end of the nuclear fuel cycle in the UK
16	P. Svec T. Rajci J. Kubant Z. Valvoda	Czechoslovakia	Approach to the Czechoslovak research to the specific fuel management concept
65	R.M. Korthof H.F.G. Geijzers	Netherlands	The Netherlands approach to radioactive waste policy

TUESDAY, 12 May 1987

14.00-15.00 Session III (b) - Options and Strategies for the Back-End of the Nuclear Fuel Cycle (cont.)

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
5	P.M.S. Jones	United Kingdom	Economics of the Back-End of the nuclear fuel cycle (invited)
21	B. Lenail C. Bernard B. Savorin J.M. Courouble L. Chaudon	France	Back-end of the nuclear fuel cycle - various techniques developed in France

15.00 - 17.00 Session IV - Transportation of Spent Fuel and Radioactive Wastes

29	G. Sert B. Kirchner	France	Design and operational features of transport packaging for high activity reprocessing wastes
89	N.S. Tichonov et al.	Union of Soviet Socialist Republics	Organization of spent fuel safe transportation in the USSR
35	R. Bach	Germany, Federal Republic of	Road transport of spent LWR fuel in Germany
50	L. Barrett	United States of America	U.S. high-level radioactive waste transportation system development-technical and institutional aspects
62	Y. Esashi K. Kobayashi H. Yamakawa T. Ito H. Abe	Japan	Optimum design and safety evaluation of high level vitrified waste transport cask
68	R.D. Cheshire R. Gowing I.J. Hunter M. Old	United Kingdom	Developments in HLW transportation technology

TUESDAY, 12 May 1987

13.30-14.00 and 17.30 - POSTER SESSION I
Transportation

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
31P	R. Cagnon	France	Active demonstration of the TN 24 storage and transport cask.
61P	N. Urabe T. Nishimura	Japan	Can ductile cast iron be suitable material for shipping cask?
82P	T.F. Kempe R.M. Zimmermann L. Grondin	Canada	Radiological assessment of transportation for the Canadian nuclear fuel waste management program
83P	K.E. Nash J.F. Tanaka	Canada	CANDU irradiated fuel cask impact analysis and testing

WEDNESDAY, 13 May 1987

09.00-12.00 Session V - Handling, Conditioning and Storage of Spent Fuel and HLW

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
1	D. McGoff	United States of America	Technical and safety aspects of handling, conditioning and storage of severely damaged nuclear fuel - the TMI experience (invited)
79	K. Einfeld H. Lahr	Germany, Federal Republic of	The DWK pilot conditioning and encapsulation plant
19	L. Baillif C. Bonnet	France	Advanced concepts for spent fuel interim storage
2	K. Einfeld M. Peehs	Germany, Federal Republic of	Comparative analysis of dry and wet spent fuel technologies for choosing of an optimal spent fuel management scheme (invited)
63	T. Saegusa Y. Nakamura K. Nemoto K. Ishida M. Hironaga H. Ohnuma Y. Yamaji S. Fukuda	Japan	Technical and economic assessment of storage systems of spent fuel from commercial LWR
85	P.K.M. Rao R.A. McEachran P.J. Armstrong	Canada	Management of irradiated fuel at the Ontario Hydro nuclear generating stations
49	J.H. Carlson	United States of America	The role of monitored retrievable storage in the U.S. integrated waste management system

WEDNESDAY, 13 May 1987

12.00 POSTER SESSION II
Handling, Conditioning and Storage of Spent Fuel and HLW

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
30P	P. Blum H. Leers V. Roland	France	A modular equipment for underwater fuel rod consolidation
51P	R.E. Steins T.L. Rasmussen	United States of America	Development of prototypical dry rod consolidation equipment for United States waste management
73P	M.J. Larkin W. Smith C.E. Magrabi R.G. Fitzsimons	United Kingdom	Development at Sellafield in support of the Windscale Vitrification Plant for HL waste
90P	V.N. Romanovskii et al.	Union of Soviet Socialist Republics	Fixation of radioactive waste in ceramic materials
78P	K. Scheffler E. Tittmann	Germany, Federal Republic of	Future lay-out of a ceramic melter for HLLW vitrification
20P	Y. Beroud	France	High sensitive analysis system of alpha emitters in radioactive waste
58P	L.P. Cecille R.A. Simon	CEC	Economic evaluation of various management strategies for the alkaline solvent wash waste (ASWW)
42P	P. Gerontopoulos V. Lupparelli A. Nobili	Italy	The application of gel supported precipitation process (GSP) in the nuclear field: conversion of U/Pu solutions for $(U, Pu)O_2$ pellets fabrication and immobilization of high level wastes in SYNROC ceramics

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
26P	J. Teulon L. Chaudon J.C. Fabre	France	Installation de stockage à sec pour combustibles irradiés ou déchets de haute activité
47P	G.H. Beeman R.D. Izatt	United States of America	Technical basis for licensing the dry storage of spent nuclear fuel in the US
34P	M. Peehs H. Ruhmann G. Kaspar	Germany, Federal Republic of	Experimental investigation on spent fuel behaviour under strong mechanical impact
13P	V.J. Kangas	Finland	TVO-KPA-STORE. A Finnish wet intermediate storage for spent fuel
93P	B.P. Shevelin et al.	Union of Soviet Socialist Republics	Design principles for the the equipment in the back-end of the nuclear fuel cycle

THURSDAY, 14 May 1987

09.00-11.30 Session VI - Development Programmes for Reprocessing Facilities

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
70	R.J. Taylor P.I. Hudson C. Phillips	United Kingdom	The development of oxide fuel reprocessing at Sellafield
27	M. Bourgeois J. Arod G. Baudin H. Rouyer	France	Les recherches et développement sur le retraitement et les déchets au Commissariat à l'Energie Atomique
87	K. Hartmann J. Fleisch	Germany, Federal Republic of	Influence of R and D results on the engineering of Germany's Wackersdorf reprocessing plant.
60	N. Tsuji T. Yamanouchi K. Takahashi H. Furukawa	Japan	Development and improvement of reprocessing technology at Tokai reprocessing plant
74	J.C. Almagro A. Menlich G.A. Dupetit D. Quilici	Argentina	Programa de reprocesamento Argentino

THURSDAY, 14 May 1987

11.30-12.30 POSTER SESSION III
Development Programmes for
Reprocessing Facilities

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
44P	N.R. Geary	United Kingdom	Development of an environmentally optimized reprocessing process
57P	Gy. Csom S. Feher	Hungary	Some aspects of fuel reprocessing development strategy for symbiotic nuclear energy systems
88P	Gasteiger Schulze Gross Hildenbrand	Germany, Federal Republic of	Safety of reprocessing plant at Wackersdorf (WAW)in the light of the accident at Chernobyl:
41P	T. Candelieri G. Grossi P. Pozzi A. Moccia	Italy	Italian experience on advanced separation processes for spent fuel reprocessing
71P	R.D. Shaw	United Kingdom	Corrosion control equipment at the Sellafield Nuclear Fuel Reprocessing Plant
17P	M. Kyrs Z. Dlouhy J. Moltasova	Czechoslovakia	The review of research and practice in Nuclear Research Institute in the field of the back-end of the nuclear fuel cycle
24P	G. Lamarque G. Frejaville J.L. Boutaine	France	Mésures utilisées dans une usine de retraitement pour la surveillance du procédé et le contrôle des déchets
8P	R.O. Korob R.R. Cordero L. Dell'Occhio G. Del Cul	Argentina	Using resins XAD-2 and XID-4 for TBP removal from acqueous solutions

THURSDAY, 14 May 1986

14.00-17.00 Session VII - Utilization of Materials Recovered by Reprocessing

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
6	K. Uematsu	Japan	The incentives for recycling of fissile materials in thermal reactors and fast reactors in Japan (invited)
10	H.F. Bairiot G. Lebastard	Belgium	Collaboration between France and Belgium on Pu recycle
45	J.A. Paleit J.A.B. Gresley	United Kingdom	Recycled uranium - a valuable commodity
75	Berthet M. Darrouzet M. Lebars J. Vergnes	France	Actions et experimentations menées en France pour l'introduction du plutonium dans les réacteurs à eau pressurisées (REP)
33	G.J. Schlosser S. Winnik	Germany, Federal Republic of	Thermal recycle of plutonium and uranium in the Federal Republic of Germany: strategy and present status
22	J. Baumier	France	Aspects economiques du recyclage du plutonium dans les réacteurs à eau pressurisées (PWR)

THURSDAY, 14 May 1987
17.00-18.00

FRIDAY, 15 May 1987
08.30-09.00

POSTER SESSION IV
Utilization of Materials Recovered by Reprocessing and Disposal of Spent Fuel and HLW

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
7P	L. Koch	CEC	Potentials of Np and Am recycling
92P	V.P. Popik et al.	Union of Soviet Socialist Republics	Study of extraction and separation of palladium, rare earth and trans-plutonium elements using FOR-TVEX
9P	E.M. Trauwaert	Belgium	Recent progress in manufacturing of plutonium fuel for recycling in LWR
18P	R. Castelli A. Chotard J.L. Mourlevat	France	Le combustible au plutonium FRAGEMA dans les réacteurs à eau sous pression
80P	D.D. Sood	India	Chemical investigation relevant to plutonium recycle
23P	J.P. Grouller G. Flamenbaum JY. Pipaud	France	Recyclage des actinides mineurs avec le plutonium dans un réacteur a neutrons rapides. Consequences sur le bilan en reactivité et sur les activités des combustibles.
37P	W. von Heesen G. Weinhold	Germany, Federal Republic of	Multi-purpose storage plant for radioactive materials

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
36P	H. Hahne	Germany, Federal Republic of	Advanced three dimensional numerical temperature calculations exemplary for for the Gorleben repository - A comparison with a semi-analytical calculation
64P	J.B.M. de Haas R.B. Helmholdt	Netherlands	Some safety aspects of the disposal of high-level radioactive waste in salt formations
72P	T.H. Bates	United Kingdom	Techniques for measurement of low activity levels of radionuclides

FRIDAY, 15 May 1987

09.00-11.30 Session VIII - Disposal of Spent Fuel and HLW

No. of paper	Name(s)	Designating Member State/Organization	Title of Paper
IAEA-SM-294/			
52	T. Isaacs	United States of America	Overview of the U.S. program to develop geological repositories for high-level radioactive waste disposal
32	R. Papp W. Bechtold R. Rölling H. Brunner	Germany, Federal Republic of	Concepts for direct disposal of spent LWR and HTR fuel in the Federal Republic of Germany
66	T.C. de Boer B. Vriesema	Netherlands	Engineering safety aspects of the High Active Waste (HAW) test disposal project in the Asse salt mine (FRG)
84	K. Nuttall	Canada	The development of engineered systems for conditioning and disposal of nuclear fuel wastes in Canada
86	D.J. Fehringer D.A. Galson J.J. Linehan	United States of America	The US Nuclear Regulatory Commission's proposed definition of "high-level radioactive waste". A risk-based criterion

11.30-12.00 Closing of the Symposium

Thursday, May 21, 1987:

o POLICY AND PRACTICE FOR THE MANAGEMENT OF SPENT FUEL AND RADIOACTIVE WASTE

chairman:	MDgt Dr. Popp, BMFT/Bonn
8:30 - 9:00 a.m	USA Ben C. Rusche, Director, Office of Civilian Radioactive Waste Management DOE
9:00 - 9:30 a.m.	France Jean Lefevre, Director, Nuclear Waste Management, CEA
9:30 - 10:00 a.m.	Switzerland Dr. Rudolph Rometsch, President, Nagra
10:00 - 10:30 a.m.	break
10:30 - 11:00 a.m.	Sweden Dr. Olof Soederberg, Director, Statens Kaernbraenslenaemnd
11:00 - 11:30 a.m.	Great Britain Dr. Ron H. Flowers, Director, Fuel Processing, UKEA
11:30 - 12:00 a.m.	Japan Dr. Kunihiko Uematsu, Executive Director, PNC
12:00 - 1:00 p.m.	Panel Discussion with the foreign speakers
o 1:00 - 2:00 p.m.	lunch

o CONCLUSION:

chairman:	Minister of State A. Dick
2:00 - 2:45 p.m.	Nuclear Waste Management and Peaceful Use of Nuclear Power as the Elements of a Responsible Environmental Policy Federal Minister of Environment and Nuclear Safety/Bonn
2:45 - 3:30 p.m.	The Back-end of the Fuel Cycle in an Ethical-moral View Father Basilius Streithofen/Bonn
3:30 - 4:00 p.m.	Resume of the Meeting in the View of the State Ministery and Closing Remarks Minister of State A. Dick

THE BACK-END OF THE FUEL CYCLE

Symposium from May 18, 1987 to May 21, 1987

Monday, May 18, 1987:

o WELCOME AND OPENING OF THE SYMPOSIUM

1:30 - 1:45 p.m.	Welcome of the Participants Minister of State A. Dick
1:45 - 2:15 p.m.	Opening Speech Minister President Dr.h.c. F.J.Strauß
2:15 - 3:00 p.m.	Credibility of Science and Confidence in the Future Prof.Dr.Dr. Maier-Leibnitz, München
o 3:00 - 4:00 p.m.	break

o SOME STEPS OF THE BACK-END OF THE FUEL CYCLE

chairman:	Prof.Dr.Dr.Ing. E.h. Birkhofer, TU München
4:00 - 4:30 p.m.	Integrated Concept for and Situation of the Back-end of the Fuel Cycle in Germany MDgt Dr. Hohlefelder, BMU/Bonn
4:30 - 5:00 p.m.	Reprocessing of Spent LWR-Fuel Elements Prof. Dr. Baumgärtner, TU München
5:00 - 5:30 p.m.	Treatment of Radioactive Wastes Prof. Dr. Böhm / Dr. Krause, KfK/Karlsruhe
5:30 - 6:00 p.m.	Final Disposal of Radioactive Wastes Dr. Kühn, GSF/Braunschweig
6:00 - 6:30 p.m.	Biological Effects of Ionizing Radiation Prof. Dr. Trott, Univ. of London

o IN THE EVENING:

from 8:00 p.m.	Reception of the Bavarian Government

ATTACHMENT 8

Tuesday, May 19, 1987:

o STRATEGIES OF THE ENERGY SUPPLY AND THE FUEL CYCLE - STATE OF ART AND IMPACTS.

chairman:	Prof. Dr. Merz, KFA/Jülich
9:00 - 9:45 a.m.	Long-range Aspects of Energy Supply and the Fuel Cycle State Secretary Dr. v. Waldenfels
9:45 - 10:30 a.m.	Safety Aspects of the Transport of Radioactive Material from and to the Reprocessing Plant Wackersdorf Dr. Rimkus / Dipl.-Ing. Nerlich, TÜV/München
10:30 - 11:00 a.m.	break
11:00 - 11:45 a.m.	A Safety Comparison of the Use of Nuclear Power together with or without Reprocessing; Status of the Activities for Direct Conditioning of Fuel Elements Dr. Closs, KfK/Karlsruhe; Dr. Einfeld, DWK/Hannover
11:45 - 12.30 a.m.	Recycling of Fissile Materials, Technology and Economy Prof. Dr. W. Stoll, Alkem/Hanau
o12:30 - 2:30 p.m.	lunch

o STRATEGIES OF THE ENERGY SUPPLY AND THE FUEL CYCLE - STATE OF ART AND IMPACTS (CONTINUATION)

chairman:	Dr. Kroebel, KfK/Karlsruhe
2:30 - 3:15 p.m.	Concepts of Tritium Waste Handling Prof. Dr. E. Merz, KfA/Jülich
3:15 - 4:00 p.m.	Waste Disposal Projects with Special Consideration of Reprocessing Waste. Prof. Dr. Röthenmeyer, PTB/Braunschweig
o 4:00 - 4:30 p.m.	break
o 4:30 - 5:15 p.m.	Safeguarding of Nuclear Fuel Dr. Randl, BMFT/Bonn
5:15 - 6:00 p.m.	Sense and Nonsense of the Collective Dose as Measure for the Assessment of Radiological Risks Prof.Dr. Streffer, University Hospital/Essen

Wednesday, May 20, 1987:

o THE PROJECT OF THE REPROCESSING PLANT WACKERSDORF (WAW)

chairman:	Prof. Dr. Levi, GSF/München
9:00 - 9:45 a.m.	Design and Basic Data of WAW Dipl.Ing. Mischke, DWK/Hannover
9:45 - 10:30 a.m.	Safety Design of WAW Dipl.Ing. Gasteiger, DWK/Hannover
10:30 - 11.00 a.m.	break
11:00 - 11:45 a.m.	Assessment of the Plant Safety Dipl.Ing. Thomas, GRS/München; Dr. Rimkus, TÜV/München
11:45 - 12:30 a.m	Radiological Impact and Environmental Surveillance Dr. Göttel, GSF/München
o12:30 - 2:30 p.m	lunch

o THE PROJECT OF THE REPROCESSING PLANT WACKERSDORF (WAW) (CONTINUATION)

chairman:	Prof. Dr. Baumgärtner, TU München
2:30 - 3:15 p.m.	Securing of Ecological Site Data; Environmental Protection and Surveillance of Natural Conditions Dr.Schaller,Planning Office/Kranzberg
3:15 - 4:00 p.m.	Economical Influences on the Region of Oberpfalz by the Construction and Operation of the WAW Dr. Weinländer, DWK/Hannover; Dr. J. Genosko, Univ.of Regensburg
o 4:00 - 4:30 p.m.	break
o 4:30 - 5:15 p.m.	Risk Analyses of Fuel Cycle Plants Prof.Dr.Dr.Ing. E.h. Birkhofer, TU München

o IN THE EVENING:

from 8:00 p.m.	Bavarian Evening

ATTACHMENT 9

Comman Press-Information of DBE, Peine, West-Germany
(German Company for Planning,
Construction and Operation of Repositories)
and Bergamt Celle (Department of Mines, Celle, West-Germany)

On May 12, 1987, at 9.45 a.m., an accident occured at shaft 1 at the Gorleben mine site.

The shaft 1 is presently 239 m below surface and the sinking is going through the overburden and the caprock of the saltdome.

During the time of the accident seven miners, two of them supervisiors were at shaft bottom.

The accident occured while the miners were sinking with jackhammers and the preparations of the installation of the shaft wall supports. The shaft lining (concrete blocks) had been installed approx. 1.4 m above the shaft bottom. In addition support rings (U-beams) were set over a height of 12 m in this area between the overburden and the caprock.

One of these support rings gave way and fell down from a height of 5 m to the shaft bottom. The cause is still unknown.

Six of the seven miners were injured. One of them died may 14. Three of them were released from the hospital after first aid treatment.

The chief mining inspector of Celle started the investigations immediately after the accident.

DBE (German Company for Planning, Construction and Operation of Repositories)
P.O. Box: 11 69
Phone 49-5171-43-1; 49-5846-498
Telex 092 646 dbe d / Telefax 49-5171-43-218

ATTACHMENT 10

The DBE (German Company for the Construction and Operation of Respositories for Waste) and the PTB (Federal Institute of Physics and Technology) joint press statement

Last Sunday (17.05.1987) the mining office in Celle ordered further security precautions in the lowest region of shaft 1 of the Gorleben exploratory mine as a result of the investigations and findings to date following the accident there on Tuesday 12.05.1987. These measures exceed the ones taken so far.

Among the safety measures taken immediately after the accident was the installation of steel ropes with the help of which the support rings were additionally secured. At the same time the positions of the support rings were measured anew and visually appraised. It could be seen from this that it had come to deformation in the support rings due to rock pressure.

In order to secure the existing situation, shaft 1 will first of all be provided with an additional support consisting of lean concrete with a minimal heat generation and a compressive strength of approx. 5 - 10 N/mm^2 from the floor to the upper rim of the support ring lining already in place (approx. depth 239 to 225 m). The work commenced on Monday the 18.05.1987.

The support concrete will enable either a new lining or a new lining reinforcement to be installed.

The recommencement of the sinking work (after 239 m) will be delayed for several months as a result of this.

The geological situation:

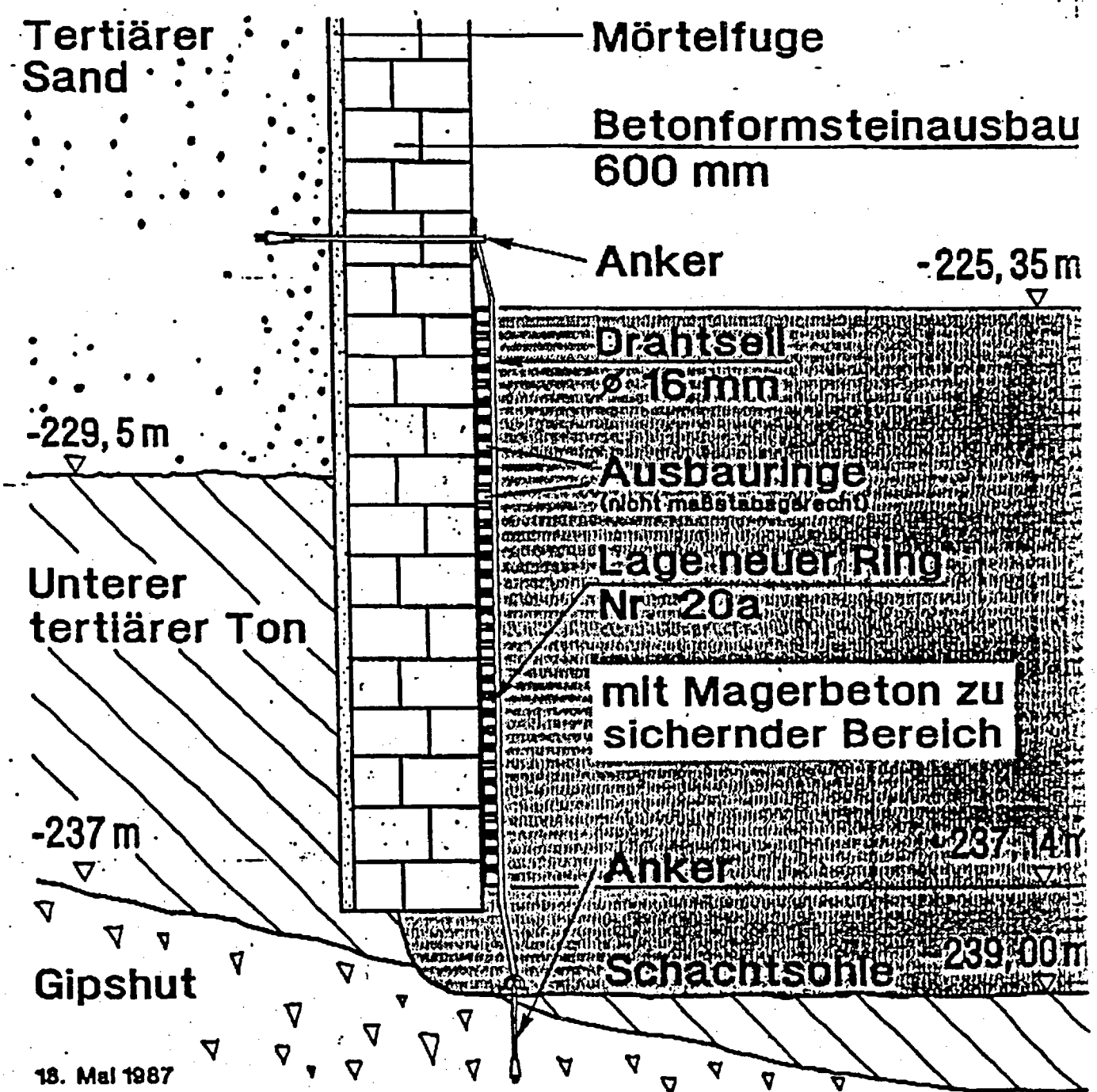
At a depth of 239 m shaft 1 of the Gorleben exploratory mine is in the transition region between the overburden and the cap rock over the salt dome.

The geological quarternary formation (0 to 162 m below the surface) including the Lauenburg clay contained there (73 to 76.5 m) was sunk through without any problem. Simplified, the tertiary formation lying beneath this at a depth of 162 to 237 m can be presented in three parts..

There is an upper clay horizon (162 to 210 m), a middle region of sand and sandstone (210 to 229.5 m) and a lower clay horizon (from 229.5 m)lying over the cap rock (the cap rock upper edge starts at 237 m). Because of its close proximity to the salt dome, the rock moisture in this lower clay has a high salt content and is interspersed with potential sliding planes (= joint faces brought about in earth history) to a greater extent than expected. Therefore only in this lower clay region did convergence worth mentioning come about because even the frost body formed by the freezing shaft sinking technique could not completely prevent the movement of rock on the sliding planes.

18.05.1987

Deutsche Gesellschaft zum Bau und Betrieb
von Endlagern für Abfallstoffe mbh (DBE)



18. Mai 1987

Prinzipskizze
Sicherungsmaßnahmen
Schacht Gorleben 1