HIGH-LEVEL RADIOACTIVE WASTE TEST DISPOSAL PROJECT IN THE ASSE SALT MINE - FED. REP. OF GERMANY

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ABSTRACT

With regard to the planning, design and license procedure for a national repository in the Federal Republic of Germany a high-level radioactive waste test disposal will be performed in the Asse Salt Mine. Thirty vitrified high-level radioactive waste canisters will be emplaced in six underground boreholes in two test galleries at the 800 m-level below the surface. The duration of testing will be approximately five years and all canisters are to be retrieved at the termination of the test due to licensing requirements.

The complete system for handling and emplacement of the waste canisters in a repository is developed and will be tested and proven under actual operational conditions. During the test disposal in-situ-investigations on the water and gas release from the heated salt, the thermo-mechanical behavior of the rock salt and spontaneously occuring stress release by seismic monitoring will be performed.

INTRODUCTION

The High-Level Radioactive Waste Test Disposal Project at the Asse Salt Mine in the Federal Republic of Germany (FRG) will be performed by the Institut für Tieflagerung (IfT) of the Gesellschaft für Strahlen- und Umweltforschung mbH München (GSF) on the request of the Federal Ministry for Research and Technology (BMFT). The experiments at the Asse Mine are considered as pilot tests for the final nuclear repository that is to be constructed in the future. The project is mainly funded by the BMFT and by the Commission of the European Community (CEC) and carried out in close cooperation with the Energy Research Center of the Netherlands (ECN).

Since 1965 the IfT developes and proves safe methods for final disposal of radioactive wastes in salt formations. The disposal techniques that were developed and applied for the disposal of low and intermediate-level radioactive waste at the Asse Salt Mine are now part of the concept for the national repository of the Federal Republic of Germany to be constructed at Gorleben. In order to prove equivalent methods for the final disposal of high-level radioactive waste (HLW) the IfT performed several research and development programs and in situ investigations mainly concerned with the thermo-mechanical behavior of the rock salt. So far the heat producing HLW was simulated by means of electrical heaters without ionizing radiation.

A significant step with regard to the test disposal of HLW is represented by the joint German-American "Brine Migration Test" (1) that was conducted from 1983 to 1985 in the Asse Salt Mine. However, this test where Co-60 sources together with electrical heaters were used to simulate HLW is only of limited validity. The gamma-dose absorbed at the borehole wall is in the range of two orders of magnitude below that dose expected from real HLW generated in the German reprocessing plant WA-350 which is under construction.

With regard to the planning, design and license procedure for a national repository in the FRG,where only proved systems and techniques will be applied, the IfT prepares the HLW test disposal as far as possible in a 1:1 scale.

EXPERIMENT DESIGN BASIS

On the basis of the present German concept, the HLW test disposal in the Asse Salt Mine is planned to have the following characteristics:

* Representative heat generation rate of the waste canisters.
* Representative ionizing radiation from the waste canisters.
* Disposal and thermo-mechanical conditions representative for a real nuclear waste repository.

The conditions of a real repository can be summarized as follows: The maximum salt temperature at the disposal borehole wall should not be higher than 200 deg C and the waste canister surface dose rate is expected to be 2.5×10^5 R/h.

Due to the accelerated creep behavior of rock salt under heat and heat induced stresses the borehole wall will creep rapidly onto the canister surface and will seal the radioactive canister completely.

Since the present license conditions do not permit any final disposal of radioactive waste in the Asse Salt Mine, the safe retrievability of the waste canisters is to be guaranteed over the complete testing period. Therefore, the emplacement boreholes will be lined with high-strength steel tubes to avoid creeping of the salt onto the waste canisters. From this point of view, the outer surface of the liner represents the outer surface of waste canisters during testing in the Asse Mine and the activity of the waste canisters is to be increased compared to real high-level waste because of the shielding capability of the steel tube wall.

The present German concept foresees the disposal of HLW canisters in 300 m deep boreholes from a working level approximately 800 m below the surface. The test disposal in the Asse Salt Mine will be performed at that depth in 15 m deep boreholes, and it is expected that this is sufficient to gain representative data.

LAYOUT OF THE EXPERIMENT

The layout of the experiment is based on the fact, that in the frame of the German-American contract on "Technical Exchange and Cooperation in the Field of Treatment and Disposal of Radioactive Wastes", thirty vitrified glass blocks, containing the radioactive elements Sr-90 and Cs-137, will be delivered by Battelle Pacific North-West Laboratories (PNL), Richland, WA.

It has been agreed, to produce differently endowed sources to obtain the following sets of canisters:

* Set 1: Ten canisters spiked with Cs-137 and Sr-90 with a surface dose rate of 5.0×10^5 R/h and a heat power of 2065 Watts
* Set 2: Ten canisters spiked with Cs-137 and Sr-90 with a surface dose rate of 5.0×10^5 R/h and a heat power of 1680 Watts
* Set 3: Ten canisters spiked with Sr-90 only which leads to a negligible surface dose rate but also to a heat power of 1680 Watts.

The waste canister data are summarized in Table I.

The configuration and dimensions of the underground test field are mainly determined by the number of boreholes that are required to perform the experiment. The test field consists of a set of eight boreholes located in two parallel galleries (A and B) at the 800 m-level (Fig. 1). Two boreholes in each gallery will have a maximum salt temperature of 250 Deg C and two of 200 Deg C.

Two of the 250 Deg C boreholes will be heated only electrically and each of the two others will be charged with five radioactive canisters of set 1. Two of the 200 Deg C boreholes will be only heated by emplacing five Sr-90 canisters of set 3 and each of the remaining two boreholes will be charged with five canisters of set 2. In this manner it is possible to investigate the impact of the gamma radiation and of the heat release at different maximum salt temperatures.

The two parallel galleries are divided by a 10 m thick pillar. In the direction of the gallery axis, the distance between the boreholes will be 15 m and perpendicular through the pillar 19 m. The two test galleries are accessible through two access drifts (necessary for ventilation), one in the western part and one in the eastern part of the test area.

Those boreholes having the same maximum temperature and being equipped with the same type of canister are differentiated as type A and type B (Fig. 2). In the boreholes of type A the annulus between the liner and the borehole wall will be backfilled with a porous medium to avoid the borehole wall creeping onto the liner and for maintaining a pathway for the released water and gas components. In the boreholes of type B, the annulus will not be backfilled so that the salt is permitted to creep onto the liner. Hereby, the influence of a possibly nearly gastight contact between the rock mass and the waste canisters can be investigated with regard to the release behavior of water and gases.

HANDLING AND EMPLACEMENT OF THE WASTE CANISTERS

Though equipment to handle radioactive components is to be found in various nuclear plants, it cannot be transferred to the conditions of routine operations underground. Consequently, one of the goals of the experiment is the development of a complete handling system and its testing under actual operational conditions. The system for the HLW test disposal (2) at Asse (Fig. 3) consists of:

Multiple Transport Cask (MTC)

The thirty waste canisters will be shipped in six MTCs, type Mosaik-GSF-5, to the Asse Mine. These specially designed casks holding five canisters each can be stored in an interim storage facility in the FRG after the retrieval of the waste canisters at termination of the experiment.

Transfer Station

At the transfer station above ground the canisters will be transferred individually into the single transport cask Asse TB1. The interface between both casks is designed nearly identically as the shielding slider (see below) at top of the underground emplacement borehole so that the same electrical control mechanisms can be used.

Single Transport Cask Asse TB1

The transport cask Asse TB1 will be used for the internal transport of each canister during emplacement and retrieval operations.

In order to facilitate licensing by the mining authorities, the container is to receive a licence as transport cask type B(U), in accordance with the international transport regulations.

TABLE I

CHARACTERIZATION OF THE WASTE CANISTERS
FOR THE HLW TEST DISPOSAL IN THE ASSE SALT MINE

Type	Number of Canisters	Heat Output	Nuclide Inventory	Maximum Salt Temperature	Gamma-Dose Rate
Set 1	2 x 5	2065 W/canister = 34.4 W/l	Cs-137, Sr-90	250 °C	5×10^5 R/h
Set 2	2 x 5	1680 W/canister = 28.0 W/l	Cs-137, Sr-90	200 °C	5×10^5 R/h
Set 3	2 x 5	1680 W/canister = 28.0 W/l	Sr-90	200 °C	Small

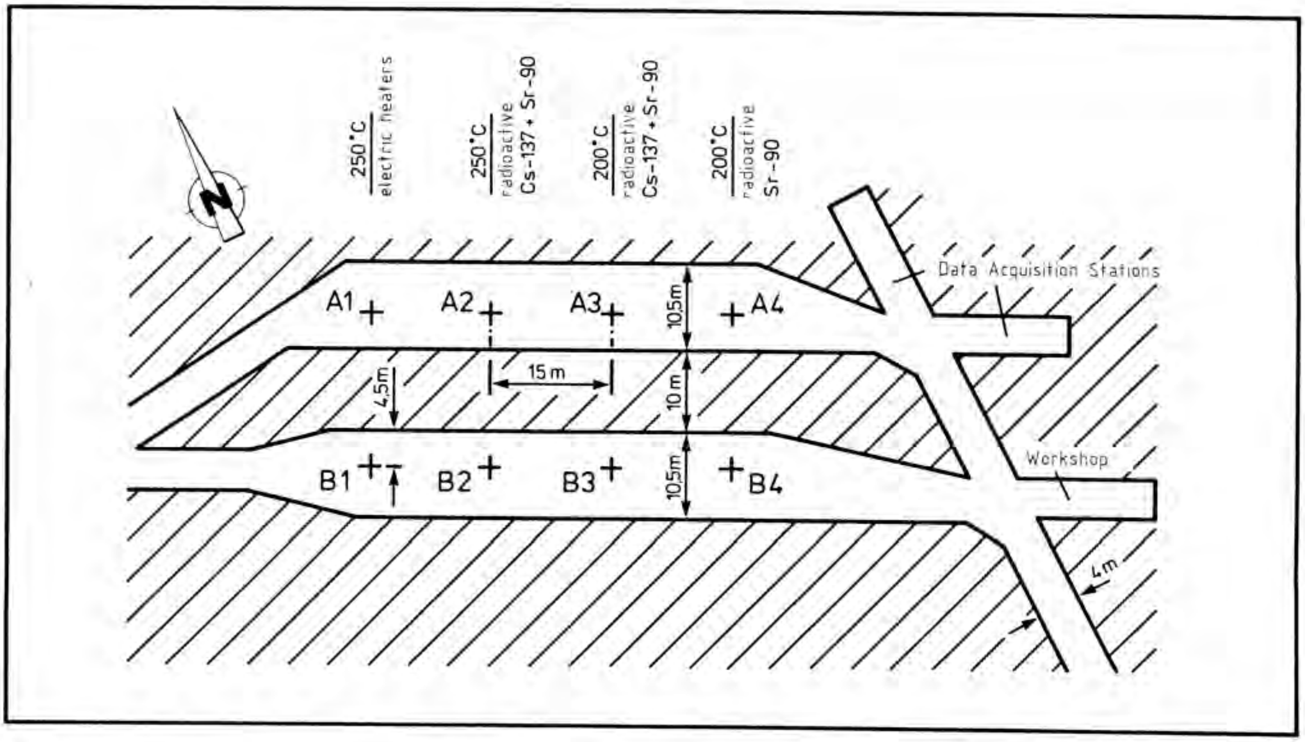

Fig. 1. Geometry of Underground Test Field

Both, design and construction were optimized to fulfill the boundary conditions for transport in the shaft (max. weight 10 t and max. width 1.15 m). This resulted in a transport cask with flat slide and an integrated grapple system and the following shielding thickness: 145 mm lead, 40 mm steel, 135 mm neutron shielding of epoxy.

The loaded Asse TB1 will be transported to the hoisting cage and brought to the emplacement level.

Transport Vehicle

At the emplacement level the Asse TB1 is removed from the hoisting cage by a specially developed transport vehicle, transported to the emplacement borehole and deposited on the borehole shielding slider. The concept of the vehicle is based on the center pin steering, well known in mining operations. With the aid of its side arm and integrated lifting device it lifts the Asse TB1 from the hoisting cage and places it upon the borehole slider. The cask is protected against falling and tilting during transport. Buffers and low transport velocity reduce possible damage which might be incurred in case of a crash of the transport vehicle inside the galleries.

Borehole Slider

During loading and unloading of the boreholes the waste canisters, the dummy-canister, and the shielding plug (see Fig. 2) are lowered through the borehole slider respectively retrieved upwards into the transport cask. The borehole slider provides the necessary shielding against gamma and neutron radiation during loading and unloading processes. It also contains the motor for the mechanical locking mechanism for the bottom slider of the transport cask.

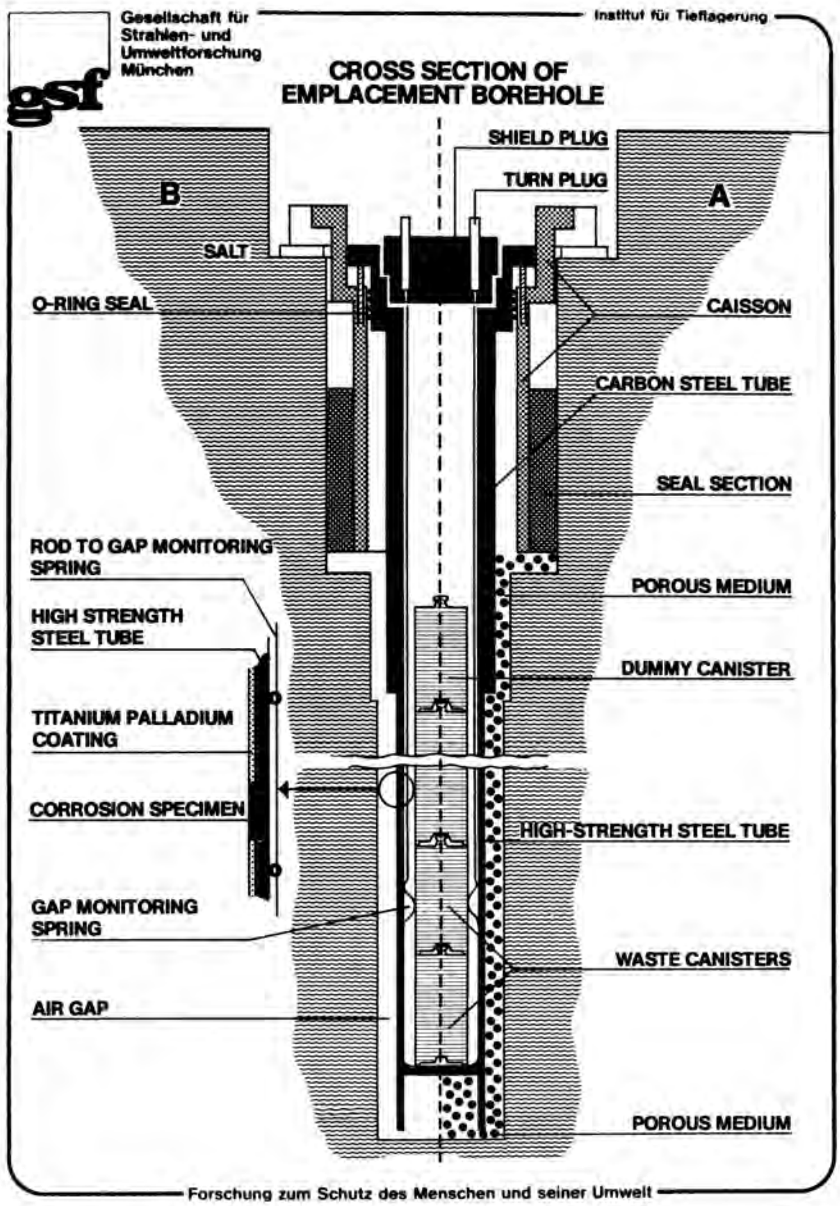

Fig. 2. Borehole Types

Disposal Machine

The disposal machine mainly consists of the winch unit, a control unit and the undercarriage. The winch is driven by an electromotor and, in case of a main power supply failure, power is provided by integrated batteries. The machine is movable in all directions and it is positioned at each borehole in such a way, that the winch is at a directly vertical position above the borehole slider. It remains in this position until the charging of one borehole is completed. When placing the Asse TB1 on the borehole slider, the winch unit of the disposal machine is swung aside.

All manipulations with the waste canisters, the dummy canister and the shield plug are carried out with the disposal machine. Moreover, it controls the connected components, such as borehole slider, the mechanical slider locking mechanism of the transport cask Asse TB1 and the magnet inside the coupling grapple which is firmly connected to the end of the lift cable.

The winch is laid out for a borehole depth of 300 m and is controlled by means of a built-in computer which ensures that each emplacement position is approached by the next canister with the necessary caution. The functioning ability of the winch will be tested later in a correspondingly deep borehole in the Asse salt mine.

After all five canisters are deposited in one borehole, a so-called dummy canister is placed on the uppermost one of the five canisters. This dummy does not only serve for thermal insulation upwards, but it also is provided with a lead shield and contains chambers for taking material specimens (e.g., rock salt), which can be exposed to radiation at an elevated temperature level for investigation purposes.

Then the borehole is closed by a shield plug and the borehole slider can be removed. Finally, a measuring system is installed for monitoring of the gap between the canister stack and the inner surface of the borehole liner. This gap monitoring system is requested by the licensing authorities to asure continuous surveying of the canister retrievability.

IN SITU STUDIES

The interaction of the waste canisters with the surrounding rock salt formation is foremost in the in situ studies during the experiment. The physical-chemical effects of gamma-radiation and heat production on the stability of rock salt will be investigated in detail. It has been observed previously in laboratory (3) and in field tests (4,5,6) that rock salt contains traces of water and gases that are released into

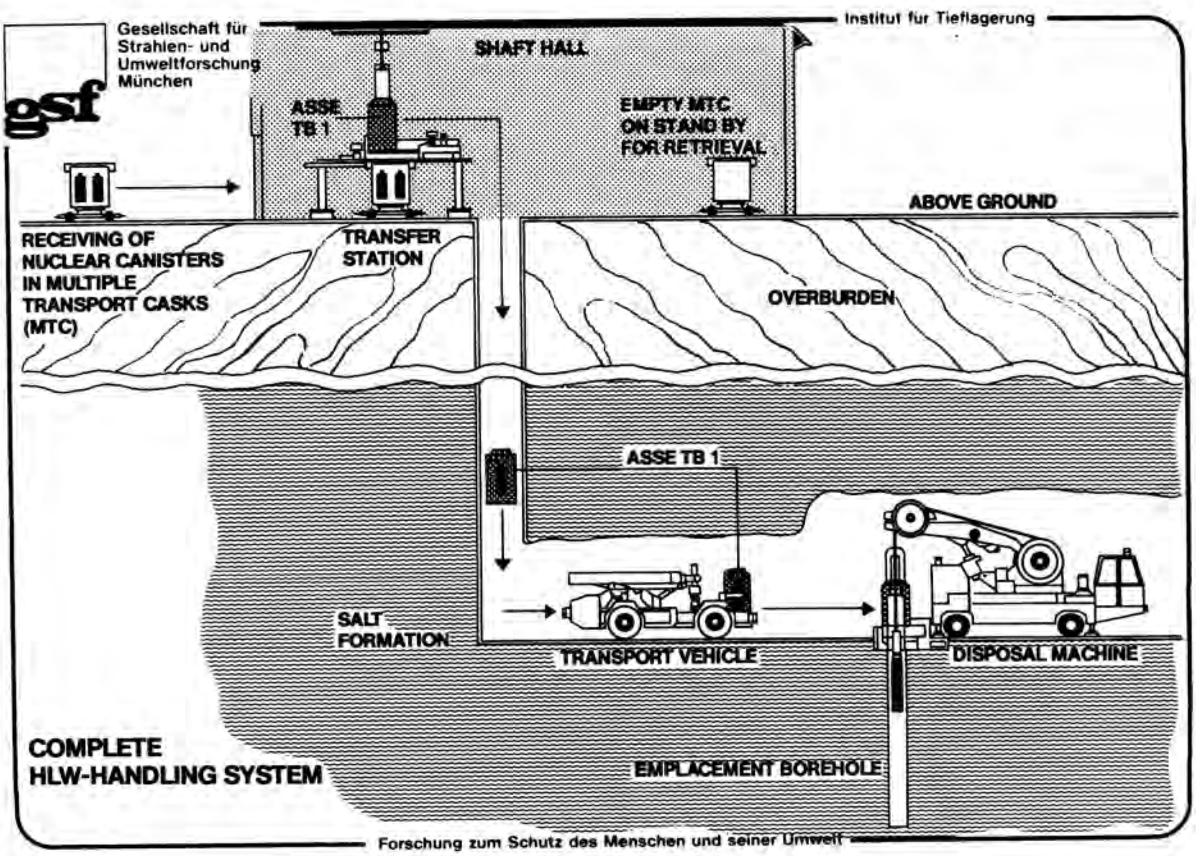

Fig. 3. HLW Handling System at Asse Mine

the volume of a borehole containing heat producing HLW canisters.

During the experiment at Asse the state of the borehole atmosphere will be studied in particular. For this, gas samples will be taken periodically from the gap between the tubing and the borehole wall and also from special smaller boreholes surrounding the emplacement boreholes. The gas samples will be analyzed immediately after sampling in an underground laboratory situated in an air-conditioned room.

With regard to the stability of the system of emplacement gallery and pillars, the thermally induced stress and strain fields in the underground test field will also be investigated. A comparison of the results of numerical calculations with the in situ measurement values is foremost here.

Figure 4 shows the result of stress measurements inside the pillar which were started prior to mining of the galleries. It can be seen that a significant increase of the vertical stress component to about 20 MPa was observed due to excavation of the galleries.

In addition measurements of dosage, temperature distribution, and spontaneously occuring stress release by seismic monitoring will be performed.

PROJECT SCHEDULE

From the time schedule for the HLW test disposal project at the Asse Salt Mine it can be derived that the canisters will be emplaced into the underground boreholes in early 1988. First data that can be interpreted will then be available in 1990 or 1991. They will find consideration when the final concept for the national nuclear repository for HLW is developed. The test disposal of the thirty canisters is planned for a five years period. This is considered to be sufficient because steady state conditions will be reached approximately two years after the start of the experiment. Final results will be available early enough for the construction and operation of the final repository in the Federal Republic of Germany.

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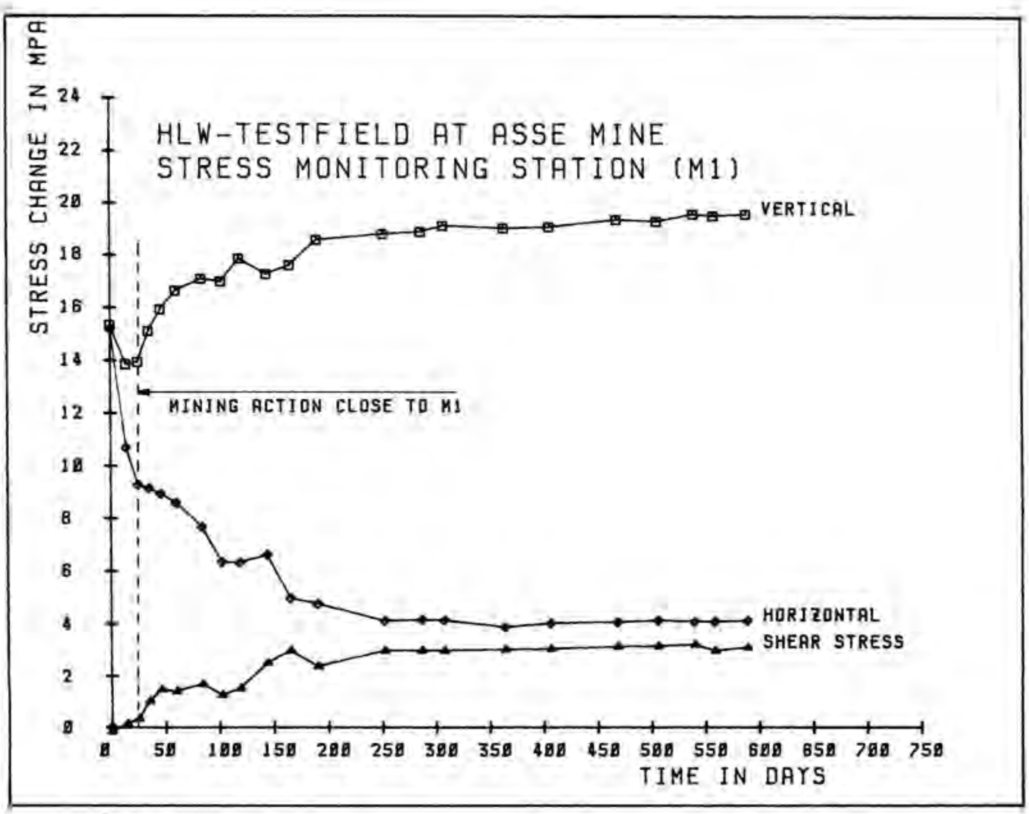

Fig. 4. Stress Measurement Inside the Pillar of the HLW Test Field

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