MEUSE/HAUTE-MARNE UNDERGROUND RESEARCH CENTER - TECHNOLOGIES AND TECHNIQUES FOR STUDYING GAS FLOW AND THERMAL PROPERTIES OF AN INDURATED CLAY ROCK

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ABSTRACT

This paper presents technologies and techniques carried out in the Meuse/Haute-Marne Underground Research Laboratory (URL) in the framework of gas flow and thermal properties experiments on the Callovo-Oxfordian argillaceous rock formation.

INTRODUCTION

The Meuse/Haute-Marne Underground Research Laboratory is located on the eastern boundary of the Paris Basin, in the Callovo-Oxfordian clay rock formation. The URL was built in the framework of Andra's research program into the feasibility of a reversible deep geological disposal of high-level and intermediate-level long-lived radioactive waste (HL, IL-LL). Its underground drifts are used to study a 160-million-year old clay layer and determine the confinement properties of this argillaceous rock [1].

DESCRIPTION OF THE URL

The underground installations consist of two shafts and drift networks (Fig. 1). The main shaft, 5 m in diameter after lining, gives access to a 445 m-deep drift network and to the 490 m-deep main drift network. The functionalities of this shaft are the access for the personnel, the transportation of equipment, the clearing of dump material and the air inlet of the ventilation system.

The auxiliary shaft, 4 m in diameter after lining, is also serviced by two elevators with the same capacity. They can descend below the shaft station to make way for heavy-load or large-bulk carrying machines. The auxiliary shaft acts as an emergency exit. It also ensures the ventilation system air circulation and to this effect it comprises, at surface level, an extraction room and a chimney.

The drift network at –445 m is 45 m long and T-shaped. This experimental zone has been equipped to monitor the reaction of the rock mass during shaft sinking from –445 m to -465 m. These drifts are 17 m2 in section. The main network of experimental and technical drifts is located at -490 m. In May 2010, this network was 900 m-long, out of which 200 m dedicated to experiments. The orientation of the scientific drifts has been determined with respect to the in-situ stress field.

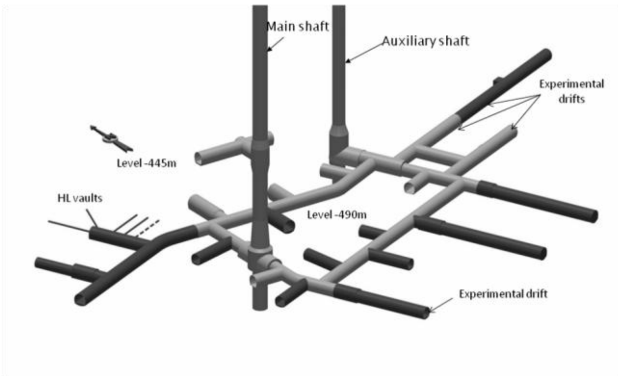

Fig. 1 Layout of the underground installations

PGZ1 EXPERIMENT

The objective of PGZ1experiment is to use gas-injection tests to characterize the formation's internal gas transfer properties. The goal is to confirm and provide additional support for the parameters and limits of the traditional biphasic model for describing gas transfer:

- Determination of the pressure at which gas can enter the undisturbed argillaceous rock and if possible the EDZ (excavation damaged zone),
- Determination of the threshold gas pressure above which pathway dilation occurs,
- Positioning of this threshold with respect to the fracturing pressure.
- Characterization of the network of joints created (reversible or not).

The main objective of PGZ1 is to obtain an understanding and a quantification of the reaction of the undisturbed rock to gas below the fracturing pressure.

In the conceptual representation of gas flows in clays it is considered that a mode of transfer exists, above a certain pressure. This mode of transfer (dilation) has been previously seen in bentonite associated with the opening of pathways for localized percolations.

The second part of the test involves gas fracturing, characterization of the damage, and a study of the effects of self-healing in the rock.

The test consists of an injection borehole (PGZ1201), a borehole parallel to the injection hole for monitoring interstitial pressures (PGZ1202), and a borehole for monitoring rock deformation (PGZ1031). This borehole is perpendicular to borehole PGZ1201 and located about 1 m above it (Fig. 2).

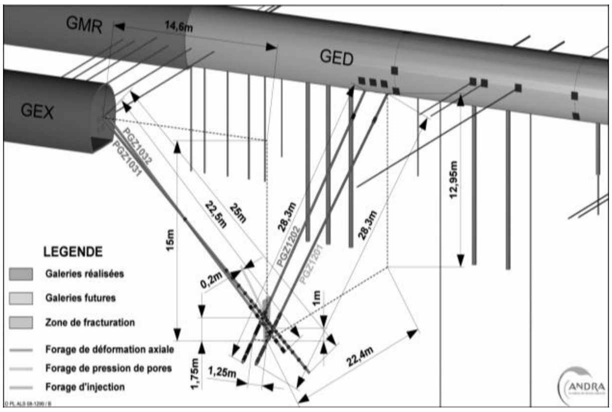

Fig. 2 Set up of the PGZ1 Experiment

Significant uncertainties remain concerning the predicted orientation of the fracture. Accordingly, after the gas-fracturing stage a final borehole (PGZ1032) designed to measure interstitial pressures should be drilled: it will enable assessment of the fracture's permeability to water and gas.

A large modeling activity has been planned to interpret and analyze all the results that will be obtained on PGZ1 experiment. Thereby, several groups will be involved in calculations (with TOUGH2 [2] and GEOSIM) and also some partners within the framework of the FORGE project (Fate of Repository Gases). This European project that began in 2009 is specifically designed to tackle the key research issues associated with the generation and movement of repository gas.

TED EXPERIMENT

A large-scale field test (TED, Thermal experiment number 2) has been designed and set up at 490 m in the main scientific drift GED.

The principal goals of the test are:

- to characterize the thermal properties of the no damaged argillaceous rock.
- to increase the knowledge of the THM behavior of the clay obtained previously with in-situ experiment TER and tests laboratory.
- to check the "overpressure" due to the heat on a zero flux plan.
- to calibrate the numerical model in order to apply it to the disposal cell cases.

The concept aims at studying the thermo-hydro-mechanical interaction of several heat sources. In the previous thermal experiment carried out at Bure, TER experiment [3], the variation of the drift temperature has significantly influenced the experiment. To avoid this influence the distance from heaters center to drift wall is of 14 m. Three heaters, each 4 m long in 160 mm borehole and generating of 600 W thermal power are installed at about 2.6 m each other to be close to the ratio of the disposal cell geometry concept. Around the heaters, there are 23 surrounding boreholes:

- 12 for water pressure measurements.
- 9 for temperature measurements.
- 2 for strain measurements.

In addition, 8 temperature sensors were installed on the drift wall to measure the boundary conditions.

To optimize and make easier the inverse problem analysis, a particular attention had been made to reduce uncertainties on the sensor's location in boreholes. Possible erroneous localization of the sensors in the TER experiment was found to be a very problematic issue for analysis and parameter determination [4].

TED experiment was installed in summer 2009. A schematic view of the experiment layout is shown in Fig. 3.

The heating schedule foresees 2 periods: a first one with only the central heater (TED1201) working and a second one with three heaters. In the first period the heater 1 has been switched on at nearly 1/4 of the nominal power to check the installation and the well-functioning of instrumentation and to allow the validation of the numerical modeling. 2 heating cycles (at 50 and 100% of nominal power) will complete in the first period. During the second year (phase 2), the same heating cycles will be applied simultaneously on the two other heaters (TED1202 and TED1203).

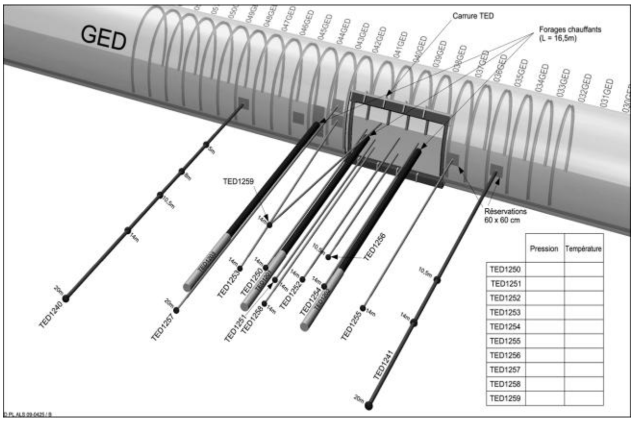

Fig. 3 Set up of the TED Experiment (pore pressure measurement)

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