2015

Activity Report

ESV EURIDICE EIG

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Contents

General foreword

Marc Demarche, Chairman of the Board of EIG EURIDICE

Dear reader,

The Activity Report 2015 provides a comprehensive overview of EIG EURIDICE's main activities and achievements last year. EURIDICE is the Economic Interest Grouping (EIG) of SCK•CEN and ONDRAF/NIRAS, and is responsible for managing and operating the HADES underground research laboratory, conducting research, demonstration and development activities relating to the disposal of radioactive waste in deep clay formations, and communicating about its activities.

For many years the PRACLAY Seal and Heater tests have been the key challenges and priorities of EIG EURIDICE. After the successful start-up of the Heater test in November 2014, a second milestone was reached in the course of 2015. Once the heating system was switched on, the temperature in and around the PRACLAY gallery steadily increased until the target of 80°C was attained at the interface between the concrete gallery lining and the Boom Clay, in August 2015 (start-up phase). The temperature at this interface will now be kept constant at 80°C for the next 10 years. The observations made during the first year of heating generally confirm the "blind predictions". These predictions were made using numerical modelling before heating started and are partly based on measurements from small-scale in-situ heater tests.

Over the coming years the EURIDICE team will ensure scientific and technical follow-up of the experiment; this work will include maintenance of the experimental set-up, management of the instrumentation system and of all the data collected, interpretation of the various measurements and observations, and systematic scientific and technical reporting during the experiment. A first report covering the start-up phase will be published in 2016.

During 2015 a great deal of effort was devoted to communicating about the successful start-up of the PRACLAY Heater test. On 20 March 2015 the government ministers with responsibility for ONDRAF/NIRAS and SCK•CEN, Deputy Prime Minister Kris Peeters and Minister for Energy Marie-Christine Marghem, visited the EURIDICE site and the HADES facility, together with more than 100 invitees and also representatives from the national and regional press. At the 6th International Conference on Clays in Natural and Engineered Barriers for Radioactive Waste Confinement, held in Brussels, a separate session and an evening event were devoted to the PRACLAY Heater test. During two weekends in May and November EIG EURIDICE opened its doors to the inhabitants of the municipalities of Mol and Dessel, giving more than 300 people the opportunity to visit EURIDICE and the HADES underground research laboratory.

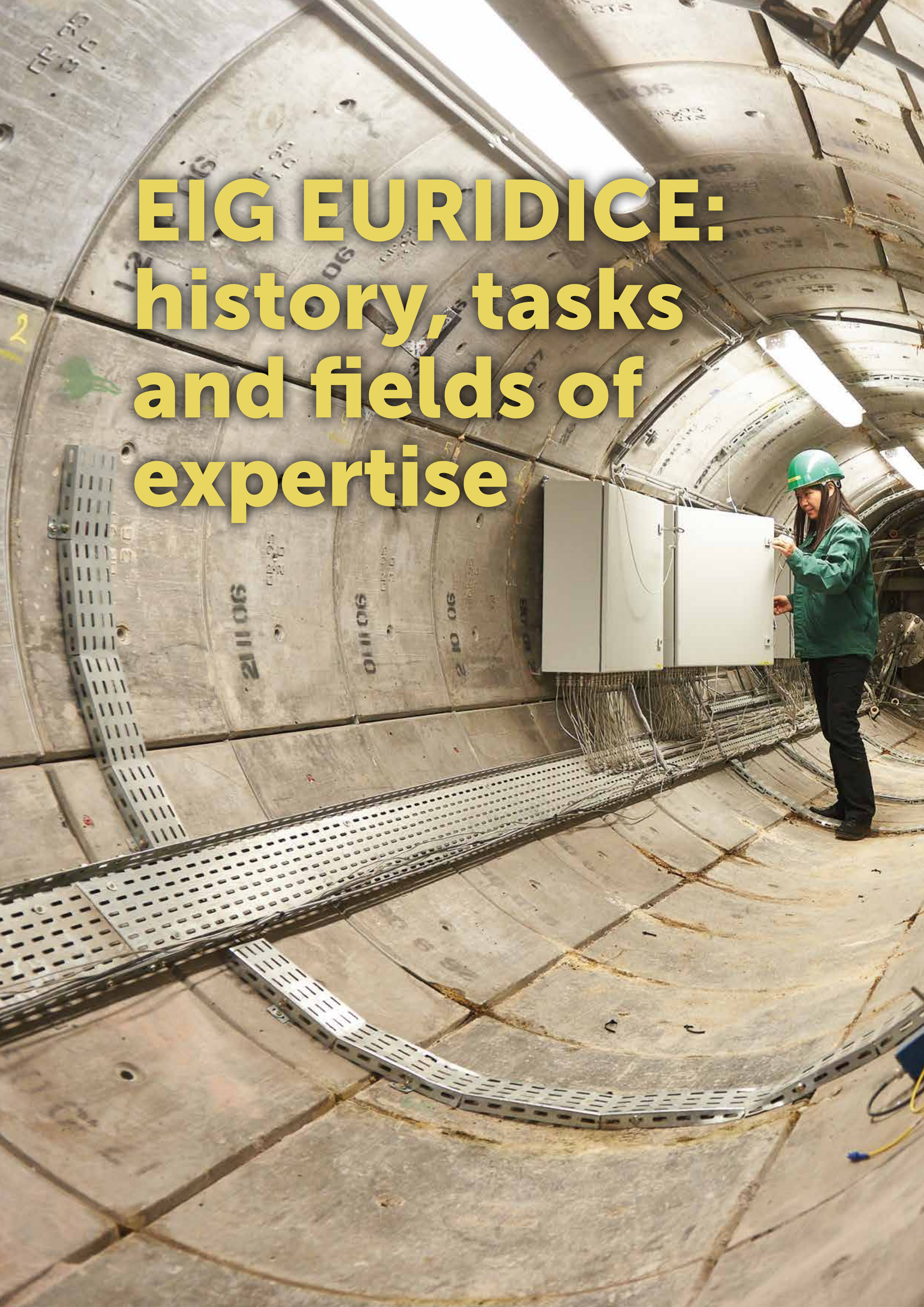
In 2015 a new agreement was signed with ONDRAF/NIRAS, providing funding for EURIDICE's RD&D activities on radioactive waste disposal and for its operation of the HADES facility during the period 2015-2020. This agreement also covers the budget for refurbishing the shaft 1 hoisting system, which will be a challenge for EURIDICE in the years ahead.

EURIDICE has had its own separate entrance since October 2015, making it easier for visitors to access the EURIDICE site and facilitating EURIDICE's efforts to communicate about its activities.

EURIDICE has contributed to the low-level waste disposal programme of ONDRAF/NIRAS in the fields of safety assessment, monitoring and instrumentation.

The EURIDICE team, together with EURIDICE's constituent members SCK•CEN and ONDRAF/NIRAS, is also looking to the future. Preparations for the refurbishment of shaft 1 are under way, a communication strategy for the next 10 years is being discussed and the RD&D priorities in EURIDICE's key fields of expertise for the next few years are being defined. This ensures that EIG EURIDICE will be able to contribute to the national disposal programme in the best possible way.

EIG EURIDICE: history, tasks and fields of expertise



EIG EURIDICE (European Underground Research Infrastructure for Disposal of nuclear waste In Clay Environment) is an Economic Interest Grouping (EIG) involving the Belgian Nuclear Research Centre (SCK•CEN) and the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS). It manages the HADES underground research laboratory and carries out RD&D, including feasibility studies for the disposal of high-level and long-lived radioactive waste in a clay host rock. In this way, EIG EURIDICE contributes to the national disposal programme for high-level and long-lived waste managed by ONDRAF/NIRAS, organised in a stepwise manner with major milestones at key decision points. EIG EURIDICE also contributes, to a more limited extent, to the surface disposal programme of ONDRAF/NIRAS for low-level waste.

In 1974 SCK•CEN started research into the geological disposal of high-level and long-lived radioactive waste in a clay host rock. The Boom Clay, a poorly indurated clay (or plastic clay), was and still is regarded as a potentially suitable host formation. This clay layer is found at a depth of 190 to 290 metres below the SCK•CEN research site in Mol. In 1980 SCK•CEN began construction of the HADES (High-Activity Disposal Experimental Site) underground research laboratory (HADES URL Figure 1), situated at a depth of about 225 metres. This was the first purpose-built underground research facility in plastic clay in Europe and worldwide. The laboratory was gradually extended, with the excavation of a second shaft (1997-1999) and a Connecting gallery (2001-2002) linking the second shaft to the then existing underground laboratory. At each stage of excavation and construction, new techniques were used and new technological and engineering expertise was gained. The HADES URL has been managed and operated by the EIG since 1995.

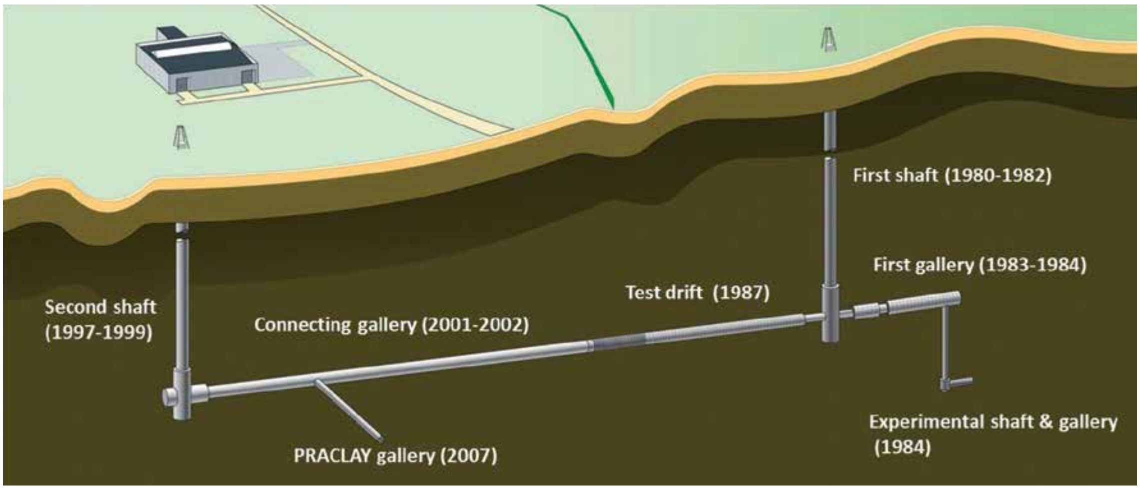


Figure 1 - The underground research laboratory HADES (High-Activity Disposal Experimental Site)

The main statutory tasks of EIG EURIDICE entail a range of activities with a view to developing and facilitating the activities of EIG EURIDICE's constituent members:

- The management and operation of the HADES URL and all the installations situated on the land for which EIG EURIDICE has a building lease.
- The development of the PRACLAY project, which aims to contribute to demonstrating the feasibility of disposal of radioactive waste in a clay host rock.
- The possible development, implementation and valorisation of other research projects and experiments with regard to the disposal of radioactive waste.
- The possible realisation, exploitation and valorisation of other research projects concerning the long-term management of radioactive waste in order to support the scientific programmes of its members using their resources.
- Communication about its own activities, in dialogue with its members, including the organisation of visits to the HADES URL.

After 30 years of research in and around the HADES URL, a lot of expertise and know-how has been acquired in different scientific and technological fields, of key importance for developing an underground radioactive waste disposal facility in poorly indurated clay formations such as the Boom Clay. The scientific and technological expertise of EIG EURIDICE focuses on three areas:

1. Excavation and construction techniques for an underground repository in a clay host rock.
2. The thermo-hydro-mechanical (THM) behaviour of the clay host rock.
3. Instrumentation & monitoring.

EIG EURIDICE's first area of expertise has changed significantly over the past 35 years, with excavation and construction of the HADES URL evolving from semi-manual and slow to industrial, using tailor-made tunnelling machines. The tunnelling techniques used for excavating in poorly indurated clay at great depth, including the crossing between galleries, have greatly reduced excavation-induced disturbance of the clay layer and have demonstrated that it is feasible to construct a disposal infrastructure, at a reasonable speed and cost. Since the natural clay layer will be the main barrier for radionuclide migration in a geological disposal system, reducing the excavation-damaged zone (EDZ) is a key objective and relates directly to the safety of a disposal system.

The second field of expertise of EIG EURIDICE involves understanding the THM behaviour and characterisation of a clay host rock, including all disturbance processes induced by the construction of the galleries and by the emplacement of heat-emitting radioactive waste. In low-permeability clays such as the Boom Clay, THM processes are strongly coupled. EIG EURIDICE's knowledge base is mainly built on the research activities in and around the HADES URL in the Boom Clay. The extensive scientific instrumentation systems installed in the clay before, during and after the construction of galleries made it possible to create a valuable geotechnical knowledge base and database to characterise and understand the hydro-mechanical response of Boom Clay in the short and long term, including the generation and evolution of the EDZ. Proper understanding of the coupled THM processes in a clay host rock around the repository is essential to determine to what extent these processes could affect the capacity of the clay to contain the radioactive substances and to isolate the radioactive waste. The most important project in this area is the large-scale PRACLAY experiment. Here, the combination of the hydro-mechanical disturbances due to excavation of galleries and the further coupled thermo-hydro-mechanical disturbance due to heat production, as in the case of the disposal of high-level vitrified waste or spent fuel, are studied on a large scale.

The RD&D programme in and around the HADES URL relies heavily on the use of various instrumentation devices and techniques to measure and monitor the main THM characteristics of the clay; some of these have been developed in-house. This is the third main area of expertise of EIG EURIDICE. Experience has been gained in several aspects specific to this type of instrumentation and monitoring, such as the long-term operation (decades) of sensors and their measurement data, reliability (e.g. how to implement field calibration and what the alternatives are when this is not possible) and robustness under adverse conditions, such as corrosion and mechanical strains. This extensive instrumentation experience will be an essential element in designing a monitoring programme for an underground repository for high-level and long-lived waste in a clay host rock.

With its RD&D activities and fields of expertise, EIG EURIDICE contributes to the national programme for high-level and long-lived waste disposal managed by ONDRAF/NIRAS. In 2011 ONDRAF/NIRAS published its waste plan for the long-term management of high-level and/or long-lived waste (NIROND 2011-02, September 2011), with a view to obtaining a policy decision on the long-term management of this waste. In 2013 ONDRAF/NIRAS finalised its RD&D plan on geological disposal (NIROND-TR 2013-12 E), describing the main achievements and future challenges. The next milestones of this programme will largely depend on the timing and nature of the policy decision.

EIG EURIDICE's activities in 2015 focused on following up the PRACLAY Heater test. After a successful switch-on of the heating system on 3 November 2014, heating continued up to the target temperature of 80°C at the interface between the concrete lining and the clay. This target temperature was reached about nine and a half months later, on 18 August 2015, marking the end of the start-up phase. Since then, the power of the heating system has been systematically adjusted to maintain a constant temperature of 80°C at the point of contact between the lining and the Boom Clay. This Activity Report gives an overview of the main observations during 2015, based on measurements from the numerous sensors that are installed in the PRACLAY gallery, the seal, the concrete lining and in instrumented boreholes around the PRACLAY gallery. In general, the experimental evolution confirms the blind predictions that were made through modelling. A detailed report on the experimental evolution during the start-up phase, including some initial interpretations, is in preparation and will be published in the course of 2016.

Activities: PART I

Geological disposal of high-level and long-lived radioactive waste

1. PRACLAY "Demonstration & confirmation experiments"

1.1. Introduction: the PRACLAY project

One of the aims of EIG EURIDICE is the development and execution of the PRACLAY project to demonstrate the feasibility of the disposal of high-level, heat-producing vitrified radioactive waste or spent fuel in deep clay strata such as the Boom Clay.

The PRACLAY project consists of several sub-projects and experiments. Together, these are referred to as the PRACLAY "Demonstration & confirmation experiments". The aims of these experiments are:

- To demonstrate the feasibility of underground construction in Boom Clay.
- To demonstrate the feasibility of the disposal concept for high-level waste in Boom Clay.
- To confirm and expand knowledge about the thermo-hydro-mechanical-chemical behaviour of Boom Clay and the gallery lining.

With the PRACLAY experiments, EIG EURIDICE is making an important contribution to the Safety and Feasibility Cases, which are part of the ONDRAF/NIRAS research programme for long-term management of category B & C radioactive waste.

In general, a distinction can be made between two groups of experiments: PRACLAY IN-SITU (meaning "in HADES") and PRACLAY ON-SURFACE experiments:

PRACLAY IN-SITU

DEMONSTRATION EXPERIMENTS
Second shaft
Connecting gallery
Gallery & Crossing test
PRACLAY gallery
Supporting studies: European Commission's CLIPEX project

CONFIRMATION TESTS
Heater test
Seal test
Supporting studies:
EDZ test (European Commission's SELFRAC & TIMODAZ projects)
PhD theses

PRACLAY ON-SURFACE

DEMONSTRATION EXPERIMENTS
OPHELIE (SAFIR 2 repository design)
SUPERCONTAINER feasibility tests
Small-scale test
Half-scale tests
Annular backfill test in European Commission's ESDRED project

PRACLAY IN-SITU experiments can be divided into demonstration experiments and confirmation tests. The **demonstration experiments** focused on excavation techniques and construction of a shaft and galleries. The excavation of the Connecting gallery using a tunnelling machine, for example, demonstrated the feasibility of constructing galleries on an industrial scale. With the construction of the PRACLAY gallery in 2007, it was shown that it is possible to make perpendicular connections between a disposal gallery and a main gallery, making use of a reinforcement structure. Most of the PRACLAY demonstration experiments are now finished. The **confirmation tests** are focusing on confirming and improving existing knowledge about the thermo-hydro-mechanical-chemical behaviour of the Boom Clay surrounding a disposal infrastructure. The **Heater test** is the main experiment in this regard. The objective of this test is to confirm, on a large scale, that the thermal load generated by the heat-emitting waste will not jeopardise the safety functions of the host rock. In particular, the Heater test aims to assess the consequences of the coupled thermo-hydro-mechanical impact on the Boom Clay and the evolution of the excavation-damaged zone (EDZ) during the thermal transient in the case of disposal of heat-emitting waste.

For this purpose, part of the PRACLAY gallery (30 m) has been closed off with a seal structure and will be heated for a period of 10 years at a temperature of 80°C at the interface between the gallery lining and the clay. After the construction of the PRACLAY gallery in 2007 and the design and installation of the seal (2007-2010), installation of the heating system started in 2010 (primary heater) and was completed in 2014 (secondary heater). A detailed report about the design, preparation and installation of the PRACLAY experiment was published in 2013, upon conclusion of the installation phase of the experiment (EUR 13-129).

The heating system was switched on on 3 November 2014 to test all components of the experimental set-up, including the control systems of both the primary and secondary heating systems. After a successful test phase it was decided at the beginning of 2015 to continue heating. The target temperature of 80°C at the interface between the gallery lining and the clay was reached on 18 August 2015, marking the end of the start-up phase. Since that date, the temperature at the contact point between the lining and the clay has been maintained at 80°C.

PRACLAY ON-SURFACE experiments are studying different components of a disposal system and comprise laboratory tests to characterise these different components and their interaction. Many of the aspects that are studied on the surface are based on a specific disposal system design. No important on-surface experiments were performed in 2015.

1.2. PRACLAY IN-SITU: the Heater test

1.2.1. Test set-up and preparation of the switch-on of the Heater test

The different parts of the PRACLAY Seal & Heater experimental set-up are shown in Figure 2. The heating system is installed in a 30-metre-long section of the PRACLAY gallery. This section is backfilled with sand, closed from the accessible part of the PRACLAY gallery by a seal structure and saturated with water.

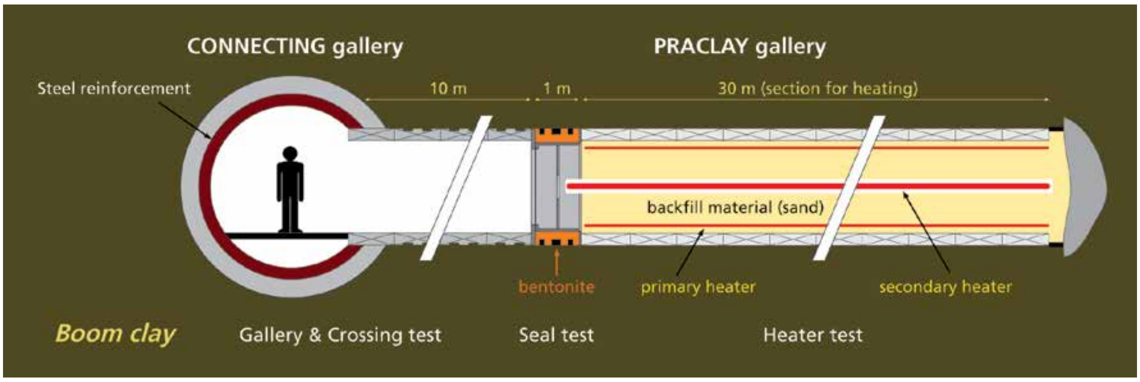


Figure 2 - Design of the PRACLAY experiment

HEATING SYSTEM

The **heating system** consists of a primary heater, attached to the gallery lining, and a secondary heater, which is placed in a central tube that rests on a support structure. Both of these are electrical heaters. Figure 3 shows the cables of the primary heater and the central tube for the secondary heater, before the gallery was closed and backfilled with sand.

Figure 3 - Cross-section of the central tube and view of the primary heating system

The **primary heater** was installed in the PRACLAY gallery in 2010. The gallery is divided into three zones (front, middle and end), each of which is subdivided into four sections (upper, lower, left, right) (Figure 4). Each section is equipped with two heater elements, ensuring 100% redundancy of the system.

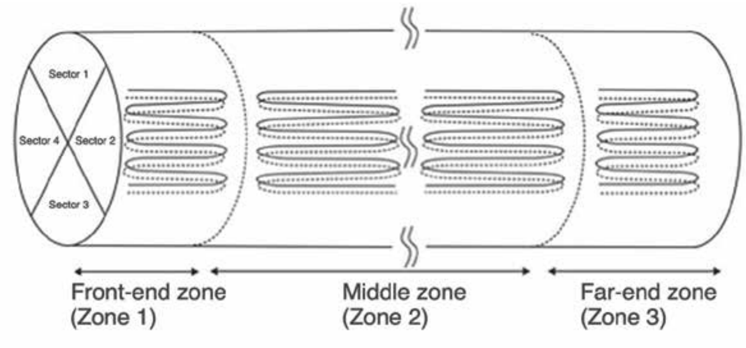


Figure 4 - The primary heating system is composed of three zones, each divided into four sections.

Installation of the **secondary heater** in the PRACLAY gallery began in 2012 and was completed in 2014. It consists of eight identical secondary heater assemblies that are inserted into the central tube. For four of the assemblies, replaceability is guaranteed at all times.

A control system regulating the heating power as a function of measured and target temperature is part of the heating system. The primary and secondary heating systems each have their own control system. Whereas the primary heater is regulated to provide a constant temperature during the steady heating phase (80°C at the interface between the gallery lining and the Boom Clay), the secondary heater will provide a constant power output, the value of which will be set at the time of the switch-over.

HYDRAULIC SEAL

The hydraulic seal consists of a stainless steel structure closing off the heated part of the gallery from the underground infrastructure, and an annular ring of bentonite (MX80) placed against the clay (Figure 5).

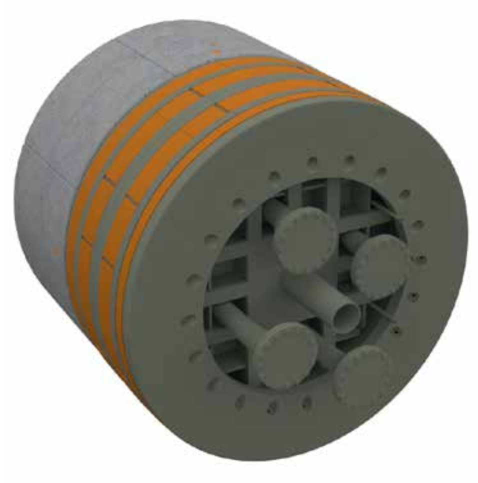


Figure 5 - 3D view of the seal with a central steel cylinder and an annular ring of bentonite (orange) against the clay

The hydraulic seal not only has to close off the PRACLAY gallery, it also has to hydraulically isolate the clay surrounding the heated part of the PRACLAY gallery, which can provide a preferential pathway for water towards the main gallery during the heating phase. Bentonite has a very low hydraulic conductivity and swells when it is hydrated. The swelling pressure exerted by the hydrated bentonite on the Boom Clay will lower the hydraulic conductivity of the Boom Clay around the seal, thus creating "undrained hydraulic boundary conditions" for the Heater test. The swelling behaviour of the bentonite ring in the seal is studied in the **Seal test**.

When designing the seal, two main criteria were defined. The maximum radial swelling pressure between the bentonite and the Boom Clay should be less than approx. 6.0 MPa (60 bar), so as not to damage the surrounding Boom Clay. The minimum swelling pressure before switch-on was set at 2.5 MPa (25 bar) to avoid creating negative effective stresses within and around the seal during the Heater test (the maximum pore water pressures in the gallery upstream of the seal and in the surrounding clay during the Heater test are estimated at 2.5 MPa by numerical prediction). The second criterion is that the hydraulic conductivity of the bentonite in saturated conditions should be lower than that of undisturbed Boom Clay (≈ 10^{-12} m/s).

To meet these specifications, the bentonite needs to be sufficiently hydrated. The bentonite seal has been hydrated since its installation in January 2010 by pore water coming from the Boom Clay and by water injected through filters placed on the outer surface (extrados) of the steel cylinder since April 2010. Different kinds of instruments were incorporated into the bentonite rings during installation to monitor the water injection rate as well as stress (swelling pressure) and pore water pressure in the bentonite and in the Boom Clay around the seal. The instruments are grouped into sections A, B and C (Figure 6).

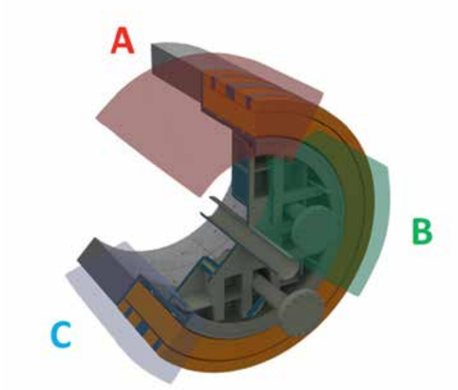


Figure 6 - Various instruments inside the bentonite, grouped into sections A, B and C

When the heating system was switched on on 3 November 2014 the radial pressures at the interface between the bentonite and the Boom Clay were around 3.3 MPa and thus higher than the required threshold value of 2.5 MPa (Figure 7). The pore water pressure in the PRACLAY backfill sand at that time had reached 1 MPa (10.0 bar) and no water leakage through the seal was observed. Hydraulic conductivity at the interface between the bentonite and the Boom Clay (at section C) was measured in September 2014 and the value obtained is similar to that of the undisturbed Boom Clay.

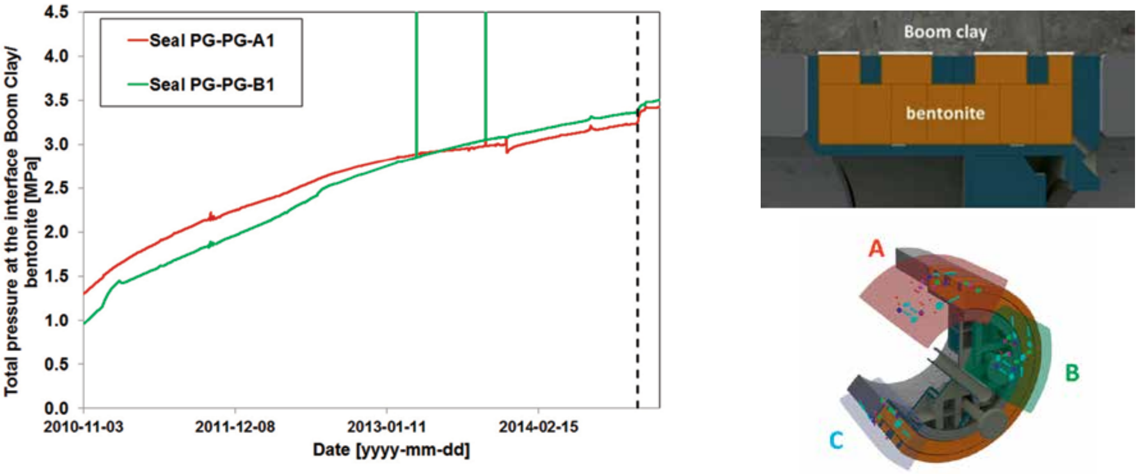


Figure 7 - Radial stresses measured at the interface between the bentonite and the Boom Clay sidewall (white line in insert), for sections A, B and C

BACKFILL SAND

The part of the PRACLAY gallery that is being heated is filled with sand (Mol sand M34) and saturated with water. The **water-saturated backfill** sand has to ensure efficient heat transfer from the heating elements to the surrounding clay and, together with the hydraulic seal, create homogeneous "undrained hydraulic boundary conditions" along the interface between the clay and the gallery lining. On 3 November 2014 the water pressure inside the gallery reached 1 MPa, and the PRACLAY gallery was estimated to be fully saturated.

MONITORING, INSTRUMENTATION AND DATA MANAGEMENT

The PRACLAY seal and Heater tests are extensively instrumented to control the heating process and for the purpose of the experimental follow-up. To ensure convenient access to the sensor data, a user interface has been built into the database. This interface has several functionalities: a “dashboard” to give a quick overview of selected variables, the generation of a daily Safety Report, and an extensive graphical module to generate both time evolution and spatial profiles of measured variables.

INSULATION DOOR
On 2 March 2015, about four months after heater switch-on, an insulation door was installed in front of the seal (at a distance of about 1.5 m from the seal) to limit the cooling of the steel cylinder that closes off the heated section of the gallery and to limit in that way the end effect of the Heater test. It also provides an operational safety barrier. The door consists of an aluminium structure that is bolted against the lining, supporting a window to allow visual inspection of the seal.

MANAGEMENT GUIDE
A management guide with a set of procedures was established in close collaboration with ONDRAF/NIRAS in 2014 to specify the follow-up of the test, define the action plan in case of unexpected events and clearly outline and assign the different responsibilities with respect to safety, scientific objectives and technical aspects, such as maintenance and checks. Based on the experience of more than one year of follow-up of the experiment, the management guide was updated during 2015.

NUMERICAL MODELLING OF THE EXPECTED AND ALTERED EVOLUTION SCENARIOS
To increase the reliability of the numerical modelling of the expected evolution of the Heater test, significant effort was devoted to understanding and then numerically reproducing past in-situ measurements. This exercise resulted in a set of reliable parameters that were used in numerical modelling:

- To support in different ways the design and control of the various components (e.g. primary heater, secondary heater and thermal insulation door) of the PRACLAY Heater test.
- To obtain a possible range of experimental evolutions based on the extensive parametric sensitivity analysis and by considering altered evolution scenarios (i.e. deviating from the expected evolution).
- To provide clear instructions in the procedures for the follow-up and/or management of the Heater test in the event of failure of the primary heater or any pore water pressure adjustments required in the PRACLAY gallery, and in the event of seal or lining instability.
- To check the influence of potential recurring electrical power “blackouts” on the PRACLAY Heater test.

In 2015 the numerical modelling work consisted mainly in supporting the decision on the heating plan during the start-up phase, and determining the primary heater power for the manual input in the heater control system during the stationary phase.

The predictive modelling of the PRACLAY Heater test that was performed before switching on the heater system, the so-called "blind predictions", was continuously updated by considering the actual heater power. The updated modelling results are used for the comparison with the actual measurements during the Heater test.

The scientific report "Predictive Reference Modelling of the PRACLAY experiment" was updated during 2015 based on the actual heater power applied after switch-on. It provides a comprehensive overview of the test set-up (geometry and test component materials), test phases, material parameters, and initial and boundary conditions used in the numerical modelling of the reference numerical model for the PRACLAY Seal & Heater tests. This report also presents the main modelling results and is an important reference document for future interpretation of the PRACLAY Heater test measurements and observations.

SWITCH-ON OF THE HEATING SYSTEM
As a final test, it was decided to switch on the primary heating system for several days or weeks to check whether it would perform as expected over a longer period of time. This test phase started on 3 November 2014 and ran until early 2015. All elements functioned as required or expected during this test, and a decision was made to continue the heating phase without interruption.

The main results from the Heater test in 2015 are presented in the next section.

1.2.2. THE PRACLAY HEATER TEST – 2015

EVOLUTION OF THE TEST-CONTROL PARAMETERS
Control of the Heater test is mainly based on the temperature at the interface between the concrete lining and the Boom Clay.

In order to attain the target temperature, the power in the three zones of the primary heating system was increased stepwise, as illustrated in Figure 8. When the target temperature of 80°C was reached at the extrados (outer surface) of the lining (August 2015), the power was decreased in Zones 1 and 2. The beginning of the power decrease indicated the start of the "stationary" phase with a constant temperature of 80°C on the contact with the clay, which will last for 10 years. Intensive modelling has been performed in order to control the experiment during the stationary phase. This predictive modelling work showed that to have a uniform temperature profile in the part of the PRACLAY gallery subjected to heating, the power in Zone 3 should be decreased with a delay of a couple of months.

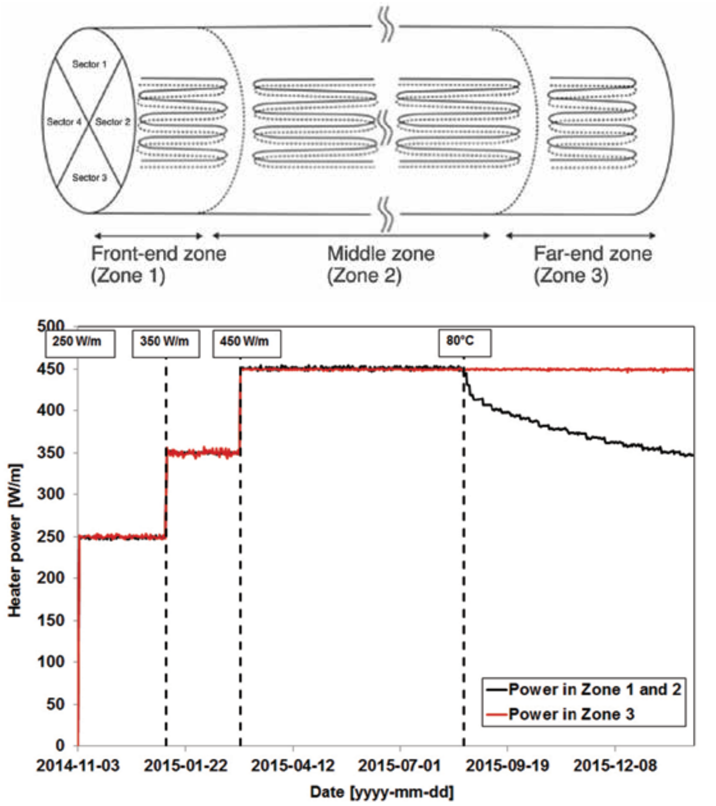


Figure 8 - Evolution of the power in watts per metre (W/m) in the three zones. The power in Zones 1 and 2 was decreased when 80°C was reached.

The temperature was monitored along the extrados of the concrete lining, i.e. at the interface with the Boom Clay, by means of thermocouples that are embedded in the concrete lining. It was observed that the temperature profiles along the extrados of the gallery lining presented a rather uniform temperature field, though with some heterogeneities, as shown in Figure 9. This meant that the target temperature of 80°C might be reached at some specific locations, while the rest might be slightly below or above this target temperature. As a consequence, an average temperature or temperature indicator was defined using the thermocouple sensors at the extrados of lining rings R37, R50 and R55, which are located around the middle of the heated part of the experiment (Figure 10). This average temperature was used to control the experiment with respect to the 80°C target. From this average temperature evolution, it was observed that 80°C was reached in mid-August 2015, which marked the beginning of the "stationary" phase. At that time, the experiment was being controlled manually, changing the power in Zones 1 and 2 according to a schedule defined by the predictive modelling.

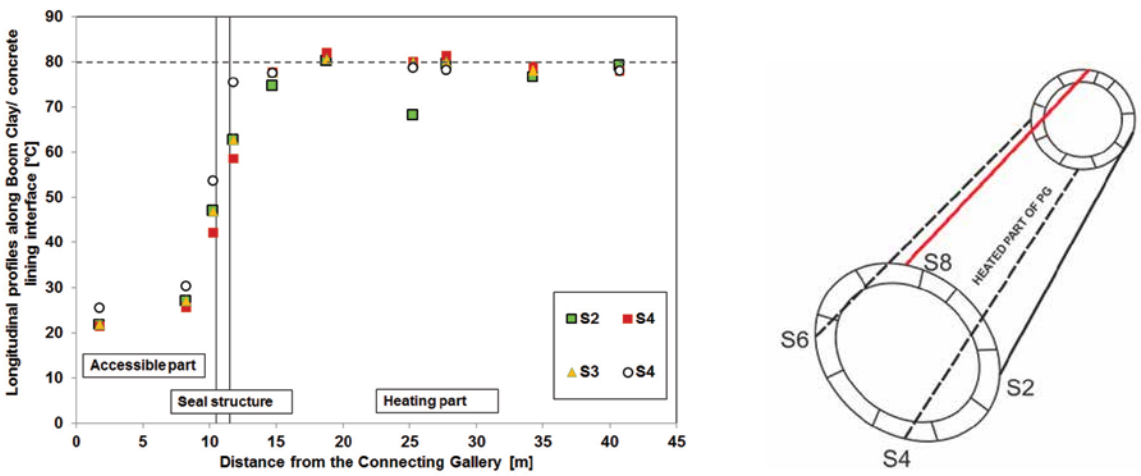


Figure 9 - Longitudinal profiles of the temperature along the extrados of the PRACLAY gallery (end 2015)

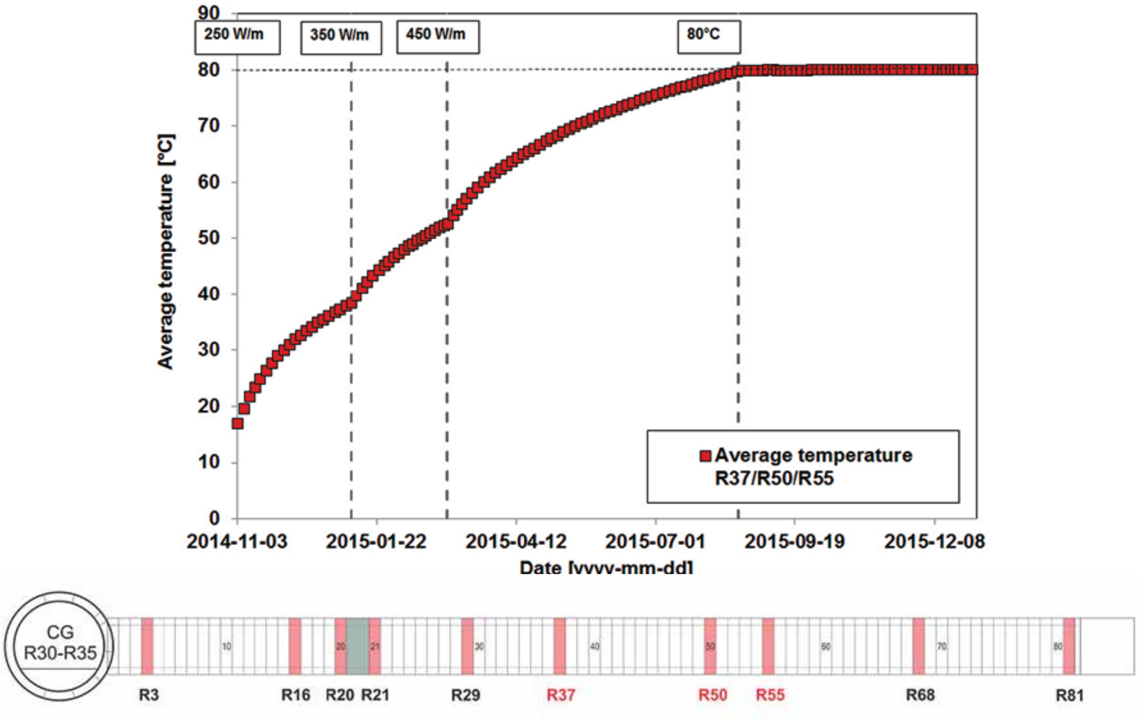


Figure 10 - Average temperature evolution measured using the extrados' sensors in R37, R50 and R55

Due to the heating process and the difference in the thermal dilation coefficient between the solid and the fluid part of a water saturated sand, an excess pore water pressure is induced. This rise in pore water pressure in the backfilled part of the PRACLAY gallery is shown in Figure 11. During the start-up phase of the Heater test, the pore water pressure rose quickly at the beginning of each heating step, followed by a more gradual increase, due to a progressive dissipation of water pressure in the surrounding clay. After the target temperature was reached in August 2015, the pore water pressure fell briefly then levelled off.

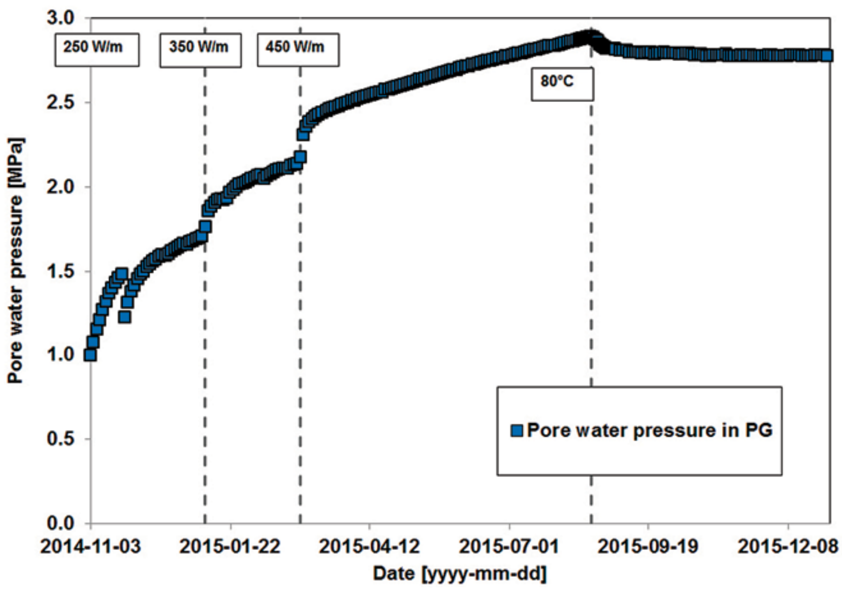


Figure 11 - Pore water pressure evolution in the backfilled part of the PRACLAY gallery

BOOM CLAY RESPONSES

The evolution of the temperature and pore water pressure inside the Boom Clay was monitored using instrumented boreholes in different directions from the PRACLAY gallery and from the Connecting gallery (Figure 12).

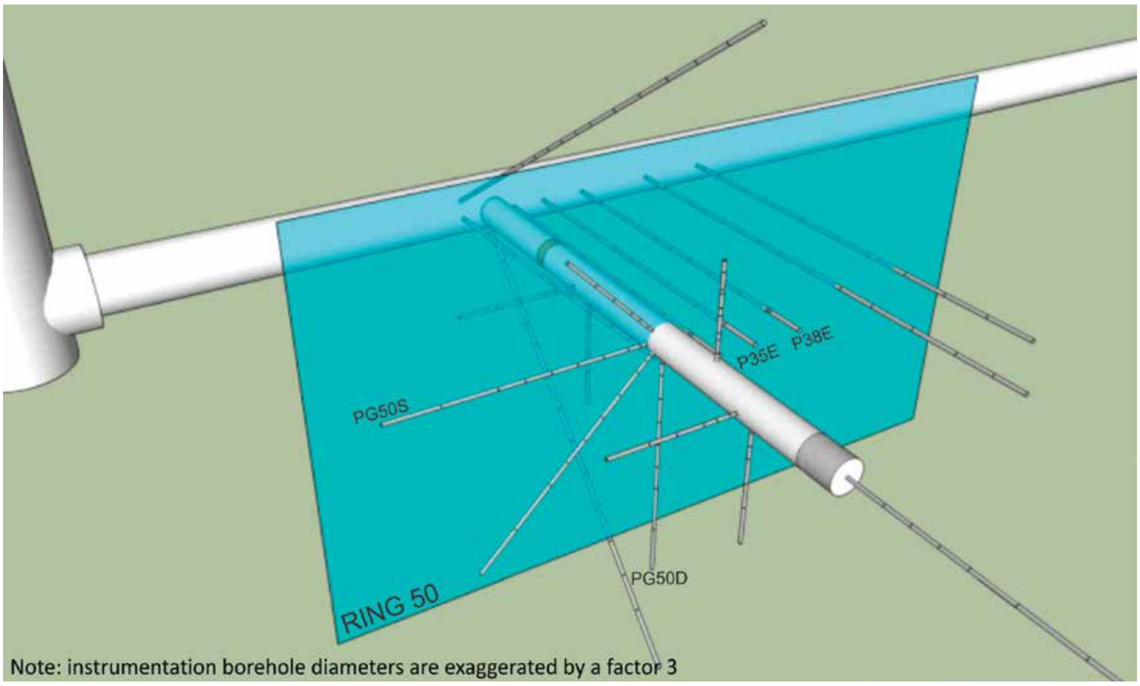


Figure 12 - 3D view of the instrumented boreholes from the PRACLAY gallery and Connecting gallery

The temperature profiles from the downward borehole PG50D in the middle of the heated section are shown in Figure 13(a). A temperature of approximately 75°C was reached close to the concrete lining. The heated area extended to 10 m around the PRACLAY gallery. The increase in temperature induces excess pore water pressure in the Boom Clay due to the differential thermal dilation coefficient between the solid (skeleton) and the liquid phase (mainly water) in the clay. Close to the lining, the initial pore water pressure increased as foreseen from 1 MPa to a value close to 3 MPa at the end of the start-up phase (August 2015). This is clearly shown in the pore water pressure profiles for PG50D (Figure 13(b)).

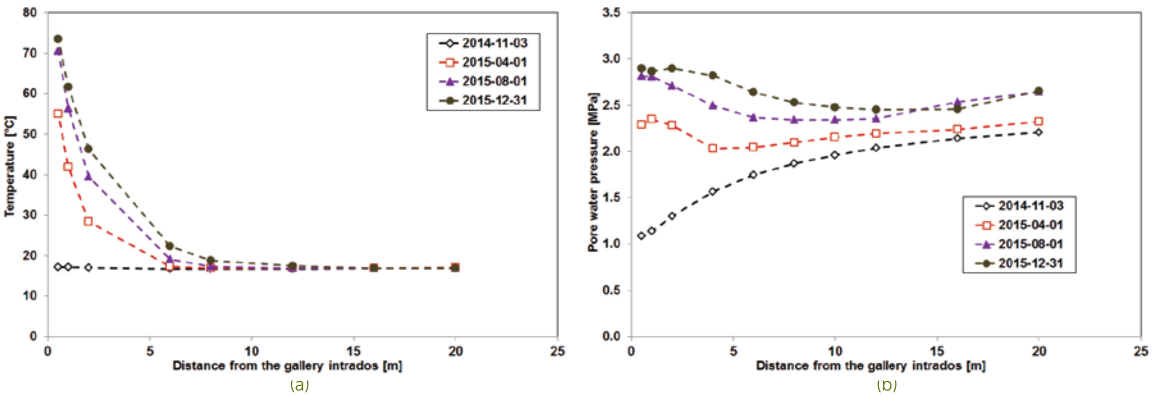


Figure 13 - Temperature and pore water pressure profiles along borehole PG50D

Figure 14 shows the temperature and pore water pressure profiles from borehole PG50S, a horizontal borehole in the middle of the heated section (Figure 12). A temperature of 52°C close to the lining was observed. Moreover, the extension of the thermally affected zone was estimated to be 15 m. The pore water pressure close to the lining reached almost 3 MPa at the end of the start-up phase. Comparing the temperature profiles between PG50D and PG50S, a significant difference can be seen concerning the extension of the thermally affected zone and also the magnitude of the temperature close to the lining.

These differences are assumed to be a consequence of the fact that the borehole was left open. As a result, water or a sand-water mixture can move freely inside the casing with the possibility of creating a convection cell in the horizontal borehole which enhances the heat transport.

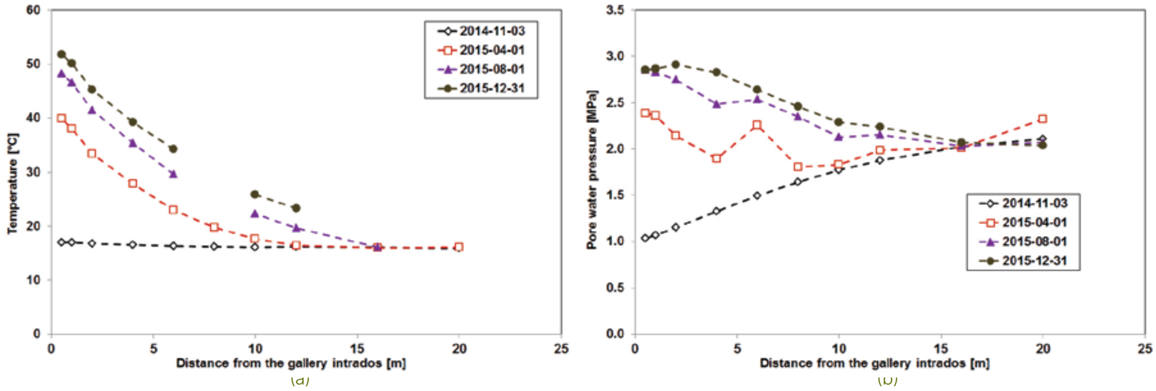


Figure 14 - Temperature and pore water pressure profiles along PG50S

From the boreholes drilled from the Connecting gallery, an increase in temperature and pore water pressure was also observed up to a certain distance from the PRACLAY gallery. Figure 15 shows the temperature and pore water pressure profiles for P35E, located approximately 0.75 m from the extrados of the gallery lining. The pore water pressure profile is almost uniform along the gallery, while the temperature profile shows a slight temperature gradient from the seal to the end part of the PRACLAY gallery.

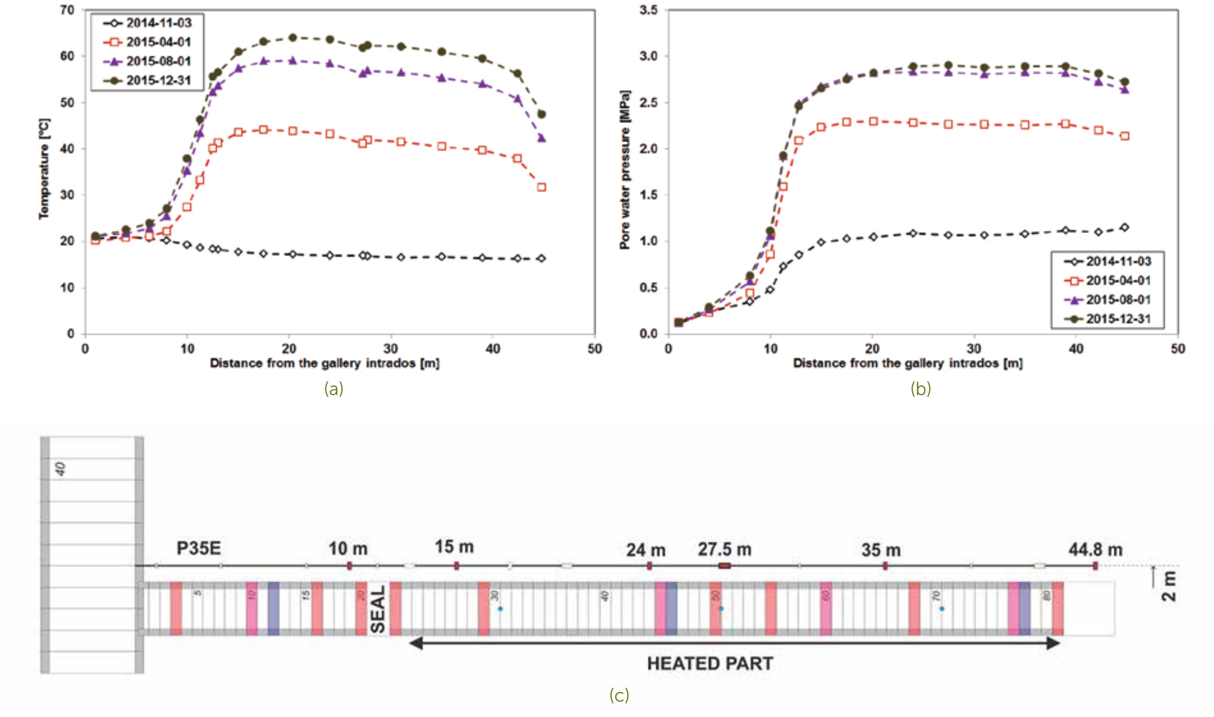


Figure 15 - Temperature and pore water pressure profiles in P35E

The temperature and pore water pressure at a distance of 5 m from the axis of the PRACLAY gallery can be seen in Figure 16. An increase in temperature and pore water pressure has been observed since the beginning of the start-up phase. The pressure in this borehole reached almost 2.8 MPa in the deepest part of the boreholes, which is also closest to the PRACLAY gallery.

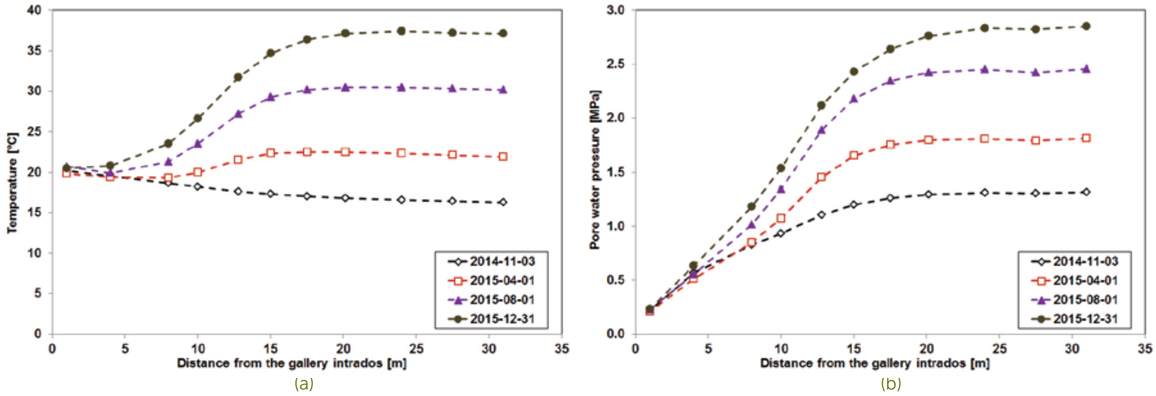


Figure 16 - Temperature and pore water pressure profiles in P38E

EVOLUTION OF THE HYDRAULIC SEAL

The hydration of the bentonite and total pressure resulting from the pressure of the Boom Clay, on the one hand, and the swelling of the bentonite, on the other, were continuously monitored during the start-up phase and the beginning of the stationary phase. Figure 17, for example, shows an increase in the pore water pressure at the Boom Clay/bentonite interface with the different heating steps. The monitored pore water pressure in the bentonite ring evolved in the same way for the three sections A, B and C. One of the main purposes of the seal structure is to provide a hydraulic cut-off between the heated and the non-heated part of the experiment. The effect can be observed in the different evolution of the pore water pressure in sensors Seal-PP-A1 and Seal-PP-A3 in section A. The first is located close to the heated part, while the second is close to the accessible, non-heated part of the PRACLAY gallery. A significant difference of about 1 MPa can be observed between both sensors, indicating that the seal structure is functioning well.

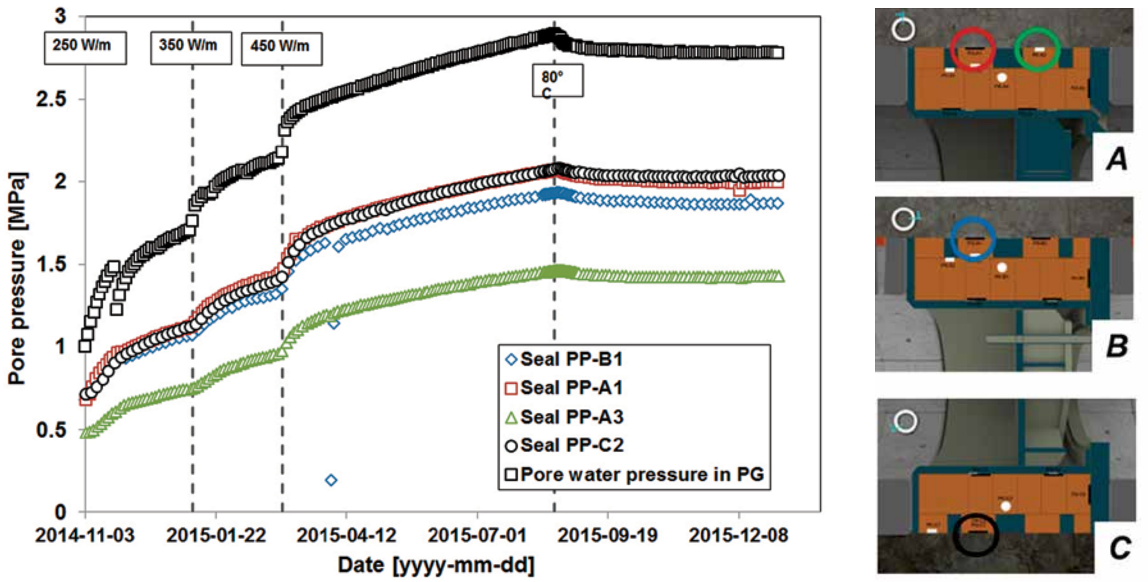


Figure 17 - Evolution of the pore water pressure at the Boom Clay/bentonite interface

In order to highlight the effect of the seal, Figure 18 shows the evolution of the pore water pressure at the Boom Clay/bentonite interface for different positions in section A, and at the Boom Clay/concrete lining interface close to section A. It is remarkable that between the non-heated and heated parts of the gallery, a big difference of pore water pressure of almost 2 MPa occurs over a distance of 1.5 m. This significant gradient is clear proof of the good hydraulic cut-off created by the seal.

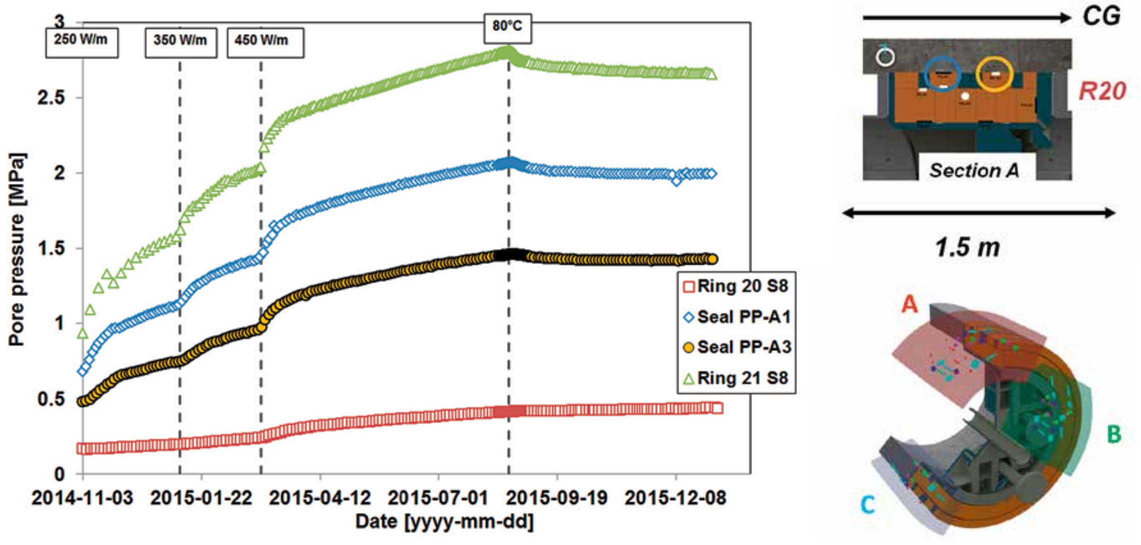


Figure 18 - Pore water pressure evolution at the Boom Clay/concrete lining interface and Boom Clay/bentonite interface

The total pressure at the Boom Clay/bentonite interface is monitored and can be seen in Figure 19. A slow increase is observed during the heating phase. This increase seems to be steady. A variation in total pressure of less than 1 MPa has been observed since heating was first applied. The small increase in total pressure at the beginning of the second heating step is most probably linked to the installation of the thermal insulation door in front of the seal, which temporarily caused a rapid increase in temperature. Indeed, the purpose of the door is to limit the heat loss in the accessible part of the PRACLAY gallery. As a consequence, the temperature of the seal increased and the total pressure at the Boom Clay/bentonite interface rose slightly.

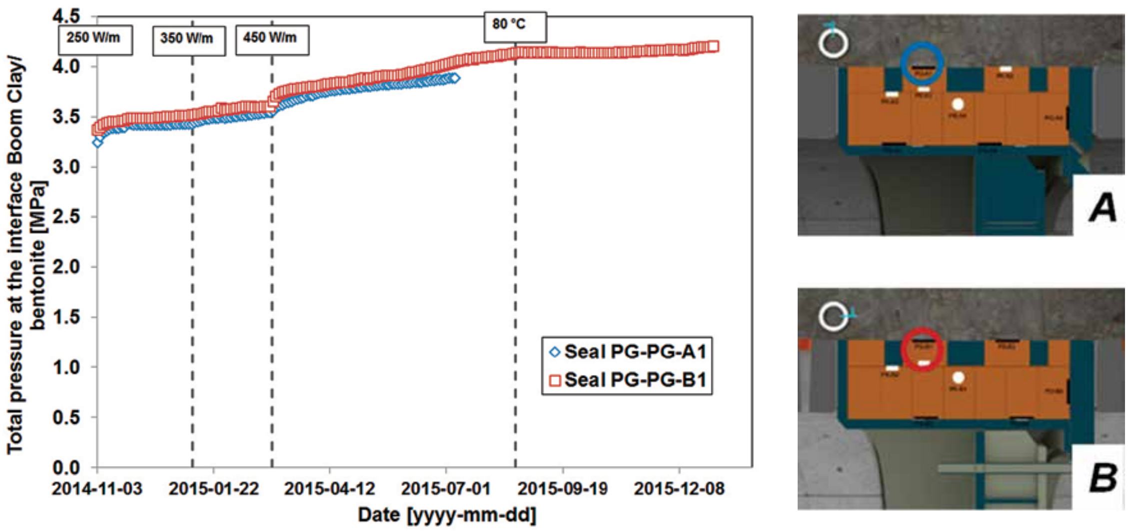
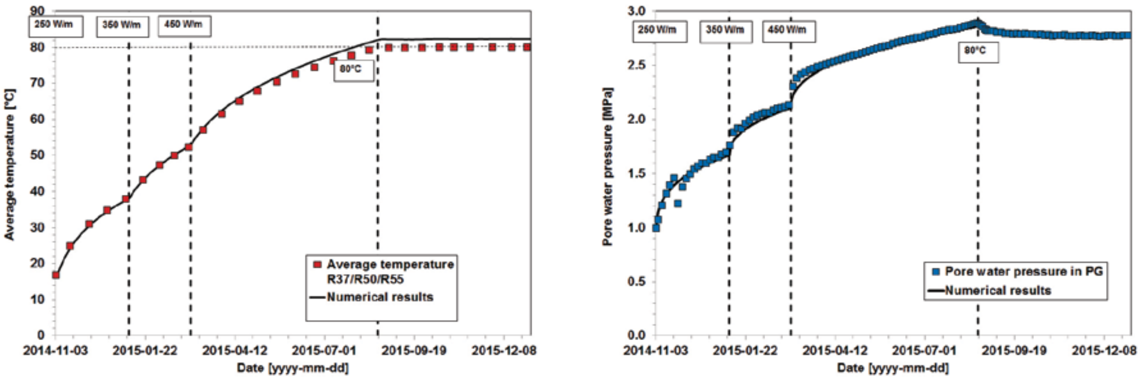


Figure 19 - Total pressure at the Boom Clay/bentonite interface in sections A and B

COMPARISON BETWEEN MEASUREMENTS AND BLIND PREDICTIONS

As already mentioned, intensive predictive modelling was performed before the start of the experiment and during the start-up phase. The aim of this work was, firstly, to provide input for the control of the experiment, mainly by managing the power input. A second very important aim was to enable comparison between the experimental measurements and the so-called "blind predictions" from the modelling. Regarding temperature, it can be stated that the modelling predictions correspond well with the actual (i.e. measured) evolution of the temperature inside all the components of the experiment. The pore water pressure evolution can also be modelled, but with a different level of agreement depending on the distance from the PRACLAY gallery. The closer to the gallery, the better the agreement. Figure 20 shows the evolution of the temperature and pore water pressure in the backfilled part of the PRACLAY gallery compared with the modelling results. Good agreement can be observed for both parameters.



(a) (b)

Figure 20 - Temperature and pore water pressure evolution, with the numerical results added for comparison purposes

2015 was mainly dedicated to controlling the experimental set-up. During 2016, a report will be published with a more detailed comparison between the blind predictions and the actual observations in the clay that surrounds the PRACLAY gallery.

2. Supporting studies

2.1. Stability of the Connecting gallery

The convergence of and the strains in the lining of the Connecting gallery have been monitored since the construction of the gallery in 2002.

The measurements indicate that convergence (diagonal reduction) can reach a value of around 10 mm for different diagonals of the rings, as can be seen in Figure 21. An ovalisation (lying egg shape) of the gallery is clearly demonstrated. Since the end of 2014 the measurements have shown the first signs of stabilisation.

The strain inside the concrete segment is continuously monitored and the frequency of measurement has been increased in order to observe the possibility of additional strain with the start-up of the Heater test. The results are shown in Figure 22. During 2015 it was observed that the Heater test did not influence the evolution of the strain inside the concrete segment. The strain evolution shows a clear tendency to be more and more stable with time.

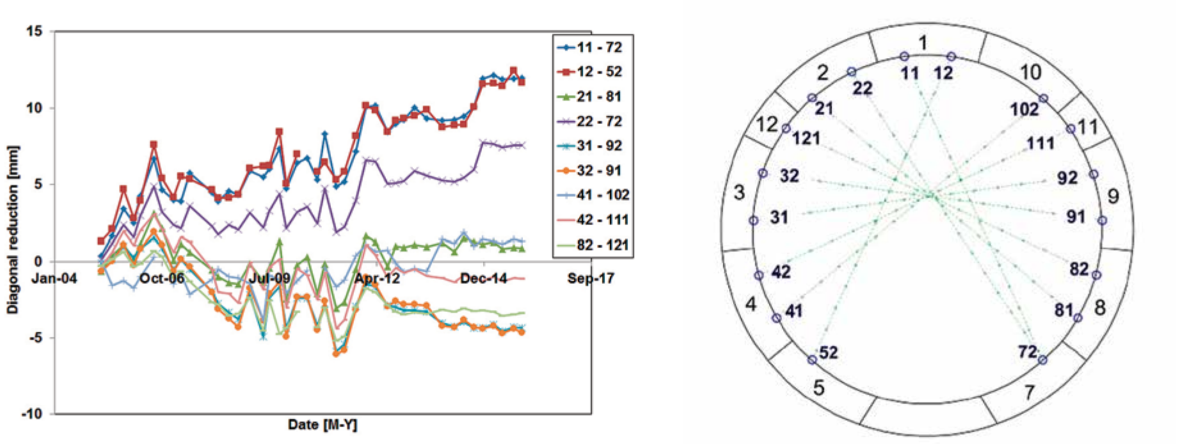


Figure 21 - Diagonal reduction measurement of Ring 50 in the Connecting gallery (Positive values for reduction, negative for elongation).

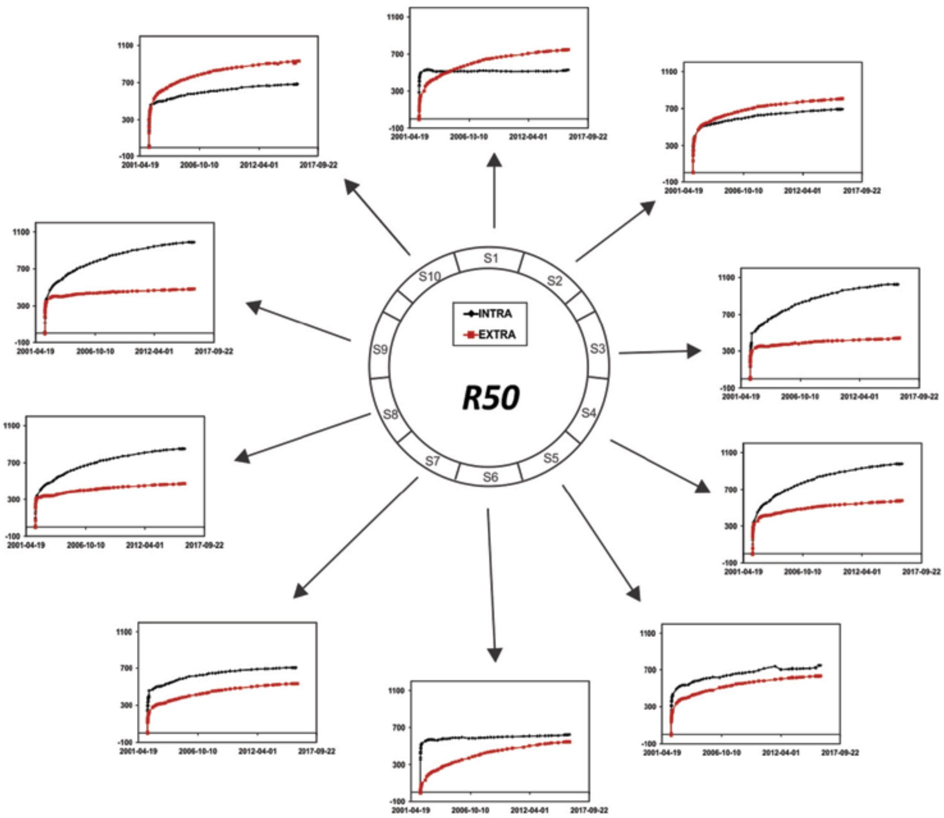


Figure 22 - Average strain measured in the concrete segment of Ring 50 in the Connecting gallery

The strains observed in the lining are used, for example, for the back-analysis of the stress inside the concrete lining. Initial analysis of the stress based on the strains observed began in 2013, carried out by TRACTEBEL Engineering, and the results showed that the stress state is probably higher than expected. For this reason, a new study was organised in collaboration with TRACTEBEL Engineering, SCK•CEN and EURIDICE. This study continued in 2015. The goal is to accurately determine the correct stress inside the concrete segments, and the pressure exerted against the lining.

TRACTEBEL performed a back-analysis calculation to determine the evolution of the anisotropic pressure acting on the concrete lining. The results show that the vertical pressure (pressure at the top (or crown)) is slightly lower than the horizontal (pressure at the side (or wall)) at initial phase just after the installation of the lining, but over time, the former one tends to be higher than the later.

It was also shown that the stresses obtained by back-analysis based on the strain measurements are higher than the "designed" values. This can be explained by the fact that the design calculations considered the soil around the gallery behaving elastically, while a visco-elasto-plastic model is more representative. Nevertheless, the estimated stresses in the concrete lining are far from the ultimate strength of the concrete. A summary of the study carried out by TRACTEBEL in collaboration with M. Scibetta (Nuclear Material Science institute from the SCK•CEN) will be prepared in 2016.

2.2. Permeability tests around the PRACLAY gallery and Connecting gallery

In order to study the excavation induced permeability variation and the self-sealing capacity of Boom Clay, a series of permeability tests were performed around the HADES. During 2015 EIG EURIDICE compiled a summary of all the in-situ permeability tests performed around the Connecting gallery and the PRACLAY gallery from 2004 to 2015. The permeability tests around the Connecting gallery were conducted to study the permeability evolution of the Boom Clay in relation to the excavation, consolidation and creep of the clay. Around the PRACLAY gallery, the impact on the Boom Clay permeability of excavation, consolidation, seal installation and pressurisation of the backfilled part of the gallery was studied. An initial value of the Boom Clay permeability before starting the PRACLAY Heater test was obtained.

One year after the switch-on of the heating system, thermal disturbance in the Boom Clay has extended more than 10 m around the PRACLAY gallery, and the maximum temperature in the Boom Clay has reached 80°C. In 2016, some new permeability tests are planned to check the combined effects of a temperature increase and a decrease in the effective stress (due to an increase in pore water pressure) on the Boom Clay permeability and some new permeability tests will be performed on the filters before affected by the Praclay heater test.

Permeability evolution of the Boom Clay is important for the interpretation of the PRACLAY Heater test and has to be taken into account in the numerical modelling.

2.3. Micro-seismic monitoring programme

A detailed analysis of the measurement data obtained with the micro-seismic installation around PRACLAY has been performed to assess the quality of the measurement data, the performance of the installation, and to provide recommendations for its future use. The work included developing software tools in LabView to analyse existing micro-seismic records and assessing the suitability of the data to determine strength and stiffness parameters for the Boom Clay.

The micro seismic monitoring system was developed and delivered by GMuG mbH (a company based in Bad Neuheim, Germany). It was installed in HADES between 2006 and 2008 with the aim of monitoring the excavation of the PRACLAY gallery and later following up the PRACLAY Heater test. The set-up starts at the Connecting gallery and extends to a distance of approximately 15 m along the PRACLAY gallery. It consists of two parts: (1) an array of transmitters and receivers installed almost parallel to the PRACLAY gallery in three boreholes drilled from the Connecting gallery, and (2) sensors installed at the interface between the PRACLAY gallery's lining and the Boom Clay. The system has continued to monitor the daily micro seismic activity around the PRACLAY gallery almost uninterruptedly since its first installation phase in 2006, providing valuable data to assess the seismic parameters of the Boom Clay. It measures the micro seismic activity generated by acoustic emission (AE) as well as by triggered events. Measurements are taken each day using different transmitter and receiver combinations. To avoid disturbances caused by work in the URL during the day, these measurements are performed at night. As such, AE monitoring starts at 20:00 and goes on until midnight. The micro-seismic triggered events run between midnight and 05:00. The system is controlled remotely via an internet connection from GMuG in Germany. The data is recorded and stored daily both at GMuG and at EURIDICE.

GMuG was under contract to EURIDICE until the end of 2014 for the maintenance and follow-up of the system, reporting on a quarterly basis as part of its contractual commitment. The analyses provided in the GMuG quarterly reports are based on measurements performed using triggered events only. They do not include the data for the AE events. This is because the seismic activity in the Boom Clay after working hours, when the AE measurements are active, is so low that the AE signals consist mainly of noise, which has no practical use for the analysis of P (compressive) and S (shear) waveforms. This could change with the progress of the PRACLAY Heater test and should be examined in the future to see if heating generates measurable AE events.

The quarterly reports provided by GMuG contain only a limited analysis of the waveforms. As a result, the reports do not contribute sufficiently to allow a follow up of the evolution of the seismic parameters in the Boom Clay, as originally expected. Because of this, an internal investigation was launched to perform a more thorough post-signal analysis of the recorded waveforms. The main objective of this study was to determine if the recorded waveforms were of good quality and if they contained sufficient information to allow the extraction of both compressive (P) as well as shear (S) waves. The results of this study will be available in the first half of 2016.

2.4. PhD research

A specific thermo-hydro-mechanical-chemical characterisation programme on Boom Clay has been run in parallel with the PRACLAY experiments, in collaboration with different universities and laboratories through several PhD research projects. EIG EURIDICE is involved in the definition and supervision of these projects.

In the context of the ONDRAF/NIRAS geological disposal research programme to examine other potential host formations for high-level waste disposal, and based on the outcomes of several PhD research programmes on the thermo-hydro-mechanical-chemical behaviour of Ypresian clays, a specific research project was initiated in 2014 and is being co-supervised by EIG EURIDICE to further study the anisotropy features of the thermal conductivity of Ypresian clays.

CIMNE (Universitat Politècnica de Catalunya, Barcelona (UPC), Spain)

A. "Laboratory investigation of gas transport processes in Boom Clay"
Financed directly by ONDRAF/NIRAS, PhD research on the "Laboratory investigation of gas transport processes in Boom Clay" started at the end of 2012. Together with ONDRAF/NIRAS, EIG EURIDICE is involved in supervising and following up the project.

This research aims to study the gas transport mechanisms and breakthrough processes in Boom Clay through an exhaustive laboratory experimental programme. Indeed, one of the important issues in the long-term performance of a geological repository concerns the generation and migration of gases that can be produced as a result of the anaerobic corrosion of metal canisters, radiolysis, microbial degradation of organic waste, etc.

Special cells have been developed to perform the gas injection tests under well-controlled pneumatic, hydraulic, mechanical and thermal boundary conditions.

The specific objectives of the project are:
- To investigate volume change behaviour during gas tests and its impact on gas permeability.
- To check the role played by the orientations of the bedding planes of rock using triaxial and oedometer cells, applying different boundary conditions.
- To estimate the influence of the gas injection rate.
- To study microstructural changes during the gas injection and the role played by the opening of fissures.

The experimental work continued in 2015. Complementary tests were performed to supplement the available information. Tests that were difficult to understand were repeated to be more confident of the results. A serious effort was made to analyse the experimental results obtained, focusing on the volume change behaviour during gas injection and dissipation and on the microstructural changes after the gas migration process.

To gain a better understanding of the gas transport mechanisms, numerical simulations of the gas tests were performed. The experimental results were simulated using a fully coupled hydro-mechanical finite element code, which incorporates an embedded fracture permeability model to account for the correct simulation of the gas flow along preferential pathways. Clay intrinsic permeability and its retention curve depend on strains through fracture aperture changes. Numerical analysis accounted for not only the correct simulation of the recorded upstream pressures and outflow volumes and pressures, but also the volume change behaviour of the gas tests. The experimental and numerical information offers good insight into the mechanisms of gas transport in deep clay formations and highlights the role played by the deformational response on the air transport properties of the sedimentary formation of the Boom Clay.

The annual meeting between ONDRAF/NIRAS, EIG EURIDICE and CIMNE/UPC was held in Brussels on 16 January 2015. The yearly progress report was delivered to ONDRAF/NIRAS and EIG EURIDICE in September 2015.

The progress of the project in 2015 led to several publications (see Scientific output).

B. Tests on the thermal anisotropy of Ypresian clays

A specific project agreement between ONDRAF/NIRAS, EIG EURIDICE and CIMNE/UPC was drawn up for the period July 2014 - October 2015 to investigate in depth the thermal conductivity of Ypresian clays.

Characterisation of the thermal properties of the host rock is necessary both to determine the evolution of the near-field temperature in the host formation around disposal galleries, as these properties may affect the design and layout of the repository, and to assess the perturbations that the system will undergo as a result of temperature changes over hundreds to thousands years after waste emplacement.

The experimental programme focuses on studying the anisotropy features of the thermal conductivity of Ypresian clays. However, an effort is also being made to analyse the influence of the state of the samples tested on the thermal conductivity measured (opening of the fissures/bedding planes and desaturation due to the sampling procedure, for example).

A new experimental set-up with heater and heat flux measurement on top and bottom caps has been designed, constructed and used, in which the thermal conductivity on two different orientations (heat flow parallel and perpendicular to bedding planes) has been explored. Since the set-up uses a low-confining stress, a careful pre-conditioning protocol has been developed and followed on the retrieved samples before directly measuring their thermal conductivity. The aim of these pre-conditioning tests is to ensure a very high degree of saturation under in-situ stress conditions and the consequent closure of fissures/gaps along bedding planes before the thermal tests are performed.

The experimental results obtained in this study have been compared with different reported values on the same sedimentary clay formation using direct and indirect determinations.

Higher values than those reported in previous reports have been directly measured with the new experimental set-up, as a consequence of the strict loading-unloading pre-conditioning protocol followed on the samples and in line with the mineralogical components (elevated quartz content) of the formation at the depth of interest (samples tested are Ypresian clays retrieved at a depth of around 370 m). Clear anisotropic features have been detected, with higher thermal conductivity when heat flow was parallel to bedding planes (λ // = 2.12 Wm-1T-1) and with a thermal anisotropy ratio λ///λλ = 1.16. This higher thermal conductivity was also consistent with the value reported when using back-analysis methodology in the constant volume heating cell (Lima et al. 2013 and Romero et al. 2013). The results also highlighted the need to follow strict protocols to pre-condition argillaceous materials with bedding planes to restore a high saturation and to minimise the effects of the opening of fissures/gaps during thermal conductivity tests.

Two progress meetings were held in 2015 and the final report will be delivered early in 2016.

The outcome of the project led to several publications (see Scientific output).

IRSM (Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, China)

The project "Research on long-term coupled thermo-hydro-mechanical (THM) behaviour of the Boom Clay" aims to investigate the effect of temperature on the creep and self-sealing capacity of the Boom Clay and to gain knowledge and information for simulating the PRACLAY Heater test. This project started in late 2011 and was concluded at the end of 2015.

The research project comprised three parts:

A. Laboratory tests
B. Constitutive law development, taking into account long-term behaviour and thermo-hydro-mechanical coupling, including damage and self-sealing processes.
C. Back-analysis of long-term in-situ measurements and prediction of the PRACLAY experiment.

An exhaustive experimental programme was established with the following main objectives:

- To perform a complete set of short-term THM tests under well-controlled boundary conditions and following a well-established protocol. The purpose of this testing is twofold. Firstly, to obtain a complete set of data for a thorough analysis of the short-term THM behaviour of the Boom Clay and secondly, to double-check some findings from previous studies.
- To perform a set of long-term THM tests under different loading conditions (confined and deviatoric stresses) and temperatures to investigate, in particular, the temperature effect on the creep behaviour of the Boom Clay.

During 2015 continual efforts were devoted to the laboratory tests. Meanwhile, the test results obtained were thoroughly analysed (interpreted). Concerning the short-term behaviour, a first set of relations governing the temperature effect on the shearing strength (cohesion and friction angle), on the stiffness (under different load cases), etc. was obtained. Moreover, thanks to the triaxial tests with loading/unloading cycles at different deformation levels and under different temperatures, a set of relations describing the stiffness evolution with strain under different loads and temperatures was also identified. Finally, some preliminary insight (quantitative and qualitative) into the temperature effect on the creep rate under different loads was gained with the long-term creep test results obtained. The temperature effect on the threshold (deviatoric stress) was also investigated. Additional tests, combined with further investigation of the in-situ stress state (K0 value), are, however, needed to get a clear picture of this aspect. The test results provided good data for the further development of THM constitutive laws for the Boom Clay.

In order to better understand the mechanism of the temperature effect on the observed THM behaviour of the Boom Clay, the microstructure variation of the Boom Clay was studied by performing SEM (scanning electron microscope) and NMR (nuclear magnetic resonance) analyses before and after different THM tests.

In the course of 2015 a thermo- elasto-plastic-damage constitutive law was proposed on the basis of the elasto-plastic-damage constitutive law already developed. The related parameters were determined by back-analysis of the laboratory test results obtained. Finally, this constitutive law was extended by considering the creep effect and, consequently, a thermo-elasto-visco-plastic-damage constitutive law was proposed and implemented in the finite element code ABAQUS. The creep-related parameters were determined by simulations of the creep tests. Numerical results of this constitutive law are quite encouraging. However, additional laboratory tests under more stress paths are still needed to further calibrate the total set of parameters of the model, which will eventually be validated by long-term in-situ measurements. This constitutive law was applied to the prediction of the PRACLAY Heater test through a 3D model.

The progress of the project in 2015 led to several publications (see Scientific output).

CERMES (Centre d'Enseignement et de Recherche en Mécanique des Sols, France), ENPC

The research activities at CERMES involved two programmes:

- Investigation of the anisotropic behaviour of Boom Clay (PhD project 2011-2014)
- Modelling the hydro-mechanical behaviour of Boom Clay in the context of HLW and bituminised waste geological disposal using the bounding surface concept (2½-year post-doctoral project)

INVESTIGATION OF THE ANISOTROPIC BEHAVIOUR OF BOOM CLAY

A PhD research project entitled "Investigation of anisotropic behaviour of Boom Clay" started at CERMES at the end of 2011 and comprised three parts:

1. Literature review
2. Experimental study
    - anisotropic hydraulic conductivity determination
    - anisotropic thermal conductivity determination
    - K0 determination (ratio of effective stress to vertical stress)
    - mechanical anisotropy in triaxial cells equipped with bender elements and/or ultrasonic sensors
    - microstructure investigation: initial state and its evolution under different loading paths
3. Constitutive modelling

This project was concluded at the end of 2014 and the PhD thesis based on it was successfully defended in February 2015.

NUMERICAL ANALYSIS OF HLW AND BITUMINISED WASTE DISPOSAL IN CLAY FORMATIONS

This post-doctoral project was undertaken in collaboration with the University of Liège and was concluded at the end of August 2015.

The main objectives were to apply and further develop two-surface plasticity models, namely the ACC-2 model, developed as part of the PhD research conducted by Hong (2013), which can accurately describe some important hydro-mechanical features of Boom Clay evidenced experimentally, such as the limited elastic zone and the smooth transition from elastic to plastic behaviour.

During the final phase of the project, the ACC-2 model was extended by considering anisotropic elasticity and then applied in the finite element simulation of the hydro-mechanical perturbations of Boom Clay during and after the PRACLAY gallery excavation, by considering different cases of anisotropy: in-situ stresses, hydraulic conductivity and stiffness of Boom Clay. The comparison between numerical simulation results and in-situ measurements shows that the anisotropy in stiffness and the initial stress state in the clay are the main controlling factors for the anisotropic pore pressure variations after excavation. This also highlights the importance of considering the smooth transition between elasticity and plasticity with a limited elastic zone of the clay when comparing with the numerical results obtained using a traditional elasto-plastic model such as the Cam-Clay or the Mohr-Coulomb model.

The ACC-2 model was then extended by considering viscosity (V-ACC2 model). The model was well validated by simulating laboratory tests involving variable stress and/or strain rate conditions. The results show the model's relevance in reproducing the general features of the time-dependent behaviour of Boom Clay. This model was applied to simulating the gallery excavation by considering different excavation rates. Numerical results indicate that the V-ACC2 and ACC-2 models predict similar hydro-mechanical responses during excavation, but that viscosity can have some effect on the deviatoric stress responses in the near field.

The ACC-2 model has been applied to investigate the hydro-mechanical responses of the Boom Clay in a bituminised radioactive waste disposal facility. In contact with groundwater, the bituminised radioactive waste will swell due to the presence of a high content of NaNO3 in combination with bitumen behaving as a highly efficient semi-permeable membrane, i.e. osmosis-induced water uptake. Considering the lifetime of this deep radioactive waste repository, a synthetic case covering four important stages was considered in the analysis: (i) the excavation of the gallery in one day; (ii) a drained phase of the gallery for 100 years; (iii) a saturation phase of the gallery extending over 300 years; and (iv) a final phase in which a swelling (better: an osmosis-induced) pressure is applied to the Boom Clay over 500 years. In the final phase, two cases were considered: a radial displacement (corresponding to the swelling rate of the waste) is applied on the concrete liner (Case 1) or directly on the gallery wall (Case 2). The development of pore pressure, stress and displacement in the clay mass during these stages was reliably simulated and was quite similar for the two cases studied. Figure 23 shows the complete effective stress paths of an element located on the excavated wall in the horizontal direction throughout the stages for the two cases. Numerical simulation also indicates that the recovery of the in-situ pore pressure is a very slow process: according to the modelling analysis, the pore pressure will not be totally recovered during the 300-year saturation phase.

In 2015 two progress meetings were organised in Brussels. The final report will be delivered at the beginning of 2016.

The progress of the project in 2015 led to several publications (see Scientific output).

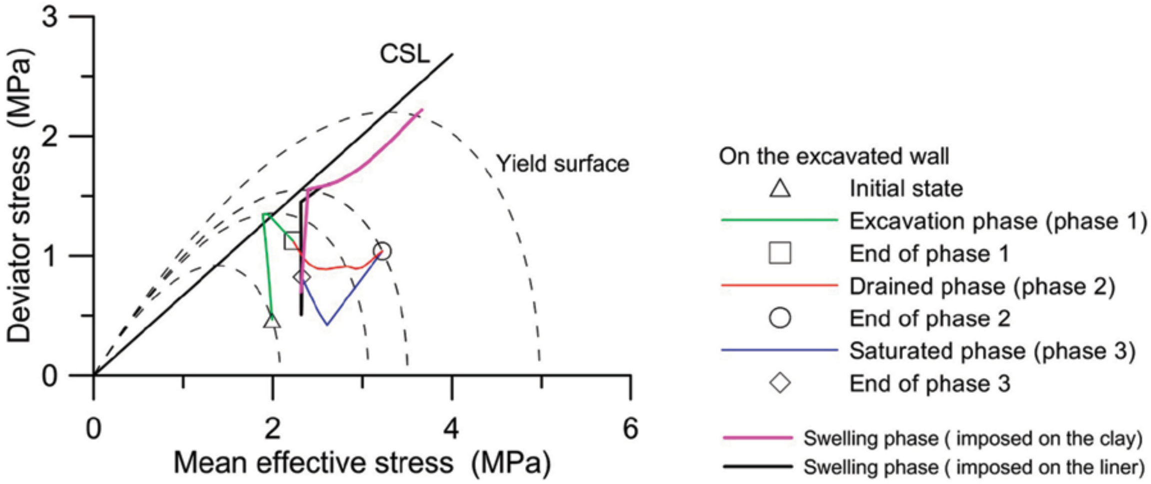


Figure 23 - Predicted effective stress paths of an element located on the excavated wall in the horizontal direction.

ULg (University of Liège, Belgium)

A PhD research project on the evolution of the excavation-damaged zone (EDZ) started in 2011 at ULg. The aim of this thesis was to study the evolution of the EDZ's structure and fractures using numerical tools, in particular the second gradient concept implemented in the finite element software LAGAMINE. This thesis is financed directly by ONDRAF/NIRAS and is supervised jointly by EIG EURIDICE and ONDRAF/NIRAS.

The main task in 2015 was to write up the thesis, which was defended at the end of the year.
The progress of the project in 2015 led to several publications (see Scientific output).

2.5. GeoScientific Information System (GSIS)

As manager of the HADES URL, EIG EURIDICE supports the GSIS (GeoScientific Information System) project being developed by SCK•CEN on behalf of ONDRAF/NIRAS. The GSIS structures all field information in a geographical way, and contains elements ranging from shafts to analysis results from specific water samples obtained at a particular piezometer filter. EIG EURIDICE's contribution consists in adding and validating the elements (constructive components like shafts and galleries, boreholes, etc.). It will also use this database as an inventory for all geographically related information on equipment and instrumentation, and for the validated data series of selected sensors to be published for external users.

SCK•CEN delivered a new database structure early in 2015. Activity during the reporting year was limited to the review of geographical data (e.g. based on survey data) and an evaluation of the data management procedures. The latter will allow a formal validation of measurement data, which will eventually be entered in the GSIS after being cleared for external use.

3. Instrumentation & Monitoring

The issue of repository monitoring has attracted a great deal of international attention in recent years – mainly due to the more detailed requirements of the regulatory bodies in countries with advanced programmes (e.g. Finland), and also because of growing awareness of the societal role of monitoring. EIG EURIDICE has therefore set out a programme to investigate this in more detail, comprising a technical part and a more strategic part.

For the technical part, EIG EURIDICE can draw on its long-standing monitoring experience in underground conditions (relevant to a repository environment) for the past 30 years and more. To secure this knowledge, it has embarked on a systematic review of relevant set-ups in HADES that have been run over the past few decades (essentially since the start of the HADES experimental programme in the 1980s), focusing in particular on the performance of the sensors in field conditions and in the long term.

For the strategic part, EIG EURIDICE will start by assessing which safety statements can be substantiated by specific monitoring parameters. In the reporting year, it did not do any work on this aspect, but had already carried out similar tasks as part of the European Commission's MoDeRn Project (see 4.1.).

The PRACLAY experiment, as well as other experimental set-ups, has made it clear that data management in a repository context requires a specific approach, which should take into account aspects ranging from technical issues (e.g. non-accessible sensors, long-term reliability) and specific organisational matters (long-term follow-up, distributed and varying monitoring configurations, etc.) to strategic considerations such as the use of the data by different stakeholders (scientists, decision-makers, local citizen stakeholders, etc.).

A specific study has been proposed to develop a methodology for the management of repository data, based on the experience acquired to date. The proposal covers a range of topics, from planning a monitoring system to follow-up and data validation. The actual study is scheduled for 2016.

Since the installation of the first experimental set-ups in HADES in the 1980s, a lot of monitoring experience has been gained on the long-term performance of sensors in repository-like conditions. This is very valuable as input for the development of a repository monitoring programme. To preserve this knowledge for a future programme over the longer term (decades), a more systematic and formal approach has been adopted to record the monitoring experiences of selected experimental set-ups.

In 2015 EIG EURIDICE initiated a review of the instrumentation installed in the context of the CLIPEX project, which was designed to assess and characterise the hydro-mechanical disturbance of the Boom Clay and, more specifically, the EDZ during the excavation of the Connecting gallery (early 2002). The monitoring system consisted of instrumented boreholes installed from the Test Drift front and from the second shaft prior to the excavation of the Connecting gallery. In addition, the instrumented lining segments were part of the CLIPEX monitoring programme. The monitoring data included pore pressure, total pressure, displacement and deformation.

The performance evaluation of the CLIPEX monitoring instrumentation set-up includes both functional and test-specific requirements and implementation procedures such as data sampling, maintenance, calibration, sensor drift, etc., where applicable. The study also includes full traceability of the data and data sheets containing all of the data available at the time of writing the final report, which is planned for 2016.

4. Participation in international research projects

4.1. European Commission (EC) projects

Modern2020

Within the framework of the Horizon 2020 Euratom Work Programme NFRP6-2014 “Supporting the implementation of the first-of-the-kind geological repositories”, a new proposal on monitoring of geological radioactive waste repositories, called “Modern2020”, was approved by the EC early in 2015. The contract started on 1 June 2015 for a period of 48 months. In the project summary of the Modern2020 project, the general objective is stated as follows:

“The Modern2020 project aims at providing the means for developing and implementing an effective and efficient repository operational monitoring programme, taking into account the requirements of specific national programmes.”

The project consists of four main work packages (WPs), and EURIDICE is participating in two of these: WP3 (Monitoring Technology) as advisor and WP4 (Demonstration and Practical Implementation) as coordinator. The other two are Strategy (WP2) and Societal Concerns and Stakeholder Involvement (WP5). The project consortium is made up of 28 partners from 12 countries. For EURIDICE, the project will involve nine person-months of staff time and a total budget of EUR 227,000 (over a total for four years).

In WP3, EIG EURIDICE is contributing to four tasks, where it mainly has an advisory and coordinating role on the development of new fibre-optic sensors, the integration of these sensors with wireless transmission, and the testing and validation of the devices in repository-like conditions.

WP4, in which EURIDICE is the Work Package leader, brings together demonstrator set-ups that are being developed and are or will be operated in Finland (Olkiluoto), France (Bure and Tournemire), and Switzerland (Mont Terri). In addition, this WP also revisits some existing cases, which will be re-assessed with the focus on monitoring experiences that are relevant for repository operation, such as the use of monitoring data for decision-making, or the involvement of local stakeholders in the field set-up.

4.2. Other international collaborations

LUCOEX (Large Underground Concept Experiments)

Within the framework of the EC LUCOEX (Large Underground Concept Experiments) project, which initially ran from 2011 to 2014 (+ 8 months' extension), an Expert Group was established. This Group contained members from the organisations participating in the project, as well as external experts. Jan Verstricht took over as external expert from Geert Volckaert when the latter moved to the Belgian nuclear regulator, the Federal Agency for Nuclear Control (FANC). The objective of this Group was to provide an independent review of the project activities.

As the project finished in 2015, EIG EURIDICE attended the final conference in Oskarshamn in Sweden (at which a presentation on the management of PRACLAY was also given by ONDRAF/NIRAS) and contributed to the final report, which was delivered at the end of 2015.

ENPC (École des Ponts ParisTech, École Nationale des Ponts et Chaussées)

On 15 June 2015 Xiangling Li was appointed by the French Ministry of Ecology, Sustainable Development and Energy as a member of the scientific board (Conseil scientifique) of ENPC for a period of three years. This board has the task of making proposals to the Board of Directors on priorities for ENPC's science policy. It regularly assesses the work carried out in the research centres and may be consulted on any issues relating to the performance of the research centres or to PhD programmes. The ENPC Director and Director of Research attend meetings of this board.

IRMM (Institute for Reference Materials and Measurements)

Since 1999 EIG EURIDICE has delivered services for IRMM's long-standing operation of an ultra-low-level radioactivity laboratory in support of European Commission policies in such fields as international standardisation, radioactive waste management and radioprotection. Some key projects in 2015 included: characterisation of reference materials for food safety, naturally occurring radioactive materials (NORM) and nuclear decommissioning, radiotracer studies from the Pacific to map ocean currents and study uptake in the food chain, and support to international research groups performing studies on rare nuclear decays and fusion research. The latter projects were carried out within IRMM's Transnational Access Programme.

For this purpose, part of the HADES underground research laboratory has been leased to IRMM. The contract is a Service Agreement that can be extended on a yearly basis.

5. Specific support for the repository technology study of ONDRAF/NIRAS

EIG EURIDICE supports ONDRAF/NIRAS in its RD&D on the technical feasibility programme of geological disposal. This programme aims to demonstrate the construction and operational feasibility of the proposed concept for geological disposal. The next programme milestone is the first Safety and Feasibility Case (SFC-1), which is scheduled for 2020.

The repository technology studies cover the following topics:
- fabrication of the waste disposal packages
- construction techniques and support for the design of the underground repository
- operation and closure of the underground repository

6. Support for Safety and Feasibility Case 1 of ONDRAF/NIRAS

EIG EURIDICE provides scientific and technical input for the development of ONDRAF/NIRAS's first Safety and Feasibility Case (SFC-1) with its expertise in the geomechanics of clays. In particular, it is preparing a state-of-the-art report on the geomechanical behaviour and properties of Boom Clay, with emphasis on the results from studies carried out within the HADES URL. EURIDICE is also in charge of the daily management, follow-up and scientific exploitation of the long-term, large-scale PRACLAY Heater test; the results from the first two years of this experiment (November 2014 – November 2016) will constitute a significant element of the SFC.

EIG EURIDICE also supports ONDRAF/NIRAS by providing samples, data and technical and scientific expertise for studies carried out in collaboration with third parties on the (thermo-) hydro-mechanical (-chemical) behaviour of Boom Clay and Ypresian clays and on gas transport.

Activities: PART II
The surface disposal programme for category A waste - cAt Project

Introduction

On 23 June 2006 the Belgian federal government decided that the long-term management of category A waste should take the form of a surface disposal facility within the municipality of Dessel, situated in the northern, Flemish part of Belgium in the Province of Antwerp. The government commissioned ONDRAF/NIRAS to carry out this integrated programme – i.e. the cAt project. To fulfil its appointed task, ONDRAF/NIRAS works in close collaboration with the STORA and MONA partnerships it has with the municipalities of Dessel and Mol, respectively.

An important step in the successful completion of this project has been the licence application that ONDRAF/NIRAS submitted on 31 January 2013 to the Belgian nuclear regulator, the Federal Agency for Nuclear Control (FANC), for the surface disposal facility.

EIG EURIDICE supports the cAt project in the following areas:
- Calculations of the long-term radiological impact of the planned repository;
- Preparation and instrumentation of the planned test cover;
- Instrumentation of the demonstration test for construction of concrete modules.

1. Radiological long-term safety assessments and quality assurance of models and codes

Radiological long-term safety assessments, prepared and documented during the period 2010-2012, are a key part of the safety arguments presented in the licence application.

After examining the licence application, FANC asked several questions on the phenomenological basis of the radiological long-term safety assessments. This resulted in a revision of the expected evolution of the disposal facility after its closure. This expected evolution entails the physicochemical state of the various barriers, their degradation modes, their expected saturation degree and the radionuclide release processes and pathways as a function of the evolution of the barriers. The expected evolution uses data from the scientific literature, experiments and characterisation tests for the specific materials used in the project, as well as insights gained from scoping calculations. Examples of such calculations, performed by EIG EURIDICE, include:
- the evolution of water flow and water saturation degree, taking into account voids and cracks in the system
- solute transport in cracked concrete systems under unsaturated conditions.

EIG EURIDICE also reviewed the description of the revised expected evolution of the disposal facility.

The key changes to the expected evolution compared to the licence application are:
- Cracks as the major degradation mode of concrete, whereas previously leaching of the concrete matrix was considered more important.
- Based on recent scientific studies in the literature, more details are now available on fibre-reinforced concrete, leading to an extension of the estimated lifetime from 350 to 1,000 years.
- Based on an extended lifetime of the fibre-reinforced concrete, the amount of water infiltrating into the monoliths and waste remains very limited during the first thousand years, leading to a slow release of radionuclides from the waste and from the monoliths and modules.
- More detailed studies on the effects of erosion of the earth cover, on the slope stability of the cover subjected to earthquakes, on the expected evolution of the vegetation on top of the cover and on the combination of these processes and events have confirmed that the majority of the impervious top slabs and modules will remain buried for at least 1,000 years.

New hypotheses and parameters for a revised safety assessment base case model of the expected evolution are being established. One key parameter in the near-field, hydrogeology and biosphere sub-models is the infiltration rate in soil and how the infiltration changes with expected climate change and uncertainties about the evolution of the climatic conditions over the next few centuries. New calculations are being performed on this infiltration rate.

FANC's analysis of the licence application also led to questions on additional validation of the hydrogeological models simulating groundwater flow and radionuclide transport in the groundwater, especially under and in the immediate surroundings of the future disposal modules (Figure 24). An experimental programme to validate the groundwater flow in the vicinity of the future disposal facility was defined in 2015 and will be further implemented in 2016.

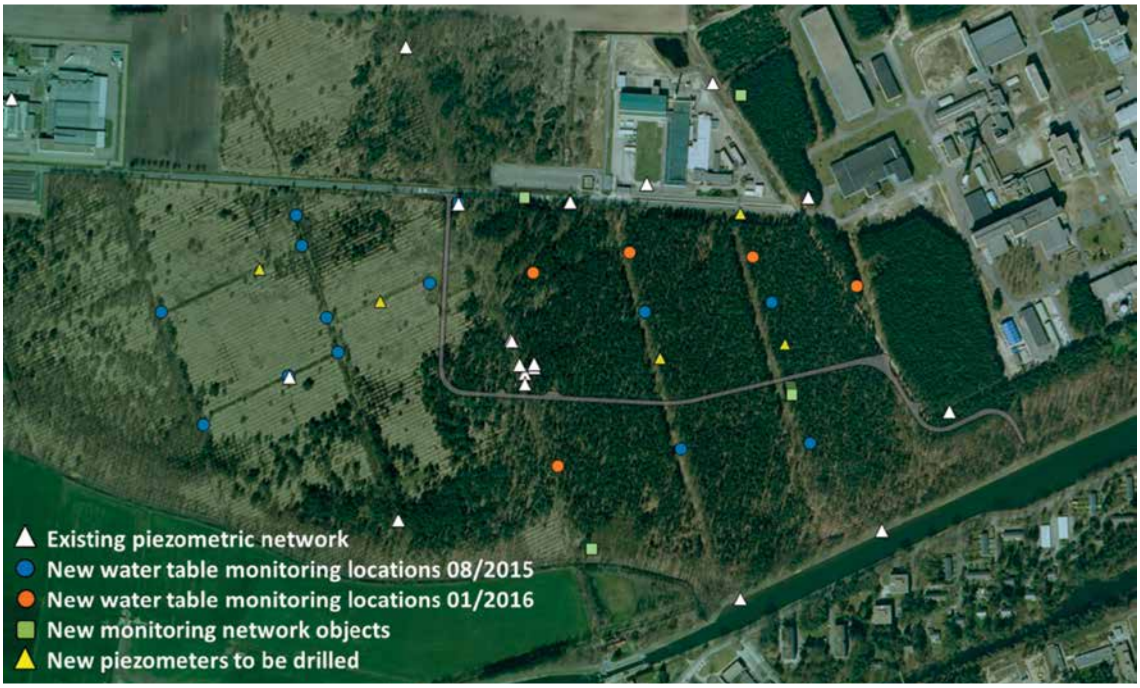


Figure 24 - Additional experimental programme for validation of the hydrogeological models.

2. Test cover

After placing waste in a surface-type disposal facility for several decades, a multi-layer cover will be placed on top of the disposal modules, with the aim of reducing water infiltration into these modules so as to limit degradation through leaching of the underlying components and to limit leaching of radionuclides from the facility. In the meantime, a long-term test cover programme has been developed to gather information on the technical aspects and the dynamics of a multi-layer cover; the experience gained will form a solid basis for building confidence and experience with multi-layer cover systems to be used in the design, construction and monitoring of the final tumulus.

For landscape architectural purposes (development of a visual quality plan for the whole cAt site), the location of the test cover has been moved next to the SME zone – Eastern side (small and medium-sized enterprises). As this new location is located on the Gras Pop festival field, the start of construction is planned for August 2017, after the last festival on that site. Work in 2015 focused on establishing the technical specifications for the instrumentation and construction issues. The following prototypes were designed, built and tested: water tank, sediment-trapping system and a double ring set-up for permeability measurements of compacted clay.

Figure 25 - 3D overview of planned instrumentation

3. Demonstration test

In order to assess the technical feasibility of the module construction techniques and the industrial feasibility of the concrete that has been optimised for long-term safety and has been tested on a laboratory scale, a demonstration module construction test for the cAt project has been underway since 2011 (Figure 26).

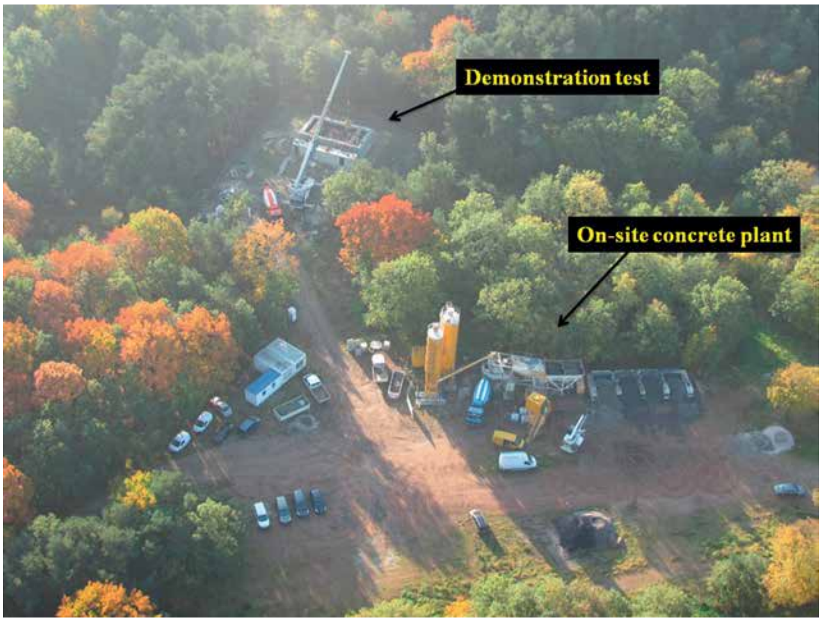


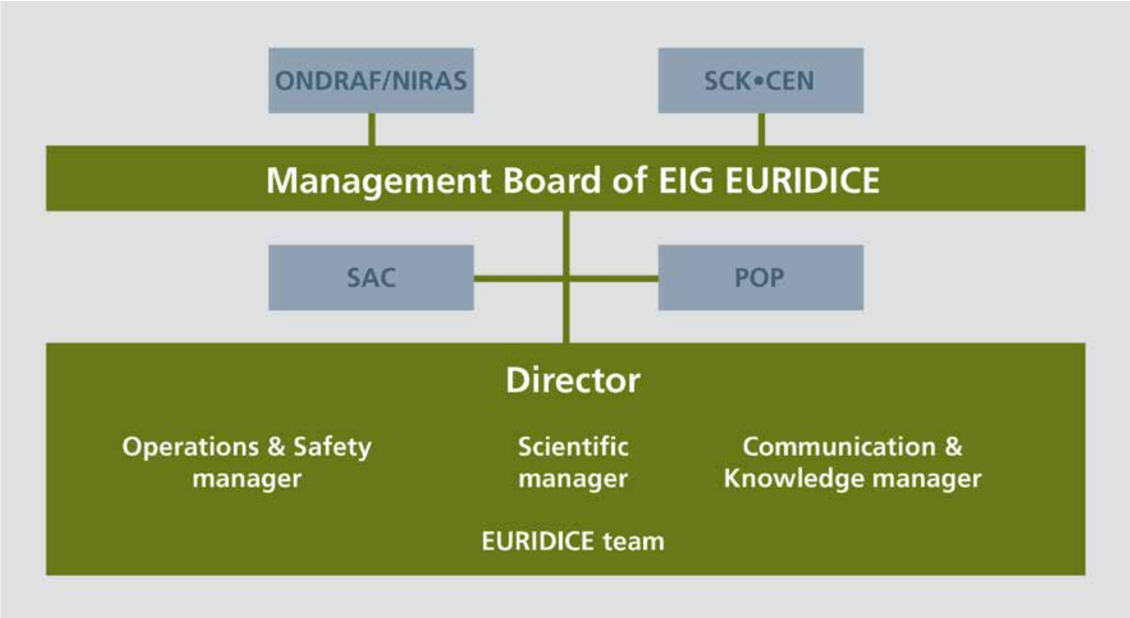
Figure 26 - Overview of the demonstration test

EIG EURIDICE, together with ONDRAF/NIRAS and Tractebel Engineering, has devised an instrumentation plan for assessing the temperature and stress conditions within the concrete used in the demonstration test.

In 2011 the test module and two test panels were built by ONDRAF/NIRAS and instrumented by EIG EURIDICE. A third panel was built in 2013 and was also instrumented by EIG EURIDICE. Vibrating wire strain gauges and formwork pressure sensors were installed. A fourth test panel was built in 2014, again instrumented by EIG EURIDICE. This time only thermocouples were installed. There was no on-site construction work in 2015. Data collection continued, however.

General Management of EIG EURIDICE

1. Organisation



EIG EURIDICE is governed by a four-person **Management Board**. ONDRAF/NIRAS and SCK•CEN each appoint two board members for a period of three years. The Chairman of the Board is appointed by ONDRAF/NIRAS. The Secretary of the Board and the Director of EURIDICE attend meetings in an advisory capacity.

The board members are as follows (June 2013 - June 2016):

- Marc Demarche, Chairman, Deputy Director-General of ONDRAF/NIRAS
- Jean-Paul Boyazis, Adviser to the Director-General of ONDRAF/NIRAS
- Eric van Walle, Director-General of SCK•CEN
- Frank Hardeman, Deputy Director-General of SCK•CEN

Responsibility for the day-to-day management of EURIDICE lies with the Director and the Scientific Manager, who are appointed by ONDRAF/NIRAS and SCK•CEN, respectively. They are supported in their task by the Operations & Safety Manager and the Communication & Knowledge Manager.

The **Scientific Advisory Committee (SAC)** advises the EURIDICE Management Board on all scientific aspects of EURIDICE's work and comprises experts from various universities and from organisations working in the field of radioactive waste management.

The **Programme Committee for Underground Experiments (POP)** analyses the safety of proposed underground experiments and their potential interference with other experiments, and advises the EURIDICE Management Board on this matter. POP comprises representatives from both of the EIG's constituent members (ONDRAF/NIRAS and SCK•CEN) and from EURIDICE.

2. EIG EURIDICE team

Under its Statutory Rules, EIG EURIDICE has no employees of its own. Personnel working for EIG EURIDICE are under contract to either SCK•CEN or ONDRAF/NIRAS and have operated as the EIG EURIDICE team since 2000, based at the EIG EURIDICE site.

In 2015 there were no new recruitments for EIG EURIDICE and the team still consists of 16 members.

Director:
Peter De Preter

Scientific team:
Xiangling Li - scientific manager
Lou Areias - scientific collaborator
Wim Bastiaens - scientific collaborator
Arnaud Dizier - scientific collaborator
Guangjing Chen - scientific collaborator
Ioannis Troullinos - scientific collaborator
Jan Verstricht - scientific collaborator

Technical team:
Jef Leysen - operations & safety manager
Hendrik Huysmans - operation technician
Christian Lefèvre - operation technician
Johan Peters - operation technician
Bert Vreys - operation technician

Office Manager:
Caroline Poortmans

Organisation of visits:
Els Van Musscher

Communication Manager:
Jan Rypens

3. Scientific Advisory Committee (SAC)

The two constituent members of EIG EURIDICE each appoint three external experts for a period of four years.

The members appointed by SCK•CEN for the period June 2013 – June 2017 are:

- Prof. Robert Charlier, Professor of Geotechnical Engineering and Soil and Rock Mechanics at Liège University (Belgium)
- Prof. Geert De Schutter, Professor of Concrete Technology at Ghent University and Technical Director of the Magnel Laboratory for Concrete Research (Belgium)
- Prof. Tilmann Rothfuchs, Retired Head of GRS (Gesellschaft für Anlagen und Reaktorsicherheit) -division of Repository Safety Research (Germany)

The members appointed by ONDRAF/NIRAS for the same period are:

- Dr Gilles Armand, Head of the Fluid and Solid Mechanics Department at the French National Agency for Radioactive Waste Management - ANDRA (France)
- Prof. Jean-Marc Baele, Professor of Geology and Applied Geology, University of Mons (Belgium)
- Prof. Philippe Claeys, Head of the interdisciplinary research unit Earth System Sciences, Vrije Universiteit Brussel (Belgium)

The SAC regulations, approved by the General Assembly of EIG EURIDICE on 23 April 2012, extend the scope of the committee's remit to all scientific and technological activities of EIG EURIDICE.

EURIDICE organised two SAC meetings in 2015, on 6 March and 3 December. During these meetings the evolution of the PRACLAY Heater test was discussed.

4. Programme Committee for Underground Experiments (POP)

In 2015 two POP meetings were held, one in June and one in December.

The joint SCK•CEN – ONDRAF/NIRAS – EURIDICE procedure on clay core management was evaluated and fine-tuned. This procedure enables a complete inventory of clay cores used for RD&D purposes to be kept.

POP has also launched a project for cataloguing past experimental set-ups in the HADES URL and for evaluating the possible future use of these set-ups. This work is planned for 2016.

POP also defined exclusion and safety zones around the PRACLAY Heater test as a procedure for the location of future experiments in the vicinity of the PRACLAY gallery. The basic idea of this procedure is to identify the zones around PRACLAY where new experiments are allowed or excluded, based on the potential impact on the PRACLAY Heater test.

5. Management, operation & safety of installations

GENERAL

The Statutory Rules define the responsibilities and tasks of EIG EURIDICE concerning the management and operation of the installations on the land for which EIG EURIDICE holds a building lease. In 2015 these tasks were performed in accordance with applicable regulations, ensuring safe operations.

Besides all routine activities relating to maintenance, checks and inspections of machinery and installations, a systematic evaluation of all safety-related aspects of EURIDICE's activities was conducted, with the support of work safety experts from SCK•CEN and ONDRAF/NIRAS. The outcome of this evaluation, with a proposal for improvements, will be reported in 2016. In the meantime, three priorities for immediate actions were identified:

- Fire safety: a study by an external company was commissioned to evaluate fire safety in the HADES URL. By the end of 2015 a GAP analysis had been presented and the complete study will be finalised early in 2016.
- Training programme: an overview matrix for all safety-related functions was established, with all training requirements defined.
- Electrical installations: AIB Vinçotte carried out the necessary inspections on old electrical installations. Based on this, a proposed risk assessment was drawn up. EIG EURIDICE implemented a new electrical drawing and calculation software. Training courses were organised, and parts of the electrical power supply have been mapped using this software. Electrical calculations will subsequently be performed. This will be done section by section on the electrical installation. Based on these calculations and after discussions with AIB Vinçotte early in 2016, it will be decided whether changes or improvements are necessary.

The operation team gave technical support to RD&D activities in different projects and also to communication activities:

- Connection of monitoring devices to the data-logging system in HADES;
- Technical adaptations to PRACLAY (e.g. insulation door, insulation jackets on seal parts, closure of leaking cables and feedthroughs, etc.);
- Operation of hoisting system and technical assistance during visits and open days.

UNDERGROUND INSTALLATIONS AND ASSOCIATED HOISTING SYSTEMS

The operation team and/or AIB Vinçotte carried out the necessary checks and inspections on the shafts, cables, hoisting equipment, etc. There were some interruptions in, for instance, the hoisting systems and shafts, but these were resolved within a reasonable period of time and without any major problems.

For the replacement of the shaft 1 hoisting system and/or refurbishment of the shaft and related technical facilities, ONDRAF/NIRAS agreed to the new financing agreement on the proposed budget. Preparations for the study phase and public tendering are due to start at the beginning of 2016.

Other standard maintenance and repair work on the hoisting systems, shafts and galleries was performed by the operation team in 2015.

ABOVE-GROUND INSTALLATIONS AND BUILDINGS

The operation team carried out standard maintenance and necessary repairs on installations, buildings and infrastructure in 2015.

The new entrance road to EURIDICE has been in use since October 2015; street lights have been installed on the site and the gates are now automatic.

The entry procedure to the EURIDICE site and between the EURIDICE and SCK•CEN sites has been put into operation in agreement with the SCK•CEN security service.

LICENCES

The operating licence is valid until 2024. Nothing changed in this respect in 2015.

The nuclear licence of EIG EURIDICE (issued in August 2006) is valid until 2021. All inspections and checks under this licence were carried out by BEL V.

The environmental licence of EIG EURIDICE (granted in November 2013) is valid for 20 years.

6. Quality Management

Since 2007, EIG EURIDICE has been ISO-certified according to the ISO 9001:2008 standard for Quality Management. The current certificate is granted for the period from 22 April 2013 to 21 April 2016. An external audit took place on 23 February 2015. There were no major or minor non-conformities.
On 7 December 2015 Pascale Palinckx from ONDRAF/NIRAS performed an internal audit. No non-conformities were found.

7. Knowledge Management

In August 2015 a knowledge management committee was created to steer knowledge management at EURIDICE in an integrated way. The committee consists of the Director, Scientific Manager, a senior and a junior scientific collaborator and the Knowledge Manager, who coordinates the committee's activities. As a first step, the general goals and needs in terms of knowledge management for EIG EURIDICE are being defined. In parallel, specific action was taken to draw up an inventory of all printed documents in the demonstration hall. This was done by an intern and will subsequently be used to reorganise EIG EURDICE's archives.

Within the context of the PRACLAY experiment, document management is an integral part of the project and is organised in interaction with the PRACLAY management team. The Vignette system is used to store all documents.

8. Agreement with ONDRAF/NIRAS 2015-2020

The new contractual agreement with ONDRAF/NIRAS (ESV EURIDICE CO2015_RA_EUR_15-116) for the programme on geological disposal of high-level and long-lived waste for the period 2015-2020 was approved by the Management Board on 24 November 2015 and subsequently signed by ONDRAF/NIRAS. This agreement defines EIG EURIDICE's main activities in relation to geological disposal RD&D and the management and operation of all EURIDICE facilities. It also specifies the total budget available.

Communication

Communication about its activities is one of EIG EURIDICE's statutory tasks. The HADES underground research laboratory (URL) and the above-ground exhibition are powerful tools for explaining the concept of geological disposal and are the ideal way to present and explain the research that has been going on for the past 35 years. During 2015 the successful switch-on of the PRACLAY Heater test was an important milestone that led to a series of communication initiatives. The goal of these initiatives was to inform a wide variety of stakeholders about this experiment, which is of major importance within ONDRAF/NIRAS's research programme on geological disposal.

EVENTS

On 20 March the government ministers with responsibility for ONDRAF/NIRAS and SCK•CEN, ***Deputy Prime Minister Kris Peeters and Energy Minister Marie-Christine Marghem, visited EIG EURIDICE*** and the HADES URL, in the presence of the national and local media. The event was widely covered on national and regional TV, on radio and in most Belgian newspapers.

Deputy Prime Minister Kris Peeters and Energy Minister Marie-Christine Marghem visiting the HADES URL

After meeting with the press, both ministers shared their views on the long-term management of radioactive waste with key local and regional political and strategic stakeholders during an event in the demonstration hall.

Following this visit, the first afternoon session on day 1 of the ***6th consecutive International Conference on Clays in Natural and Engineered Barriers for Radioactive Waste Confinement*** in Brussels was devoted to large-scale in-situ heater tests, with several presentations on the PRACLAY Heater test. To celebrate the successful start-up of the Belgian Heater test, members of the scientific community were invited afterwards to an ***EIG EURIDICE event***, including a standing buffet.

The EIG EURIDICE event during the International Clay Conference in Brussels

FILM

In preparation of these and other communication events, a ***film on the PRACLAY Heater experiment*** was made to inform a wide audience about the set-up and goals of this large-scale experiment. The film was presented during the EIG EURIDICE event at the International Clay Conference, in the presence of Eric van Walle, Director-General of SCK•CEN, and Marc Demarche, Chairman of the Board of EIG EURIDICE. The film contains a 3D animation on the temperature evolution around the PRACLAY gallery and can still be viewed at www.euridice.be.

Film on the set-up and goals of the PRACLAY Heater experiment

VISITS

Anyone over the age of 18 can visit EIG EURIDICE and the underground research laboratory in small groups. Sociocultural organisations are looked after by trained guides, who also lead visits at ISOTOPOLIS, ONDRAF/NIRAS's information centre on radioactive waste. Geological disposal experts, journalists, university students with a scientific background and key political and economic figures are given a guided tour by scientific personnel, the Communication Manager and/or the Director of EIG EURIDICE, sometimes accompanied by ONDRAF/NIRAS or SCK•CEN management.

The above-ground EIG EURIDICE exhibition

In 2015 EIG EURIDICE welcomed 1,975 visitors in the course of 114 visits to the HADES URL and the above-ground exhibition on geological disposal; 73 of these visits were led by trained tour guides. Of the 114 visits, 52 were for training and educational purposes and 20 involved sociocultural organisations. The remaining 42 concerned direct stakeholders of EIG EURIDICE or were arranged at the request of SCK•CEN or ONDRAF/NIRAS. Sixty-five were Dutch-speaking, 34 English-speaking and 15 French-speaking.

In addition to these visits, which were organised on a continuous basis, all inhabitants of Mol and Dessel were invited to visit EIG EURIDICE and learn more about the PRACLAY Heater test during the ***open days on Saturday 30 and Sunday 31 May 2015***. Because of the limited numbers that can visit the HADES URL at the same time, pre-registration was required. During the weekend of 30 and 31 May, 180 people visited the laboratory in small groups of 8, escorted by trained guides. More than 250 people were put on a waiting list and were invited again on Wednesday 26 June and Sunday 22 November to visit the above-ground exhibition and underground laboratory.

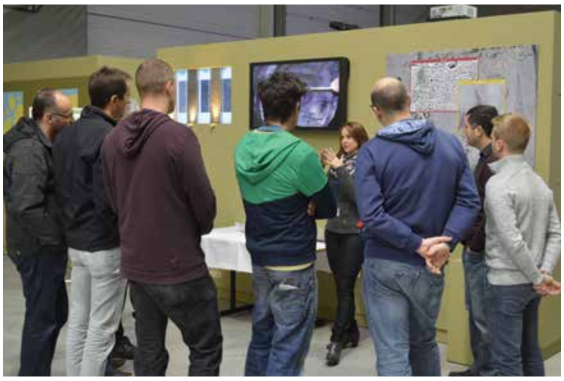
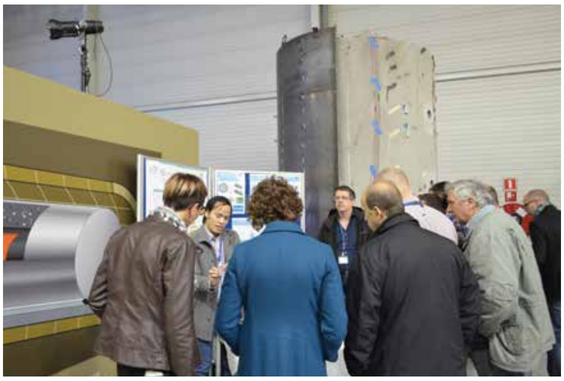
Trained guides escort people around during the EIG EURIDICE open days

The open day idea was an overall success. More than 300 people from Mol and Dessel took the opportunity to learn more about the research that is ongoing in their backyard. After being underground, visitors have a more realistic view of the scope and effort of the RD&D work on geological disposal and of what an actual repository might look like. At the end of the visit, they had the opportunity to put their questions to researchers and the management of EIG EURIDICE.

Together with SCK•CEN's Institute for Environment, Health and Safety (EHS), EIG EURIDICE organised ***a Meet & Greet event for SCK•CEN personnel*** on Friday 4 December. After a general introduction on the concept of geological disposal and the research under way, the participants were divided into smaller groups.

General introduction during the Meet & Greet for SCK•CEN personnel

The above-ground exhibition was extended for the occasion with information stands about all the different topics relating to geological disposal that are studied within the EHS Institute and EIG EURIDICE. This was also an excellent opportunity to visit the PRACLAY Heater test in the HADES URL. A total of 120 people took part in the event, 80 of whom visited the HADES URL.

SCK•CEN personnel are informed about the different geological disposal research projects

Taking into account the additional visitors from the open days and the Meet & Greet event, EIG EURIDICE welcomed about 2,400 visitors in 2015.

CORPORATE BROCHURE EIG EURIDICE

A new corporate brochure has been available in Dutch, French and English since March 2015. This gives a concise overview of EIG EURIDICE as an organisation, its areas of expertise, the HADES underground research laboratory, the PRACLAY experiment and the options for visitors.

The new corporate brochure of EIG EURIDICE

COMMUNICATION STRATEGY EIG EURIDICE

In 2015 a workflow was launched to develop a communication strategy for EIG EURIDICE covering the period 2015-2025. As its communication activities strongly interact with those of its two constituent members, SCK•CEN and ONDRAF/NIRAS, this strategy needed to be developed in close interaction with both.

Before developing a strategy, a scenario analysis needed to be performed to examine how the context in which EIG EURIDICE operates might change. This was done with the support of PROSPEX during a two-day workshop held on 19 and 20 May at the Faculty Club in Leuven and attended by the management of both constituent members. Based on this workshop, a limited number of scenarios were developed that can serve as input for formulating the communication strategy. However, the workshop raised several strategic questions for both members that may have an impact on the future context of EIG EURIDICE. During the meeting of the extended communication committee, it was decided that both members would first discuss these strategic questions internally and give their response to EIG EURIDICE by the beginning of 2016. For this reason, the development of the communication strategy was postponed.

The strategy will be developed in 2016, taking into account input from SCK•CEN and ONDRAF/NIRAS on these strategic questions.

Scientific output

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