French Geological Repository Project for High Level and Long-Lived Waste: Scientific Programme - 8016

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ABSTRACT

The feasibility study presented in the Dossier 2005 Argile set out to evaluate the conditions for building, operating and managing a reversible disposal facility. The research was directed at demonstrating a potential for confining long-lived radioactive waste in a deep clay formation by establishing the feasibility of the disposal principle. Results have been enough convincing and a Planning Act was passed on 28 June, 2006. Decision in principle has been taken to dispose of intermediate and high level long-lived radioactive waste in a geological repository. An application file for a license to construct a disposal facility is requested by end of 2014 and its commissioning is planned for 2025. Based on previous results as well as on recommendations made by various Dossier 2005 evaluators, a new scientific programme for 2006-2015 has been defined. It gives details of what will be covered over the 2006-2015 period. Particular emphasis is placed on consolidating scientific data, increasing understanding of certain mechanisms and using a scientific and technical integration approach. It aims at integrating scientific developments and engineering advances. The scientific work envisaged beyond 2006 has the benefit of a unique context, which is direct access to the geological medium over long timescales. It naturally extends the research carried out to date, and incorporates additional investigations of the geological medium, and the preparation of demonstration work especially through full-scale tests. Results will aim at improving the representation of repository evolutions over time, extract the relevant parameters for monitoring during the reversibility phases, reduce the parametric uncertainties and enhance the robustness of models for performance calculations and safety analyses. Structure and main orientation of the ongoing scientific programme are presented.

INTRODUCTION

The feasibility study of a deep geological repository for disposing of intermediate and high level long-lived radioactive waste in France has been presented in the Dossier 2005 Argile [1]. It set out to evaluate the conditions for building, operating and managing a reversible disposal facility, for the purpose of protecting humans and the environment. The research was directed at demonstrating a potential for confining long-lived radioactive waste in a deep clay formation, the Callovo-Oxfordian argillite deposited 155 million years ago. A 3D diagram of the sedimentary sequence is shown on Fig. 1, with indication of the underground research laboratory (URL) which has been built close to the Bure village.

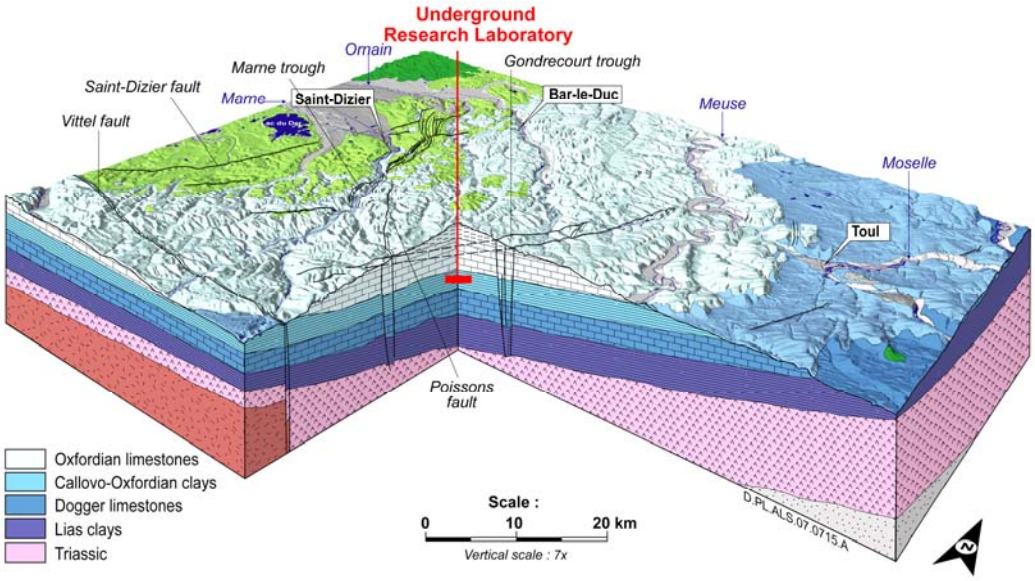

Fig.1. Sedimentary sequence in the Paris Basin, with indication of the Bure underground research laboratory in the Callovo-Oxfordian argillite (clay) formation

While the Dossier 2005 was being produced, a preliminary version of a scientific and technical programme for 2006-2010 was being drafted with a view to enlightening the evaluators and the Parliamentary office for Evaluating Scientific and Technology Options (OPECST) without taking as read the decisions due to be made in 2006.

A development scheme with scope for accommodating a number of studies was drawn up based on scientific and technical considerations. It distinguished the broad brushstrokes of a number of periods for building an industrial facility by a dateline around 2025. It gave details of what could be covered over the 2006-2010 period, which would coincide with moving on to the development, optimisation and detailed study phase. Particular emphasis would be placed on consolidating scientific data, increasing understanding of certain mechanisms and using a scientific and technical integration approach. This preliminary version of the document was to list the programme's main research orientations to support the options presented over that period. It would include technological aspects, demonstrating further commitment to integrate scientific developments and engineering advances.

The various orientations have been set as a result of the analysis conducted since then, to incorporate the recommendations made by the various Dossier 2005 evaluators and are based on the schedule laid down in the act passed in June 2006 [2]. The HAVL Argile project Development Plan [3] has also been organised for the intermediate and high level long-lived radioactive waste disposal. It is now supported by additional documents that set out the ANDRA activity schedule in this area after 2006 and organizes it through nine main programmes:

- Surface-based exploration programme within the so-called transposition zone in the vicinity of the Bure site. The transposition zone has been identified as having the same properties as in the Bure site. It is a 250 km^2 area situated north of Bure,
- Laboratory experimentation and demonstration test programme; all the research work undertaken in Bure is pursued, even with a new set of experiments to refine our knowledge of the site and to describe processes involving interactions between natural materials and manmade materials,

- Scientific programme, especially to reach a high level of understanding of the physical processes likely to occur in a repository,
- Simulation programme, which is the most suitable way to describe the behaviour of the repository on the very long term, out of the scope of any experiment,
- Engineering studies and technology testing programme,
- Monitoring and observation programme, which aims at giving means to detect any discrepancy between the simulated behaviour of the disposed waste packages in their environment and the measured or observed one,
- Management, monitoring and transport of waste packages,
- Information and consultation programme, mainly based on communication and on sociological studies,
- Surface storage facilities.

This article introduces the organisational package for the work to be carried out over the 2006-2015 period, at the end of which, under the terms of the 2006 Act, Andra must file its application for a licence to construct a disposal facility. An interim deadline of the year 2012 has been set for compiling a Dossier containing all the requisite elements for making a preliminary assessment of the work carried out, and also holding a public debate. Previously, in 2009, Andra will have proposed criteria for selecting a 30 km^2 area on which additional geological investigations should be carried out for facilitating the final location of the repository and its related surface installations.

This article summarizes the roadmap through the HAVL-Argile project's scientific programme. It should give a clear perspective of ANDRA's priorities and the research project schedule. Accordingly, it forms a scientific policy reference base for setting up or revising ANDRA's tools, mainly its partnership agreements, laboratory groups, theses and post-doctorate work.

RECOMMENDATIONS MADE BY THE EVALUATORS

The various assessments of the Dossier 2005 have been published by the evaluators, the National Review Board, the Permanent Group on "waste" and the International Review Team [4] set up under the aegis of the NEA/OECD on the request of Andra's supervisory ministries. These assessments were essentially carried out during the second half of 2005. They provide major input data for setting up the dossier HAVL-Argile development plan and particularly the scientific programme. Their conclusions on scientific aspects are recapped below.

Characterization of the Geological Medium: The Transposition Zone

The advice of the evaluators is that a transposition zone exploration strategy should be defined to identify which volumes of rock present no fracturing or fracturing that may be compensated by adapting the repository architecture, without penalising safety, so that the repository location and footprint can be established. This exploration strategy should be supported by verifying the validation of the Callovo-Oxfordian formation properties on the transposition zone, with special reference to the transport parameters.

Characterization of the Geological Medium: Callovo-Oxfordian Properties

The low spatial variability of the Callovo-Oxfordian's chemical and hydrodynamic properties, especially its diffusion and permeability coefficients, should be confirmed and backed up. A set of data was obtained for permeability at different scales and is reported on Fig. 2.

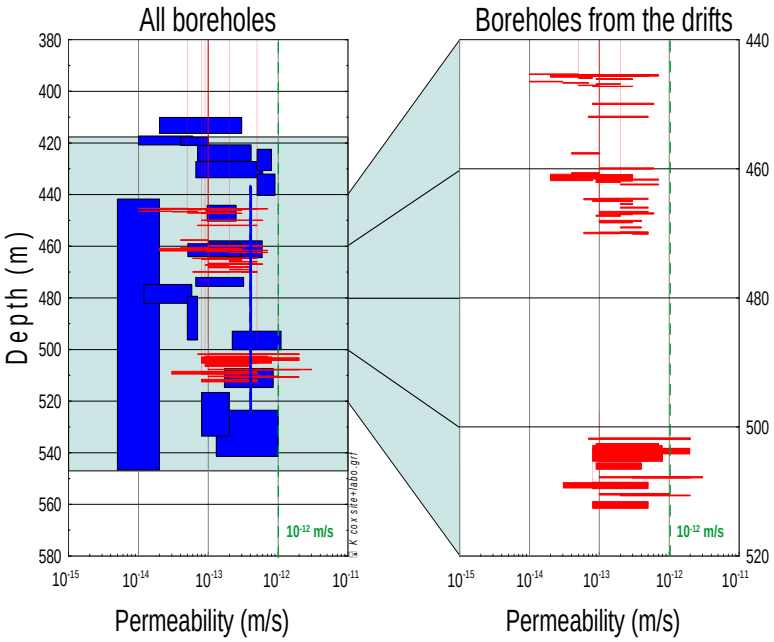

Fig.2. Permeability measurements at different scales for the Callovo-Oxfordian argillite formation

There is a very high level of consistency between the values generated from surface boreholes and boreholes from the drifts in the underground research laboratory. Values are very low, ranging from 10^{-12} to 10^{-14} m/s.

Detail is also required on the origin of overpressures and their possible influence on water flows. The research effort concentrates on **(i)** extending the experiments in progress in the underground laboratories over longer periods **(ii)** characterising the transposition zone and **(iii)** pursuing international joint ventures.

The detailed recommendations are accordingly to: **(i)** make routine use of the isotopic analyses of the Uranium series, **(ii)** assess the role of organic matter on radionuclide speciation, complexing and transport, especially for iodine retention, **(iii)** deepen understanding of retention and transport mechanisms in the Callovo-Oxfordian, **(iv)** assess the role of bacterial activity and **(v)** pursue the studies on the composition of interstitial waters. These recommendations on the study aims are supplemented by recommendations on suitable resources, particularly in the underground research laboratory.

Characterization of the Geological Medium: The Hydrogeology of the Surrounding Formations

The evaluators raised the need to remove uncertainties and gain better understanding and representation of the water flows inside the surrounding formations, particularly the Dogger and Oxfordian limestones, both at the current time and over the next million years. Special emphasis is placed on **(i)** specifying the hydraulic role of the main structures, **(ii)** establishing the origin of salinity (and salinity gradients) in the Oxfordian Limestones and Dogger, **(iii)** assessing the possibilities and consequences of the localised transfers in the limestone formations, and **(iv)** adapting the regional scale hydrogeological model to the sector scale.

The Near-field Behaviour and Evolution of the Repository: Thermal Load

A more accurate estimate of the effects of vertical thermal conductivity variations on the change to the thermal field around the waste packages needs to be made for the entire thickness of the Callovo-Oxfordian formation and for the footprint of the exothermic waste repository zones.

The Near-field Behaviour and Evolution of the Repository: Hydraulic Transient, Gas Production and Transfer

It has been recommended that allowance is built in prior to the design stage for the issue of gases (reducing the quantity of metal, long length cell design to encourage the evacuation of gases through the geological medium). The research effort should take two major, complementary directions: **(i)** production and transfer process validation and characterisation and **(ii)** digital simulation and validation at the scales of the structures and the repository. Lastly, the evaluators all indicate the need for in situ gas migration experiments to support the characterisation and simulation work.

The Near-field Behaviour and Evolution of the Repository: The Mechanical Behaviour of the Callovo-Oxfordian

Recommendations are made to improve understanding of the mechanical behaviour of the Callovo-Oxfordian and the excavation disturbed zone (EDZ) with regard to the short and long-term behaviour of the rock, primarily looking at excavation techniques and couplings between the various phenomena (thermal, hydraulic and chemical).

The demand has been made for instrumented demonstrators of the major structures to be built in the different geomechanical units considered using the confirmed construction methods.

The Near-field Behaviour and Evolution of the Repository: Chemical Disturbances of the Callovo-Oxfordian Caused by the Repository

The uncertainties surrounding the modelling the alkaline disturbance extent need to be removed. The issue of nitrates arising from bituminised sludge package degradation (oxidising disturbance of the Callovo-Oxfordian) has been raised.

The Future of Repository Materials & Long-term Behaviour of Waste Packages

Several recommendations have been made in this area to:

- Continue the long-term behaviour studies and study the lifetime of the materials,
- Study hydrogen's role in spent fuel dissolution,
- Reduce the uncertainties surrounding coupled chemical and physical property alterations in cement-based materials,
- In the case of the repository's metal components: verify the dimensioning of these components. Precautions built into the design must eliminate corrosion mechanisms, such as hydrogen embrittlement and stress corrosion. A decision must be made on whether or not non-alloy grades of steel will be selected,
- Produce a more accurate evaluation of the vitrified waste package-fracturing rate. Efforts must concentrate on gel formation mechanisms, their durability and the interactions with the materials surrounding waste packages,

Radionuclide Migration

Radionuclide migration does not elicit any particular recommendations from the evaluators. Nonetheless, ANDRA recommended that the role of complexing agents arising from degradation of the organic matter contained in some types of B waste should be assessed and that further work should be developed on the possible mechanisms for iodine sorption.

Digital Simulation

The recommendations favour continuing and redoubling past simulation work, in conjunction with the in situ experiment results. Robust digital models are required and software development needs to be pursued to improve their accuracy, robustness and performance. The use of algorithmic techniques, parallel computations and inverse calculations is recommended in this context.

ORGANISATION OF THE SCIENTIFIC PROGRAMME

The 2006-2010 scientific programme is based on the results acquired since 1994, and in particular those of the 2002-2005 period from the experiments undertaken in the underground research laboratory. It takes up the main deliverables acquired and the construction work and on-site experimentation schedule. However its organisation diverges from that of the 2002-2005 scientific programme, in that it sets out to offer a better vision of the priorities arising from recent work and the sequencing of ensuing work through its theme-based presentation.

The work revolves around a number of priority objectives that are developed further on into lines of research:

- Consolidation of data acquired over the previous period and long-term experiments to support the modelling,
- Conducting integrated tests with technological intent (pre-commercial demonstration of the repository elements) and use of repository observation and monitoring resources,
- More accurate quantification of safety margins: through a more refined assessment of the behaviour and evolution of the repository and its components (less conservative approach),
- The development of digital simulations to represent the behaviour of the geological medium and of the repository as faithfully as possible in preparation for the safety analyses,
- Exploration of the transposition zone around the laboratory to delimit the precise location of the future repository.

These general objectives are split along three main scientific themes for this programme:

(i) Greater understanding of the basic phenomena, primarily those that govern radionuclide and toxic chemical release and transfer,
(ii) The coupling between phenomena and at the interfaces between repository components and the repository environment,
(iii) Changes of scale and more specifically the spatial and temporal variabilities of the geological sequence.

The projects to be developed over the 2006-2010 period set out to reduce remaining uncertainties. They must contribute to choices of representation that overcome the penalising character of the hypotheses adopted for the safety assessment made during the Dossier 2005. Behind this lie basic work objectives to support the conceptual models adopted and confirm the robustness of the scientific approaches developed.

Thus, the proposed programme should be considered as an optimisation programme destined to confirm the hypotheses, flesh out the existing database using full-scale operations, develop technological and

simulation tools and combine the progress made in engineering and on repository phenomena in a single approach.

THE SCIENTIFIC RESEARCH THEMES OF THE 2006-2010 PROGRAMME

The scientific work beyond 2005-2006 has the benefit of a unique context, which is direct access to the geological medium over long timescales. They naturally extend the research carried out to date, and incorporate additional investigations of the geological medium (boreholes and seismic campaigns over the period 2007-2008, followed by 2009-2010), and the preparation of demonstration work and full-scale tests. The scientific investigations are developed in support of the dimensioning and monitoring methods for these experiments. They use the results to improve the representation of repository alterations over time, extract the relevant parameters for monitoring during the reversibility phases, reduce the parametric uncertainties and enhance the robustness of models for performance calculations and safety analyses. A few points that appear to be major design factors in the context of this scientific programme deserve to be mentioned by way of example:

- The long-term behaviour of disposal packages and their contents, the relevant research work now being within Andra's remit,
- The necessary synergy with the interim storage studies, presently led by Andra,
- Consistency with the experimental and demonstration programmes implemented in the underground laboratory,
- The continuous links to be established with the input data requirements of the simulation programme,
- The efforts to enhance the representation of phenomenology and various transients (primarily thermal, mechanical and hydraulic) over the first millennia. Scientific progress will have to set out to provide the elements needed to characterise the reversibility phase and provide input to the repository monitoring and observation programme (sensors, data transmission facilities, etc.).

Hence, the programme's core is based on fundamental research as before, to make the best qualification and quantification of the processes in question, make the most accurate identification of the thermodynamic bases and kinetics of the simulations, itemise the major processes and rank the problem areas. If responses to the evaluators' recommendations are to be forthcoming, the progress to be made requires considerable scientific effort. This is because progress is often rooted in data, modelling and simulation resources acquisitions that are at the limits of currently available scientific knowledge.

Understanding Phenomenological Processes

These processes are mainly those that govern the radionuclide and toxic chemical (RN/TC) transfers. These processes primarily occur within the immediate repository environment, therefore full knowledge and understanding of them are highly dependent on the capacity to describe and model the physical and chemical evolution of the structure components to site element transfer accurately in context.

The knowledge levels of six particular fields of research need to be improved:

- The chemistry of radionuclides in solution (related to site water chemistry) and further development of the thermodynamic database, ThermoChimie,
- Improvement of knowledge about thermodynamic properties of materials, their behaviour in the environment and with temperature rise,
- Gas transfers and the development of (i) underground and surface laboratory experimental systems and (ii) simulation systems to enhance assessment of consequences over the long term,

- Radionuclide and toxic chemical release mechanisms in repository conditions, that incorporate the interactions with the structure materials and the geological barrier,
- Further work on characterising natural processes arising from fluid-rock interactions so that details of their dating, intensity and consequences in the various geological formations can be confirmed,
- Radionuclide transport-retention coupling in very low permeability clay materials to get a full grasp of scale changes (nano to macro). Thus specific development is required on understanding the interaction of cationic radionuclide diffusion with solid surfaces, and applying consistency to the charge exclusion processes with anionic radionuclide retention. The effects of temperature rise must also be pinpointed, incorporating surface affinity alterations and the interpretation of geochemical transients. Further work needs to be conducted on colloidal transport assessment. In the area of transfers in the surrounding formations and biosphere, additional data is required on RN/TC behaviour (particularly, retention, transfer parameters of the main contributors to impact in the biosphere, conceptual biosphere modelling).

It should be noted that the prime objective is to improve on the acquired results through more sophisticated understanding of the mechanisms to eliminate the penalising simplifications adopted at the feasibility study stage.

Couplings in the Repository and with the Repository Environment

Mechanical, thermal, chemical and hydrological disturbances are induced when ground confinement is lost and exogenous materials and air are introduced, causing an imbalance with the environment of the medium as a result of underground structure construction, operation and closure. The phenomena resulting from these alteration processes are described in the Dossier 2005 and design provisions have been made to limit the allowance made for complex couplings in the proposed repository design. However, further research is required on the physical and chemical interactions between alteration processes, to optimise repository architectures and more refined phenomenological modelling for future safety analyses. This will entail scientific monitoring of the underground and surface laboratory experiments on materials behaviour in the repository situation, in real geochemical conditions conducive to assessing reactivity to the interfaces.

Continuous multidisciplinary in situ investigation of the mechanical and chemical alterations to the damaged zone will be permanently conducted to monitor, observe and characterise the processes responsible for damage, such as fissuring, desaturation and oxidation. Meticulous quantification of the consequences on the physical and chemical properties of the rocks and materials is also envisaged. This long-term monitoring phase is programmed for the 2006-2010 stage, to gather experimentally accessible data, and take advantage of large-scale models and simulations. It will furnish a representative size of samples of the various alterations. Their retention and transport capabilities will have to be defined. Special efforts have to be made on the first millennia, the period during which the main transients develop.

In the area of thermohydromechanical (THM) couplings, there are outstanding questions about the nature of the phenomena to be taken into account and any competition between them when the medium consists of multiple interfaces. Research has to be conducted into THM behaviour during the unsaturated phase with gas production. This approach is closely associated with technological demonstration actions and will set out to propose behaviour models for each repository structure. On the basis of a good grasp of phenomenology in 2005, these actions are exploited to produce results capable of putting fine detail into the repository design and broaden the conceptual models required for the safety analyses. The only coupling built into the simulations made in 2004 combines chemistry with transport as the other phenomena (T & M) were considered to be external constraints. The recommendations made on the

gradual incorporation of some of the THMC couplings in the Alliances platform development will be followed. The mobilisation of applied mathematics research teams is continued accordingly to take methods and tools further forward so to optimise the representation of physical models, and make progress on computing resources and techniques (discretisation methods, breaking down domains, uncertainty management and inverse problems).

All the work on couplings and simulation tool development for these couplings will be gradually incorporated and accumulated through phenomenology alteration models of the repository and its geological environment. This part of the scientific programme is closely linked to the simulation programme that covers all the main actions that aim to improve representation of coupled phenomena.

Changes of Scale

This part primarily covers the spatial and temporal variabilities of the geological medium. It mainly relies on additional data acquisition that will be associated with the borehole and 2D geophysics campaign started in 2007 and scheduled for 2007-2008.

It is useful to break down the operation of a repository by time and space to understand the decisive phenomena governing the changes to the repository and thus make simulation easier. This approach clearly points to the need for a grasp of spatial and temporal scale changes. The approach uses experimentation and digital simulation to: (i) characterise the processes at microscopic (nano- to micrometric) scale, then develop their representative quality up to a macroscopic scale (typically millimetric to centimetric), (ii) define the relevant parameters needed to verify the consistency of the data acquired from the sample size to full-scale experiments, (iii) transcribe these results to make a sector scale representation, and (iv) use techniques and digital simulation resources capable of processing these changes of scale, through deterministic and stochastic methods (for example, by using methods such as the breakdown of the spatial and/or temporal domain, homogenisation, etc.) to define the most favourable zone, in the sector, for any future repository installation. The transport and geomechanical aspects of these various leaps of scale are dealt with in the scientific programme.

In the case of time scales, the qualification of the behaviour laws needs to be researched at the different scales of the processes, incorporating representative states of equilibrium and transients from the kinetics at the scale of elements up to geodynamic processes and their consequences on the geological medium, water runoffs and surface environment. To understand how the medium operates in the short and long term and deduce the rules that will govern its future evolution, best use will be made of past geological history reconstitutions and/or analogues of situations (glacial climate at high latitude) and mechanisms (archaeological examples of metal and glass corrosion) .

Mapping surveys, borehole data (oil boreholes and Andra boreholes including offset boreholes), seismic reflection (2D profiles and 3D block) and the first URL observations and measurements have all boosted knowledge of the geological medium. The URL drifts give access to comprehensive profiles that are essential if assessment of sedimentary variabilities is to improve. All this data has led to the development of a geological model of the Callovo-Oxfordian formation and its surrounding rocks.

Additional observations and measurements will fine-tune the variability assessment and establish correlations between the geological characteristics and geomechanical properties of the argillites, and in so doing, consolidate the model of the URL at the scale of the site. This model will include the variability of the petrophysical and mechanical properties that characterise the confinement capabilities of the Callovo-Oxfordian formation, which will make extrapolation easier.

This is because these data need to be extrapolated to a more extended area for a future repository. Additional work in 2007-2008 followed by work in 2009-2010 will be required for this extrapolation (seismic reflection and boreholes). The results obtained will be used to:

- Firm up fracturing hypotheses, and set at best the geological structural frame likely to govern the siting of a potential repository,
- Study the stationary state of the correlations between geological and geomechanical parameters beyond the underground laboratory. The aim of this is to identify the geomechanical properties at the scale of the transposition zone to facilitate dimensioning, demonstration structure and possibly the repository structure geometry and positioning,
- Refine sedimentary body geometry and petrophysical properties (porosity, permeability, etc.) and by the same token, their role in the transfer mechanisms inside the Callovo-Oxfordian and the more porous horizons of the Oxfordian and Dogger. These parameters will form a database for consolidating the consistency, robustness and reliability of the hydrogeological model from the local scale to the regional scale, to arrive at more accurate transfer times and outlet sites.

Over the longer term, the natural alteration of the site and region will be researched to ascertain:

- The erosion and geometry of the hydrographic systems,
- The direct effects of the climate on water infiltrations.

As in the case of research into couplings, research that is governed by changes of scale could rely on simulation tools that have the benefit of the latest developments, primarily homogenisation and domain breakdown methods and uncertainty handling. The main part of this work will be developed as part of the Alliances project.

Here for the most part, changes of scale of the geological aspect are presented (from the sample to the sector). The methods used are also needed to gain perspective of the situations (for example near-field/far-field), and incorporate the various spatial and temporal constants of the processes and their interactions.

RESEARCH METHODS

The scientific programme over the 2006-2010 period uses five methods:

- Evaluation of the experiments and survey campaigns conducted up to 2005,
- Pursuit of underground laboratory experiments,
- Implementing demonstration operations and developing engineering studies,
- Conducting high-resolutions seismic reflection campaigns and making additional boreholes from 2007,
- Developing and qualifying powerful digital tools.

These methods, in association with European Commissions' EURATOM Framework Programme 6 (FP6) ESDRED, FunMig, NF-Pro, MICADO and PAMINA projects and those expected from FP7, offer many systems for additional data acquisition and assessments of the uncertainties outstanding at the end of the 2002-2005 exercise. This is how the scientific repository study programme for a clay medium is envisaged over the 2006-2010 period. It *de facto* involves significant contribution from the scientific community. Andra is involved in discussions on FP7. In this connection, ANDRA seeks to enlist its national partners in the best interests and encourage their involvement in defining, then conducting future programmes scheduled to be set up by 2008.

In recent years, the research mission entrusted to Andra has taken the form of a scientific policy that has used many developmental methods involving the French and international scientific communities. It has laid special emphasis on establishing long-lasting partnerships, selecting the best available competencies and aligning ANDRA's needs with the operating dictates of the research laboratories involved. This policy has been adjusted over recent years to improve coordination between ANDRA's and the national partner laboratories' objectives.

This trend provides a vast set of recognised competences that cover the whole spectrum of project-related disciplines. The aim is to pursue and redouble these interactions to devote scientific research to the design and demonstration operations that are the priorities for the 2006-2010 period. Mobilisation to this extent in the context of such an important stage, calls for sustainable partnership relations and the display of strong commitment to the research operations on the part of Andra. In particular, the 2006-2010 scientific programme is piggybacked to a thesis and post-doctoral studies allocation policy of similar scope to that used during the 2002-2005 period.

The programme primarily turns to existing scientific partnerships. To ensure continuity in collaborative work and give future research and development operations the best start, a partnership renewal procedure between Andra and the major French research bodies has commenced and will be continued on the basis of this scientific programme. At the same time, comparable laboratory groupings to those set up or renewed in 2002-2003, also form major organisational elements of the research to be developed.

This scientific programme is an element of information and consultation with Andra's partners. It is part of ANDRA's approach to openness that aims to accommodate academic involvement in medium- and long-term programmes and on complex subjects, often at the current limits of knowledge, that require increased multi-disciplinary input. It is with this in mind that the research programmes and their organisation are being forwarded to Andra's main partners at the time of publishing for preparation by the end of 2006.

CONCLUSION

At the completion of research conducted since 1994, Andra considers that it has established the feasibility in principle of a repository in a clay formation. This is, however, only one stage in the design and possible creation of an industrial facility. The latter calls for technological demonstration operations and refined knowledge of the mechanisms that were handled in a simplified and sometimes penalising manner when making the assessments presented in Dossier 2005. Cognisant of this, Andra has drawn up an initial programme of work that is mainly covered over the period from 2006-2010, that allows for certain experimental, methodological and technical developments to extend beyond 2010. This programme is closely linked to demonstration and engineering work to be carried out on the basis of which the research will be more specifically aimed at refining our understanding of the elementary mechanisms and couplings. Lastly, a final dimension concerns the changes of scale, linked to the problems of siting a potential repository. The programme presented is the fruit of discussions carried out in connection with Dossier 2005, and in particular the assessments made of it. It is likely to be modified and adjusted, primarily on the basis of the underground laboratory experiment results and the lessons drawn from the borehole and 2D seismic campaign during years 2007-2008.

Lastly, although it carries on continuity with the 2002-2005 programme, its content attests to a very clear shift towards acquiring in situ data (experiments and demonstration operation in the underground laboratory) and modelling complex processes as recommended by the Dossier 2005 evaluators.

Thus for Andra and its partners, the most suitable structures for the research to be carried out for the 2012 and 2015 datelines will have to be defined in common to a tight timetable.

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