Current Status of the French Radioactive Waste Disposal Programme

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Abstract

The 15 years of research prescribed by the Law of 1991 are now over. Their results led to the promulgation of a new planning act on 28 June 2006 detailing the applicable conditions and process for the pursuit of further programmes. It sets 2015 as the deadline to submit the statutory application in order to commission a deep geological repository for high-level and long-lived radioactive waste by 2025. The new law also sets the prescribed framework for the management programmes of the different waste categories.

As the years went by, experience kept accumulating and helped us to advance. Today, we are able to draw some lessons concerning the success factors of the most difficult projects in complex environments. Significant progress was recorded not only on the scientific and technical scales, but also and mainly with regard to governance and decision-making.

The *Planning Act of 28 June 2006* concerning the sustainable management of radioactive materials and waste marks a new step in the French legislation. It represents the natural outcome of the 15 years of research instigated by the Law of 30 December 1991. It is known also as the "Bataille Law" from the name of Christian Bataille, MP, who drafted it and monitored its enforcement as a member of the Parliamentary Office for Scientific and Technological Assessment (*Office parlementaire d'évaluation des choix scientifiques et techniques* – OPECST). Many advances were made concerning not only scientific and technological knowledge, but also governance. The new law opens brand new prospects in relation with those different aspects.

Lessons from experience

Andra's history began in 1969 with the implementation of the *Centre de stockage de la Manche* (CSM), the first disposal facility for low-level and intermediate-level short-lived radioactive waste. It continued with the commissioning of the *Centre de stockage de l'Aube* (CSA), the second disposal facility for the same waste categories at Soulaines, Aube. A large number of lessons were drawn from the first experiment in the field of site selection, implementation, design and operation. In this paper, a few examples will serve to illustrate how initial weaknesses needed to be corrected for the CSA's sake. The first point deals with the selection of a suitable site. All initial disposal operations at the CSM were essentially justified by the proximity of waste-generating facilities.

The first waste packages were deposited in trenches on a site with a complex geology and hydrogeology that made the safety demonstration all the more difficult to validate. First and foremost, the CSA was selected for its intrinsic characteristics: a very simple geometry consisting of a draining-sand layer above a clay layer. The sand layer allows potential seepage waters to be transferred to a single outlet that is easy to characterise and monitor. The clay layer prevents any contamination risk of the deeper aquifers and, consequently, any radionuclide transfer over several kilometres.

However, selecting the site on the sole basis of natural, geological and hydrogeological criteria would not have been sufficient to implement a disposal facility without taking into account also the human and social environments. The quality of the CSM's relationships with its environment derives from the

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sound integration of its activity and of its staff within the local fabric. Many crisis situations occurred since 1969, but each of them helped to progress towards improved information and transparency. One might add, though, that the climate of confidence was not only due to the quality of communications. A responsible management, including the retrofitting of certain structures when necessary, as well as safety studies and demonstrations concerning the environment, human beings and their health, were most instrumental in building confidence. The improvements achieved at the CSM, sometimes due to crisis situations, were taken into account for the implementation of the CSA. The sound integration of Andra's staff within the local fabric, together with a communication programme that is increasingly available to all and a financial-incentive policy, have all contributed to the creation of the CSA.

Concurrently, the first safety assessments showed the advantages of multi-barrier mechanisms and the CSM was restructured according to that principle. Integrating the multi-barrier approach as early as the design stage of the CSA facilitated significantly the implementation procedure. Although that approach is now considered classical, it is still quite recent and consists in prescribing performance criteria for the packages, the structures and the site. It helped, for example, to specify the strict characteristics for waste packages, which are used today as waste-acceptance criteria (WAC). The classification of radioactive waste is based on the possibilities to dispose of them. Those possibilities rely on the WACs through combined criteria relating to the activity and the radioactive half-life of the radionuclides contained in the waste.

Disposal structures also benefit from new design and construction approaches. From the very beginning, the monitoring and the closing of the site were both taken into consideration. The seepage-water-collection networks run under the CSA's overall system of existing and projected structures. Their purpose is to monitor precisely the presence of any seepage, to trace back its origin, as well as to collect and analyse samples of it. Those networks, together with the piezometers spread through the environment are monitored on a permanent basis and the corresponding results are published every six months. Fortunately, no anomaly has been detected so far at the CSA and in its environment since commissioning in 1992. An experimental cover was installed right from the start in order to provide hindsight and experience concerning the selection of sound design and construction options when time comes to shut down the site definitely and to move on to the monitoring phase.

With regard to operation, controlling compliance with WACs on the waste-production sites and upon delivery of the packages at the CSA proves to be one of the major achievements. The computerised monitoring of the content of waste packages also ensures a finer management and a better control of their position within the disposal cells. Hence, suitable methods and tools have been developed in order to ensure a state-of-the-art traceability and to track down the origin of any anomaly, if need be.

The know-how transmission between the CSM and the CSA proved most fruitful. It also worked most successfully for the implementation and the commissioning of the disposal facility for very-low-level radioactive waste (*Centre de stockage pour les déchets de très faible activité* – CSTFA) at Morvilliers, located close to the CSA.

Figure 1: Aerial view of the CSA.

Figure 2: Aerial view of the CSTFA.

Research context in 1989

On the other hand, when new studies were launched in 1989, they were met with an opposition movement that was sometimes violent. However, the conditions were quite different. A broad research programme had been initiated without any prior information in order to study disposal options for high-level and long-lived radioactive waste. Doubts were raised and opposition developed due to the lack of information, thus leaving the field open to all sorts of interpretations and fears. Apart from the lack of information, the situation worsened due to the ignorance surrounding the issue. Until then, the only issue to be addressed had been low-level and intermediate-level waste, whose half-lives lie within the order of 30 years, a historical timescale that everybody is able to grasp. All of a sudden, though, citizens were requested to change their reference timescale and to jump to one million years, a timescale with which geologists may be familiar, but totally out of the boundaries of a layman's imagination. In addition, since people had just lived the Chernobyl catastrophe, it is easy to understand that they would associate it readily with the disposal of radioactive waste generated by nuclear power plants, that was now at stake, and increase their own anxiety.

Within such a context, the Prime Minister declared a moratorium that lead to the adoption of the Law of 30 December 1991 in which the following innovating approaches were prescribed:

- a stepwise decision-making process;
- the study of alternative solutions;
- independent assessment;
- information;
- the independence of the agency responsible for radioactive-waste management in relation to waste producers.

Main steps and achievements since 1991

Soon after the adoption of the Law and the corresponding decree, the government entrusted upon Mr Christian Bataille, MP, to organise a public consultation with a view to seeking potential implementation sites for underground research laboratories (URL). In the meantime, however, the situation had changed drastically, since the information mission was now given to a member of Parliament, detailed monitoring and control conditions were prescribed and financial-incentive modalities were clearly defined. In 1993, four candidate sites were selected among approximately 30 voluntary applications: a granite site under a sedimentary cover located in the Vienne; a deep marl site located in the Gard close to the Rhône River, as well as two sites located in Callovo-Oxfordian argillites, one in the Meuse and the other in the Haute-Marne. Those two last sites were rapidly combined to form the Meuse/Haute-Marne Site.

As early as 1994, and for a period of two years, detailed investigations were launched. At this stage they were limited to the form of surface boreholes and in geophysical-measurement campaigns. Concurrently, local information and oversight committees (*commission locale d'information et de suivi* – CLIS) and incentive funds were set in place. Based on the conclusions of its studies, Andra submitted three applications to authorise the implementation of URLs on the Vienne, Gard and Meuse/Haute-Marne Sites. In 1997, the applications were the subject of public inquiries. Relevant territorial communities were called upon to express their views and confirmed their willingness and, consequently, their agreement to host such URLs.

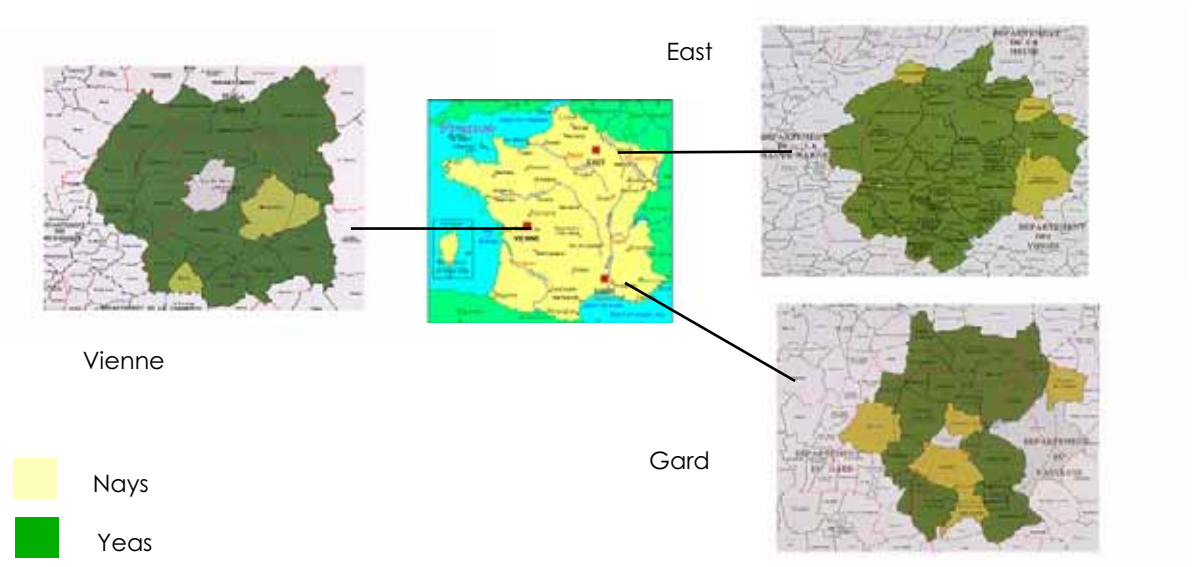

Figure 3: Vote results of the territorial communities in 1997 concerning three sites: Vienne, East (Meuse/Haute-Marne) and Gard Sites.

The government's decision following the review of the applications by the competent services confirmed the continuation of operations in the Meuse/Haute-Marne with the creation of a URL in Bure. On the other hand, both the Gard and Vienne Sites were abandoned. In parallel, the government set in place a research mission in order to find a new granite site, but the project was not met with any local support and was finally terminated in 1999 following numerous opposition movements. In the meantime, the preliminary work started for the construction of the Meuse/Haute-Marne URL. The construction phase and the first experiments took place from 2001. The accumulated information served as the basis for the *Dossier 2005 Argile* that was submitted to the government in mid-2005.

The scientific and regulatory assessments of the *Dossier* were entrusted to the National Review Board (*Commission nationale d'évaluation* – CNE) and the Nuclear Safety Authority, respectively. The French government also requested that an international peer review be carried out under the aegis of the OECD Nuclear Energy Agency (NEA). The resulting opinions were quite remarkable and very encouraging for Andra and for its scientific and technical partners, thus emphasising the quality of the work undertaken according to the best international standards and concluding to the feasibility of a deep geological repository.

The government also wished that a national debate be organised concerning the long-term management of radioactive waste. Consequently, it called upon an independent entity, the National Commission on Public Debate (*Commission nationale du débat public* – CNDP). After six months of preparation, the debate included 13 meetings that were held in different cities from September 2005 to January 2006. Scientific and technical themes, management strategies and governance were discussed at length. In its final report, the Commission stressed the existence of a general demand for:

- all waste categories to be taken into account by the legislation;
- the need to improve governance regarding radioactive-waste management;
- the advantages of a stepwise decision-making process;
- and the need for a true economic-incentive programme for the territories on which any deep geological repository would be implemented.

Lastly, the report of the OPECST, published in March 2005 by Messrs Birraux and Bataille, MPs, analysed the results of investigations from the standpoint of management strategies. It concluded to the complementarity of the three research areas prescribed by the Law of 30 December 1991: partitioning and transmutation, deep geological disposal and long-term storage.

Presentation of the Law of 28 June 2006

The new act falls in line with the approach adopted by the Law of 1991 by prescribing specific deadlines for the different management solutions to be enforced. For partitioning and transmutation, industrial prospects relating to the investigations for the fourth generation of reactors shall be established by 2012. With respect to a reversible repository within a deep geological formation, all relevant elements shall be gathered in order for the corresponding application for the implementation of a deep geological repository to be submitted and reviewed by 2015 and for the repository to be commissioned in 2025. This date is compatible with the production schedule of high-level and long-lived waste by the French nuclear-fuel-cycle industry.

The new act also provides two essential elements in areas that were not addressed by the Law of 1991. It meets one of the recommendations formulated during the public debate and advocates a true national management policy, not only for radioactive waste, but also for radioactive materials, whether recoverable or not, by instituting the National Radioactive Waste Management Plan. Besides setting specific deadlines for high-level and long-lived waste, the act also prescribes that a decision be made by 2013 for graphite and radium-bearing waste, a category of low-level but long-lived waste. Hence, within the next few years, all categories of radioactive waste will have been attributed a relevant management solution.

<table>
<tr><th></th><th>Short-lived
(half-life < 30y years)</th><th>Long-lived
(half-life > 30y years)</th></tr>
<tr><td>Very low level
(VLL)</td><td colspan="2">VLL Waste Disposal Facility (Aube)</td></tr>
<tr><td>Low level
(LL)</td><td rowspan="2">LL/IL Waste Disposal Facility(Aube)</td><td>Investigations on repository projects
Commissioning in 2013</td></tr>
<tr><td>Intermediate level
(IL)</td><td rowspan="2"></td></tr>
<tr><td>High level
(HL)</td><td colspan="2">Investigations conducted in accordance with the Law of 30 December 1991, and now with the Planning Act of 2006</td></tr>
</table>

Figure 4: Classification of radioactive waste and status on disposal solutions.

Moreover, the new law establishes the legislative framework for the dismantling of nuclear facilities and, particularly, for the secured financial provisions to be constituted by waste producers in order to ensure that an amount of 68 billion euros, which is currently deemed adequate, be available. Parliament will participate in the control of those financial provisions and in their appropriation as dedicated assets in the companies' accounts.

Lastly, the law strengthens the socio-economic incentive programme applicable to the territories concerned by the implementation of a potential waste repository. It reinforces the status of the existing public-interest groups (*groupement d'intérêt public* – GIP) devoted to the local development in the Meuse and the Haute-Marne with a view to involving the nuclear industry in local industrial projects, while improving the status of the local consultation and information structure for elected officials and citizens.

Beyond its industrial mission regarding radioactive-waste management, its research mission notably with respect to high-level and long-lived waste, and its information mission to disseminate relevant knowledge, the major evolutions of Andra's mandate involve:

- leading investigations on waste storage;
- designing, implementing and managing waste-storage and disposal facilities;
- taking over orphan waste and sites (public-service mission).

Success factors

The accumulated experience certainly constitutes the most important capital since it has allowed us over the years to improve operational and safety procedures and should prove beneficial for the implementation of any new facility. However, it is not sufficient to undertake field investigations without preparing adequately the various publics and without launching a broad information campaign beforehand. What happened in local communities in 1989 highly proved that point, since over and above the triggered opposition to the implementation project and the associated work, the events instilled a climate of doubt at National level. Consequently, it was necessary to gain back public confidence, a challenge that proved all the more delicate since the progress to be achieved after a crisis period is always broader in scope. The purpose is by no means to move from indifference to confidence anymore – a situation that represents a larger gap on a value scale – and requires a much more significant effort altogether.

The 1989 crisis will have served to provide a structured process with regular controls and prescribed deadlines as clearly indicated in the Law of 1991, thus marking a decisive step with regard to governance for radioactive-waste management.

Based on the certainties formulated by the technicians, the Law of 1991 was able to introduce alternative solutions. In order to undertake the disposal of radioactive waste within a deep geological formation, it is necessary to verify that there are no other suitable means to eliminate or to process that waste. That is the purpose of the investigations on partitioning and transmutation, the first area over the last 15 years of prescribed research. The second solution involves deep geological disposal itself. By prescribing that the reversibility of such an option be ascertained, the Law of 1991 introduced a brand new concept, at least in the mind of many people, since the approach moved from a rationale based on burying the waste and, to some extent, on forgetting about it, to the approach of a responsible manager who may be called upon not only to recover the waste during a certain timescale, but also to ensure the monitoring of the facilities and of their environment, sustaining thus any further decision either to retrieve waste packages or to close disposal drift or access tunnels. The most important criteria upon which a decision would be taken is the comparison between the monitoring results with those predicted from all the studies and models. Lastly, the third area involved stabilising, conditioning and storing the waste over the long term, which represents another form of long-term alternative before considering a final solution.

Policy-makers have also placed research programmes and results under the strict control of the CNE, whose responsibility is to submit an annual report to Parliament and the government. The assessment of management strategies is entrusted upon the OPECST. A deadline was set in 2006 in order to take stock of the investigations and to recommend whether to move on to further steps.

Besides programme control, two accompanying structures were set on the sites themselves in order to involve and to give responsibilities to local representatives, elected officials, administrations and associations. The first structure consists of the CLIS, whose mandate is to monitor the evolution of investigations and to inform the public on the related programmes, their advances and their results. The second structure, consisting of various public interest groups (GIP), manages the incentive funds dedicated to local development projects.

Through the political framework and the local incentive programmes for each site, a general system is set for both the national and local supports of new implementations, as in the case of the Meuse/Haute-Marne URL. Inversely, once the government decided not to pursue the granite project in the Vienne,

the mission prescribed by the government to seek a new site was not met with the essential local support for its implementation.

Among the success factors, the evolution of Andra's views has also played an important role. In the past, Andra was but a simple agency within the French Atomic Energy Commission (*Commissariat à l'énergie atomique* – CEA), one of the major actors in the nuclear field. Thanks to the Law of 1991, Andra's status evolved into a public establishment, independent from waste producers and reporting to three supervisory ministries: Industry, the Environment and Research. That evolution reflected also the direct implication of the State in safe management practices for the protection of human beings and their environment. Once again, it also involved a switch-over since the purpose was to make clear that not only was the State responsible for managing and conducting research on radioactive waste, but it was also exerting a full control on policies that might have been imposed otherwise by waste producers.

Lastly, the confidence deficit also resulted from the general lack of transparency. The regular publication of an updated national inventory of all radioactive waste present on French soil has largely contributed to re-establish part of that confidence and all the more since the successive editions have been enriched progressively with new information, notably with regard to military activities, which are normally secret in nature.

The Law of 1991 provided a very rich framework with a view to reviving essential values, such as responsibility, not only in the sense of the collective responsibility towards radioactive-waste management, but also the responsibility of each actor, each political decision-maker at the national scale, each local supporter of new facility projects, each scientist, each association and, of course, each waste producer through the requirement to fund the relevant programmes.

At the scale of important decisions such as the future of radioactive waste, the statutory 15-year timescale also allowed a stepwise approach within the decision-making process, including a major threshold to be crossed when the Law of 28 June 2006 was promulgated.

A sustained information programme is necessary for the sound conduct of such projects. Its purpose is to ensure that everybody is able to follow their evolution, to assess their achievements and to organise a debate in order to improve and to share the general reflection. Provided that projects and investigations are launched on a clear, transparent and stable basis that has been determined from the very beginning of the process and that continues to be shared among the different actors, Andra is readily in a position to relay messages in accordance with its communication and information mission. That basis must therefore help to reinforce confidence and, in order to achieve that goal, must abide by the two following principles: the possibility to verify information and the requirement never to leave a pending issue without a legitimate answer. A wide communication approach was launched to reach the various publics with a special emphasis on the clarity of the messages to be disseminated, particularly with regard to complex scientific issues. The primary objective is to explain and never to run the risk of introducing doubt by creating a mental block of the general public when faced with a seemingly unexplainable complexity.

Communication documents are made available free of charge, in either paper or electronic version, or are downloadable from Andra's Web site (www.andra.fr); they represent the Agency's main information vectors. Guided tours of the different surface disposal facilities and of the Meuse/Haute-Marne URL also help in improving public confidence by providing the public an opportunity to observe *in situ* the quality of the Agency's achievements. In 2005, for example, no less than 13,000 visitors were greeted on Andra sites.

Lastly, one of the requirements to control the external processes prescribed by the Law relates to the quality of internal activities. It gives rise to the different assessments mentioned above and it is also confirmed in its application by the delivery of ISO-9001 and ISO-140001 certificates, which implies the strict observation of the commitments taken by the Agency, especially with regard to deadlines.

Examples of specific recent achievements

A major milestone was reached in 2006 with the promulgation of the Law of 28 June, which opens up new prospects for managing the entire set of radioactive waste categories, including high-level and long-lived residues. In the meantime, surface disposal facilities continue to operate and to undergo specific developments, such as the experimental work carried out in the Meuse/Haute-Marne URL.

Surface disposal facilities

Close to 25,000 m^3 of radioactive waste were delivered at the CSTFA. At the CSA, 15,514 m^3 of radioactive waste were accommodated in 2005 and the filling rate is progressively reaching the 20% mark.

In both facilities, specific solicitations from producers have led to consider storing bulky items.

The waste intended for disposal in Andra facilities exists in the form of packages whose shapes and dimensions are mentioned in detail in the handling specifications within those facilities and in the deposit specifications within disposal structures. However, some waste categories may have a complex and bulky shape that requires major cutting operations in order to be conditioned into acceptable packages within those facilities.

In certain cases, the direct transfer of such large-size waste may provide additional radiation-protection benefits by reducing the intervention time on dismantling worksites.

Andra has already taken over the responsibility for such waste at both the CSA and the CSTFA. In the first case, which deals with low-level and intermediate-level waste, specific structures have been designed to accommodate reactor-vessel covers originating from *Électricité de France*'s (EdF) nuclear power plants. Six covers were received in 2005, bringing to nine the total number of disposed covers.

Figure 5: Transfer of a reactor-vessel cover towards the disposal-cell area (*left*) and placement in a disposal cell (*right*).

In the second case, the VLLW Disposal Facility received the exchange bottles from the Saint-Laurent A NPP as well as used transport containers from Cogéma Logistics. Andra is currently studying the possibility to take over the steam generators of the Chooz A NPP and the light neutron shields from the Creys-Malville NPP.

A parallel reflection is under way in consultation with waste producers concerning the definition of a waste inventory suitable for direct disposal in order to anticipate the facility's future operational and equipment requirements with sufficient lead-time.

Andra's capability to take into account waste with atypical characteristics after carrying out feasibility and safety studies and after obtaining any relevant agreements also helps to reinforce the confidence of not only waste producers who are provided with a suitable reference structure that is able to grasp a

difficult issue and, above all, to provide them with an adequate solution, but also of the public in general who appreciates the fact that a safe solution exists in each case.

Meuse/Haute-Marne Underground Research Laboratory

The construction of the Meuse/Haute-Marne URL was completed with the junction of the connecting drift between the two shafts and the opening of the drifts and structures prescribed in the initial programme. Final operations are under way in the shafts with the installation of the permanent lift machinery.

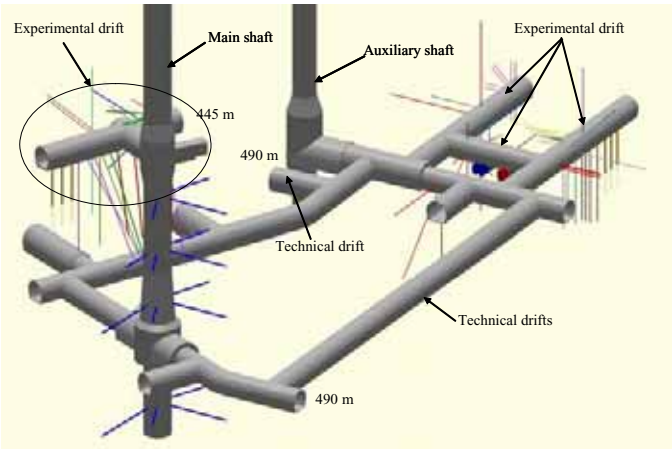

Figure 6: Layout of the Meuse/Haute-Marne Underground Research Laboratory.

The experimental programme started as early as shaft-sinking operations at the end of 1999 and culminated with the opening of the drift located at a depth of 445 m. During excavation operations, a fine geological and hydrogeological survey was undertaken to study the overall sedimentary profile down to the roof of the Callovo-Oxfordian formation at a depth of 420 m. Work in the argillites not only provided detailed geological surveys, but also allowed for observations and measurements to be made concerning the mechanical behaviour and the resistance of the formation to excavation. A large number of preliminary experiments were conducted in the niche before the actual experimental drifts located at a depth of 490 m became operational, thus allowing for the first data to be collected and for the initial set-up to be made in preparation for the further experiments to be performed at the bottom.

Figure 7: Drilling operations for the installation of geomechanical-measuring devices during the sinking of the main shaft.

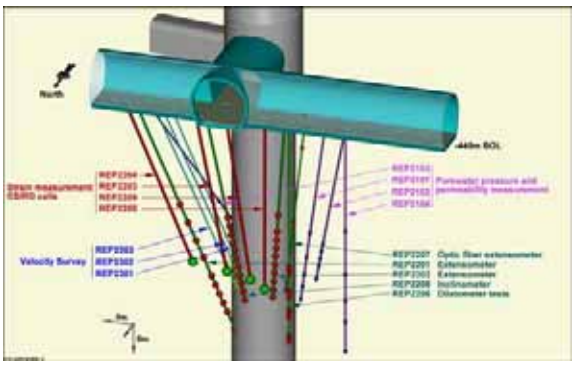

Figure 8: Drilling of boreholes from the experimental drift (-445 m) in order to monitor the hydrodynamic characteristics around the shaft during shaft-sinking operations.

One of the initial motivations to create a niche was to excavate observation and measurement wells in the immediate vicinity of the main shaft before its sinking and, thus, to record all signals likely to describe the mechanical behaviour of the argillite during and after excavation. The impact of excavation on hydrodynamic behaviour was also analysed thanks to the instruments set in place. In addition, the first diffusion experiments were conducted, and confirmed the characteristic values of transfer properties that had been obtained from laboratory specimens.

At a depth of 490 m, the number of observations, measurements and experiments intensified in order to confirm primarily the validity of existing data. One of the challenges was to collect and to characterise water samples within an environment known for its low water content in the order of a few percent and mostly for its very low mobility (horizontal permeability in the order 10^{-13} m/s).

A last mention should also be made that mechanical measurements were used to study various means to seal disposal structures. In order to prevent any risk of hydraulic short-circuit through the excavation-disturbed zone (EDZ), various cuts were made on the drift walls and filled with bentonite briquettes.

Since the launching of operations on the Meuse/Haute-Marne URL Site, 27 deep boreholes were drilled from the surface and 130 scientific boreholes were drilled from the 40-m-long niche and from the different drifts extending over a total length of 484 m at a depth of 490 m.

Current research programme until 2015

Today, the first phase of the experimental programme is fully operational. The programme for the second phase was prepared and will be launched progressively with a view to reducing further the margins of uncertainty, confirming acquired data and submitting the formation to various solicitations (e.g., heat or the presence of exogenous materials, such as hydraulic binding agents or steels).

Technological tests are also scheduled in order to verify the feasibility of certain methods and processes to be implemented before a future disposal facility may be implemented and operated.

Since the Act of 2006 prescribes that no disposal site may be proposed if its host geological formation has not been submitted to various studies within a URL, all investigations will need to be concentrated in the Bure area. Proposing a site will be the main challenge before submitting by 2015 at the latest an authorisation application to implement a waste repository. A 200-km^2 transposition zone has been therefore delineated around Bure: its geology is well described and its characteristics are deemed sufficiently similar to those of the Bure Site to be directly transposable to the zone. Both a 2-D seismic campaign, followed by a 3-D seismic campaign at a lower scale, are scheduled to take place before 2009 in order to verify the absence of any major tectonic accident.

Seeking a suitable site for the authorisation application to implement a waste repository also requires a sustained information, consultation and co-operation effort with local communities who will be expected to participate in a territorial project integrating the repository project. Besides the significant incentive programme prescribed by the Law, industrialists have committed themselves to supporting local-development endeavours. Many industrial implementations are already planned in the region. The political, social and economic dimensions have been incorporated as early as possible and are very closely monitored by the government.

Investigations continue at the Meuse/Haute-Marne URL and the information generated by the related experiments keeps accumulating. The major research themes include the furthering of the knowledge and the representation of the phenomena involved in the operation of the waste repository, the study of their couplings, upscaling over the entire expansion of the repository and over timescales beyond the field of experience, as well as the description of mechanical, hydraulic, thermal and chemical transients, especially to provide a finer knowledge in preparation for the reversibility study and the associated monitoring means.

Among the important issues that gave rise to recommendations by the various assessment authorities, a special mention should be made of the need to further knowledge about the EDZ, radionuclide migration within the Callovo-Oxfordian argillite and the behaviour of gases. Another recommendation

addressed the need to create demonstrator models not only for building and closing disposal structures, but also for transferring and emplacing waste in those structures. Those suggestions were incorporated in the research programme to be conducted until 2015.

All those elements, whether scientific, technical, socio-economic or political, will nurture the public debate prescribed by the Law of 2006 in preparation for the authorisation application to implement a disposal facility for high-level and long-lived waste. A sustained programme has therefore been developed and includes the preparation of a first report by 2012 with a view to organising the debate and to finalising the report by 2015.

Conclusion

The last 15 years of hard work that recently resulted in the promulgation of a new act were marked with several significant developments with regard not only to scientific and technical expertise, but also to human behaviour and governance, especially in the context of complex social challenges.

Today, new issues are at stake, but are in direct line with the ones experienced so far. The Law of 2006 opened the way to the implementation of a waste repository for high-level and long-lived radioactive waste. It also refined the national radioactive-waste management mechanism by instituting the National Management Plan for Radioactive Materials and Waste, thus prescribing suitable management methods, whether under study or already implemented, for every waste category. The Plan will take into account the different programmes, including those for the disposal of high-level and long-lived waste, as well as of graphite and radium-bearing waste, for which the Law prescribes that a suitable facility be commissioned by 2013.

All those projects will need to be accompanied by a sustained effort in favour of information, communication, training and diffusion of know-how. Such an endeavour will require a strong implication of all stakeholders with a constant concern not only to share their knowledge and the new data, but also to promote them within the framework of a project of national interest.

Before closing, I would like to reiterate how strongly I feel about international co-operation. Without it, Andra would not have been able to develop its experiments as efficiently as it did in the underground laboratory and would have desperately fallen short of a most fruitful debate and of the resulting advances. As in the case of the first phase, Andra is inviting all foreign teams to participate in its ongoing experimental programmes at the Meuse/Haute-Marne URL.