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PHASED REVERSIBILITY UNDER THE CURRENT FRENCH DISPOSAL CONCEPT

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Abstract

The French law of 30 December, 1991 and the implementing decrees provide for taking into account the reversibility in the study of geological disposal. This takes place within the framework of a 15 year research program. The research in this field implies both the assessment of technological possibilities for retrieving waste packages safety from the repository and the assessment of the consequence of delaying the closure of the repositories on the long term safety. This research program aims at proposing to the decision makers, by the year 2006, an open range of relevant options with regards to reversibility.

1. INTRODUCTION — THE FRENCH CONTEXT

The French law of 30 December, 1991 concerning the management of high level and long lived radioactive waste defined three main research directions [1]. 15 years of research are considered to prepare choices and decisions for 2006.

One research direction consists in studying the possibilities of reversible or irreversible disposal in deep geological formations, notably through the creation of underground research laboratories.

The reasons for the reversibility of a geological disposal are manifold: they are essentially based on the principle that future generations whether near or far should have the possibility of re-examining our current technical decisions or solutions to manage high level and long lived waste, and should consequently have a freedom of choice. These reasons were widely discussed during the drafting of the law of 30 December, 1991. During the 1997 public inquiries for the construction of underground research laboratories, ANDRA has taken careful note of public interest and of the elected representatives' insistence for the study of reversible geological disposal.

In 1998, following the French Government's request to the National Reviewing Committee (CNE) for a report on reversibility, ANDRA explained to the Committee what the scientific and technical implications of a reversible repository might be during its construction, operation and closure [2]. ANDRA sought more particularly to define at which moments, under which conditions and with what ease or difficulty, it would be possible to access and retrieve radioactive waste packages disposed of deep underground.

The report of the CNE pointed out in particular ethical issues which connect the acceptability of decisions to their reversibility [3].

On the 9 December, 1998, the French Government confirmed the decision to carry out the research in two underground laboratories and in the "logic of reversibility". The Government noted the CNE's definition of "reversibility" which consists in the possibility of retrieving the disposed waste safely and providing an important advantage for the society. In its decision, the French Government mentions that the "architecture of the repository must also provide for the logic of reversibility" [4].

On the 3 August, 1999, the Government issued the implementing decree for the construction and operation of the underground research laboratory on the Meuse/Haute–Marne site in the East of France. According to this decree, the research to be performed within the laboratory aims at providing data required to "the design, the optimization, the respect of the reversibility and safety, of a potential radioactive waste repository".

Another demand of the French Government is to pursue the research on the possibilities of geological disposal in granite rock on a new site to be selected.

2. THE PHASED APPROACH

The basic objective of a geological repository is to ensure the protection of human beings and of the environment. The safety of such a repository must be guaranteed over long periods of time. Safety requirements are naturally strict on the issue. They must not be challenged by further hazardous technical solutions concerning the reversibility of disposal.

Schematically speaking a repository consists of shaft leading to deep underground access/haulage drifts, and to further handling drifts. These handling drifts give access in turn to vertical or horizontal cells (silos, vaults, boreholes and tunnels) where waste packages are emplaced. A series of identical cells containing similar waste constitutes a "disposal module".

As such, the life-cycle of a repository (Fig. 1) starts with the construction and operation phases (Phase 1), followed by the step–by–step closure of the cells, the modules and the repository itself, each step corresponding to a successive disposal phase (Phases 2, 3, 4 and 5).

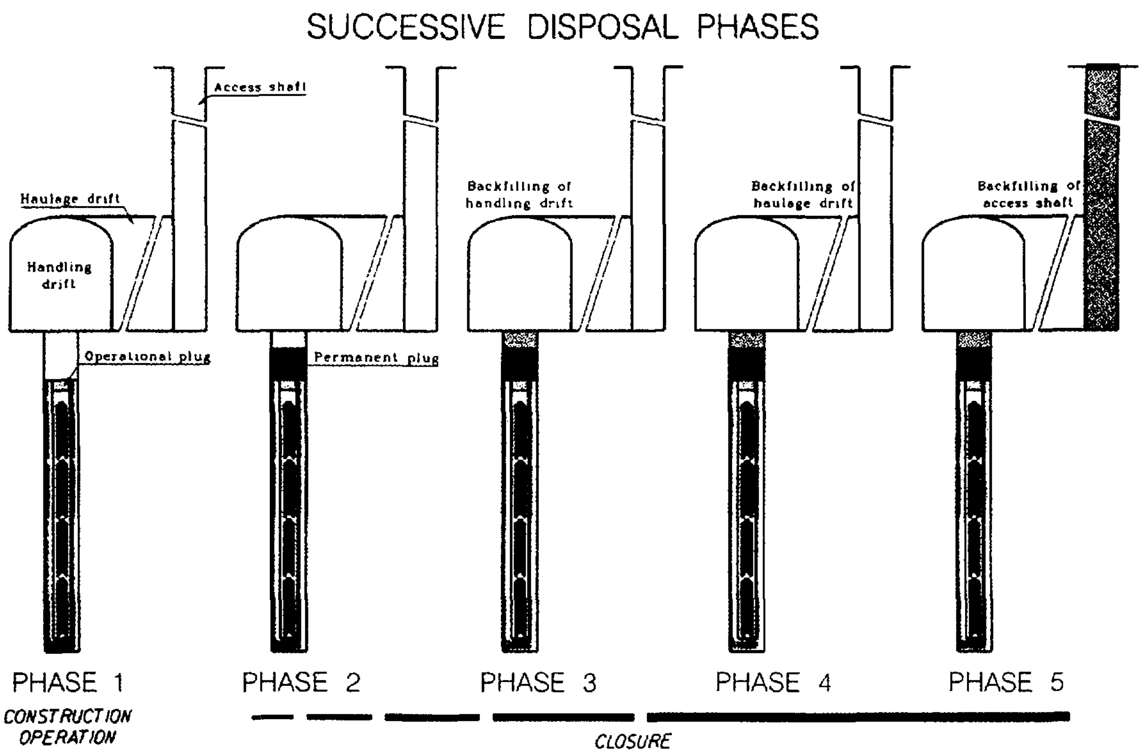

FIG. 1. Successive disposal phases.

3. THE CRITERION REVERSIBILITY IN THE DESIGN OPTIONS

At the current stage of the research programme, the selected preliminary design options include the possibility to retrieve the waste packages during the operational phase without jeopardizing long term passive safety" it is the "initial retrievability of a repository" or "initial reversibility".

Practically in the argilites of the Meuse/Haute–Marne site, different options of disposal cells are designed with respect to the type of waste (see Fig. 2):

- Transuranic no heat emitting waste packages are planned to be disposed in horizontal tunnels. Their length is about one hundred meters and their diameter six meters. An option based on larger section caverns is also being studied. For both options, the "engineered barriers" placed between the waste packages and the argilite are made of concrete.
- Heat generating vitrified waste packages are disposed in shorter horizontal tunnels. Their length is about 25 meters and their diameter 2.5 meters. A swelling clay based buffer material is envisaged around the packages. Vertical borehole option is also being studied.
- For the option of disposal of spent fuel, the packages can be placed in the bottom half section of a horizontal drift, the upper half section being devoted to handling operations. To constitute an engineered barrier, options on concrete and swelling clay are both being considered.

In order to ensure the "initial retrievability" of a repository during operation phase without jeopardizing long term safety, different factors are taken into account in the design of a repository. For instance:

- The modularity of a repository contributes to the "logic of reversibility": the higher the modularity, the easier it is to adopt specific reversibility requirements as the state of each module may differ along with the successive life-phases of the repository.
- A few centimetre's clearance between the waste packages and the engineering barriers are provided within the range of design options. This clearance facilitates the retrieval of waste packages from the cells.
- The sizing of the excavations, that of the support–systems of packages and that of the steel liner of swelling engineered barriers should guarantee the mechanical stability of the system and the steadiness of the clearance between the waste packages and the engineered barriers.
- As for high level vitrified C wastes, the potential adoption of an overpack facilitates the retrieval of waste packages. An overpack provides a great mechanical strength of packages and a high level corrosion resistance.
- Shielded handling equipment and shielded operational plugs ensure the radiological protection of the operators.
- Additional remote handling equipment is defined to potentially retrieve the packages in the case of horizontal disposal tunnels.
- Lastly, means to ensure general operating conditions which are favourable to accessing and retrieving packages are provided, e.g., for instance adequate ventilation.

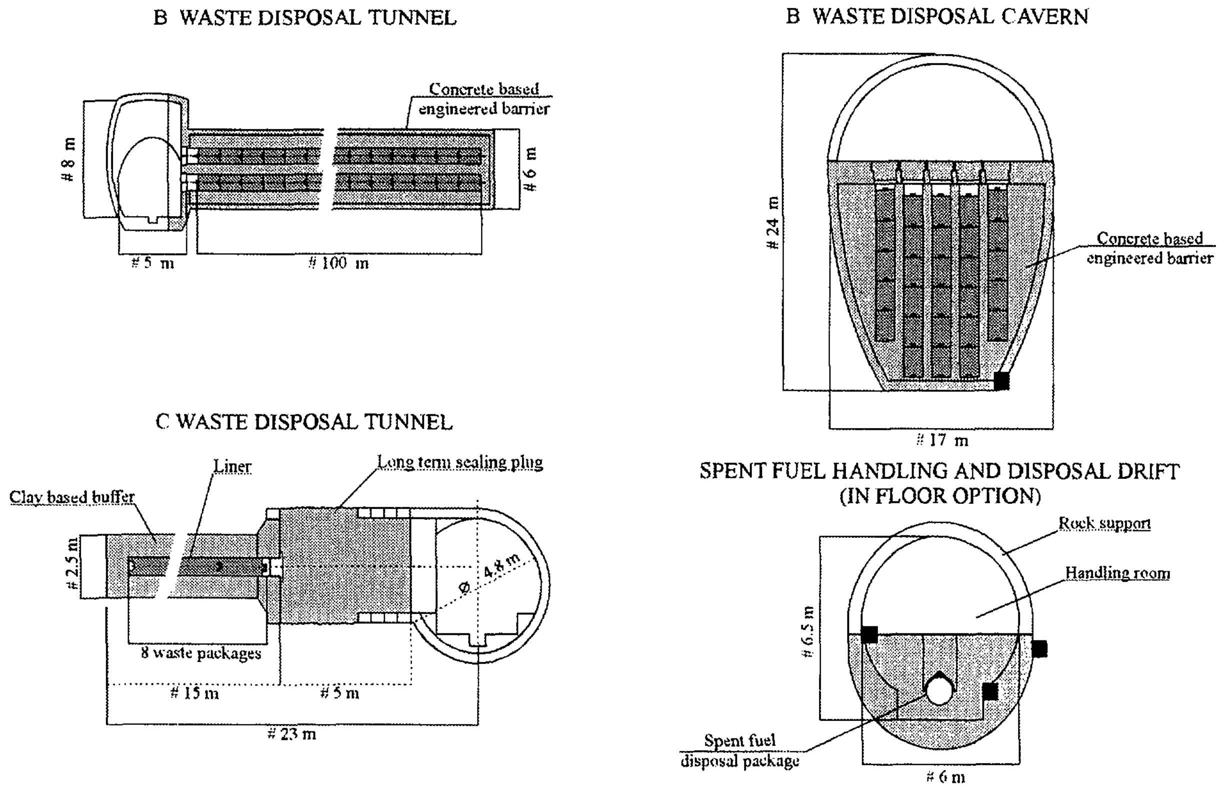

FIG. 2. Design options of waste disposal cells in argilites.

4. NEXT STEPS TO DEFINE REVERSIBILITY TO ANDRA'S RESEARCH PROGRAM

On the basis of the preliminary design options, the pursue of the study of reversibility in the next steps of the research programme implies both:

- to assess in each successive disposal phase, the technological possibilities for accessing and retrieving waste packages safely from the repository; and
- to assess the possibilities of delaying the partial or total closure of the repository with respect to the long term safety.

This research should aim at putting–across any relevant data showing the realistic flexibility in managing a geological repository.

4.1. The assessment of technological possibilities of retrieval relating the successive disposal phases

After each successive closure step the access to the waste package is less and less easy due in particular to the amount of material to remove. The study consists in describing for each step the available or potential equipments and processes to retrieve the waste package, for instance by removing backfill and bulkheads from shafts, drifts and cells, and repairing rock supports.

However, the retrieval of waste packages is generally considered as feasible in all cases, at least as long as the memory of the location of the repository is kept.

The assessment of the possibilities of delaying the successive closure steps

Assessing the possibilities of delaying the closure of disposal cells, handling or access drifts without consequences on long term safety suggest, first of all, identifying the phenomena, which could have an impact on the stability and integrity of the repository components.

These phenomena could be triggered by the excavation of the repository cavities, by the emplacement of heat emitting waste packages, then by backfilling and sealing of the repository cavities and drifts. They can consist, for instance, in mechanical, thermal or hydraulic discharges and recharges, in the corrosion or alteration of waste packages, engineered barriers, rock–supports and the rock itself. They lead to an evolution of the state of the cavities, such as the collapse of the clearance between waste package and engineered barrier.

Studying these phenomena, particularly through experiments on the argilite within the underground research laboratory enables the assessment and modelling of their kinetics. This modelling makes it possible to describe the evolution of the repository in its successive life-phases. Therefore, the influence of the delaying of the closure steps on the repository can be assessed.

With regard to safety, the phenomena analysis is a basis to the definition of additional scenarios, resulting from the potential delaying of closure steps.

The phenomena analysis also contributes to define a monitoring programme appropriate to the stepwise closing process.

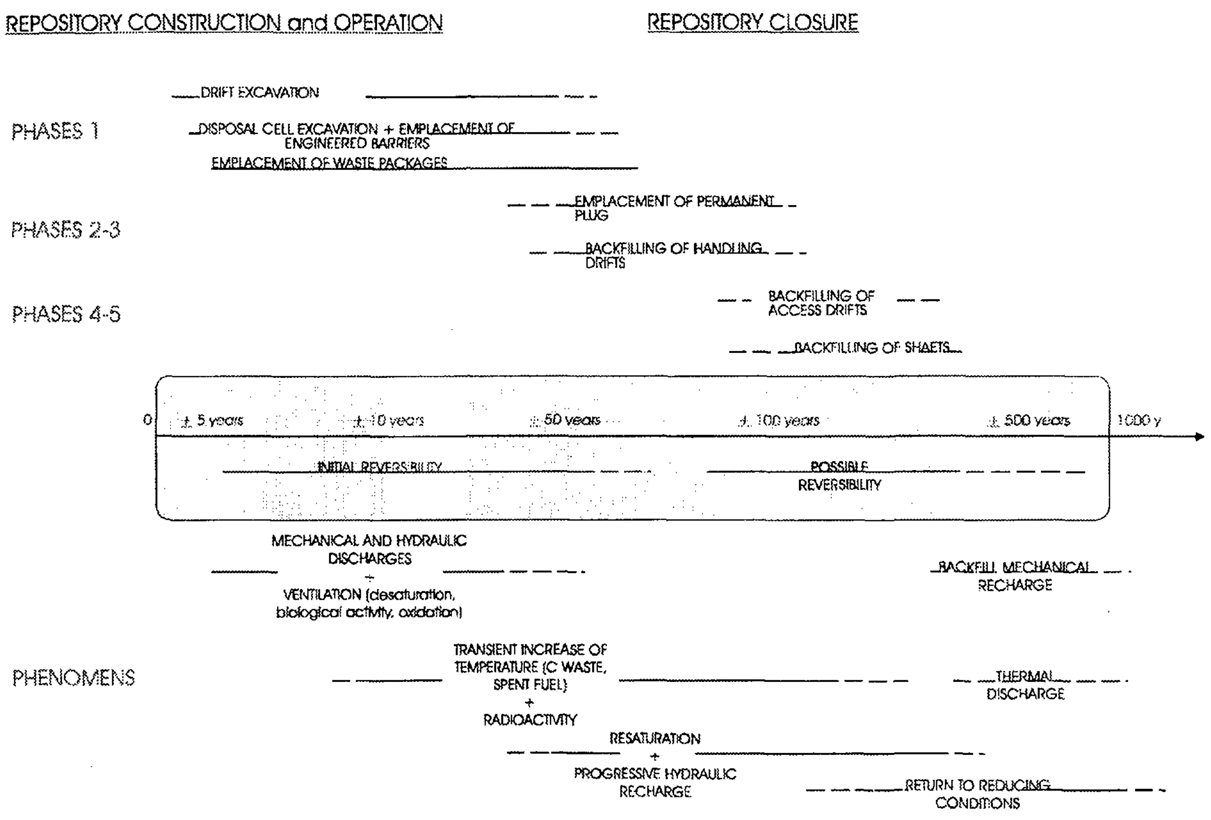

FIG. 3. Reversibility and life phases of the repository.

5. CONCLUSION

a) Studying reversibility means turning a political demand into a technical and scientific approach.
b) By distinguishing successive phases within repository's life span, one can describe how retrievability evolves with time.
- This allows to forecast the times when retrievability demands new technical means and specific set-ups regarding safety.
- Scientific and technical legibility contributes to:
  - Building up confidence in repository design; and
  - Proposing to the decision makers, by the year 2006, an open range of options with regards to reversibility.

REFERENCES

[1] FRENCH LAW NO. 91–1381, Radioactive Waste Management Research, 30 December (1991).
[2] ANDRA, The reversibility of radioactive waste disposal in deep geological formations. The role of underground research laboratories and programme of studies, 19 March (1998).
[3] COMMISSION NATIONALE D'EVALUATION (NATIONAL REVIEWING COMMITTEE), Réflexions sur la réversibilité des stockages, June (1998).
[4] PREMIER MINISTRE, Questions nucléaires, Relevé de conclusions, 9 December (1998).

QUESTIONS (Q), COMMENTS (C) & ANSWERS (A) AFTER THE PRESENTATION

Q: Is this ethical principle also applied to other types of waste, for example hazardous waste?

A: The 1991 law, which is the first one to provide for reversibility, says that we have to study both reversible and irreversible options for nuclear waste. This law provides for reversibility in any geological disposal of any kind of waste. This has had an impact on the geological disposal of chemical waste in France, which has to be reversible. The first packages are now underground and this is made according to a reversible process. But the law addresses only the geological disposal, not the above ground disposal.

Q: You mention a monitoring programme based on some phenomena you have identified by performance assessment modelling and URL (Underground Research Laboratory) research. We also heard this morning that we do not expect any results related to safety from the monitoring programme. Could you comment on that and also on the time span you are including in the study. Are we talking about decades or centuries?

A: A common safety indicator is the dose from the released radionuclides. But we do not expect the radionuclide release to start before hundreds or thousands of years. We can monitor in the repository phenomena like mechanical deformation, increase in temperature, hygrometry in the clay buffer etc. These phenomena occur at relatively short scale and they are directly connected to the modelling of the evolution of the repository.

Q: You showed a figure in which is indicated a period of initial reversibility up to maybe 50 years, followed by another period of possible reversibility extending up to about 500 years. Is 500 years based on any systematic consideration of the host rock formation or is it only an illustrative figure based on your present feelings?

A: The figure you refer to is addressing the reference case, which means a life cycle of a repository without the enhancement of reversibility. Based on this reference case, we are studying the possibilities to postpone some closure steps and to prolong some intermediate phases. The figure 500 years indicates an order of magnitude in the phenomenological approach and, on the other hand, it is also mentioned in the French basic safety rule as the acceptable duration for the "memory" of the repository.

Q: Coming back to the earlier question about what you can monitor, I am rather worried about all these things that you claim that you can monitor. I am afraid that people will monitor them because they are measurable and not because they are relevant. One big danger is that we monitor transient effects which do not have a long term effect. Don't you think there is a real danger with the monitoring of the whole repository system? One danger is that you will monitor irrelevant things. Another danger is that if you try to use the monitoring as a test of how well you understand the system, then the test will be too strict, because you do not have to understand the system as well as that.

A: My point was monitoring with regard to reversibility, so I am addressing a time scale of several decades, maybe a few hundreds of years. I am not addressing the long term safety in terms of potential long term release of radionuclides. My presentation points out the possibilities of monitoring. These are very open and there is no decision for the time being.

Q: In principle you say that future generations should have a choice of freedom and that is why you provide retrievability. But suppose that future generations would have preferred the freedom to have nothing to do with the waste and with the closure of the repository. Which were the arguments in France in the discussion of these two types of freedom, when you arrived at the conclusion to give them the freedom of choice in terms of retrievability but not to give the choice of not having to do anything with the disposal of today's waste?

A: It is not a yes or no situation. Our generation or maybe the next one will start the operation phase, but then the kinetics of the decision process is in the hands of the next generation and so on. It is a step-wise disposal process with the possibilities to decide at each step, but the decision is in the hands of the people who will have to decide at that time.

Q: Can they also decide not to go along with your planned monitoring programme over 100 years?

A: Yes, they can decide that. The only thing we do is that we make research in order to know what is feasible or not from a technical and scientific point of view.

Q: I noticed that you have some plans for spent fuel disposal. Is that only MOX-fuel or are you also preparing for once through spent fuel disposal?

A: The research addresses mixed oxide fuel and also uranium oxide fuel.

Q: Does that mean that there is a policy change on reprocessing in France?

A: No, this is research. We want to know if it would be feasible to dispose of spent fuel. The idea is that if we would like to consider to dispose some percent of the spent fuel, or maybe more, in the long term, everything should be open. That does not mean that any decision has been taken in one sense or another.

Chair: It is interesting to note that a country like France, which is in the main geared to reprocessing and taking care of plutonium, also looks equally at the question of retrievability as those countries which go for spent fuel disposal. After all, we all know that for spent fuel there is still a great energy potential. And yet, those who have already extracted it look for other potential values in the waste. This is a point worth retaining.

Another reflection is on the relation to other types of waste. You mentioned that in France there are similar ideas on retrievability for other types of waste than nuclear. But it occurred to me that one may say that the discussion within the nuclear sphere perhaps is far ahead of discussions in relation to other wastes. In the opening speech yesterday, it was said that it is useful to compare what we are doing in the nuclear sphere with what is being done in other spheres. It gives a useful perspective to what we are dealing with.