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DEPARTEMENT D'ANALYSE DE SURETE



CEA RAPPORT DAS N° 522

FRENCH RADIOACTIVE WASTES PERFORMANCE
ASSESSMENT AND THE NATURAL ANALOGUES
APPROACH : AN OVERVIEW

P. ESCALIER DES ORRES*

CCE - 3ème réunion du groupe de travail
"Analogues naturels".
(Snowbird, 15-22 juin 1988)

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Octobre 1988

**FRENCH RADIOACTIVE WASTES PERFORMANCE ASSESSMENT AND THE
NATURAL ANALOGUES APPROACH : AN OVERVIEW**

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SUMMARY

One of the main difficulties linked to the Radioactive Waste Performance Assessment calculations lies in the scale of time and space underlying these calculations : mechanisms and parameters can directly be affected by time or space dependency. The "natural analogues" approach has evident advantages, at least qualitative, to enlighten these aspects. It may also provide confidence in our ability to model partial or overall natural systems.

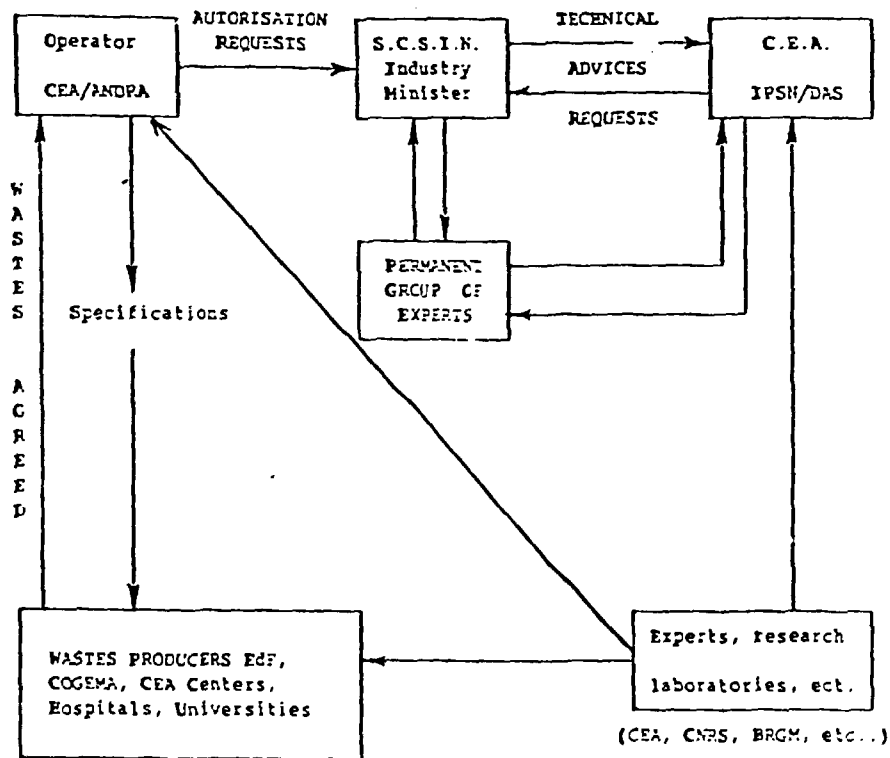
The following paper gives the headlines of the use of the "natural analogues" methodology in the French Radioactive Wastes Performance Assessment in the field of waste disposal.

I - INTRODUCTION

The French Atomic Energy Commission is engaged in a waste management program briefly recalled here :

- for LLW, closure around 1990/1991 of the first surface waste disposal site at "La Manche", with 400.000 cubic meters ; construction of a second disposal site, with a capacity of about 1.000.000 cubic meters, in the "Aube" department, to be operational towards 1990,
- for HL and TRU wastes, a site for a deep continental repository in a geologic medium is looked for. The first step consists in the investigation of 4 different geologic settings (granite, bedded salt, clay and schists) through deep boreholes and geophysics during the next years ; one site will be then proposed for the construction of an underground laboratory : this second phase, for 5/6 years, should give data in order to qualify the site as a repository for alpha wastes (a capacity of 250.000m³ is aimed at), operational around year 2000. Afterwards, if it is suitable, this site will also be used for vitrified high level wastes (less than 13.000m³) 5 to 10 years later.

The following chart shows the place and the role of the different partners in the waste French management field : the waste producers (COGEMA reprocessing and waste conditioning plants, EDF fuel and reactors, CEA research centers, Hospitals, Universities), the national Agency for the waste management ANDRA, operator of the disposal sites, within the CEA, and responsible of the safety of its installations in front of the Safety Central Service, the SCSIN of the Ministry in charge of Industry. This service has technical supports : a Permanent Group of experts and the Department of Safety Analysis, in the CEA/IPSN, Institute of Nuclear Protection and Safety.



WASTES MANAGEMENT FIELD IN FRANCE

ROLE OF THE DIFFERENT PARTNERS

II - THE PERFORMANCE ASSESSMENT FRAMEWORK

The Department of Safety Analysis, since 1984 develops a tool for the long term performance assessment of repositories in deep geologic formations. A 2-D finite element code, "MELODIE", joins three components :

- a model, representative of the "source-term", elaborated by the CEA/DRED (Waste R & D Dpt.),
- a model relative to the geologic barrier, developed by the Paris School of Mines,
- a model dealing with the biosphere, in charge of the Technical Protection Dpt. of our Institute.

These models, as far as possible, take into account the results of laboratory or field experiments, the following and monitoring of different nuclear installations.

Calculations are based on a deterministic approach (best estimate values and best models) for the "normal evolution" scenario. They are completed by a scenario type approach for altered conditions.

At the end, uncertainties and sensitivity analysis are done for the parameters taken into account.

Figure 1 shows the data needed for these performance assessment calculations.

Figure 2 identifies the spatial zones involved in PA and the processes related to each zone.

Time dependency affects selectively the different zones :

- a short term period (interim storage and setting of the waste packages in the repository) - 30 to 100 y -
- a medium term period (decay of the fission products/"thermal phase") - 300 to 500 y -
- a long term period based on considerations about the stability of the geologic barrier, a substantial decrease of the overall activity and on regulatory requirements - 10.000 years is the duration suggested for this period.

Engineered barriers play a role more difficult to assess.

Whatever their longevity, their degradation products must be taken into account,

- a very long term period, hundreds of thousands years up to millions y - this phase is mainly concerned by the evolution of the geologic barrier.

The "natural analogues" approach may intervene in each box of figure 1, in each zone of figure 2 and in the definition of the different periods concerned by performance assessment. We are going to see, in the French PA, which needs have been identified and what has been already done in this field.

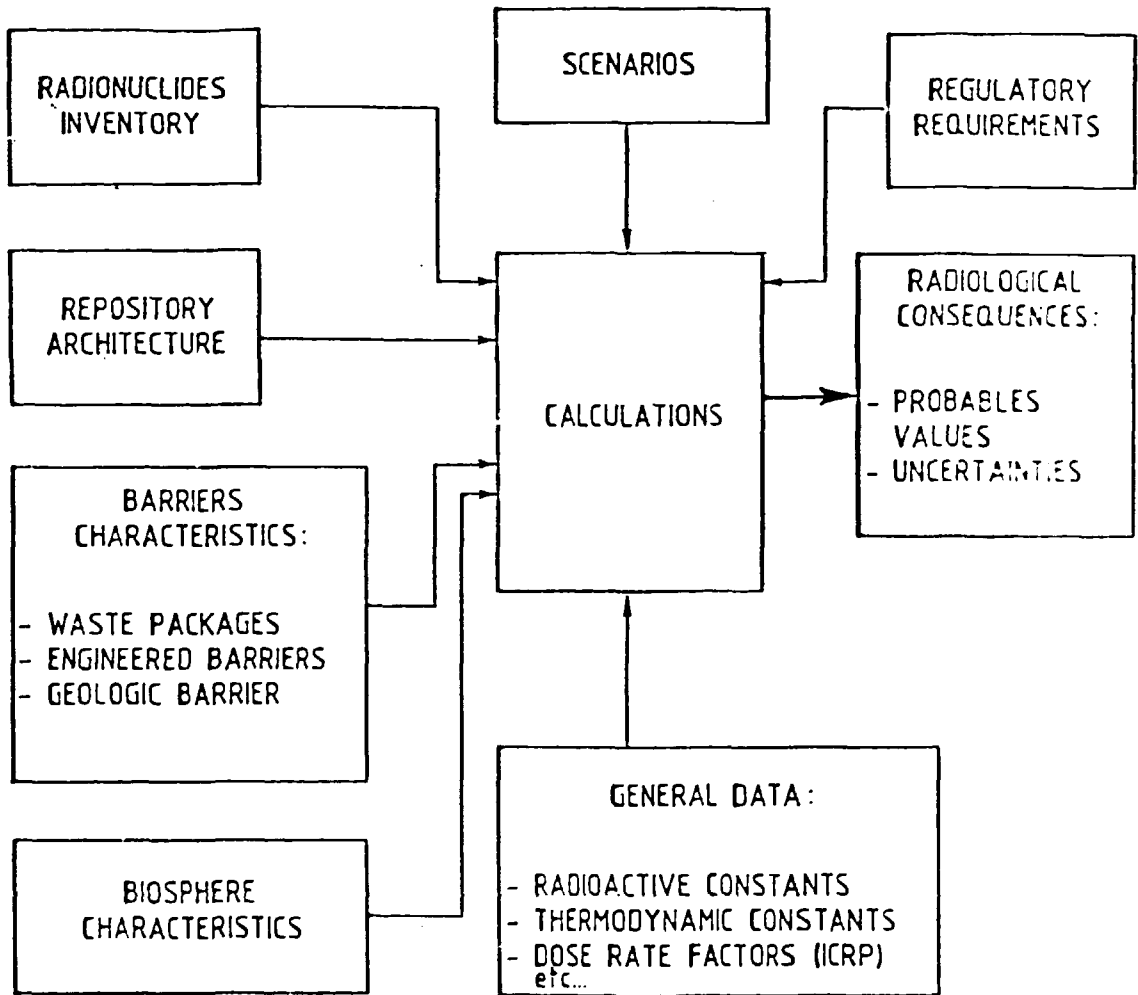


Fig. 1 - DATA NEEDED FOR PERFORMANCE ASSESSMENT CALCULATIONS

		OBSERVATIONS	MAIN PHENOMENA TO BE MODELLED	
N E A R E	S O	WASTES FORMS	Characteristics evolution RN release (chemical speciation) Matrix constituents release	
		CANISTERS	This zone disappears after the canisters failure corrosion, watertightness failure	
	F I E	ENGINEERED BARRIERS	*buffers zones *underground openings seals	Characteristics evolution RN transport and sorption colloids formation and release
		REPOSITORY	Specified by its overall design	Integration of results from the different components. Interaction of the components
	L D O S P H E R E	G E O	DISTURBED ZONE	Defined either by : - the works effects - hydraulic alteration - chemical " " - thermal " "
FAR FIELD			*nearfield and farfield limits may vary with time * possibility of successive geologic media	Radionuclide transport and sorption Discharge areas location
B I O S P H E R E		ENVIRONMENT		Radionuclide transfer
	MAN		Transfer to man, consequences (doses, ...)	

FIGURE 2

Identification of the spatial zones involved in performance Assessment and processes related to each zone

			OBSERVATIONS	MAIN PHENOMENA TO BE MODELLED
N E A P E	S O U R C E	WASTES FORMS *		Characteristics evolution RN release (chemical speciation) Matrix constituents release
		CANISTERS	This zone disappears after the canisters failure	corrosion, watertightness failure
		ENGINEERED BARRIERS *	*buffers zones *underground openings seals	Characteristics evolution RN transport and sorption colloids formation and release
		REPOSITORY	Specified by its overall design	Integration of results from the different components. Interaction of the components
		DISTURBED ZONE *	Defined either by : - the works effects - hydraulic alteration - chemical " " - thermal " "	Thermo-hydro-mechanical effects geochemical " " radiation " " Physico-chemical evolution Hydrogeologic characteristics
L O S P H E R E	G E O S P H E R E	FAR FIELD *	* nearfield and farfield limits may vary with time * possibility of successive geologic media	Radionuclide transport and sorption Discharge areas location
		ENVIRONMENT		Radionuclide transfer
F I E L D	B I O S P H E R E	MAN		Transfer to man, consequences (doses, ...)

FIGURE 2'

Identification of the spatial zones involved in performance
Assessment and processes related to each zone

* NA application field

III - ANALOGUES STUDIES : WHAT IS GOING ON

My colleague Jean Claude PETIT has already done, at this meeting, a detailed review of the French studies in the field of "natural analogues". I will just emphasize those which are directly linked to performance assessment and modelling.

As concerns wastes forms, studies of occurrence of natural glasses and laboratories experiments on natural or synthetic specimens were (and still are for future model development) helpful for establishing a glass source term model, mainly for the "gel" layer, the ionic exchange first step and the temperature influence on water molecules permeation.

Antique cements (about 1800 y old) are analyzed in order to understand their degradation or their stability. The results will at least have a qualitative impact.

For the engineered barriers, buffer zones behavior can be enlightened by the study of clay minerals transformations with temperature and time, such as smectite to illite. The understanding of the natural mechanisms will give us a better confidence in the barrier itself.

All the studies (in course or finished) on radionuclide transport and sorption in the geosphere are not yet integrated in the models : e.g. the Jalerys study for the migration of U, Th, REE in a granite setting ; the Auriat work on the alterations in the boreholes, however, this last study shows the complexity of the processes accompanying hydrothermalism. In such natural systems, the soluted elements are trapped in secondary phases (coprecipitation with carbonates) and not only sorbed on the minerals of the fissures. A thermodynamic approach is necessary in these crystalline media : the Kd modelling is insufficient. This is why we are developing such a methodology with the Ecole des Mines de Paris (ENSMF) and the CEC and participate to CHEMVAL. The Auriat studies have also shown that alteration follows two types of development : a fissural one, limited to the lips of the fractures, and a pervasive one, invading the microfissured zones.

In the MIRAGE program, our department is directly engaged with the ENSMF and the BGS on the Needle's Eye (Scotland) study : in a sedimentary context, at the periphery of a granitic intrusion, overlain with recent quaternary silts or organic matter rich sediments, we try to modelize the transport of U, Th and REE, either linked to run-off or underground waters, from hydrothermal uraniferous veins. Matrix diffusion can also be looked at. A good understanding of such a site needs a large quantity of data. At present, many uncertainties remain on the source-term, the geologic and hydraulic context and on the age of the quaternary sediments : a big effort on sampling and analysing is still necessary.

IV - ANALOGUES STUDIES : IDENTIFIED NEEDS AND PROJECTS

In March 1988, the Permanent Group of Experts for radioactive Wastes has issued a recommendation to the French safety authorities on the use of natural analogues :

"...the CEA should pursue it's reflexions, in an international framework, on the interest of natural analogues in different fields, in particular to complete the studies of the long term behavior of the artificial barriers (glasses, cements, bitumens, clays of the engineered barriers, ...) and to validate the transport models of the radionuclides through natural or man-made barriers".

This gives the main trends of what is waited from the natural analogues ; information, at least qualitative, on parameters or processes unaccessible to experimentation (versus time and spatial scales that can be observed in nature) and validation of models for the long term, for large systems, for coupled processes.

A word must be said about a new project that we are assessing at this moment on the possibility to study as a natural analogue the OKLO (Gabon) nuclear reactors. At least a large reaction zone (see fig.3 - n°10) should be accessible to sampling from 1988 to 1990. We will make a field trip to the mine next month to determine what can be done, the planning and cost of all the studies,... We are mainly interested by direct data on the long term behavior of different radionuclides or elements, of different type of rocks or minerals, of the geologic setting as a whole and the altogether interferences of the processes involved, including radiation and thermal effects.

We would apply or elaborate geochemical and hydrogeological models (like EQ 3-6, CHIMERE, METIS, STELE, THEMIS) in order to get good simulations of what is observed on the field. OKLO could also give us confidence in our performance assessment approach and prove us the utility of a such natural analogue for the PA calculations and methodology.

V - CONCLUSION

For the performance assessment, the main interest of the natural analogue approach lies in the confidence gained on the following points :

- long term behavior of different materials or elements,
- thoroughness and rightness in the selection and identification of the processes taken into account in the PA,
- confining properties of different geologic settings,
- ability to model coupled processes, overall systems.

This can be very useful to assign a reasonable role to such or such barrier, in PA, and to limit the uncertainties affecting PA. Quantitative aspects, when possible, should not be neglected, of course.

We must keep in mind, however, that complete validation of models and complete analogy with waste disposal repositories are pure nonsense.

VI - REFERENCES

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J.C. PETIT - Analogue studies at the French Atomic Energy Commission during the period 1986-1988. Third CEC Natural Analogue working group Meeting - 15-17 juin 1988.

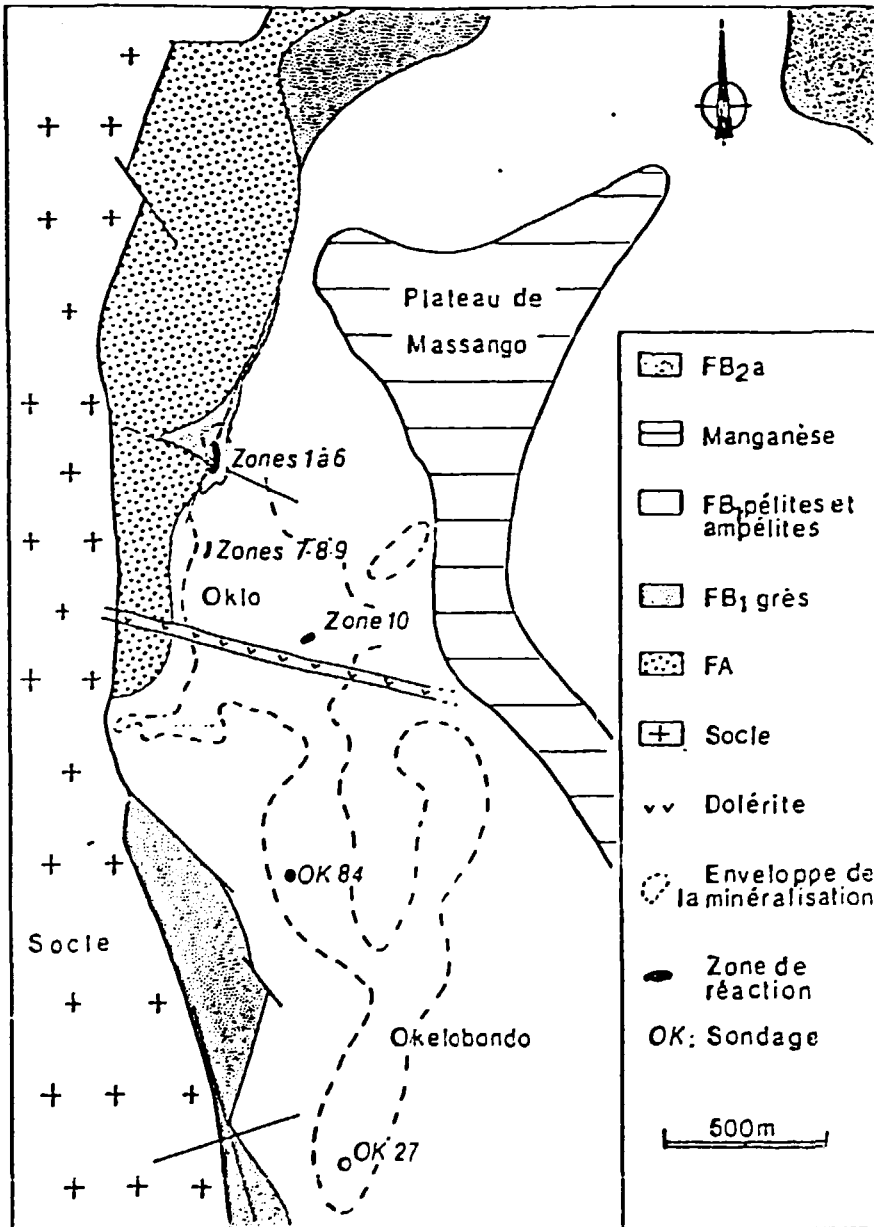


Fig. 3

Natural fission reactors localisation map at Oklo and Okelobondo (Gabon), in :

F. GAUTHIER-LAFAYE, les gisements d'Uranium du GABON et les réacteurs d'Oklo - Thèse - Strasbourg, 1986 ; Zone n° 10 is proposed to be studied as an analogue site.

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