TRIP REPORT:
WORKSHOP ON RISK ANALYSIS AND GEOLOGIC MODELING
IN RELATION TO THE DISPOSAL OF RADIOACTIVE
WASTES INTO GEOLOGICAL FORMATIONS

H. C. Claiborne

Ispira, Italy
May 23-27, 1977

MASTER

UNION
CARBIDE

OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

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TRIP REPORT:
WORKSHOP ON RISK ANALYSIS AND GEOLOGIC MODELING
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May 23-27, 1977
H. C. Claiborne

Summary

A Workshop on Risk Analysis and Geologic Modeling in Relation to the Disposal of Radioactive Waste into Geological Formations was held at Ispira, Italy, on May 23-27, 1977. The Workshop was co-sponsored by the Commission of European Communities (CEC) and the Office of Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA). The primary object was to promote international cooperation in developing and using risk assessment techniques for the long-term safety assessment of waste disposal.

The attendance was restricted to specialists in the field and a few observers; 43 people were in attendance representing 14 different countries.

Nothing particularly new or novel was presented nor any formal cooperation agreed upon. However, there was a feeling that continued informal cooperation was helpful and should be continued. Greater or lesser degrees of formality could be decided later. The U.S. program was definitely more advanced and larger in scope than the others that

were discussed. Countries that seemed to have significant programs include the Federal Republic of Germany, France, Canada, Sweden, and the CEC.

Introduction

A Workshop on Risk Analysis and Geologic Modeling in Relation to the Disposal of Radioactive Waste into Geological Formations was held at Ispra, Italy, on May 23-27, 1977, at the Joint Research Center of the Commission of European Communities (CEC). The Workshop was co-sponsored by the CEC and the Nuclear Energy Agency of the Office of Economic Development and Cooperation (OECD/NEA).

A first workshop (sponsored by OWI) on Geologic Data Requirements for Radioactive Waste Management Assessment Models was held in Santa Fe, New Mexico at the end of June 1976 and it indicated the need for increased cooperation between geologists and modeling specialists. This almost exclusively U.S. meeting (only 3 came from Europe and one from Canada) caused realization by the Coordinating Group on Geologic Disposal, a subcommittee of the NEA Radioactive Waste Management Committee, of the need to stimulate and coordinate work on risk analysis on a more international basis. Given similar plans of the CEC this led to the jointly organized workshop at Ispra with co-scientific secretaries, F. Gera (OECD/NEA) and F. Girardi (JRC Euratom/CEC). Due to the highly specialized nature of the workshop and the desirable free discussions, it was decided to limit the participants to around 30 and an additional limited number

of observers. Actually 43 people were in attendance representing 14 different countries. It was strongly urged in the workshop announcements that each country present concrete proposals.

The announced goals of the workshop were: (1) review available information; (2) exchange scientific data; and (3) agree on the scope, program and mechanism for the implementation of cooperative actions with a view to developing a uniform methodology of the international level.

It was requested that the workshop should be restricted to the discussion of the following topics:

1. Description of potential containment failure mechanisms and assessment of their probabilities.
2. Description of scenarios for the release of radionuclides and assessment of possible release rates.
3. Models for the transport of radionuclides through the geosphere.

The technical program included topical papers and status reports on activities and future plans in the various countries.

A brief discussion of the program and the proposals for international cooperation are given in the following sections.

The program (as amended), a list of attendees, the drafts of the consensus results of the working groups on containment failure modes and geosphere transport modeling, and abstracts of the papers (those available) that were presented are appended to this report.

Accommodations and Arrangements

The participants stayed at the Palace Hotel in Varese and each day was transported by bus (about 15 miles) to the Joint Research Center

(JRC) at Ispra for the meetings. Transportation between the Alitalia Air Terminal in Milan and the at Varese hotel was also furnished.

The meeting room at Ispra was equipped with microphones and earphones for each participant. The languages used were English and French. A simultaneous translation was made into the language other than that used by the speaker. With the exception of the French delegation, everyone else used English.

The entire presentation and discussion was recorded. It was emphasized, however, that the recording was not for record purposes but merely to help the scientific secretaries prepare summaries. Everyone was urged to speak freely and that none of the verbal remarks that could be attributed to an individual would become part of the record of the proceedings. As it turned out, the tapes were not needed by the secretaries since it was unanimously agreed to have the proceedings published containing only the written material that was either submitted or approved by the participants.

In general, the accommodations and arrangements were excellent. It was obvious that the CEC and the OECD spent a good deal of time and money on this meeting and was determined to leave a favorable impression.

Program

The program for the five-day meeting is appended to this report. The first day was devoted to essentially technical papers and the next two days to programs and proposals. The fourth day was spent with the group divided into two workshops for discussion and writing of consensus

viewpoints on geologic waste disposal. This is discussed later. Friday morning of the last day was a plenary session in which the two working groups presented their reports for the general discussion.

The technical papers were varied in quality and offered nothing particularly new. Countries with significant programs in risk assessment for geologic disposal appear to be the Federal Republic of Germany, the CEC, France, Canada, and Sweden. It was obvious that the U. S. was far in the lead with its programs at Battelle (OWI sponsored) and at Sandia for the WIPP.

The technical paper (which has been submitted for publication in Science) by de Marsily, et al., was a rather simple model for nuclide migration and it stressed the role of sorption. His conclusion that neither the thickness nor the permeability were major factors in confining long-lived nuclides over long time periods because the ion exchange capacity of the terrain will be the most important factor. This conclusion is inconsistent with the philosophy of disposal in salt. de Marsily agreed to stress that his results apply only to nonsalt geologic media.

The papers by Bertozzi, et al., (Euratom), Proske (FRG), and Logan (University of New Mexico) used fault-trees extensively. All involved hypothetical sites and the probabilities were mostly assumptions. Questions on the sources of the probabilities used were frequent. The papers by Put and Heremans (Belgium) and Butzer and Chakraborty (Switzerland) discussed simplified models for geosphere transport and gave the results

of some parametric studies on simplified models. The paper by Lande (France) discussed the characteristics of glass waste forms and its importance to slowing the leaching process.

It was decided by the group that the papers presented, both technical and programmatic, should be published along with the conclusions of the working groups. Publication will be by the CEC/NEA within about two months. I brought back copies of the complete papers that were made available.

Workshops

After the formal presentations two working groups of about 20 each were formed for free discussion and an attempt to arrive at consensus viewpoints on (1) Containment Failure Modes and (2) Geosphere Transport Modeling.

I took part in Working Group 1. Discussion was very lively at times but amiable. For example, getting agreement on the definitions as shown in the appended results of Working Group 1, took nearly half the allotted time with the induced tangential discussions. It was reported that the same difficulties were experienced by Working Group 2. Presentation of the results at the final plenary session engendered additional discussions and arguments over the exact wording. The amended drafts of the two working groups are appended. It was understood that some final editing will be necessary prior to final publication.

The report of Working Group 1 (see Appendix) lists the waste container as a barrier, which I protested. However, there was a general

consensus that for disposal in granites, the waste canister could be considered a barrier. I conceded the point when it was agreed to add a caveat that the reliance placed on the various barriers differs considerably among the geologic disposal systems. In other aspects, the report is in agreement with OWI's program. An interesting point was the suggestion that consideration be given to establishing an international documentation center and central data bank for geologic disposal and safety assessment programs.

The report of Working Group 2 is also in agreement with the OWI program. The most important points made are that reliance should not be placed on any one particular model and that sensitivity studies should be made with available models to identify those parameters that control the accuracy of the model results.

International Cooperation

A proposal for a formal method of international cooperation was made by F. Gera representing the OECD/NEA. The proposal entailed the establishment of an international project on the safety analysis of geologic disposal of nuclear waste. The objective was to develop an internationally approved methodology of risk assessment by an assembled group at an as yet unspecified location of 6 to 10 experts from various countries in the fields of geology, modeling, and risk analysis. The target time for accomplishing this well-defined goal should be two to three years. The participants all received preprints of the proposal by mail prior to the meeting. Gera's proposal lacked full support.

P. Venet representing Euratom proposed a standing group from various countries to have periodic meetings on safety assessment of geologic disposal that is to be sponsored by Euratom. It was pointed out that it would need approval by the CEC Program Committee and the Coordinating Group on Geologic Disposal. This proposal will be discussed by the latter group at a meeting on September 12 and 13 in Stockholm, Sweden. It was generally felt that the workshop group could not make a decision in regard to this proposal and it was better left to the Coordinating Group for a final determination.

D. Richter representing the International Atomic Energy Agency (IAEA) read a lengthy statement after the initial welcoming speeches pointing out the IAEA efforts in the waste disposal field and on the basis of recommendations of consultants (drafted in March 1977) from IAEA members states it is now considering a program to develop a series of guidelines on the safe disposal of radioactive wastes into geologic formations in the next three to ten years. In particular, a set of codes and associated series of guides is proposed to be developed covering such areas as (1) regulatory activities, (2) site selection and confirmation, (3) design and construction, and (4) operation, including environmental and long-term surveillance. For developing the above mentioned codes and guides on geologic disposal, the IAEA is proposing to hold a number of working groups, technical committees and advisory groups meetings during the next several years. These proposed meetings and their objectives are to be reviewed by an advisory group meeting in the Agency's program on geologic disposal, expected to be held in early 1978.

The participants from Switzerland were very interested in the cooperative program between OWI and Sweden involving the in situ tests in granite. Apparently they have ideas of disposal in their local granites and wanted to get involved in the program also. I said that it was quite possible that they could take part as an observer, and that in any event the data would be available. I suggested that they first discuss this with the Swedish delegation and to contact OWI if they finally desire to participate. After the technical details were agreed to, ERDA could then make a final determination on the matter.

As outlined in my paper, I mentioned the German-U.S. and the Sweden-U.S. (OWI) formal agreements on cooperation and the informal one with Canada. I pointed out that other unilateral or multilateral agreements of cooperation are possible with the approval of ERDA. In an informal discussion, I pointed out that new ideas or suggestions for research and development work could be included in the OWI Safety Program if deemed helpful to our program.

General Observations and Impressions

The third goal of the meeting; namely, to agree on the scope, program and mechanism for developing a methodology on the international level was not achieved. Obviously the OWI program could not be slowed or geared to an international agreement unless specifically directed by ERDA. It was apparent that delegates from other countries were not keen about the third goal either and no real effort was made to achieve it except as to reach consensus on the workshop reports, which are innocuous in content.

Generally there was a feeling that the workshop was useful in bringing together the safety assessment specialists from the various countries. It brought into focus the problems and constraints of the different countries which could help in developing the necessary co-operation in waste management within the European community. For example, Sweden and Switzerland have essentially only granite as a geologic disposal medium and Switzerland, because of the topography and small area, has hydrologic conditions that could generate protests from surrounding countries if disposal occurred there. The U.S. does not have these geographic and geologic constraints and has a wider range of choices. Consequently, the U.S. program on waste management has a greater freedom of action.

The discussions were useful and a feeling of camaraderie developed among the participants, which was useful in promoting the very free and amiable arguments that would develop during the non-working hours.

The new nuclear policies of the U.S. became a frequent subject in these afterhours discussions. A few of the participants had been at the Salzburg meeting two weeks earlier. The position expressed frequently by the Europeans was disapproval of the new policies. They felt that other countries will generally ignore them and express general disbelief that these policies will be fully implemented in the U.S.

The previously discussed proposal by P. Venet in the name of OECD/NEA in regard to international cooperation seems quite reasonable and to be more flexible than the Gera proposal. This seems worthy of further discussion at the Stockholm meeting of the NEA coordinating group in September.

The proposed development of Guidelines for Waste Disposal by the IAEA as presented by D. Richter also seems worth further consideration. The IAEA also has the merit of being a truly international organization.

APPENDIX

1. Program
2. List of Attendees
3. Workshop Report on Containment Failure Modes
4. Workshop Report on Geosphere Transport Modeling
5. Abstracts of Papers

WORKSHOP ON RISK ANALYSIS AND GEOLOGIC MODELING IN
RELATION TO THE DISPOSAL OF RADIOACTIVE WASTE INTO
GEOLOGICAL FORMATIONS

Ispira, 23rd-27th May 1977

PROGRAMME

Monday 23rd May

Chairman: S. E. Logan

10:30-11:00 Welcome and introduction

G. R. Bishop, Director, Dept. of Physical and Natural Sciences.

S. E. Logan, Univ. of New Mexico, Chairman of workshop on geologic data requirements for radioactive waste assessment models - Denver, 1976.

11:00-11:30 D. Richter (International Atomic Energy Agency) remarks on the NEA/CEC Workshop on Risk Analysis.

11:30-12:00 G. Bertozzi, M. D'Alessandro, F. Girardi, M. Vanossi - Safety assessment of radioactive waste disposal into geologic formations.

12:00-12:30 R. Proske - Previous results and future objectives of risk analysis on repositories for radioactive wastes in geologic salt formations in the Federal Republic of Germany.

12:30-13:00 Discussion

13:00-14:30 Lunch

Chairman: J. Hamstra

14:30-15:00 F. Laude - Le verre comme première barrière pour le stockage à long terme des déchets de haute activité.

- 15:00-15:30 S. E. Logan, M. C. Berbano - Geologic modeling in risk assessment methodology for radioactive waste management.
- 15:30-16:00 M. Put, R. Heremans - Modelisation mathématique de la migration de radionuclides dans une formation argileuse homogène.
- 16:00-16:30 P. Bützer, S. Chakraborty - A geosphere transport model for risk evaluation.
- 16:30-16:50 Coffee break
- 16:50-17:30 Discussion

Tuesday 24th May

Chairman: H. C. Claiborne

- 9:00-9:30 G. de Marsily, E. Ledoux, A. Barbreau, J. Margat - Nuclear waste disposal: Can the geologist guarantee long-term isolation?
- 9:30-10:00 Activities of the Nuclear Energy Agency - Computer Library Program.
- 10:00-10:30 R. Krejsa - Status and programme of the Austrian activities for final disposal of radioactive wastes into geologic formations.
- 10:30-10:50 Coffee break
- 10:50-11:20 R. Proske - Status and future developments of risk analysis for repositories of radioactive wastes in salt formations in the Federal Republic of Germany.
- 11:20-11:50 F. Girardi - Status report of research programmes of the Commission of European Communities related to risk evaluation of geologic disposal of radioactive waste.

11:50-12:20 S. E. Logan - Radioactive waste risk assessment methodology development supported by the U.S.A. Environmental Protection Agency.

12:20-13:00 Informal status reports from other countries.

The following status reports on abstracts were not made available until the meeting date and were not on the original agenda:

D. W. Prowse - Safety Analysis of the Proposed Canadian Geologic Nuclear Waste Repository.

M. S. Tierney (Sandia Corporation) - Estimating Probabilities of Disposal System Failure - A Status Report.

J. D. Mather - Status Report for the United Kingdom.

No written reports were made available for the following presentations:

J. Hamstra (Netherlands)

N. A. Kjellbert (Sweden)

13:00-14:30 Lunch

Chairman: F. Laude

14:30-15:00 F. Gera - NEA Proposal for an International Project on the Safety Analysis of Geologic Disposal.

15:00-15:30 Discussion

15:30-15:50 Coffee break

15:50-16:20 H. C. Claiborne - The United States Program for the Safety Assessment of Geologic Disposal of Commercial Radioactive Waste.

16:20-16:50 H. C. Burkholder - Status Report on the Waste Isolation Safety Program.

16:50-17:30 Discussion

Wednesday 25th May

9:30-9:20 A. R. Sattler (Sandia Corporation-on loan to FRG) - A brief discussion of the WIPP program was given.

9:20-13:00 Workshop breaks up into working groups which will write short status reports and prepare recommendations and proposals for future work.

AFTERNOON FREE

Thursday 26th May

Working groups to continue all day.

Visit to JRC laboratories and installations will be possible during the afternoon.

Friday 27th May

Chairman: D. R. Prowse

9:00-12:30 Plenary session

-Presentation and discussion of reports of working groups.

-Conclusions of workshop.

WORKSHOP ON RISK ANALYSIS AND GEOLOGICAL MODELLING IN RELATION TO THE
DISPOSAL OF RADIOACTIVE WASTE INTO GEOLOGICAL FORMATIONS.

Ispira, 23 - 27 May 1977

FINAL LIST OF PARTICIPANTS

Austria	KREJSA Peter	Osterr. Studienges f. Atomenergie	Lenauasse 10 A-1060 VIENNE
Belgium	PUT M.J.	SCK/CEN - Dep. Scheikunde	Boeretang 200 B-2400 MOL
Belgium	HEREMANS René	Centre d'Etude de l'Energie Nucléaire	CEN/SCK Boeretang 200 b62400 MOL
Canada	PROWSE Daniel R.	Atomic Energy of Canada	Whiteshell Nuclear Research Establishment Pinawa, Manitoba
Denmark	BO Peter	Research Establishment Risø	Chemistry Department Risø 4000 RØSKLEDE

Finland	PELTONEN Esko	Technical Research Centre of Finland	Reactor Laboratory Rakentajanaukio 2 SF-02150 ESPOO 15
France	BARBREAU Andre	Departement de Sécurité Nucléaire Inst.de Protection et de Séc.Nucl.	CEN-SACLAY B.P.N. 2 91 - GIF SUR YVETTE
France	LAUDE Francis	French C.E.A. Solidification of Radioactive Wastes	SAP/SSPF Centre de Marcoule B.P. 106 BAGNOLS/CEZE 30200
France	DE MARSILY G.	Ecole des Mines de Paris	35, rue St. Honore 77305 FONTAINEBLEAU
France	MARGAT Jean	Bureau des Recherches Géologiques et Minières	BRGM B.P. 6009 45018 ORLEANS CEDEX
France	LEDOUX Emmanuel	Ecole des Mines de Paris Centre d'Informatique Géologique	35, rue St. Honore 77305 FONTAINEBLEAU
Federal Rep. of Germany	BETZ Volker	Lehrstuhl für Erdölgeologie	Leibnitz Str. 10 3392 CLAUSTHAL-ZELLERFELD
Federal Rep. of Germany	PROSKE Reinhart	GSF-Int. für Tieflagerung- Wissenschaftliche - Abteilung	Berliner Str. 2 D-3392 CLAUSTHAL-ZELLERFELD
Federal Rep. of Germany	HORST W. ZUR HORST	Niedersächsisches Sozialministerium	Postfach 144 D 3000 HANNOVER

Italy	BCCOLA W.	Comitato Nazionale Energia Nucl.	CASACCIA CP 2400 00100 ROMA
Italy	POLIZZANO A.	Comitato Nazionale Energia Nucl.	CASACCIA CP 2400 00100 ROMA
Italy	TONDINELLI L.	Comitato Nazionale Energia Nucl.	CASACCIA CP 2400 00100 ROMA
Japan	MURANO Tohru	Nuclear Fuel Development Division, Power Reactor - Nuclear Fuel Development Corporation	1-9-13 AKASAKA MINATO-KU TOKYO
Netherlands	HAMSTRA J.	Energie-onderzoekCentrum Nederland ECN	Westernduinweg 3 PETTEN
Netherlands	WEBER J.	Ministerie van Volksgezondheiden Milieuhygiene	Dokter Reyerstraat 12 LEIDSCHENDAM
Netherlands	VAN DORP F.	Institute for Atomic Sciences in Agriculture	Keyenbergseweg 6 Postbus 48 WAGENINGEN
Norway	LINDAHL INGVAR	Geological Survey of Norway	P.O. Box 3006 7001 TRONDHEIM

Sweden	KJELLBERT N.A.	AB Atomenergi	Post S-61101 NYKÖPING
Sweden	RÖSHOFF K.	Technical High School of Luleå Department of Rock Mechanics	S-95189 LULEÅ
Switzerland	HERRNBERGER Volker	Federal Inst. of Reactor Research	5303 WÜRENLINGEN
Switzerland	CHAKRABORTY Sabyasachi	Federal Inst. of Reactor Research Nuclear Safety Division	5303 WÜRENLINGEN
United Kingdom	HILL Marion D.	National Radiological Protection Board	HARWELL - OXON
United Kingdom	MATHER John David	Institute of Geological Sciences	Building 151 HARWELL LABORATORY DIDCOT, OXON
United States of America	BURKHOLDER H.C.	Battelle Pacific Northwest Lab. Waste Isolation Safety Assessment P.	P.O. Box 999 RICHLAND, WA 99352
United States of America	CLAIBORNE H.C.	Office of Waste Isolation Union Carbide Nuclear Division	O W I P.O. BOX Y OAK RIDGE, TENN. 37830
United States of America	LOGAN Stanley E.	University of New Mexico Chemical and Nuclear Engineering Department	Albuquerque, NEW MEXICO 87110

ited States
America

SATTLER Allan R.

SANDIA LABORATORIES

Albuquerque
NEW MEXICO 87115

ited States
America

TIERNEY Martin S.

SANDIA LABORATORIES

Albuquerque
NEW MEXICO 87115

mission of
ropean
community

AVOGADRO Alessandro

BERTOZZI Giuseppe

D'ALESSANDRO Marco

GIRARDI Francesco

CCR - EURATOM

ISPRA - VARESE

LANZA Franco

LEY Jean

SCHNEIDER Johan

ROCCO Paolo

VENET P.

DG III / E-1 EURATOM

200 Rue de la Loi
BRUSSELS

International
Atomic Energy
Agency

RICHTER Dieter

International Atomic Energy Agency

P.O. Box 390
Kärntner Ring 11
A-1011 VIENNA

OECD
Nuclear Energy
Agency

GERA Ferruccio

Nuclear Energy Agency of OECD

38, boulevard Suchet
75016 PARIS

WORKSHOP ON CONTAINMENT FAILURE MODES

1. The first point under discussion was the definition of the terms: barrier, containment, failure and release.

The following were agreed:

A barrier is a mechanism or effect which retains activity for a defined time period.

Containment is the cumulative effect of a number of barriers.

A failure is an event which substantially influences the effect of an individual barrier.

Release to the biosphere is the ultimate result of successive barrier failures.

2. The Working Group (WG) agreed that in geologic disposal radioactive wastes are excluded from the biosphere by a number of barriers, such as: waste form, waste container, disposal formation and retention along the underground pathways from the disposal formation to the surface. The reliance placed on the various barriers differs considerably among geologic disposal systems.
3. Afterwards, the questions of radioactivity indices and of the duration of required containment were discussed in depth. It did not prove possible to reach a consensus of opinion on these points.
4. Presentations were made by WG members on the models presently under development in their respective establishments. The various models describe the impact of a number of geologic events on a repository. These can be conveniently grouped into slow and rapid events. Models such as fault trees were considered to be more suitable for the treatment of rapid events; whereas other techniques presented

in the workshop, such as the respository simulation approach, might be better suited to deal with the slow events. One difficulty which was emphasized was the modelling of the continual interaction between various geological processes.

5. Another important category of events that could affect the safety of repositories includes disturbances caused by the activities of man. The weight given to these events by the various modelers differed considerably.
6. It was stressed by some WG members that the sophistication of models should not exceed the reliability of input data. Most geological systems are presently poorly characterized at least at the depths visualized for geologic disposal.
7. The need for the development of general and rock-type specific vs site specific models was discussed. It was agreed that all types of models are useful; but the effort devoted to their development should not be out of proportion to their potential usefulness.
8. The WG agreed that generally the sophistication of the models has already outstripped the availability of data. Consequently, the most urgent needs are for improved input data.

These are particularly required in the following fields:
 Probabilities of relevant disruptive geologic events and their time dependence.

Maximum rates of slow geologic processes.

Formation response data, i.e., effect on the various barriers of a particular event or process.

Probabilities of man-induced failures and their time dependence.

9. As far as international cooperation is concerned the WG felt that the establishment of an international project is probably impracticable. However, there was considerable support for the idea of bilateral or multilateral cooperation among scientists working in similar fields; either on similar models or on the same rock types.
10. It was suggested that, as the primary need is for input data, a documentation center incorporating as far as possible, a central data bank might offer considerable advantages for the geologic disposal and safety assessment programs of individual countries. The WG recommended that NEA investigate the feasibility of setting up such an information system.

WORKSHOP ON GEOSPHERE TRANSPORT MODELING

I. Current Status of Simulation Models

Simulation models have been developed or are partly developed for predicting:

1. The leaching of radionuclides from waste forms destined for isolation in geological media,
2. The transport of nuclides through the geological barrier to the biosphere and
3. The transport of nuclides through the environment to man and interaction with man. The geosphere transport models of this group have the following characteristics:
 - a. analytical or numerical
 - b. one-, two-, or three- dimensions
 - c. convection
 - d. dispersion
 - e. chain decay
 - f. instantaneous or non-instantaneous sorption
 - g. continuous media (either particulate or fractured)
 - h. homogeneous or heterogeneous
 - i. multiple chemical forms or species.

However, none of the models alone has all of the above characteristics.

II. Directions for Future Work

1. Knowledge of the Phenomena

Work is needed to develop a better understanding of the phenomena important to the leaching, geosphere transport, and environmental transport processes. These include:

- a. Long-term waste form degradation behavior
- b. Influence of physico-chemical parameters on sorption - desorption mechanisms
- c. Stability of the various chemical forms
- d. Stability of initial geologic conditions and
- e. Potential reconcentration processes with the geological barrier.

2. Simulation Model Development

Work is also needed to improve the simulation models. This includes the mathematical description of:

- a. The hydrodynamics of flow in large faults
- b. Sorption in fractured media
- c. The migration of multiple chemical forms
- d. Uncertain propagation from input data to modeling results.

3. Data Generation

Finally, work is needed to improve the methods for obtaining the data necessary to characterize geosphere transport. These include:

- a. Sorption and dispersion measurement methods in fractured media

- b. Measurement of hydrodynamic and sorption properties for media with low permeability
- c. Estimation of measurement and interpolation uncertainties
- d. The correlation between laboratory and field measurements.

III. Conclusions

The group concluded that:

1. Models should not be used that are more sophisticated than the quality of the input data. However, we must be careful not to neglect important phenomena in our desire for simplicity.
2. Sensitivity studies should be performed with available models to identify those parameters which control the accuracy of model results. This information can then be used to properly allocate the resources within the various programs.
3. The development of data measurement methods and the generation of data should be emphasized over the development of more sophisticated models.

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WASTES INTO GEOLOGIC FORMATIONS

organized by the
OECD NUCLEAR ENERGY AGENCY
in cooperation with the
CEC JOINT RESEARCH CENTRE, ISPRA

ABSTRACTS

Ispra, Italy
23rd-27th May 1977

SAFETY ASSESSMENT OF RADIOACTIVE WASTE DISPOSAL INTO
GEOLOGICAL FORMATIONS: A PRELIMINARY APPLICATION
OF FAULT TREE ANALYSIS TO SALT DEPOSITS

G. Bertozzi, M. d'Alessandro
F. Girardi, M. Vanossi
JRC Euratom, Ispra

ABSTRACT

The methodology of the fault tree analysis (FTA) has been widely used at the Joint Research Centre of Ispra in nuclear reactor safety studies.

The aim of the present work consists of studying the applicability of this methodology to geological repositories of radioactive wastes, including criteria and approaches for the quantification of probabilities of primary events.

Since it is generally agreed that risk is conveniently expressed as the product of a probability multiplied by a severity factor, the FTA may provide the first term, while deterministic models must be developed to obtain the second term.

The present work has just an illustrative purpose. Two ideal cases of saline formations, i.e. a bedded salt and a diapir were chosen as potential disposal sites for radioactive waste. On the basis of arbitrarily assumed hydrogeological features of the salt formations and their surrounding environment, possible phenomena capable of causing the waste to be released from each formation have been discussed and gathered following the logical schemes of the FTA.

The assessment of probability values for release events due to natural causes as well as to human actions, over different time periods, up to one million years, has been discussed.

Though a meaningful analysis can only be performed on a well identified site, the present example shows that the methodology is practicable, and can furnish valuable information.

STATUS AND FUTURE DEVELOPMENTS OF RISK ANALYSIS
FOR REPOSITORIES OF RADIOACTIVE WASTES IN SALT FORMATIONS
IN THE FEDERAL REPUBLIC OF GERMANY

R. Proske

Gesellschaft für Strahlen - und Umweltforschung mbH München
Institut für Tieflagerung - Wissenschaftliche Abteilung
Clausthal-Zellerfeld

ABSTRACT

In the Federal Republic of Germany a hypothetical repository for High-Level Radioactive Waste in a salt formation was taken as basis for a first attempt to use the methodology of risk analysis in order to get statements on the safety of such a geologic and mining system. Several institutions were engaged in drawing up fault trees, development of release models and calculation of the risk.

A lot of R&D work is scheduled to be carried out in future which includes optimization of the application of risk analysis methodology to geologic and mining systems, further development of release models, development of a model describing the migration of radionuclides in typical geologic strata and soils of the Federal Republic of Germany and application of risk analysis methodology to different repositories and disposal technologies. Institutions engaged in that work are cited.

PREVIOUS RESULTS AND FUTURE OBJECTIVES OF RISK ANALYSIS ON
REPOSITORIES FOR RADIOACTIVE WASTE IN GEOLOGIC SALT FORMATIONS
IN THE FEDERAL REPUBLIC OF GERMANY

R. Proske

Gesellschaft für Strahlen - und Umweltforschung mbH München - Institut
für Tieflagerung - Wissenschaftliche Abteilung - Clausthal-Zellerfeld (FRG)

ABSTRACT

In the scope of the "Systemstudie für Radioactive Abfälle in der Bundesrepublik Deutschland" the methodology of risk analysis was applied to a hypothetical waste management system and also to a hypothetical repository for High-Level Radioactive Waste in the Asse Salt Mine in order to test the applicability of this method to those systems especially to the geologic and mining system of the repository and to get first statements on the risk of such systems.

Thus, a preliminary analysis was carried out and fault trees and release models for the repository were developed for three time phases: the "Operational phase," the " 10^3 -years-phase" and the " 10^6 -years-phase." After determination of the probabilities of the basic failure events mainly by means of estimate the fault trees of the "Operational Phase" and the " 10^3 -years-phase" were calculated. The results combined with the respective release of radionuclides out of the salt formation allowed first statements on critical areas in that system with relative high risks and to give first recommendations in order to optimize the safety of such systems.

In future, several other "real" sites and disposal technologies are planned to be analyzed with the methodology of risk analysis for instance the former iron ore mine "Konrad," the cavity technology and the repositories to be built in the future waste management center which is planned in the Federal Republic of Germany.

MODELISATION MATHÉMATIQUE DE LA MIGRATION DE
RADIONUCLIDES DANS UNE FORMATION ARGILEUSE
HOMOGÈNE*

(Application au cas de l'argile de Boom à Mol)

M. Put, R. Heremans
C.E.N./S.C.K.-Mol, Belgique

Les travaux entrepris en 1974 sur la possibilité d'utiliser, pour le rejet de déchets radioactifs conditionnés, une formation argileuse située sous le domaine nucléaire de Mol ont permis de rassembler une première série de données expérimentales sur les caractéristiques de ce site potentiel. L'analyse du risque de contamination de la biosphère a ainsi pu être abordée sur la base d'un certain nombre d'informations réelles. Actuellement les efforts sont concentrés sur l'étude des barrières géologique et géochimique. En collaboration étroite avec le CCR/Ispra, une analyse approfondie des données géologiques, sismiques et tectoniques de la région est en cours. Elle doit aboutir à une première évaluation des risques de rupture de cette barrière sous la forme d'un arbre de défauts. Parallèlement le C.E.N./S.C.K. a mis sur ordinateur un modèle tridimensionnel simple pour l'évaluation de la vitesse de migration des actinides et des produits de fission dans la formation argileuse considérée. Les résultats de mesures faites sur terrain, des analyses et des essais de laboratoire ont été introduits dans ce modèle. Au départ d'un certain nombre d'hypothèses on a pu suivre ainsi le mouvement des radionuclides les plus importants en fonction du temps. Les premières informations ainsi obtenues indiquent un excellent comportement de la barrière géochimique vis-à-vis des produits de fission à demi-vie moyenne et un bon comportement vis-à-vis des actinides de longue demi-vie.

*Travaux effectués sous contrat (013-76-1 WASB) entre la Communauté Européenne de l'Energie Atomique et le Centre d'Etude de l'Energie nucléaire (C.E.N./S.C.K.) de Mol, Belgique.

Des expériences complémentaires au laboratoire et in situ, ainsi que l'adaptation du modèle à des cas particuliers de non homogénéité de la formation géologique (p.ex. créée localement sous l'influence d'une source chaude) sont toutefois nécessaires pour aboutir à une évaluation aussi pragmatique que possible des phénomènes de migration.

RESEARCH PROGRAMMES OF THE COMMISSION OF EUROPEAN COMMUNITIES
RELATED TO RISK EVALUATION OF GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

F. Girardi
JRC-Ispra

ABSTRACT

The E.E.C. Programmes related to risk evaluation of geological disposal are presented. The Joint Research Centre carries out the theoretical modeling activities and a few selected experimental activities which are related to models verification. A set of contractual research activities, primarily set up to encourage development of optimised conditioning techniques and waste disposal strategies, will provide the many additional experimental data which are necessary for a realistic evaluation of long term hazard to man and the environment.

A GEOSPHERE TRANSPORT MODEL FOR RISK EVALUATION:
Calculation of maximum concentration of activity
at given distances from the waste disposal site
due to water invasion

P. Bützer

S. Chakraborty

Nuclear Safety Division

5303 Würenlingen, Switzerland

ABSTRACT

A simplified model for the calculation of radioactivity concentration in water due to invasion of water in an underground disposal area of radioactive waste is described. The methodological framework for computation is based on processes like leaching, hydrodynamic dispersion and diffusion and physico-chemical sorption.

A computer program LEDIRE is written in FORTRAN language for the purpose of a parametric study. The results of an example calculation are given and some limits of such calculations are shown.

NUCLAR WASTE DISPOSAL
CAN THE GEOLOGIST GUARANTEE LONG-TERM ISOLATION?

G. de Marsily*, E. Ledoux*

A. Barbreau**

J. Margat***

ABSTRACT

What role can geologic formations play in the confinement of waste from the nuclear power industry? The safety of an underground repository is shown to be a function of its ability to retain leaking solutions of radionuclides, should water invade the site. We believe that this invasion can almost never be proved impossible over periods of time related to the very long half-lives of some of the elements present in the waste. We also believe that no geologist is able to seriously assess a probability coefficient for such an intrusion of water, as the earth mechanisms are neither random, nor stationary. If he does, however, this probability might be high, as water is universally present in the underground.

Consequently, a model of migration of elements with water in hypothetic geologic formations, ranging from poorly to highly confining ones, was built to determine which are the controlling parameters of the migration. The predominance of sorption (interaction with the rock formation) then became obvious.

It is shown that, when water reaches the waste, geological formations can indeed confine the waste efficiently in case of intense sorption. In the case of a conservative hypothesis: little or sorption and a hydraulic gradient, geological processes can only delay, or dilute the

*Ecole Nationale Supérieure des Mines de Paris, Centre d'Informatique Géologique, Fontainebleau, France.

**Commissariat à l'Energie Atomique, Saclay, France.

***Bureau de Recherches Géologiques et Minières, Orléans, France.

release coming from the long lived part of the waste, with only very little attenuation. This seems to be especially true for radionuclides with no or little exchangeability, such as Iodine 129: it is stored in the underground, the safety of the repository will not only depend on the confining power of the geologic formation, but also, to a great extent, on the yet unknown ability of the environment to receive and accept this delayed effluent at the surface.

GEOLOGIC MODELING IN RISK ASSESSMENT METHODOLOGY
FOR RADIOACTIVE WASTE MANAGEMENT

S. E. Logan and M. C. Berbano
The University of New Mexico

ABSTRACT

Under contract to the U.S. Environmental Protection Agency (EPA), the University of New Mexico is developing a computer based assessment methodology for evaluating public health and environmental impacts from the disposal of radioactive waste in geologic formations.

Methodology incorporates a release or fault tree model, an environmental model, and an economic model. The release model and its application to a proposed repository in bedded salt is described. Fault trees are constructed to provide the relationships between various geologic and man-caused events which are potential mechanisms for release of radioactive material beyond the immediate environs of the repository. The environmental model includes: (1) the transport to and accumulations at various receptors in the biosphere, (2) pathways from these environmental concentrations, and (3) radiation dose to man. Finally, economic results are used to compare and assess various disposal configurations as a basis for formulating policy decisions.

RADIOACTIVE WASTE RISK ASSESSMENT METHODOLOGY DEVELOPMENT
SUPPORTED BY THE
U.S. ENVIRONMENTAL PROTECTION AGENCY

S. E. Logan

ABSTRACT

Under contract to the U.S. Environmental Protection Agency (EPA), The University of New Mexico (UNM) is developing a computer based assessment methodology for evaluating public health and environmental impacts from the disposal of radioactive waste in geologic formations [1,2]. Work under EPA support commenced in August 1975, extending earlier work started at UNM in 1972. Within EPA's mission, applications of the assessment model developed by this project include the following: (1) develop generic ability to evaluate environmental acceptability of fuel cycle facilities, (2) develop technical bases and guidelines for establishing environmental policy relative to commercial wastes, and (3) assist in developing criteria and standards relating to waste management.

The assessment methodology is being developed in generic form with the intention of applying the model (Radioactive Waste Management Systems Model) to various geologic formations by use of appropriate sets of input data. Within the Systems Model, a Fault Tree Model evaluates: (1) probability for release of radioactive material beyond the immediate environs of the repository, and (2) the fraction of the inventory released by each such occurrence. An Environmental Model follows released material and includes: (1) the transport to and accumulations at various receptors in the biosphere, (2) pathways from these environmental concentrations, and (3) radiation dose to man. An Economic Model applies incidence rates of health effects associated with radiation dose and calculates economic costs of health effects in the population.

The geologic modeling considers all apparent geologic and man-caused events which have the potential for releasing radioactive material beyond the immediate environs of the repository. This considers the disruptive events, leaching by ground water, and transport through the geosphere.

This work has coordinated interdisciplinary study into a Systems Model and developed an operational computer code which implements the model. The work does not include experimental research or field studies. Formulation of the model and estimates of input parameter values are from published literature and consultation with workers in the various disciplines. Effort to date has concentrated on the terminal storage (disposal) branch of the model. Application to one specific site has been accomplished for purposes of: (1) aiding a more complete development of the model and computer code, and (2) providing a demonstration of the model for a real locality. The site chosen for this initial application is in an area of bedded salt in southeastern New Mexico (in the southwest of the United States). This is an area under study for possible installation of a Waste Isolation Pilot Plant; however, there are no plans at the present time to expand this facility into a full scale high-level waste repository. The application of the model to this site represents a conservative case for demonstration of the assessment methodology and does not represent present waste management planning. A report covering work to date is presently under review [1].

Ongoing work is refining the model and computer code, performing sensitivity analysis for purposes of: (1) identification of the more significant contributors to long-term risk, and (2) determination of the most significant geologic parameters and data accuracy required. Present funding is through September 1977.

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LE VERRE COMME PREMIERE BARRIERE POUR LE STOCKAGE A LONG TERME DES DECHETS DE HAUTE ACTIVITE

F. Laude

Commissariat à l'Energie Atomique - Centre de
Marcoule-Boite Postale 170-30200 BAGNOLS S/CEZE

RESUME

Le verre, matière minérale homogène, pouvant dissoudre à chaud la plupart des oxydes, répond pour l'instant le mieux au problème du confinement à long terme des éléments radioactifs contenus dans les solutions de produits de fission. Les verres sélectionnés pour cet usage, de composition siliceuse, doivent posséder des propriétés de stabilité nucléaire, chimique et thermique suffisantes.

Après une période en stockage artificiel en surface nécessaire pour leur refroidissement, la destinée normale des blocs de verre est l'enfouissement dans un site géologique approprié, où ils achèveront de décroître.

Pour pouvoir évaluer les risques de propagation d'activité dans le milieu, à partir du moment où ces blocs seront enfouis, il est primordial de connaître les caractéristiques de ces verres et quelle est l'influence du temps sur leurs propriétés essentielles.

Ce rapport donne des premiers éléments de réponse, en faisant le point des études effectuées par le C.E.A. à Marcoule sur les propriétés des verres. Les principaux résultats sont présentés séparément suivant que les verres contiennent ou non des actinides.

SOME CONSIDERATIONS ABOUT CONTINUITY EQUATIONS DESCRIBING
MIGRATION OF RADIONUCLIDES THROUGH AN ADSORBING MEDIUM

A. Saltelli

Laboratorio Rifiuti Radioattivi
CNEN-CSN, Casaccia, Rome, Italy

ABSTRACT

The existing models for migration of radionuclide chains from a repository in geological formations following a leach incident were analyzed. The relative importance of different parameters such as path length L , sorption constants K_i , decay times Λ_i , diffusion coefficients D_i , time of initial release T , water stream velocity V and leach time^T on discharge rate to a surface water body were examined. Two and three members chain equations were solved in a simplified way to analyze chains differing in the K_i and Λ_i values of relative nuclides. Attempt was made to obtain solutions easily evaluable in a risk analysis.

NOTE: Paper was cancelled

THE UNITED STATES PROGRAM FOR THE SAFETY
ASSESSMENT OF GEOLOGIC DISPOSAL OF
COMMERCIAL RADIOACTIVE WASTES

H. C. Claiborne

ABSTRACT

The safe disposal of commercial radioactive wastes in deep geologic formations is the goal of the National Waste Terminal Storage (NWTs) Program, which is managed for the U.S. Energy Research and Development Administration by the Office of Waste Isolation (OWI), Union Carbide Corporation-Nuclear Division.

Safety, both during the operational and long-term (or sealed) phases of a waste repository, is the primary concern; consequently, a comprehensive safety assessment program has been established which is consistent with start up of two waste repositories in late 1985. Safety assessment begins with selection of a disposal site, that is, all geologic and hydrologic factors must indicate long-term stability of the formation and prospective isolation of wastes from circulating ground waters for hundreds of thousands of years. The long-term stability of each site under thermal loading must then be demonstrated by sophisticated rock mechanics analyses. Therefore, it can be expected that a chosen site will effectively isolate the wastes for a very long period of time.

However, to help provide answers on the mechanisms and consequences of an unlikely breach in the integrity of the repository, OWI is sponsoring a Waste Isolation Safety Assessment Program (WISAP) at the Battelle Pacific Northwest Laboratories. The overall objective of this project is an assessment of the safety associated with the disposal of high-level radioactive waste in a geologic formation. This objective will be achieved by developing methods and generating data necessary to characterize the safety of generic geologic waste disposal concepts, which are to be

applied to the assessment of specific sites. It is expected that no one particular model will suffice, both deterministic and probabilistic approaches will be used and the entire spectrum of phenomena that could influence geologic isolation will be considered.

Other long-term safety-related studies that complement WISAP are in progress, for example, borehole plugging, salt dissolution, and salt transport in vertical boreholes. A repository will require licensing by the U.S. Nuclear Regulatory Commission (NRC) and it is anticipated that the safety assessment program will provide the necessary input for the required licensing procedures. These requirements are in the process of being formulated by the NRC.