UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 14 1990

MEMORANDUM FOR: Ronald L. Ballard, Chief
Geosciences and Systems Performance Branch
Division of High-Level Waste Management

John J. Linehan, Chief
Repository Licensing and Quality Assurance
Project Directorate
Division High-Level Waste Management

FROM: William Ford, Senior Hydrogeologist
Hydrologic Transport Section
Geosciences and Systems Performance Branch

King Stablein, Senior Project Manager
Repository Licensing and Quality Assurance
Project Directorate

SUBJECT: OCTOBER 19-20, 1990, VISIT TO GRIMSEL ROCK LABORATORY AND WELLENBERG PROPOSED LOW LEVEL WASTE SITE, SWITZERLAND; OCTOBER 22-24, 1990, FLOW HETEROGENEITY AND SITE EVALUATION WORKSHOP SPONSORED BY ORGANIZATION OF ECONOMIC DEVELOPMENT (OECD) IN PARIS, FRANCE; OCTOBER 25-26, 1990, MEETING OF THE NUCLEAR ENERGY AGENCY COORDINATING GROUP ON SITE EVALUATION AND DESIGN OF EXPERIMENTS FOR RADIOACTIVE WASTE DISPOSAL (SEDE) IN PARIS, FRANCE

Enclosed is an abstract and a detailed trip report which contains a summary of some of the more important observations that we made as a result of our attendance at the OECD sponsored Flow Heterogeneity and Site Evaluation Workshop and associated field trips. In addition, the detailed report contains a summary and results of the first SEDE meeting.

William Ford

William Ford, Senior Hydrogeologist
Hydrologic Transport Section
Geosciences and Systems Performance Branch

King Stablein

King Stablein, Senior Project Manager
Repository Licensing and Quality Assurance
Project Directorate

Enclosures: As stated

cc: RBrowning, Director, DHLWM
JTaylor, EDO
Div. of Security
GPA/IP

TRIP REPORT ABSTRACT
DATE OF REPORT
12/12/90

OFFICIAL TRAVELERS:
William Ford
King Stablein

TRAVEL TO:
Lucerne, Switzerland
and Paris, France

BEGINNING ON: 10/17/90

OFFICE: NMSS
Division of High Level Waste Management
Geosciences & Systems Performance Branch
and Project Directorate

UNTIL: 10/27/90

* * * * *

MEETING TITLE AND/OR AFFILIATION:

October 19 & 20, 1990, Visit to Grimsel Rock Laboratory and Wellenberg Proposed Low Level Waste Site, Switzerland

October 22 - 24, 1990, Flow Heterogeneity and Site Evaluation Workshop Sponsored by Organization of Economic Development (OECD) in Paris, France

October 25-26, 1990, Meeting of the Nuclear Energy Agency Coordinating Group on Site Evaluation and Design of Experiments for Radioactive Waste Disposal (SEDE) in Paris, France

ORGANIZED BY: Organization of Economic Development (OECD)

ABSTRACT AND/OR SUMMARY OF MEETING RESULTS

The theme of this trip was to determine how to adequately characterize the ground water hydrology of a proposed nuclear waste repository. Many of the talks described specific field testing technologies and the ground water characterization plans of countries who had representatives at the workshop. In general no dramatically new testing techniques and characterization approaches were presented that have not been considered in the U.S. program. At the Paris workshop more than one speaker made the point that it may be more important to characterize the near field or local environment rather than large features in the repository environment. This is because, large features such as regional faults can be readily identified and avoided in repository design, whereas local faults and fractures cannot be avoided. William Ford (U.S. NRC) suggested that iterative performance assessment conducted in concert with site characterization activities should be considered as an additional tool to help insure adequate characterization of a site. This technique would require that there be good communication between the characterization team and the performance assessment team so that the interaction of both groups drives the characterization program. This would have the advantages of: (1) focusing the characterization program on those items believed to be important to performance, (2) developing performance assessment tools, (3) keeping performance assessment concepts up to date, and (4) providing more time to make needed changes in the characterization and performance assessment programs.

On October 25 and 26, 1990, King Stablein attended the first SEDE meeting as a member of the U.S. delegation. An important function of the SEDE group is the identification and development of initiatives for the international exchange of information in the area of site evaluation and the design of experiments for radioactive waste disposal. The SEDE group agreed to sponsor or co-sponsor three workshops over the next two years. The first, to be held in June or September of next year is on the topic of gas generation and gas release from radioactive waste repositories. The second workshop was tentatively scheduled to be held in Finland in September, 1991, on the topic of preclosure monitoring of the geologic environment for deep waste disposal. The topic for the third workshop, planned for sometime in 1992, was left open. The SEDE group also agreed to establish a working group on the measurements and physical understanding of ground water flow through argillaceous rocks.

DETAILED TRIP REPORT OF:

William Ford, Senior Hydrogeologist
Hydrologic Transport Section
Geosciences & Systems Performance Branch

King Stablein, Senior Project Manager
Repository Licensing and Quality Assurance
Project Directorate

SUBJECT: OCTOBER 19 & 20, 1990, VISIT TO GRIMSEL ROCK LABORATORY AND WELLENBERG PROPOSED LOW LEVEL WASTE SITE, SWITZERLAND

OCTOBER 22 - 24, 1990, FLOW HETEROGENEITY AND SITE EVALUATION WORKSHOP SPONSORED BY ORGANIZATION OF ECONOMIC DEVELOPMENT (OECD) IN PARIS, FRANCE

OCTOBER 25-26, 1990, MEETING OF THE NUCLEAR ENERGY AGENCY COORDINATING GROUP ON SITE EVALUATION AND DESIGN OF EXPERIMENTS FOR RADIOACTIVE WASTE DISPOSAL (SEDE) IN PARIS, FRANCE

This trip report contains a summary of some of the more important observations that we made as a result of our attendance at the OECD sponsored Flow Heterogeneity and Site Evaluation Workshop and associated field trips. In addition, it contains a summary and results of the first SEDE meeting.

On October 19, 1990, we attended a tour of the Grimsel high level waste test facility. The is an underground tunnel constructed in granitic rock and is used by the Swiss organization NAGRA for conducting tests that will be used to characterize a future high level waste repository site in Switzerland. We toured ongoing ground water experiments in the tunnels. All the tunnels were constructed with a tunnel boring machine with the exception of a few rooms. In the United States it is currently being debated if it is better during site characterization to construct tunnels using a tunnel boring machine or with explosives. Future tunnels at Grimsel will be constructed using a machine with a movable single arm or with explosives so that fractures can be mapped more effectively by the geologists. We viewed a number of experiments designed to test the hydrologic properties of the rock at a variety of scales from borehole size to rooms 3.5 meters in diameter and 30 meters long. All of these tests were modeled before and after to improve the models of the test facility.

At this time all proposed European high level sites are saturated sites, unlike the Yucca Mt. site in Nevada, which is a saturated and unsaturated site. However, while the Grimsel facility is constructed in saturated rock, it is hypothesized that the tunnels have drained water from the rock, creating an unsaturated zone around the tunnels. Other European underground test sites have also reported this phenomenon. This has a created an interest in studying the unsaturated zone to better interpret the larger tunnel tests designed to test the saturated zone.

On October 20, 1990, we attended a tour of the Wellenberg site, which is one of six sites being characterized as a low level and intermediate waste repository.

This facility will be constructed underground in a marl (a rock made up of an intimate mixture of clay and particles of calcite), with the waste placed in tunnels. The site is presently being characterized using boreholes, with most of the ground water tests focusing on the determination of hydrologic parameters of low permeability rock from field tests. When underground testing begins, the access tunnel will be constructed so that any fluid flowing in the access tunnel would have to flow for some distance in a direction opposite to the ground water flow, making it harder for wastes to escape from the repository.

From October 22 to 24, 1990, we attended the OECD workshop on Flow Heterogeneity and Site Evaluation in Paris, France. The theme of this workshop was determining when a site has been adequately characterized. Many of the talks described specific field testing technologies and the ground water characterization plans of countries who had representatives at the workshop. Other talks focused on statistical methods such as Monte Carlo and Krieging techniques and the problems of combining hard and soft data of different scales. In general no dramatically new techniques were presented that have not been considered in the U.S. program.

More than one speaker made the point that it may be more important to characterize the near field or local environment rather than large features in the repository environment. This is because, large features such as regional faults can be readily identified and avoided in repository design, whereas local faults and fractures cannot be avoided.

William Ford (U.S. NRC) suggested that iterative performance assessment conducted in concert with site characterization activities should be considered as an additional tool to help insure adequate characterization of a site. This technique would require that there be good communication between the characterization team and the performance assessment team so that the interaction of both groups drives the characterization program. This would have the advantages of:

(1) focusing the characterization program on those items believed to be important to performance;

(2) developing performance assessment tools;

(3) keeping performance assessment concepts up to date;

(4) providing more time to make needed changes in the characterization and performance assessment programs.

Alan Flint (USGS) presented an interesting talk on prototype experiments conducted for Yucca Mountain in nonwelded and welded tuffs of "G" Tunnel at the Nevada Test Site. This study showed that core (3.2 and 6.1 cm in diameter) of different diameters exhibited the same hydrologic properties, establishing the usefulness of the smaller diameter core in characterizing Yucca Mt. It was also discovered that core data could not be used to predict the results of a larger hydrologic (imbibition) experiment conducted on the boreholes, unless the geometry of the borehole was known. Neutron geophysical logging could be used to predict the results of the larger tests, but not the results of hydrologic (imbibition) tests on the individual core samples.

On October 25 and 26, 1990, King Stablein attended the first SEDE meeting as a member of the U.S. delegation headed by Robert Levich, U.S. Department of Energy. An important function of the SEDE group is the identification and development of initiatives for the international exchange of information in its area of responsibility. The agenda for this first meeting featured the proposed program of work for the SEDE group, but also included four technical papers on the topic "New Measurement Techniques for Site Evaluation", as well as a brief discussion of recent developments in national and international programs in the area of site evaluation and design of experiments for radioactive waste disposal.

The SEDE group agreed to sponsor or co-sponsor three workshops over the next two years. The first, to be held in June or September of next year, is on the topic of gas generation and gas release from radioactive waste repositories. This workshop is to be co-sponsored by SEDE and NEA's Performance Assessment Advisory Group (PAAG). Because of the relevance of the topic to the Waste Isolation Pilot Plant Site (WIPP) in New Mexico, the member of the U.S. delegation representing WIPP volunteered to participate in the planning for and conduct of the workshop.

The second workshop, tentatively scheduled to be held in Finland in September, 1991, is on the topic of preclosure monitoring of the geologic environment for deep waste disposal. The workshop could consider such matters as: parameters that might be monitored; how the data would be used in model verification; design of monitoring programs; frequency of measurements; and design of instruments for monitoring purposes.

The topic for the third workshop, planned for sometime in 1992, was left open. Two topics were discussed as possibilities: (1) calibrating and testing predictive migration models using paleohydrogeological models; and (2) geological investigations in support of long-term scenarios and time-dependent scenarios. Some combination of these two topics may be SEDE's choice for the 1992 workshop.

The SEDE group also agreed to establish a working group on the measurements and physical understanding of ground water flow through argillaceous rocks. Despite a general lack of enthusiasm for this activity, a few countries agreed to send representatives in the early part of 1991 to explore what contribution could be made by the working group.

Possible follow-up activities to the 1990 Flow Heterogeneity and Site Evaluation Workshop were discussed, but there was no agreement on any future activities based upon the workshop. The meeting closed with a tentative agreement that the next SEDE meeting will take place in September, 1991, in Helsinki, Finland.

Copies of the titles and abstracts from papers presented at the workshop are attached, as well as copies of title pages from technical papers given at the SEDE meeting. Written status reports were also submitted to the SEDE group by eleven countries, the International Atomic Energy Agency (IAEA), and the Commission of the European Communities (CEC) on recent developments in national and international programs in the area of site evaluation and design of experiments for radioactive waste disposal. A complete set of the technical papers has been transmitted to the Center for Nuclear Regulatory Analyses and the Advisory Committee on Nuclear Waste. A copy of any paper can be obtained by contacting William Ford (ext. 20506) or King Stablein (ext. 20446)

MODELLING OF BEDROCK AND GROUNDWATER FLOW FOR SITE EVALUATION

K. AHOKAS, P. SAKSA , Saanio & Riekkola Consulting Engineers Ltd
P.ANTTILA, Imatran Voima Oy (IVO)
K.MELING, Technical Research Centre of Finland
T.AIKAS, Teollisuuden Voima Oy (TVO)

ABSTRACT

Site for final disposal of spent nuclear fuel in Finland will be selected by the end of the year 2000. TVO is responsible for site selection program. In 1987 five areas were selected for preliminary site characterization. Areas comprise Finnish Precambrian crystalline rock types. Typical extent of an area under investigation is 5-8 square-km. In 1992 will be decided which 2 or 3 areas will be characterized in detail during 1993-2000. The emphasis of site investigation is put on the identification and analysis of hydraulically conductive zones and fracturing. Three-dimensional groundwater modelling has been a tool to evaluate suitability of the area for final disposal from the safety point of view. Attempts are made to increase the degree of reality in groundwater modelling.

EVALUATION OF STRATEGIES FOR HYDROGEOLOGIC CHARACTERIZATION OF A REPOSITORY AREA IN MARINE AND FLUVIOTERRESTRIAL SEDIMENTARY STRATA

R.W. Andrews [1], P. Hutschmied [2], S. Löw [3], J. Black [4], and W. Dershowitz [1]

[1] INTERA Inc., Austin, TX, U.S.A.
[2] Emch + Berger, Bern, Switzerland; formerly at NAGRA, Baden
[3] COLENCO Power Consulting, Ltd., Baden, Switzerland
[4] Golder Associates, Ltd., Nottingham, U.K., and Redmond, WA, U.S.A.

(Work sponsored by NAGRA, Parkstrasse 23, CH-5401, Baden, Switzerland)

A B S T R A C T

The present paper describes a comprehensive repository development strategy that includes a quantitative approach to quantify (i) the uncertainty about the existence of hydrogeologic key features and (ii) one's ability to reduce this uncertainty by a phased field exploration program. The quantitative methodology is based on the premise that one of the primary goals of the site exploration program is to intersect, detect, and characterize key hydrogeologic features which have some likelihood of forming preferential pathways through the geosphere. The "success" of the exploration strategy is determined by the probability that adequate information will be obtained by the exploration program to confirm either the absence or the presence of preferential pathways at the repository site. The application of the methodology demonstrated the utility of the approach and indicated some key differences between the two host rocks under consideration.

IDENTIFICATION OF SPATIAL VARIABILITY AND HETEROGENEITY OF THE CULEBRA DOLOMITE AT THE WASTE ISOLATION PILOT PLANT SITE*

Richard L. Beauheim
Sandia National Laboratories*
Fluid Flow and Transport Division 6344
P.O. Box 5800
Albuquerque, New Mexico, USA 87185

ABSTRACT

The Culebra dolomite is a heterogeneous, locally fractured medium whose transmissivity varies over seven orders of magnitude in the vicinity of the Waste Isolation Pilot Plant (WIPP) site in southeastern New Mexico, USA. The spatial distribution of hydraulic properties within the Culebra has been defined by performing 150 hydraulic tests at 41 well locations. Different scales of tests are performed to provide data for different purposes. Small-scale tests such as drillstem tests and slug tests, and intermediate-scale pumping tests provide point data useful in developing initial parameters for numerical modeling. Large-scale pumping tests provide information on the distribution of fractures between widely spaced wells, and also provide data for model calibration. Tracer tests provide data on transport mechanisms needed for transport modeling.

INTERPRETATION OF FRACTURE SYSTEM FLOW TESTS BY FRACTURE ANALYSIS AND NUMERICAL SIMULATION

A. PAHL, V. BRAUER, L. LIEDTKE & A. NAUJOKS

Federal Institute for Geosciences and Natural Resources (BGR),

Hannover, Federal Republic of Germany

ABSTRACT

As part of a Swiss-German cooperation together with NAGRA (National Cooperative for the Storage of Radioactive Waste), and GSF (Research Centre for Environmental Sciences), the BGR is responsible for the research project "Fracture System Flow Test" at the Grimsel Test Site. The hydraulic tests are aimed at developing and improving investigation techniques to assess the barrier efficiency of fractured rock for waste repository purposes. Detailed engineering geological mapping and special geological core logging enabled the identification of different fracture systems and the determination of hydraulically important fractures. A 3-D finite element model was used to simulate some in situ tests. The performance capabilities of the "QUEST" computer program are demonstrated by the non-steady-state hydraulic computations as well as the transport calculations.

NETWORK AND EXPERIMENT DESIGN FOR CHARACTERIZING HETEROGENEOUS MEDIA. A THEORETICAL FRAMEWORK

Jesus Carrera, Sebastian Olivella and Javier Samper.
Dep. de Ingenieria del Terreno. E.T.S.I. Caminos.
Universidad Politecnica de Cataluña.
Barcelona, Spain.

ABSTRACT

The observation network and experiment design problem is posed in the framework of numerical modeling of flow and solute transport through permeable media. This leads to formulating the design as minimizing the uncertainty of the model to be calibrated once the measurements have been made. There are several types of uncertainty. Thus, one may minimize the uncertainty of model parameters (design for parameter estimation), or that of predictions to be made with the model (design for prediction). One may also formulate the design so as to best distinguish among alternative conceptual models (design for model discrimination). We present an algorithm for selecting the location of observation points and the measurements to be made at them so as to minimize (or maximize) a scalar function of the parameter estimates covariance (or information) matrix. This approach allows designing a network for parameter estimation and model prediction. The robustness of the method is illustrated with a example showing that the design is only marginally altered when model assumptions are varied. Model discrimination is more subtle, as it is more sensitive to parameter values than minimization of uncertainty. We present a methodology to overcome this difficulty.

THE INFLUENCE OF SCALE ON CALCULATED SORPTIVITY VALUES FROM IMBIBITION EXPERIMENTS ON WELDED AND NONWELDED TUFF

Alan L. Flint, U.S. Geological Survey,
Lorraine E. Flint, Fenix and Scisson of Nevada
and
Kenneth A. Richards, U.S. Geological Survey
Mercury, Nevada

ABSTRACT

Imbibition experiments were conducted on welded and nonwelded volcanic tuffs to determine the influence of sample size on the calculation of Philip's sorptivity parameter at four different scales. Rock cores, 3.2 and 6.1 cm in diameter by an average of 5 cm long, were used in two laboratory scale experiments. A horizontal borehole, 10 cm in diameter by 10 m long, was used for the two field scale experiments. Imbibition into the entire borehole was the largest scale experiment and neutron log data collected before and after the imbibition experiment yielded the intermediate scale data. The two sizes of core exhibited virtually the same sorptivity and either could be used to predict the results of the borehole scale experiment as long as the number of samples was large enough to represent the spatial heterogeneity. Core samples could be used to predict the neutron log data only if the unique system geometry was known and accounted for *a priori*. The neutron log data could be used to predict the results at the borehole scale but could not be used to predict the results of the core samples due to the spatial heterogeneity and the larger sampling volume.

AN APPROACH TO IDENTIFICATION AND MODELLING OF FLOW HETEROGENEITIES AT THE ASPO HARD ROCK LABORATORY

G Gustafson[1], G Bäckblom[2]

Chalmers University of Technology, Dept of Geology
S- 412 96 Gothenburg

Swedish Nuclear Fuel & Waste Management CO
Box 5864, S-412 96 Stockholm

OECD/NEA Paris October 22-24, 1990
Workshop on Flow Heterogeneity and Site Evaluation

INTRODUCTION

Siting and site characterization of a repository for spend fuel is a key issue within the SKB's R&D program. In order to prepare for the siting and licensing of a spent fuel repository, SKB has decided to construct a new underground research laboratory. Site characterizations was initiated in 1986. Predictions have been made prior to construction and they will be compared to reality during the construction of the laboratory.

Construction work for the Äspö Hard Rock Laboratory started in August 1990. The main goals of the underground research laboratory are to [1]:

- Test the quality and appropriateness of different methods for characterizing the bedrock with respect to conditions of importance for a final repository.
- Refine and demonstrate methods for how to adapt a final repository to the local properties of the rock in connection with planning and construction.
- Collect material and data of importance for the safety the final repository and for confidence in the quality of the safety assessments.

Extensive pre-construction investigations started 1986. These investigations (geology, geophysics, geohydrology, groundwater, chemistry, rock mechanics) have been performed and evaluated in stages [2], [3]. Evaluations were done in several scales from regional >>1000 m down to the detailed scale 1-5 m. The final predictions before construction are now under way.

Hydraulic tests have been performed in 35 percussion holes (100-200 m deep) and 19 cored holes (500-1000 m deep). These tests included measurements of transmissivities in several scales and more than 20 interference tests.

The characterization and modelling of this complex system has basically followed two main avenues:

FLOW HETEROGENEITY IN A FRACTURED ROCK A CASE STUDY FROM THE STRIPA PROJECT

by

A.W. Herbert+
D.C. Holmes++
J.H. Black*
J.E. Gale**
O. Olsson#

+AEA Decommissioning and Radwaste, Harwell, UK.
++British Geological Survey, Keyworth, UK.
*Golder Associates, Nottingham, UK.
**Fracflow Consultants Inc, St Johns, Canada.
#ABEM AB, Stockholm, Sweden.

ABSTRACT

Part of the on going research effort of the international Stripa Project, based at the Stripa Mine in Sweden, involves a Site Characterisation and Validation Programme (SCV). This comprises investigation of a block of fractured crystalline rock some 250 x 250 x 100m in extent penetrated by 12 angled boreholes drilled from tunnels in the mine. The SCV is intended to represent the type of investigation which might occur at a repository site during construction to identify significant flow pathways through the rock mass as well as volumes of "good rock".

A staged approach of investigation has been employed in which periods of measurement have alternated with periods of conceptual and mathematical modelling. Predictions have been checked by additional measurements.

A variety of single borehole geophysical (radar and seismic), geological mapping, geochemical and hydrogeological (a novel focused packer system) techniques have been employed in the early stages to construct a conceptual model of fracture flow within the rock mass. Mathematical models, based on a fracture-network approach, have been constructed from these data, and used to predict fluid flux into the purpose built boreholes and tunnels. Measured flows, combined with transmissivity distribution information derived from inter-borehole hydraulic interference testing, were then compared with the predictions showing good agreement and building confidence in our approach. New models of flux and transport have been developed which incorporate the additional measurements. Predictions of these models will be evaluated using tracer tests.

DESIGN OF LONG TERM LOW YIELD PUMPING TESTS FOR IDENTIFYING HIGH TRANSMISSIVITY ZONES (+)

J. Heredia (*), F.J. Elorza (*), J. Carrera (**), J. Samper (**)
C. Bajos (***) y C. del Olmo (***)

(*) Dpto. Matemática Aplicada (DMAMI). ETSIMM. Univ. Pol. Madrid. Spain.
(**) Dpto. Ingeniería del Terreno (DIT). ETSICCP. Univ. Pol. Cataluña. Barcelona. Spain.
(***) ENRESA. Madrid. Spain.

ABSTRACT

The field experiments designed and used to characterise the high transmissivity zones of the radioactive waste disposal site of "El Cabril" (ENRESA) are presented. The designed methodology involves the use of long term, low yield pumping tests coupled with tracer tests to identify the preferential flow paths of the geological environment. The results of the pumping tests and the current status of their interpretation calibration is also presented. This experience allows us to be optimistic in the investigation and characterisation of the heteregeneity of low permeability rocks.

SPATIAL VARIABILITY: A REPOSITORY PERFORMANCE ASSESSMENT PERSPECTIVE

David Hodgkinson and Tim McEwen
INTERA-ECL, Henley-on-Thames, Oxfordshire,
and Melton Mowbray, Leicestershire, UK

Abstract

This paper presents an overview of spatial variability from the perspective of repository performance assessment. In hard rocks extensive fracture zones can be avoided when siting waste containers and thus the primary geological barrier is the system of ubiquitous joints and small fractures between zones. Discrete fracture models provide a useful means of integrating and interpreting fracture-related measurements and for extrapolation to larger length scales. Moreover, they can qualitatively reproduce many of the seemingly erratic phenomena observed in fractured rock hydrogeology. In addition to deriving input data for models from site investigations and field experiments, paleohydrogeological evidence should be used to build confidence in our understanding of slow geochemical processes.

GEOSTATISTICAL METHODS FOR SITE CHARACTERIZATION AT YUCCA MOUNTAIN

J. D. Istok[1] and A. L. Flint[2]

[1]Department of Civil Engineering, Oregon State University
[2]U. S. Geological Survey

ABSTRACT

Yucca Mountain, Nevada, U.S.A. is being considered as a repository for commercial, high-level nuclear waste. One objective of site characterization is to obtain information for numerical models that are used to predict pre-waste-emplacement groundwater travel times. This information will be obtained by analyzing a variety of types of field and laboratory data that can be broadly classified into two groups: *hard data* consisting of measured values of a quantity, and *soft data* consisting of "guessed" values based on qualitative observations and/or subjective interpretation of the available hard data. Hard and soft data can be further classified into three categories: exact, interval, and inequality. The objective of this paper is to review the assumptions and limitations of several geostatistical methods that are potentially useful for analyzing these data to obtain estimates for rock unit contacts, properties, and state variables at Yucca Mountain.

THE IMPLICATIONS OF HETEROGENEITY FOR REPOSITORY PERFORMANCE ASSESSMENTS

C. P. Jackson, J. D. Porter, S. T. Morris and A. W. Herbert
AEA Technology, Harwell Laboratory, Didcot, Oxon, UK

ABSTRACT

We outline the current views of the Nirex Disposal Safety Assessment Team on heterogeneity, we describe the pragmatic approach to modelling the consequences of heterogeneity that is being currently used, we present work that is being undertaken in the Nirex Safety Assessment Research Programme to develop improved models and we discuss the implications of heterogeneity for site investigation. We point out the need to develop simple models for use in probabilistic analyses. Heterogeneity leads to dispersion, which is currently modelled using a simple diffusion-like model. We discuss the differences between structured heterogeneity, such as fracture zones, and random heterogeneity. We consider that the geostatistical approach to modelling random heterogeneity is probably that most suitable for the needs of Nirex. More measurements are needed in order to characterize heterogeneous media than to characterize homogeneous media.

Hydraulic and Air Permeability Tests to Assess the Effectiveness of Jointed Rock as a Barrier

Langer, M., Liedtke, L. and Pahl, A.
Federal Institute for Geosciences and Natural Resources, Stilleweg 2, D-3000 Hannover 51

FIELD MEASUREMENT OF THE SPATIAL VARIABILITY OF EVAPORATION RATE ALONG SOME FRACTURES ON A TUNNEL WALL

Kunio Watanabe
Associate Professor, Saitama University, 255 Shimo-Okubo Urawa, Saitama 338 Japan

Hideki Sakuma
PNC, 1-9-13 Minatoku, Tokyo 117 Japan

Yoshifumi Noguchi
Nittetsu Mining Co., Ltd., 2-3-2 Marunouchi, Chiyoda-ku, Tokyo, Japan

Noriyuki Arai
Graduated Student, Saitama University, Japan

Abstract

Spatial distribution of evaporation rate along some major fractures was successfully mapped on a tunnel wall of the Kamaishi Mine, Japan. A 10m section in the tunnel was selected for the measurement. Two air-tight walls had been constructed at the both ends of the section to cut off the air flow in the tunnel. Prior to the measurement, warm and dry air had been sent into the section for about 1 month to dry up the wall surface. The evaporation rate from the wall was then measured by the use of an equipment newly developed.

Several spots of high evaporation rate, which seemed to be the special seepage ways (channels) in those fractures, were clearly identified. Some of the locations of those high evaporation points were identical to the intersection points between the major fractures.

PERMEABILITY TESTS FOR UNCONSOLIDATED INHOMOGENEOUS FORMATIONS OF LOW PERMEABILITY

G.C.Wijland, P.Glasbergen
H.D.Langemeijer, R.A.M.Stapper

Soil and Groundwater Research Laboratory,
National Institute of Public Health and Environmental Protection
BILTHOVEN, The Netherlands

Studies are currently being carried out in The Netherlands to assess the environmental consequences of geological disposal of radioactive waste in salt formations. In these studies transport models are used to evaluate the geohydrological system in formations overlying the potential host-rock, and to establish the potential pathways for radionuclides to the biosphere. The determination in the field or in the laboratory of geohydrological parameters for these models for unconsolidated inhomogeneous sediments of low permeability is associated with a number of technical problems. Therefore, it was considered essential to obtain practical experience and insight in the reliability of the various methods under the governing geohydrological conditions. Two wells reaching a representative formation have been selected. Both core measurements as well as several field test methods were tested and evaluated.

DETERMINATION OF FORMATION HETEROGENEITY AT A RANGE OF SCALES USING A NOVEL MULTI-ELECTRODE RESISTIVITY SCANNING TECHNIQUE - RESCAN.

by

G M Williams [1], P D Jackson [2] and R S Ward [1]

British Geological Survey, Keyworth, Nottingham.
[1] Fluid Processes Research Group. [2] Regional Geophysics Research Group.

Abstract

The traditional method of measuring ground resistivity involves passing a current through two outer electrodes, measuring the potential developed across two electrodes in between, and applying Ohm's Law. In the RESCAN system developed by the British Geological Survey, each electrode can be electronically selected and controlled by software to either pass current or measure potential. Thousands of electrodes can be attached to the system either in 2-D surface arrays or along special plastic covered probes driven vertically into the ground or emplaced in boreholes. Under computer control, the resistivity distribution within the emplaced array can be determined automatically with unprecedented detail and speed, and may be displayed as a tomographic image.

So far, the system has been applied at the meso-scale in monitoring the radial migration of an electrolyte introduced into a recharge well in an unconsolidated aquifer, and at the micro-scale on drill cores to evaluate spatial variability in physical properties. The RESCAN technique has considerable potential for determining formation heterogeneity at different scales and provides a basis for developing stochastic models of groundwater and solute flow in heterogeneous systems.

FLOW METER

Presentation for OECD/NEA/Steering Committee for Nuclear Energy/Radioactive Waste Management Committee/Co-ordinating Group on Site Evaluation and Design of Experiments for Radioactive Waste Disposal (SEDE)

First Meeting, Paris, France, 25th-26th October 1990

PEKKA ROUHIAINEN
DOCTOR OF TECHNOLOGY
GEOPHYSICIST

G-SYST OY
Soukanniitty 15
SF-02360 ESPOO
Finland

tel national (90) 802 5583
international + 358 0 802 5583
telefax + 358 0 802 6203

APPLICATION OF BOREHOLE FLUID CONDUCTIVITY LOGGING WITHIN NAGRA'S FIELD INVESTIGATION PROGRAM

PREPARED BY:

S. Vomvoris (NAGRA)

V. A. Kelley (INTERA, Inc.)

S. Loew (COLENCO Power Consultants, Ltd)

October, 26, 1990

Nagra – Cédra – Cisra

EVAPORATION MEASUREMENT ON A TUNNEL WALL FOR MAPPING THE SPATIAL VARIABILITY OF GROUNDWATER INFLOW

- EVAPORATION SENSOR -

Kunio WATANABE

Associate Professor, Dr. Engineering, Saitama University, Faculty of Engineering, 255 Shimo-Okubo, Urawa, Saitama 338 Japan
Telefax: + (Japan) 48 855 9361

Paper presented at:
Co-ordinating Group on Site Evaluation and Design of Experiments for Radioactive Waste Disposal (SEDE)

First meeting 25th-26th October 1990 Paris, France

FLOW METER

Presentation for OECD NEA/Steering Committee for Nuclear Energy Radioactive Waste Management Committee/Co-ordinating Group on Site Evaluation and Design of Experiments for Radioactive Waste Disposal (SEDE)

First Meeting, Paris, France, 25th-26th October 1990

PEKKA ROUHIAINEN
DOCTOR OF TECHNOLOGY
GEOPHYSICIST

G.S.P. OY
Soukanniitty 15
SF-02360 ESPOO
Finland

tel. national: 90) 802 5583
international: + 358 0 802 5583
telefax: + 358 0 512 620

EVAPORATION MEASUREMENT ON A TUNNEL WALL FOR MAPPING THE SPATIAL VARIABILITY OF GROUNDWATER INFLOW

- EVAPORATION SENSOR -

Kunio WATANABE

Associate Professor, Dr. Engineering, Saitama University, Faculty of Engineering, 255 Shimo-Okubo, Urawa, Saitama 338 Japan
Telefax: + (Japan) 48 855 936

Paper presented at:
Co-ordinating Group on Site Evaluation and Design of Experiments for Radioactive Waste Disposal (SEDE)

First meeting 25th-26th October 1990 Paris, France

APPLICATION OF BOREHOLE FLUID CONDUCTIVITY LOGGING WITHIN NAGRA'S FIELD INVESTIGATION PROGRAM

PREPARED BY:

S. Vomvoris (NAGRA)

V. A. Kelley (INTERA, Inc.)

S. Loew (COLENCO Power Consultants, Ltd)

October, 26, 1990

Nagra - Cédra - Cisra

KS/REPORT ON TRIPS - OCT

- 1 - DEC 14 1990

MEMORANDUM FOR: Ronald L. Ballard, Chief
Geosciences and Systems Performance Branch
Division of High-Level Waste Management

John J. Linehan, Chief
Repository Licensing and Quality Assurance
Project Directorate
Division High-Level Waste Management

FROM: William Ford, Senior Hydrogeologist
Hydrologic Transport Section
Geosciences and Systems Performance Branch

King Stablein, Senior Project Manager
Repository Licensing and Quality Assurance
Project Directorate

SUBJECT: OCTOBER 19-20, 1990, VISIT TO GRIMSEL ROCK LABORATORY AND WELLENBERG PROPOSED LOW LEVEL WASTE SITE, SWITZERLAND; OCTOBER 22-24, 1990, FLOW HETEROGENEITY AND SITE EVALUATION WORKSHOP SPONSORED BY ORGANIZATION OF ECONOMIC DEVELOPMENT (OECD) IN PARIS, FRANCE; OCTOBER 25-26, 1990, MEETING OF THE NUCLEAR ENERGY AGENCY COORDINATING GROUP ON SITE EVALUATION AND DESIGN OF EXPERIMENTS FOR RADIOACTIVE WASTE DISPOSAL (SEDE) IN PARIS, FRANCE

Enclosed is an abstract and a detailed trip report which contains a summary of some of the more important observations that we made as a result of our attendance at the OECD sponsored Flow Heterogeneity and Site Evaluation Workshop and associated field trips. In addition, the detailed report contains a summary and results of the first SEDE meeting.

ORIGINAL SIGNED BY

William Ford, Senior Hydrogeologist
Hydrologic Transport Section
Geosciences and Systems Performance Branch

ORIGINAL SIGNED BY

King Stablein, Senior Project Manager
Repository Licensing and Quality Assurance
Project Directorate

Enclosures: As stated
cc: RBrowning, Director, DHLWM
Div. of Security
JTaylor, EDO
GPA/IP

DISTRIBUTION

CNWRA	NMSS R/F	HLPD R/F	LSS
LPDR	ACNW	PDR	Central File
REBrowning, HLWM	BJYoungblood, HLWM	JBunting, HLEN	JLinehan, HLPD
RBallard, HLGP	On-Site Reps	KStablein, HLPD	WFord, HLGP
CArlotto, NMSS	RBernero, NMSS		

OFC	:HLPD	:HLGP	:	:	:	:
NAME:	KStablein/v	:WFord	:	:	:	:
Date:	12/14/90	:12/ /90	:	:	:	:

OFFICIAL RECORD COPY