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MEMORANDUM FOR: Malcolm R. Knapp, Section Leader
Hydrology Section
Geotechnical Branch
Division of Waste Management

FROM: Matthew Gordon
Geotechnical Branch
Division of Waste Management

SUBJECT: TRIP REPORT: MATERIALS RESEARCH SOCIETY (MRS) MEETING, BOSTON, NOVEMBER 14th-17th, 1983

Attached please find my summary notes from the MRS meeting in Boston, November 14th-17th, 1983. I attended Symposium D, "Scientific Basis for Nuclear Waste Management".

"ORIGINAL SIGNED BY"

Matthew Gordon
Geotechnical Branch
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cc: WMGT Staff

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TRIP REPORT - MATERIALS RESEARCH SOCIETY ANNUAL MEETING
SYMPOSIUM D - SCIENTIFIC BASIS FOR NUCLEAR WASTE MANAGEMENT
BOSTON, MASSACHUSETTS NOVEMBER 14th-17th, 1983

The subject meeting provides an annual forum for the presentation of interdisciplinary status reports on technical progress being made towards repository development. The topics of discussion of this year's meeting were relevant to all aspects of the NRC regulatory program, particularly the technical criteria specified in 10 CFR Parts 60.112 and 60.113. The general emphasis of the lectures was on hydrogeological and chemical considerations to be made in complying with regulatory criteria and/or protecting public health and safety.

The four days of lectures were divided into ten half-day topical sessions, with two sets of half day sessions held concurrently the final day. The topical sessions which I attended were:

1) Repository Relevant Research: Salt (Europe, WIPP);
2) Repository Relevant Research: Basalt
3) Repository Relevant Research: Granite
4) Repository Relevant Research: Tuff
5) Repository Relevant Research: Salt (Texas, Utah, Mississippi)
6) Summary of National Academy of Sciences' Report on Radwaste Disposal, plus Comments by Review Panel, plus Miscellaneous topics;
7) Modeling; and
8) Far Field Sorption and Migration.

Other NRC staff attended the concurrent sessions

9) Leaching, Source Term Investigations; and
10) Waste Form and Related Materials Evaluation and Characterization.

The sessions provided much information of interest to Hydrology Section staff. I provide my impressions of each of the topical sessions which I attended below, with special emphasis on Hydrology Section concerns:

<u>Repository Relevant Research: Salt (Europe, WIPP)</u>

Since, under expected conditions, there will be no "hydrology" in salt formation, the main focus of concern in salt media, apparent in the papers presented, is corrosion of the waste package. N. Jockwes of Germany presented evidence that the generation of gases by thermal cracking is important for HLW waste repositories in salt. These gases would exist at high pressures and could accelerate corrosion of the package. The amount of gas generation is dependent on the water content of the salts, which is generally on the order of 10^{-1}% by weight. R.

Odog, also of Germany, noted two sometimes opposing considerations in container design: the container should be corrosion resistant and should have minimal interactions with the waste form. In salt formations a low-alloyed material is beneficial in terms of the second consideration, while a high-alloyed material is more effective in terms of the first consideration. The implication was that an inner and outer container may be necessary in salt. Bentonite as backfill was considered effective in salt due to its low sodium content and resultant capacity for sodium adsorption. However, for radionuclide transport in both dissolved and colloidal forms, E. Nowak of Sandia noted that bentonite may not retain all of the radionuclides well, particularly pertechnetates. It does appear to isolate plutonium well, particularly at lower bentonite compactions. The compaction of the bentonite backfill is expected to increase with time due to salt creep. J. Prij of the Netherlands noted that for a maximum repository temperature of 180°C, the pressure predicted by thermomechanical salt creep models may be as high as 400 bars. W. Coons of D'Appolonia described an investigation into the origins of the high-pressure brine pockets encountered at WIPP. By comparing brine chemistry to meteoric water and ancient seawater chemistry, Coons concluded that the brine pockets represented ancient, trapped seawater. He contended that the brine pockets are stagnant, non-connected and not increasing in size. This was supported by tests which indicated that the brines are in equilibrium with all components of the host rock. Coons also noted the presence of unexplained elevated concentrations of lithium in the brines.

It should be noted that the American presenters avoided use of the phrase "disturbed zone", favoring "disturbed rock zone" instead.

Repository Relevant Research: Basalt

The BWIP presenters, similarly to the American salt presenters, avoided the use of the words "disturbed zone", also using the words "disturbed rock zone". Roy Gephart of BWIP presented an overall status report of the BWIP project. He stated that four repository horizons are being considered: Rocky Coulee, Cohassett, McCoy and Umtanum flow tops. He noted ubiquity of fractures, but suggested that they were largely filled with secondary minerals (clay and silica). Gephart noted the spatial heterogeneities of the site and noted that in one (unnamed) hole on the site an anomolous conductivity of 10^{-4} m/sec in a deep fractured zone at the base of an interior was found. He also (cautiously) noted that a vertical conductivity measurement, calculated by the Neuman ratio method, appeared to yield a value for vertical hydraulic conductivity on the order of 10^{-10} to 10^{-11} m/sec. I conferred with Dr. Gephart privately and he stressed that this result is highly preliminary. The results will have to go through internal review and analysis, whereupon they will be transferred to DOE-RL, who will presumedly pass the results on to NRC. D. Lane of RHO presented test results on hydrothermal reactions between basalt and groundwater which may have affects on sorption and solubility of radionuclides. The effects of temporarily increased pH and dissolved

oxygen with temperature were not seen to have any adverse impact on repository performance, and in fact, may result in decreased permeability due to plugging by alteration assemblages.

The use of Monte Carlo methods for probabilistic evaluation of travel times was discussed by P. Clifton of BWIP. His presentation was identical to the presentation at the BWIP performance assessment workshop last September. The results of his simulation suggested a median travel time of 17,000 years to the accessible environment with a standard deviation of about an order of magnitude. This result should not be considered definitive since it is dependent on some unsubstantiated assumptions. These assumptions include: horizontal flow, effective porosity of 5×10^{-3}, a mean hydraulic conductivity of $0.15 m^2$/day with a log standard deviation of 1.83, a hydraulic gradient of 10^{-3}, and a correlation range of 5 km for hydraulic conductivities.

Repository Relevant Research: Granite

The durability of the waste form in a granite media was suggested by R. Heiman of Canada to be much more dependent on the geologic environment than on the composition of glass used. The package backfill was seen by several presenters as an excellent opporunity to retard waste transport by adsorption and diversion of groundwater flow.

The Swedes have done a large amount of laboratory and field tests on the granites of the Stripa mine. A significant portion of their efforts have focused on the effects of fracture flow. Fractures in granite may range from large scale fissures to microcracks. Diffusion into non-connected microcracks may provide a positive retardation mechanism; however, L. Bingersson of Sweden has found microfissures open and connected even at depths on the order of 400 meters under natural stress conditions. H. Aberlin of Sweden studied migration of tracers in individual fissures at depth in-situ and found not only the expected channeling of flow into fissures, but also channeling of flow within the fissures. In his controlled experiment, the apertures of the fissures were determined through a mass balance, and compared to apertures calculated by the popular parallel-plate "cubic" law. The results often differed by a factor of 1000, which indicates serious problems in applicability of the parallel-plate conceptualization of fracture flow.

Repository Relevant Research: Tuff

Conceptual models of the NNWSI site was presented by both D. Vieth of DOE and W. Dudley of USGS in separate presentations. Vieth stated that major geochemical retardation is expected in the Calico Hills formation below the repository horizon (Topopah Springs). Another favorable aspect of placing waste in the Topopah Springs, according to Vieth, is its thermal stability and good engineering properties. Dudley seemed to contradict Vieth on the last point, stating that the highly fractured nature of the Topopah Spring formation presented significant engineering problems. The

Topopah Spring is also considered to be a good choice of repository horizon from the standpoint of retrievability. Vieth stated that water around the repository during its early (hot) stages will exist only in the gaseous phase.

Dudley presented three alternative conceptual models of NNWSI under consideration at present:

1) Recharge uniform in time and space at 8 mm maximum downward flux. Little flow diverted to faults or fractures. Vertical flow to water table.

2) Widely spaced intense recharge events causing temporarily saturated conditions in non-welded tuff. Fast flux pulses with little matrix diffusion. Potential for perched water tables. Strong horizontal flow component in densely welded unit. Flow diverted into fractures.

3) Periodic recharge events. Flow diverted into fractures and down to water table. "Capillary barrier" within Paintbrush non-welded units. Vapor diffusion with conective currents. Limited matrix diffusion.

Dudley indicated that the ultimate model may combine elements of all three conceptual models. Dudley seemed confident that the hydrologic system is a closed one which has, as a sink, the Death Valley. This idea is supported by the extremely low hydrologic potentials observed in Death Valley. In response to a question, Dudley acknowledged presence of springs on Yucca Mountain which he attributed to seasonal perched conditions. The impact of such seasonal springs on repository performance was not discussed.

P. Bish of Los Alamos noted positive geochemical conditions in zeolotized tuff below the repository horizon. It was noted that the thickness of the zeolotized layer exceeded 25 meters at all points on the site.

L. Scully of SNLA noted that proper design could reduce the amount of rock that would need to be removed for construction of a waste repository from 10 million m^3 to 2 million m^3, and from 300 boreholes for waste emplacement to 200 boreholes. Scully suggested horizontal emplacement as the most favorable from a design standpoint.

A. Ogard presented calculations which indicated a potential sorption capacity of the Calico Hills formation of $5* 10^5$ metric tons, which is greater than the total contents of a repository. In response to a comment, it was noted that if flow is diverted to faults or other features, advantage will not be taken of this sorptive capacity.

L. Tyler of SNLA presented NNWSI Performance Assessment considerations, which included compilation of a documentable and traceable data base, and

the development and application of new computer codes (FEMWASTE adaptation, SAGUARO, AND LHS). Tyler also presented some preliminary mimimum travel time estimates: 2600 years through lower clastic unit of Calico Hills and 3400 years through the aquifer system. The expected travel times were on the order of billions of years. Roy Gephart of BWIP questioned the validity and the public perception of these estimates. (Dr. Gephart made this comment to several speakers throughout the four day seminar).

Repository Relevant Research: Salt (Texas, Utah, Mississippi)

Conceptual models of each site (Richton Dome, Gibson Dome, and Palo Duro Basin) were presented. All three conceptualizations included travel time estimates in excess of 100,000 years. Dr. Gephart took strong issue with these preliminary estimates, as did several other speakers. Many in the audience expressed displeasure at the apparent "salesmanship" each lecturer seemed to have for his/her particular site. Dr. Gephart noted that "we are in a site characterization mode at this point, rather than a licensing mode".

Summary of N.A.S. report on Radware Disposal

T. Pigford of UCB presented a summary of the report known as the WISP report. The WISP study favored a "dose to maximum exposed individual" standard over the integrated dose standards proposed by EPA. The WISP study also concluded that borosilicate glass was the most promising waste form. The results of the WISP study were presented in terms of curves of radionuclide doses at the accessible environment versus groundwater travel time.

It is important to note that the WISP study considered only anticipated conditions, based on the current hydrogeologic system. The dose rates, which are based on solubility dilution factors, may not apply at long times into the future when the system may change. The dose rates which Pigford presented, in my opinion, suffer from some of the same problems for which deterministic estimates of travel times have been criticized. That is, the curves are presented as single-values for each assumed groundwater travel time. Uncertainties in the dose rate due to uncertainties in retardation, solubility and dilution factors are ignored. The results would be more useful if "uncertainty bands" were presented around each curve of dose rate versus travel time. Pigford acknowledged the need for uncertainty analyses.

Review Panel Comments on Geomedia-Specific Repository Relevant Research: Salt, Basalt Granite and Tuff

At this point in the meeting, a review panel consisting of G. Cowan (Los Alamos), C. Heath (NUS corporation)) and D. Runnels (University of Colorado) offered their impressions of the first two days of presentations.

Heath felt that although progress is being made, there is still a lack of focus to the national and international program. He described the impact that this lack of focus has on the U. S. taxpayer and on the success of the program. He also noted that the data ranges currently being looked at for various parameters are so large that alternative approaches should probably be sought. Heath considered the assumption of constant properties (such as hydraulic properties) over periods on the order of a billion years to be absurd; he noted that the earth is expected to be varporized in a supernova in less than a few million years.

Cowan noted that public perception of the risks of nuclear waste diposal will largely depend on the future political and social needs. He recommended the abandonment of more groundwater travel time studies out of a fear of "Swiss-cheesing" the site in pursuit of the elusive "reasonable assurance" of long travel time. He recommended that next year a "mock licensing action" be acted out at the MRS meeting to help provide a focus to the waste management program.

Runnels expressed satisfaction with the fact that colloidal chemistry is receiving a great deal of attention by geochemists at the meeting. However, he took issue with the emphasis on Eh in many of the lectures. He considers Eh to be both immeasurable in-situ and physically meaningless for complex multi-component systems. He also doubts that backfill will contribute substantially to retardation due to its higher permeability.

Modeling

Several modeling studies were presented in this session. C. Carnahan of LBL presented an analytical model which demonstrated the importance of thermal osmotic, chemical osmotic, and "ultrafiltration" flows in clay backfills. In more permeable backfill, the Darcian and Fickian diffusion processes will dominate.

J. Wang of LBL presented a canister heating study in unsaturated tuff media by NRC using TOUGH. The results were noted to be highly sensitive to the capillary function near the irreducable liquid saturation level. Data for the capillary function for media at low saturations are scarce. This is likely to create problems to users of TOUGH and other variably-saturated groundwater flow and heat transport models.

Far-Field Sorption and Migration

Most of the presentations on this afternoon of the meeting were less informative than in previous days. In general, it was recognized solubility and adsorption are important in nuclear waste diposal safety assessment.

D. Brookins of UNM presented a study of the secondary minerals found in deep basalt fractures at BWIP. The objective of the study was to

determine whether the mineralization was derived from a basaltic source. The chemical analyses cited by Brookins supported the latter interpretation. A questioner from BWIP did not agree with Brookins' results, noting cores which contained secondary mineralization of differing chemical content than those analysed by Brookins.

I. McKinley of Switzerland (nee Scotland) proposed to study elemental migration from a sedimentary layer beneath Loch Lomond in Scotland as an analog for radionuclide retardation. However, it was not clear from his presentation whether there was a source term and transport process truly involved, and if so, how it could be related to radionuclide migration from a repository.

Conclusion

The MRS 1983 meeting provided an excellent forum for the exchange of ideas in all aspects of nuclear waste management. While the papers were of varying quality and significance, the majority of them were quite interesting and well-presented. The degree of contradiction between speakers is disturbing, however, and clearly indicates a need for further meetings like this one, and a need for further efforts in the various technical areas. I recommend that the Division of Waste Management take a more active part in next year's meeting either by presenting papers or encouraging our contractors to present papers which we feel are important to the NRC program. I also would like to recommend the continued presence of WMGT staff members at future MRS/Waste Management symposia. NRC geologists, geochemists, hydrologists, metallurgists, and mining engineers will undoubtedly benefit from the experience.