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Seth M. Coplan, Section Leader
NTS Project Section
Repository Projects Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

GEOCHEMISTRY WORKSHOP SUMMARY

The subject summary, for the workshop held at Los Alamos, New Mexico on July 10-12, 1984, is attached for your signature.

Following your review and approval, please return the summary so that we can add the enclosures and complete distribution.

Donald L. Vieth

Donald L. Vieth, Director
Waste Management Project Office

WMPO:JSS-1114

Enclosure:
As stated

cc:
D. L. Oakley, LANL, Los Alamos, NM, w/o encl.
G. S. DePoorter, LANL, Los Alamos, NM, w/encl.
M. A. Glora, SAI, Las Vegas, NV, w/encl.
M. B. Blanchard, WMPO, w/encl.
J. S. Szymanski, WMPO, w/o encl.

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NRC-DOE GEOCHEMISTRY MEETING SUMMARY
JULY 10-12, 1984

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

Attendees

A list of attendees and their organizational affiliations is attached as Enclosure 1.

Background/Facts

An agenda, and copies of viewgraphs used by the NRC and DOE speakers, are attached as Enclosures 2, 3, and 4 respectively.

Observations

The NRC had the following observations:

1. The meeting was conducted in a professional manner and provided a useful exchange of information. The NNWSI speakers encouraged open, productive discussion.

2. The current and previous workshop agendas were structured along the technical disciplines that are being explored by NNWSI. This leads to presentations that appear to give only limited attention to potential licensing issues and application of planned investigations, data, or information to resolution of those issues. Restructuring the agenda of future meetings by issue (for example, the NRC site issues presented at this meeting) would be one way of addressing this NNWSI shortcoming.

3. USGS has described alternative conceptual models regarding movement of water in unsaturated fractured tuff. The alternatives differ with respect to how much water moves through fractures as opposed to the rock matrix itself. Also, there is uncertainty as to how much recharge occurs at the site (between 0.1 and 8 mm per year). As a result, there is a wide range of possible groundwater residence times that are consistent with what is now known about the Yucca Mountain site. In planning investigations of geochemical processes at the site and in interpreting the results of investigations completed to date, the NNWSI have assumed the hydrologic conditions and models that lead to the longer, less conservative residence times. It is the NRC staff's view that these assumptions are still questionable. Accordingly, the staff considers that the full range of residence times should be considered by the NNWSI in planning and interpreting the geochemistry investigations.

4. Values for many geochemical parameters will be needed to support site performance assessment calculations of future behavior, as required by 10 CFR 60. "Accurate" values (i.e. values to be existent) for given parameters under future repository conditions may be difficult to establish by measurement or calculation. The use of bounding values and limiting geochemical conditions, which would support reasonably

conservative performance assessment calculations, could simplify the collection of needed information. The NNWSI Program seems to be giving little consideration to a reasonably conservative vs "accurate" performance analysis, i.e. the collection of limiting or bounding values. Greater consideration of a reasonably conservative approach by NNWSI could greatly facilitate licensing decisions.

5. The solubility or apparent concentration limit of radionuclides in site groundwater/rock systems is likely to be an important barrier to the migration of radioactivity from emplaced waste to the accessible environment. The rate of radionuclide release can be no greater than the product of the apparent concentration limit and the groundwater volumetric flux.

   Several aspects of the NNWSI approach to radionuclide solubility may be subject to concern. These include:

   (1) A possible over reliance on solubility values based on geochemical models rather than experimental measurements. Solubility calculations must assume equilibrium which may not be appropriate, and rely on a thermodynamic data base, which may be inadequate for some elements, particularly actinides at elevated temperatures, as well as aluminosilicates.

   (2) Neither the solubility measurements nor the modeling calculations seem to be giving enough emphasis to the effects of altered groundwater composition on radionuclide solubility. The in situ groundwater composition will be altered by contact with waste package and engineered facility components at elevated temperature and radiation fields during migration. It would be desirable to consider the solubility of radionuclides in this altered groundwater. This solubility may be the most representative of the source terms for far-field analysis.

6. The mineralogy/petrology program may have much to offer the overall hydrology program. Information was presented regarding mineralization both in the rock matrix and in fractures above the water table. The origin of such mineralization could shed light on which of the alternative conceptual models for unsaturated zone flow is most nearly correct. Also, fracture density and mineralogy offers an opportunity to determine the paleo flow currents through the Topopah Springs. These data/observations may lead to useful information on mineral stabilities on a repository time scale and aid in extrapolating laboratory data to the long term and in determining paleo flow paths. The NRC staff considers that mineralogy studies should be pursued and factored into whatever interpretations are made regarding groundwater movement in the unsaturated zone.

7. Reaction path calculations pertaining to rock/water interactions have been done by the NNWSI using the assumption of a closed system. These calculations bear on determining the design bases for the engineered barriers. The NRC staff would encourage that open-system calculations be done as well.

8. The potential physiochemical effects of kinetics have not been adequately addressed in NNWSI studies of mineral stabilities. The NRC staff believes that certain features of Yucca Mountain petrology and mineralogy (e.g. variation of zeolite mineralogy with depth) may be more correctly explained if the potential role of kinetics is investigated fully.

9. In this meeting there was little discussion of groundwater flow paths and rates of flow in the saturated zone, and, likewise, little mention of geochemical conditions along potential radionuclide migration routes in this zone. Additional information on groundwater flow paths and geochemical conditions in the saturated zone beneath Yucca Mountain is required for a complete and accurate assessment of the potential radionuclide isolation performance of the Yucca Mountain site.

10. One phenomenon that may pertain to movement of water in the unsaturated zone is cycles of wetting and drying. Such cycles would affect many unsaturated zone geochemical processes in a variety of ways -- some of which are obvious and others more subtle. Some of the more subtle aspects do not appear to have received full consideration in NNWSI studies. For example, proposals to empirically determine unsaturated zone groundwater travel times by ^{36}Cl dating do not seem to have fully considered the implications of wet-dry cycles with respect to how Cl samples might be emplaced and interpreted for dating.

11. Ionic species in the groundwater of the unsaturated zone may be concentrated due to evaporation and condensation in the near field. Upon cooling, potential flow of these fluids to the Calico Hills may adversely affect the radionuclide sorptive capacity of the tuffaceous host rocks. It is the view of the NRC staff that such a scenario be addressed.

12. The model of secondary mineral (zeolite) stability is important to future decisions about the location of the repository horizon and the choice of a suitable backfill. Two theoretical models have been proposed for zeolite diagenesis at Yucca Mountain. The more recent model suggests that the secondary mineral stability is controlled primarily by the activity of SiO_2 in solution and is not strongly affected by temperature. At present, this model is not well supported by available data and relies on a number of assumptions. In particular, the phase(s) controlling silica activity and the mineral stability fields are not known. It is the less conservative of the two models since it implies that irreversible phase (mineralogical) changes will not occur in the vicinity of the waste at temperatures less than 200°C. An earlier model suggested that mineral stability at Yucca Mountain would be a strong function of temperature. This more conservative model should not be abandoned but should be considered an alternate working hypotheses until more field, experimental and theoretical data have been obtained.

13. Studies of clay mineral and zeolite dehydration under vacuum do not seem to provide any direct or indirect ("baseline") data that bear on investigations of the behavior of repository host rocks under thermal loading. A much more relevant approach is to investigate clay mineral and zeolite dehydration under prescribed and controlled temperature (T) and

partial pressure of H_2O (P_{H_2O}) conditions that mimic T-P_{H_2O} conditions that are expected to develop in the near field of an HLW repository in tuff beneath Yucca Mountain.

14. From the workshop presentations, it is not clear that a sound approach has been developed by NNWSI for determining that all significant species are included in the data base for geochemical modeling and for picking the controlling solid for modeling solubilities in specific groundwaters.

15. The in situ tests of fracture transport planned for the exploratory shaft may not have adequately addressed problems of interpretation of results due to (1) multiple fractures; (2) plume formation and position of sample borings within that plume; (3) extrapolation from 2 m to 2 km; and (4) the fact that only one result will be obtained, not allowing adequate estimation of uncertainty of that result.

16. Colloids have been suggested as a possible means for radionuclide transport; hence research on colloids and their properties may be warranted. However, the applicability of the colloid work, as described in the workshop, to repository performance assessment is not clear.

17. The sorption work should be guided more by consideration of key nuclides than it appeared to be from the presentations.

18. It is still not clear how results of experiments, particularly sorption work with high water/rock ratios (water-dominated system) are going to be applied to the unsaturated zone with very small water/rock ratios (rock-dominated system).

19. Simple models may often be most useful for sensitivity analysis. Use of a model as complicated as TRACR3D may not be warranted. Analytical models may be more appropriate at this time.

20. There is a need for a conceptual geochemical model of mineral stability that integrates the field observations and the laboratory work; until this is done the experimental work, no matter how well conceived, will appear unrelated to repository performance.

21. The defense wastes at SRL likely will not be stored in South Carolina but will be sent to a national repository. The NNWSI geochemistry program apparently has not considered inclusion of defense wastes (in addition to spent fuel and reprocessing wastes) in their site analysis scheme. It would be desirable for NNWSI to do so.

The DOE had the following observations:

1. Workshop was generally useful; it acquainted us with NRC concerns, especially with respect to characterizing the unsaturated zone. The value of the workshop should be weighed against that of data reviews.

2. Speakers were required to skip back and forth, referring to other talks that were presented out of logical sequence due to the NRC-imposed agenda.

3. DOE understands that it is NRC's view that in developing plans there is a lot of room for professional judgment at this time; DOE fully concurs.

4. Regulatory framework is still evolving and is ambiguous. Regulatory uncertainties that affect project direction due to delays in issuing of definitive positions exist for: 10 CFR 60 including the unsaturated zone amendment; 40 CFR 191, Draft 4 especially with respect to the definition for accessible environment; rewriting of Reg. Guide 4.17; and technical guidelines on solubility, which are being rewritten (communication at the workshop level would be more helpful as opposed to written interaction on proposed changes).

5. In lieu of these regulations, meaningful interaction between NNWSI and NRC is desirable. However, DOE is responsible for the planning and direction of the Project. NRC and NNWSI both expect sensitivity analysis to redirect emphasis on the Project. NRC should recognize that Project redirection takes time and proper planning as well as requiring sound reasons that are related to the overall issue of radiological safety of the public and environment.

6. NRC staff need to become familiar with simplifying assumptions that can be made in the TRACR3D radionuclide transport code.

The State of Nevada had the following observations:

1. Since the age of the waters in the various parts of the repository system is important, it is critical to consider all age dating techniques. We have heard exhaustive discussions on the use of ^{36}Cl. Is there a program to look at other age-dating techniques such as He, ^{3}H, Kr, and I? All of these methods have problems, but they may be complimentary. The stable isotopes such as D, ^{18}O, and ^{13}C should also be examined. These efforts should be coordinated with the USGS programs.

2. If Rainier Mesa is intended to be an analog to Yucca Mountain, then there needs to be a more comprehensive understanding of the hydrologic and geochemistry conditions. Our experience indicates Rainier Mesa may be a valid analog.

3. Since so many parameters are dependent upon knowing unsaturated zone water chemistry and actual <u>in situ</u> saturation, a program should be identified to obtain these data.

4. DOE studies have used hydrologic parameters to determine water flow rates in the unsaturated zone. This approach is based on numerous assumptions. There need to be examples of where these techniques have been used successfully.

5. What is the Los Alamos program to determine actual input water quality to the bedrock? This seems to be an important parameter to the current experiments and modeling activities.

6. We understand that both NRC and DOE have developed heat flow codes and are modeling the proposed Yucca Mountain Repository. We would request complete description and documentation of these activities.

7. Discussions have identified that some very minor minerals may contribute ions to the complexing of radionuclides. We feel that it is important to have a program to identify the amounts and locations of these minerals.

8. A statement was made that manganese oxides coat some fracture surfaces. Since flow may occur in these fractures, these coatings should not be ignored. Particular attention should also be paid to sorption experiments on natural fracture surfaces both in the field and in the laboratory.

9. Geostatistics should be used to identify alternative flow paths to the accessible environment. Particular attention should be given to potential flow paths that bypass zeolites or other sorptive minerals, as a worst-case scenario.

10. If laboratory experiments and modeling continue to use reducing conditions as one possible scenario, then more information is needed on Redox conditions in the repository block in both the saturated and unsaturated zones. The mineralogy/petrology data should be integrated with the geochemical data in establishing a more complete understanding of redox conditions.

11. If the repository is to be located in the unsaturated zone, then vapor and aerosol transport should be considered. We heard little discussion on this subject at this workshop.

12. We feel that multiple working hypotheses must be considered in developing the geochemical and mineralogical/petrological research plans for NNWSI. Our perception from this workshop is that most of the research evolved from single hypotheses. We do not feel that this is the best approach to asses the characteristics of the Yucca Mountain site.

Agreements

1. DOE and NRC agreed to conduct discussions concerning the results of numerical simulations of pore water movement under the influence of thermal fields.

2. DOE and NRC agreed to conduct discussions concerning a restructuring of the format and emphasis of future technical meetings. Specifically, a format is needed that addresses more narrowly defined issues that focus on specific phases of repository performance; for example, radionuclide transport in the unsaturated zone.

Open Items

As noted

DOE Requests of NRC

1. Would like to see the QA Review Plan as soon as possible.

2. Would like to get the technical positions on Sorption, Solubility, and Mineralogy/Redox conditions as quickly as possible.

3. Would like NRC to review the Los Alamos Geochemistry Program Plan and provide feedback.

NRC Requests of DOE

1. Correlation of the Los Alamos work plan with "issues" as presented.

Jerry S. Szymanski Waste Management Project Office DOE/NV	Seth M. Coplan Division of Waste Management US NRC