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WM Project 10,11,16
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Distribution:
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Dr. D. J. Brooks
Geotechnical Branch
Office of Nuclear Material
Safety and Safeguards
U.S. Nuclear Regulatory Commission
623-SS
Washington, D.C. 20555

Dear Dave:

Enclosed is the progress report for the month of August 1985 for B0287, "Technical Assistance in Geochemistry."

Sincerely,

Susan

S. K. Whatley, Manager
Repository Licensing Analysis
and Support
Chemical Technology Division

SKW:bek

Enclosures:

Monthly Progress Report for August 1985, w/attachments

cc: Office of the Director, NMSS (Attn: Program Support Branch)
Division Director, NMSS Division of Waste Management (2)
M. R. Knapp, Chief, Geotechnical Branch
K. C. Jackson, Geochemistry Section, Geotechnical Branch
Branch Chief, Waste Management Branch, RES
D. G. Brookins, University of New Mexico
C. Hackbarth, Waste Management Branch, RES
W. D. Arnold
J. T. Bell
J. G. Blencoe
N. H. Cutshall
L. M. Ferris
R. M. Gove
J. R. Hightower
G. K. Jacobs
A. D. Kelmers
D. C. Kocher
A. P. Malinauskas
R. E. Meyer
R. G. Wymer
SKW File (2)

3410

SKW
9/9/85

MONTHLY PROGRESS REPORT FOR AUGUST 1985

PROJECT TITLE: Technical Assistance in Geochemistry

PROJECT MANAGER: S. K. Whatley

PROJECT STAFF: J. G. Blencoe, R. M. Gove, G. K. Jacobs, A. D. Kelmers, and R. E. Meyer

ACTIVITY NUMBER: ORNL #41 37 54 92 4 (FIN No. B0287)/NRC #50 19 03 01

TECHNICAL HIGHLIGHTS:

Task 1 - BWIP Geochemical Technical Assistance

The report, Chlorine Isotopes as Environmental Tracers in Columbia River Basalt Groundwaters, by D. L. Graham, S. Gifford, and H. Bentley, RHO-BW-SA-372 P, 1984, was received and a detailed review initiated. A Letter Report will be furnished during September on the detailed review.

Task 2 - NNWSI Geochemical Technical Assistance

The report, Verification and Characterization of Continuum Behavior of Fractured Rock at AECL Underground Research Laboratory, BMI/OCRD-17, LBL-14975, 1985, by J. C. S. Long, was reviewed as part of the preparation of the final draft of the topical report on matrix diffusion and for input into the data base (LR-287-10, attachment 1).

The report, Petrologic and Geochemical Characterization of the Topopah Spring Member of the Paintbrush Tuff: Outcrop Samples Used in Waste Package Experiments, UCRL-53558, 1984, by K. G. Knauss, was reviewed for input into the data base (LR-287-11, attachment 2).

Task 3 - SRP Geochemical Technical Assistance

G. K. Jacobs attended a DOE/NRC meeting in Austin, Texas, to examine drill core from the Palo Duro Basin. His trip report (MR-287-4) was forwarded to you August 15, 1985.

Task 4 - Short-Term Geochemical Technical Assistance

A brief outline of the summary report on plutonium chemistry (attachment 4) is enclosed for your information. Preparation of the report will begin during October. If you have comments on the outline please let me know.

Task 5 - Project Management

Please find enclosed a progress report form D. G. Brookins on the preparation of the catalog for natural analogs (attachment 3).

MEETINGS AND TRIPS:

G. K. Jacobs attended a DOE/NRC meeting in Austin, Texas, to examine drill core from the Palo Duro Basin.

REPORTS AND PUBLICATIONS:

Meeting Report, MR-287-4, "NRC/DOE Meeting to Discuss Palo Duro Basin Geology and to Examine Rock Core from the Permian Basin," by G. K. Jacobs, August 14, 1985.

Letter Report, LR-287-10, "Evaluation of: Verification and Characterization of Continuum Behavior of Fractured Rock at AECL Underground Research Laboratory," by J. C. S. Long, BMI/OCRD-17, LBL-14975, (1985)," by J. G. Blencoe.

Letter Report, LR-287-11, "Evaluation of: Petrologic and Geochemical Characterization of the Topopah Spring Member of the Paintbrush Tuff: Outcrop Samples Used in Waste Package Experiments, by K. G. Knauss, UCRL-53558, (1984)," by J. G. Blencoe.

PROBLEM AREAS:

None.

COST/BUDGET REPORT:

Expenditures were $35.3K for August 1985 and $333.8K for FY 1985. A detailed cost/budget report will be sent under separate cover.

Attachment 1.

LR-287-10
9/9/85

LETTER REPORT

TITLE: Review of "Verification and Characterization of Continuum Behavior of Fractured Rock at AECL Underground Research Laboratory, BMI/OCRD-17, LBL-14975"

AUTHOR: J. G. Blencoe

PROJECT TITLE: Technical Assistance in Geochemistry

PROJECT MANAGER: Susan K. Whatley

ACTIVITY NUMBER: ORNL #41 37 54 92 4 (189 #B0287)/NRC #50 19 03 01

SUMMARY

This highly theoretical report describes a sophisticated methodology for modeling groundwater flow in fractured rock media. The principal goal of the research was to further elucidate theoretically the conditions under which a fractured medium behaves as a homogeneous anisotropic porous medium. In particular, the author considered it desirable to quantify the effect of finite fracture length vis-a-vis "infinite" fracture length in an analysis which also tested the effects of varying other geometrical properties of fractures such as fracture spacing, fracture orientation, and aperture distribution. Another important aim of the study was to determine how the permeability of a fractured geologic medium is affected by various fracture parameters — e.g., fracture length and fracture density — that cannot easily be quantified via borehole geophysical logging. The author stresses that the conclusions drawn in her study apply solely to regions of rock that are statistically homogeneous — that is, rock systems in which the geometric characteristics of fractures are distributed uniformly throughout the rock.

The principal value of this report lies in the fact that it is a good example of state-of-the-art modeling of fractured geologic media. In this regard, it is especially revealing that the report is almost completely theoretical; little mention is made of field data that could be used to validate the results of the theoretical modeling. Furthermore, in the single instance in which the results of modeling were compared with field data — specifically, data obtained from borehole measurements — it was found that the two sets of results are in poor agreement. In attempting to explain the discrepancies, the author identifies the following potential sources of error: (1) the modeling is "wrong"; (2) the patterns of fracturing apparent at the surface changes with depth, thus diminishing the accuracy of the modeling; and (3) a combination of potential errors (1) and (2). This broad-brush explanation indicates that the author is very uncertain where the difficulty really lies.

The circumstance described above appears to be a typical example of the difficulties that are encountered in practical applications of fracture modeling. In view of these difficulties, it is reasonable to conclude that fracture modeling cannot be applied successfully in the characterization of candidate HLW repository sites unless there is abundant field data available on the geometrical properties of fractures at depth.

Attachment 2.

LETTER REPORT

TITLE: "Review of 'Petrologic and Geochemical Characterization of the Topopah Spring Member of the Paintbrush Tuff: Outcrop Samples Used in Waste Package Experiments, UCRL-53558,' K. G. Knauss"

AUTHOR: J. G. Blencoe

PROJECT TITLE: Technical Assistance in Geochemistry

PROJECT MANAGER: Susan K. Whatley

ACTIVITY NUMBER: ORNL #41 37 54 92 4 (189 #B0287)/NRC #50 19 03 01

SUMMARY

This well-written and informative report summarizes the general geology of the Topopah Spring Tuff (Tpt) and presents a detailed description of the petrographic, mineralogic, and geochemical characteristics of samples of this tuff obtained from the southern end of Fran Ridge. The recounting of the general geology of the Tpt, originally described by Lipman et al. (1966), is useful because it serves to remind the reader that this rock is not a single homogeneous layer, but rather a multiple-flow, compound cooling unit. This fact is manifested by the observation that there is considerable textural variability — and even some notable mineralogical variability — in the direction perpendicular to layering. However, more useful still are the very detailed descriptions of the petrographic properties and mineralogic characteristics of the Tpt samples obtained from Fran Ridge. These descriptions include numerous photomicrographs and analyses of individual minerals, and thus, collectively, they constitute an important data base for use in predicting and assessing the performance of this rock in various laboratory and field tests relative to the siting of an HLW repository at Yucca Mountain. To cite one example, it is noteworthy that Knauss has found that many of the microfractures observed in thin sections of the Tpt are nearly completely filled with iron-rich and/or manganese-rich materials (it is likely that these materials are hydrated oxides of iron and manganese). This observation is potentially significant for interpreting the results of radionuclide sorption tests, because iron-rich materials (and perhaps the manganese-rich materials as well) are potentially important radionuclide sorbents.

The numerous admirable qualities of this report notwithstanding, two apparent shortcomings are evident. First, the report is somewhat limited in scope. Sensu stricto, detailed descriptions of the mineralogic and geochemical characteristics of the Tpt presented by Knauss pertain only to a narrow interval of this unit — namely, the densely welded section of the Tpt which has been identified as the leading candidate host rock for an engineered facility. Therefore, in specific instances, the data obtained

by Knauss may not apply to the partly welded and unwelded layers of the Tpt that underlie the densely welded zone. Second, the mineralogic characterization of the samples from Fran Ridge is unsatisfactory for some applications. In particular, the characterization of clay mineralogy is unsatisfactory for interpreting the performance of Tpt in radionuclide sorption experiments. Knauss notes that clay minerals are present in the Fran Ridge samples, occurring most commonly in the altered rims of pumice fragments in the rock, but the quantity of these minerals is insufficient to be detected by XRD methods, and no additional effort was expended to determine the kinds and amounts of these minerals that occur in the rock. Clearly, some follow-up work is called for because, despite their meager amounts, clay minerals may be the dominant sorbing minerals in the Tpt.

Attachment 3.

S. K. WHATLEY
Received 30/85
Tickler
Action
File B0287
Ans
Copies to [redacted]

UNM
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87131

8.23.85

Dr. Susan K. Whatley
Oak Ridge National Laboratory
P.O.Box X
Oak Ridge, TN 37831

Dear Susan:

Please consider this letter as my progress report for Contract No. 19X-27435V (RE: catalog preparation for possible natural analogs).

To date we have inspected twenty five journals in detail, and are examining some forty others. From the completely inspected journals, we have identified some five hundred (plus..) references which are in the process of being typed. A list of the journals covered in detail, and three sample entries, are enclosed for your inspection.

The work is on, or slightly ahead of, schedule.

If you have questions in this matter, please contact me.

Sincerely yours,

Douglas G. Brookins
Professor of Geology

DGB:amf

enc.

copy: Dr.Gary Jacobs , ORNL

COMPLETED JOURNALS:

- Economic Geology
- Canadian Journal of Earth Sciences
- American Mineralogy
- Chemical Geology
- Geochemical Journal
- Israeli Journal of Earth Science
- Lithos
- Mineralium Deposita
- Contributions to Minerology and Petrology
- Geochimica Et Cosmochimica Acta
- AAPG Bulletin
- Environmental Geology
- Mountain Geologist
- Australian Journal of Earth Sciences
- Journal of Geology
- American Journal of Science
- Geochemical International (+ Geochemistry)
- Clay and Clay Minerals
- Earth and Planetary Science Letters
- Canadian Mineralogist
- Bulletin Volcanologique
- Geological Magazine
- Journal of Petrology
- Journal of Research of the USGS
- Journal of Volcanology and Geothermal Research

JOURNALS TO BE RESEARCHED

- Earth Science Bulletin
- Earth Science
- GSA Abstracts
- GSA Bulletin
- X Geological Journal
- Radiation Effects
- Radiochemical and Radioanalytical Letters
- Radiochemistry
- Radiochimica Acta
- Seismological Society of America
- Sedimentary Geology
- Journal of Structural Geology
- Tokyo University Earthquake Research Institute
- X New Zealand Journal of Geology and geophysics
- Royal Society of New Zealand Transcripts
- California Geology and Surf
- Southeastern Geology
- X Precambrian Geology
- Geology of the UAR
- X Journal of Australian Geology and Geophysics
- Oklahoma Geological Society
- Physics and Chemistry of Minerals
- Journal of Sedimentary Petrology
- Clay Minerals
- Geological Society of London
- Geology (GSA)
- International Geology Review

2. A) Gen. Cat.--Contact Metamorphism

B) Frisch, C. J.; Helgeson, H. C., 1984, Metasomatic phase relations in dolomites of the Adamillo Alps: American Journal of Science, v. 284, no. 2, p. 121-185.

C) Purpose: provide information on the chemical composition of minerals and fluids and mineral paragenesis during metasomatism.

Methods: petrography, microprobe.

Results: 5 mineral zones are present near the intrusive contact: 1) calcite and forsterite; 2) diopside; 3) diopside + tremolite + clinozoisite + chlorite; 4) clinozoisite $\pm$ plagioclase; 5) silica-enriched zone. Highest Fe/Mg is found in zones 4) and 5) (i.e., nearest the intruded quartz diorite). Metasomatism involved the loss of CO_2 and Na, and the addition of Si, Mg, Fe, and K to the country rock. Metasomatism was accomplished over thousands of years by an H_2O rich fluid ($X_{CO2} \leq 0.021$) at pressures $\leq$ 1 kbar and T between 400 and 440°C.

2. A) Gen. Cat.--Behavior of fission products in geomedia.

B) Sholkovitz, E. R.; Mann, D. R., 1984, The pore water chemistry of $^{239,240}Pu$ and ^{137}Cs in sediments of Buzzard's Bay, Massachusetts: Geochimica et Cosmochimica Acta,v.45, no. 5, p. 1107-1114.

C) Purpose: quantify diagenesis and mobility of the artificial radionuclides $^{239,240}Pu$ and ^{137}Cs.

Methods: titration, precipitation, AAS, auto-analyzer, wet chemical oxidation, GC analysis; Pu was counted with a silicon surface barrier detector and Cs with low background beta detector.

Results: 1) Pronounced subsurface maximum activity of $^{239,240}Pu$ of .28dpm/100 kg at depths between 3 and 11 cm., followed by decrease to non-detectable levels at 20 cm. Seawater has $^{239,240}Pu$ activity = .01 dpm/100kg. 2) ^{137}Cs is more mobile than $^{239,240}Pu$ and exhibits broad maximum (3-20 cm.) of 35-40dpm/100 kg vs. 17-24 for overlying seawater. 3) Pu mobility is controlled by biological and diffusional mixing and equilibria with solid Pu phase. Pu does not undergo significant post-depositional mobility.

26. A) Gen. Cat.—Behavior of actinides in geomedia

B) Santschi, P. H.; Yuan-Hui, L.; Alder, D. M.; Amdurer, M.; Bell, J.; Nyffeler, U. P., 1983, The relative mobility of natural (Th, Pb and Po) and fallout (Pu, Am, Cs) radionuclides in the coastal marine environment: results from model ecosystems (MERL) and Narragansett Bay: Geochimica et Cosmochimica Acta, v. 47, no. 2, p. 201-210.

C) Purpose: investigate in detail the relative mobility of radionuclides in water and in bioturbated oxic sediments.

Methods: gamma spectrometry with Ge(Li) detector, alpha spectrometry.

Results: mobility of ^{210}Pb, $^{234,228}Th$, and $^{239,240}Pu$ is controlled by attraction to particles and mobility of these particles. Thus particle matter concentration and flux are very important in determining the fate of these elements. Cs is much more mobile than other elements in the study. Relative mobilities: $^{236}Pu < {}^{228}Th \approx {}^{210}Pb < {}^{59}Fe < {}^{54}Mn \approx {}^{137}Cs$. Short term experiments such as this one cannot explain the behavior of elements, such as Po, with long cycling times.

Attachment 4.

SUMMARY OF PLUTONIUM CHEMISTRY AND BEHAVIOR IN WASTE REPOSITORY ENVIRONMENTS

1. INTRODUCTION
   a. Isotopes - properties
   b. Inventories in waste
   c. Hazards to man

2. BRIEF GENERAL CHEMISTRY
   a. History
   b. Elemental
   c. Oxidation states

3. STATE IN OXIDE FUEL
   a. Valence
   b. Solid solution aspects

4. STATE IN GLASS
   a. Valence
   b. Silicate chemistry

5. DISSOLUTION CHEMISTRY OF OXIDES
   a. Catalytic agents
   b. Rate controlling phenomena

6. DISSOLUTION CHEMISTRY OF GLASSES
   a. Catalytic agents
   b. Rate controlling phenomena

7. COMPLEXES FORMED
   a. Inorganic (except hydroxy)
   b. Organic

8. HYDROLYSIS AND POLYMERS
   a. Hydrolysis constants
   b. Rates of formation of polymers
   c. Colloidal properties

9. CHEMISTRY IN GROUNDWATERS
   a. Speciation in tuff and basalt ground waters
   b. Possible solubility-controlling solids

10. REVIEW OF SORPTION PROPERTIES
    a. Generic studies on minerals
    b. Sorption on basalt
    c. Sorption on tuff