Encl to ltr dat'd 4-1-87.
rec'd 4-6-87 To: Blencoe
From: Kennedy

MR-287-1
12/14/84

TRIP REPORT OF GEOLOGICAL SOCIEITY OF AMERICA MEETING AT RENO, NEVADA

AUTHORS: J. G. Blencoe and G. K. Jacobs

LOCATIONS: Nevada Test Site (pre- and post-meeting field trips) and Reno, Nevada (GSA Annual Meeting)

DATES: Pre-meeting field trip--November 2-4, 1984; GSA Annual Meeting--November 5-8, 1984; Post-meeting field trip--November 8-10, 1984

PURPOSE: Participate in field trips to the Nevada Test Site, and attend the Annual Meeting of the Geological Society of America.

PROJECT TITLE: Technical Assistance in Geochemistry.

PROJECT MANAGER: S. K. Whatley.

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

SUMMARY

This report describes the activities and experiences of J. G. Blencoe and G. K. Jacobs during: (1) pre- and post-meeting field trips to the Nevada Test Site (NTS), and (2) the annual meeting of the Geological Society of America (GSA). The pre-meeting field trip, attended by J. G. Blencoe, was conducted to examine the geology of the NTS. The post-meeting field trip, attended by G. K. Jacobs, was undertaken to review the regional flow systems, groundwater recharge, and unsaturated flow within the NTS and adjacent areas. The GSA Annual Meeting was attended by both J. G. Blencoe and G. K. Jacobs.

GENERAL OBSERVATIONS AND COMMENTS ON THE GSA MEETING AT RENO

The 1984 GSA Annual Meeting was held in the MGM Grand Hotel in Reno, Nevada, on November 5-8. Approximately 6,000 geoscientists were present at the meeting, making it the most well-attended GSA annual meeting ever.

Symposium on the Geology, Hydrology, and Geochemistry of the NTS 2:00 p.m., November 5, 1984)

In addition to the usual technical sessions on geoscientific subjects (petrology, paleontology, geophysics, etc.), this year's GSA Annual Meeting included a half-day symposium on the geology, hydrology, and geochemistry of the NTS. The speakers who delivered presentations at this symposium, and the titles of their papers, are:

1. Thomas R. Clark: The Role of Earth Science at the Nevada Test Site--The Manager's Viewpoint.

2. H. Lawrence McKague, Paul P. Orkild: Geologic Framework of Nevada Test Site.

3. Carol J. Boughton, Roger L. Jacobson, John W. Hess: Regional Groundwater Characteristics Determined From Geochemistry and Environmental Isotopes at the Nevada Test Site.

4. W. J. Carr: Timing and Style of Tectonism and Localization of Volcanism in the Walker Lane Belt of Southwestern Nevada.

5. Robert B. Scott: Internal Deformation of Blocks Bounded by Basin-and-Range-Style Faults.

6. Barney J. Szabo: Uranium-Series Dating of Fault-Related Fracture- and Cavity-Filling Calcite and Opal in Drill Cores From Yucca Mountain, Southern Nevada.

7. Christopher C. Barton: Tectonic Significance of Fractures in Welded Tuff, Yucca Mountain, Southwest Nevada.

8. Richard K. Waddell: Solute-Transport Characteristics of Fractured Tuffs at Yucca Mountain, Nevada Test Site--A Preliminary Assessment.

9. Norman R. Burkhard: Applications of Geophysical Exploration Techniques to Structural Interpretations at the Nevada Test Site.

10. J. N. Rosholt, C. A. Bush, W. J. Carr: Uranium-Trend Dating and its Application to Quaternary Deposits in the Nevada Test Site Region.

11. J. L. Wagoner, H. L. McKauge: The Alluvial Valley Fill, Yucca Flat, Nevada.

12. Clinton M. Case, Mark Kautsky, Peter M. Kearl, Diane M. Nork, Thomas F. Panian, Sarah L. Raker: Unsaturated Flow Through the Alluvium at the Nevada Test Site.

13. Stephen W. Wheatcraft, Thomas J. Burbey: Numerical Modeling of the Tritium Breakthrough at the Cambric Site, Nevada Test Site.

14. Richard H. French: Assessment of Flood Risk to Facilities Sited on Alluvial Fans at the Nevada Test Site.

15. E. M. Romney: Restoration of Vegetation in Areas Disturbed by Nuclear Testing at the Nevada Test Site.

Our principal observation concerning these papers is that the speakers did not focus on information obtained recently, and most of the discussions were directed toward the hydrology and geology of the entire NTS (i.e., very little was said about the "local" hydrology, geology, and geochemistry of Yucca Mountain). Furthermore, many of the presentations were poorly delivered, and sometimes accompanying slides were difficult to read.

Miscellaneous Papers on Topics Related to Disposal of High-Level Radioactive Waste

Several technical sessions held during the Annual Meeting included presentations that dealt with the geochemistry of brines at the various candidate salt sites (however, most of the discussions focused on the Palo Duro Basin site). From the talks dealing with the Palo Duro Basin site, we learned that the deep water-bearing Wolfcamp Formation is being studied extensively by the Texas Bureau of Economic Geology to determine: (1) the source(s) and age(s) of the fluids, and (2) the significance of brine chemistry for conceptual models of groundwater flow.

Several technical sessions devoted to geochemical topics included interesting presentations on rock/water interactions. For example, a researcher from Stanford University described experimental work that he has performed on the solubility of UO_2 at high temperatures. His data suggest that calculated solubilities of UO_2 at 100-300°C obtained from the thermodynamic data that is currently available may be off by as much as 3-4 orders of magnitude! There were also several papers which described work currently being performed on the mechanisms of oxidation and reduction of aqueous species at or near the surfaces of minerals. Still another interesting paper presented evidence that some form of bacteria may have been found in fluid inclusions from a geothermal area (temperatures up to 200°C). This is the first observation of this sort and it may have implications for evaluations of the significance of bacterial processes in the mobilization and retention of radionuclides released from a repository. In the past, it has been considered that bacteria would not survive the thermal period; however, it seems evident now that the validity of this assumption should be reassessed.

Conclusions

As expected, this year's GSA Annual Meeting included the usual mix of excellent, good, mediocre, and terrible talks. However, in our opinion, the overall "value" of the meeting is not properly assessed by considering only the number of interesting talks that were delivered during the technical sessions. In addition to being able to attend technical sessions that dealt wholely, or in part, with waste-management subjects, the meeting provided us with an opportunity to verbally exchange information with colleagues from other national laboratories and from universities who share some of our interests and concerns regarding the geochemistry of high-level waste (HLW) disposal. Such exchanges enhance our professional development in three ways: (1) we gain knowledge directly from our peers in a scientific atmosphere that encourages expression of honest opinion; (2) by meeting and talking with our peers face-to-face, we establish a positive standing and credibility among scientists who are working on HLW disposal problems; and (3) we reestablish old contacts with peers, and make new contacts, which preserve or open up lines of communication which can be of great value at a later time (e.g., when it is necessary to obtain new information quickly, and you are wondering who to contact to obtain this information). In view of these beneficial aspects of attending this year's meeting, we hope that the NRC will allow up to attend future GSA Annual Meetings.

COMMENTS ON THE PRE- AND POST-MEETING FIELD TRIPS TO THE NEVADA TEST SITE

Field Trip on the Geology of the Nevada Test Site (J. G. Blencoe)

a. Comments concerning events and observations on the first day of the field trip (November 3, 1984)

The first day of the field trip was spent traveling from Las Vegas to Mercury (NTS) and observing the geology along the way. It was emphasized that, while the rocks around Las Vegas are Precambrian or Paleozoic in age, and contain many sedimentary lithologies, the rocks on—and adjacent to—the NTS are predominantly Cenozoic (mainly Miocene) and Recent volcanic rocks. Due to the significant distance that we had to travel, we only made a few stops to perform some "roadside geology;" the rest of the time was spent observing distant rock formations through the windows of the bus. There were no discussions of a geochemical nature at all during the day, which was disappointing. I suspected that geochemistry would not be emphasized in verbal discussions presented by our field-trip guides, mainly because the field trip was advertised as a geology field trip, but I was a little surprised that no attempts were made to present information that would have been of great interest to geochemists. (For example, it would have been very interesting to learn more about the patterns of alteration of tuffaceous rocks at the NTS.) However, the day was "saved" (from the point of view of this geochemist) by two events: a brief visit to Yucca Mountain in the early afternoon, and a tour of the USGS Core Library at Mercury at the end of the day.

The visit to Yucca Mountain was rewarding because, after seeing it, I now have a good mental image of the topographic and geologic environment of the candidate-repository site at Yucca Mountain. During the brief lunch-hour stop at the summit of the mountain (Yucca Mountain is actually a broad ridge), there were detailed discussions of the regional geology and hydrology of the area, but essentially no discussion of the geochemistry of the rocks beneath the mountain. Nevertheless, the lectures delivered by the field-trip leaders were interesting, especially the presentation given by Rick Waddell of the USGS. From his talk I conclude that the hydrology of the Yucca Mountain region is still poorly understood, the principal unknowns being: (1) the rate of groundwater recharge at Yucca Mountain, and (2) the rates and volumes of fracture flow vis-a-vis matrix flow of groundwater at the site.

The visit to the USGS Core Library at Mercury was the last stop of the day. This core library, officially designated "The Geologic Data Center and Core Library" at Mercury, is a depository for systematic processing, cataloguing, and storage of drill-bit cuttings, drill core, and other rock samples from the NTS and other test areas. The facility serves as: (1) a field headquarters for USGS geologists, hydrologists, and geophysicists, and (2) a work area for earth scientists employed in support of weapons testing and DOE waste-management projects. The facility maintains reference files of reports, maps, aerial photographs, and downhole video tapes and geophysical logs for selected drill holes at

the NTS and other test areas. Water samples are analyzed both chemically and radiologically in a hydrologic-chemical laboratory adjacent to the Core Library.

Continuous core, sidewall samples, and rock cuttings stored at the Core Library have been used to resolve geologic problems encountered by personnel concerned with nuclear-test containment and HLW disposal. For example: (1) primary minerals and whole rocks are analyzed to help correlate volcanic units found at the Test Site, and (2) secondary (diagenetic) minerals have been studied intensively to gauge their ability to inhibit migration of radionuclides. Regarding (1), LANL geochemists are analyzing phenocryst minerals and whole rocks to model the origin and evolution of the late-Tertiary volcanic sequence at the NTS. Recent work has allowed accurate correlation of individual petrologic units as well as entire petrologic suites. The spatial distribution patterns of correlative petrographic units point to the Timber Mountain - Oasis Valley magmatic system as the primary source of Miocene volcanic rocks at the NTS. This observation, along with supporting geochemical data, indicates that Miocene volcanic rocks at the NTS are the effusive product of a single, large, evolving rhyolitic-magma body that was located beneath the present expression of the Timber Mountain Caldera.

b. Comments concerning events and observations on the second day of the field trip (November 4, 1984)

Like the first day of the field trip, activities on this day consisted mainly of "geologic sight-seeing." The highlight of the day was a visit to the SEDAN crater, a circular pit--approximately 390 m in diameter and 98 m deep--which was formed in tuffaceous alluvium just to the east of Rainier Mesa as a result of the detonation of a 100 kt atomic device on July 6, 1962. During the stop at this crater, there was much discussion of "containment geology" (geologic studies in support of underground testing of nuclear devices) and nuclear-excavation scaling laws (the empirical relationships between the kilotonnage of an atomic device, depth of detonation, and the size of the resulting crater produced by the explosion of the device).

The only activity of the day which possessed a geochemical "flavor" was a visit to the Radionuclide Migration (RNM) project site on Frenchman Flat. The RNM project was initiated in 1974 to study the rates of underground migration of radionuclides from explosion-modified zones at the site of the "Cambric event." The Cambric event, which refers to the detonation of an atomic device beneath Frenchman Flat in 1965, was chosen for study because, among other amenable conditions: (1) sufficient tritium was present to provide an easily measureable tracer for water from the cavity region; (2) the post-shot debris and groundwater in the cavity and overlying chimney contained quantities of plutonium, uranium, and fission products that were sufficient for measurement and comparison; (3) the small nuclear yield from the Cambric event was expected to have little effect on the local hydrology; and (4) it was judged that alluvium is a good medium for radionuclide-migration

studies because it is more permeable than tuff and does not contain large fractures through which groundwater might selectively flow.

Beginning in October, 1975, water was pumped from a satellite well located 91 m from the Cambric cavity; this produced an artificial gradient that was sufficient to draw water from the Cambric cavity, thereby providing an opportunity to study radionuclide migration under field conditions. The satellite well was pumped at the rate of ~600 gal/m. Every week samples were taken and analyzed for radionuclides. The first radionuclide detected was ^{36}Cl. Later (in the summer of 1978), tritium was detected, and by late summer, 1980, the concentration of this radionuclide reached a peak of 7000 pCi/mL. By September 30, 1982, over 42% of the tritium from the Cambric event had been removed by the satellite well.

Field Trip on the Hydrogeology of the Nevada Test Site and Amargosa Desert (G. K. Jacobs)

This field trip was excellent. We observed and discussed many aspects of the flow regimes pertinent to the area (ie., alluvium, tuff, and Palezoic carbonates). There is apparently still significant controversy concerning not only the location of recharge and discharge areas, but also the potential impact of groundwater flow on the containment and isolation of radionuclides resulting from the testing of nuclear devices and the proposed repository at Yucca Mountain.

Because a nuclear device was scheduled to be tested at the NTS on Friday, November 9, the field trip was run in reverse order from that described in the field trip guide. We were supposed to be able to get onto the NTS on Saturday in order to observe and discuss the hydrology of Yucca Mountain and other aspects of the NTS. As it turned out, the device was tested on the morning of Saturday, November 10. Therefore, our first stop that day was Yucca Mountain and the rest of the NTS portion of the field trip followed.

a. Comments concerning events and observations on the first day of the field trip (November 9, 1984)

The first day was spent traveling from Las Vegas to Beatty through the Amargosa Desert to observe and discuss hydrologic characteristics of the area. The Amargosa Desert is a possible discharge area for groundwaters which originate within the NTS. Groundwater discharge occurs as small springs emanating from Palezoic carbonate units. We observed a population of pupfish — "minnow-like" fish which live in the springs of the Amargosa Desert. These pupfish are significant because a large irrigation project in the desert was discontinued when it was shown that overpumping of the aquifer system was lowering the level of water in the springs to a point below which the pupfish could no longer reproduce — thus endangering their existence.

During the day, useful discussions concerning the regional geology and hydrology occurred with the participants and leaders of the field trip. These discussions were particularly interesting because the field trip

leaders were with the Desert Research Institute (DRI) and are currently involved in evaluating the hydrochemical work which is being carried out by the USGS and LANL. Apparently, DRI has access to water samples and other hydrologic data being collected by the USGS and LANL.

The last stop of the day was at the U.S. Ecology waste disposal area, just outside of Beatty, NV. This facility accepts low-level radioactive waste as well as toxic chemical waste. Only solidified waste are currently disposed of at the facility. We observed and discussed the disposal practices including the segregation of wastes and the hydrology of the unsaturated zone in which the facility is located.

b. Comments concerning events and observations on the second day of the field trip (November 10, 1984)

The first stop was at Yucca Mountain to observe a pump test which was being conducted. We discussed the general geology and hydrology of the Yucca Mountain area, however, few details were covered. As J. G. Blencoe discussed earlier, being able to visualize the geologic and hydrologic setting of Yucca Mountain will be valuable in future review efforts concerning the NNWSI Project.

The next major stop was at a low-level waste (LLW) site on the NTS. This site has been instrumented to investigate the hydrology of the unsaturated zone as related to the disposal of LLW. DRI is involved in many studies of unsaturated zone hydrology. Though much uncertainty remains in their understanding of the hydrology of the unsaturated zone, the residence time of water in the unsaturated alluvium is thought to be on the order of months. Therefore, it is possible that the conceptual model of NNWSI for the rapid transport of water through the unsaturated zone — thus little time for reaction with repository materials — may be realistic, although the repository will be constructed in rock, whereas most studies to date by DRI have addressed the alluvium.

Also included in this field trip were stops to the SEDAN crater and the Radionuclide Migration (RNM) site on Frenchman Flat. These areas were discussed by J. G. Blencoe earlier and will not be repeated here.