Lawrence Livermore National Laboratory

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Yucca Mountain Project Office
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SUBJECT: Yucca Mountain Project Status Report - March 1993
SCP: N/A

Attached is the March Project Status Report for LLNL's participation in the Yucca Mountain Project.

If further information is required, please contact Elizabeth Campbell of my staff at 510-422-7854 or Jim Blink in Las Vegas at 702-794-7157.

4/8/93

Sincerely,

W. L. Clarke
LLNL Technical Project Officer
for YMP

WC/EC

cc:
Distribution

RECD W/YMP
4/16/93

DISCLAIMER

The LLNL Yucca Mountain Project cautions that any information is preliminary and subject to change as further analyses are performed or as an enlarged and perhaps more representative data base is accumulated. These data and interpretations should be used accordingly.

ENCLOSURE 3

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LAWRENCE LIVERMORE NATIONAL LABORATORY
(LLNL)
YUCCA MOUNTAIN PROJECT (YMP) STATUS REPORT

MARCH 1993

EXECUTIVE SUMMARY
(Items Proposed for Reporting in YMPO or OGD Reports)

1) 1.2.2.2 (Waste Package Environment). The Preliminary Near Field Environment Report, Vol. I and II, was approved by YMPO and will soon be available as an LLNL report. This completes Milestone T359.

2) 1.2.2.3.1.1 (Waste Form Testing - Spent Fuel). An analysis of the test matrix from PNL's spent fuel dissolution tests shows a uranium dissolution dependence primarily on temperature and oxygen concentration. Carbonate concentration is less important. Existing data from LLNL's UO_2 dissolution tests show a similar relationship. The data from PNL and LLNL show pH as an insignificant factor under the alkaline conditions of these test matrices. Dissolution data under acidic conditions should be different, if only because of solubility differences.

3) 1.2.5.3.4 (Geologic and Engineering Materials Bibliography of Chemical Species - GEMBOCHS). Three organic acids (formic, propanoic, and butanoic) were transferred to the auxiliary basis set of aqueous species in the SUPCRT92 and composite data subsets of GEMBOCHS. This transfer permits specification of the concentrations of these acids as input parameters for EQ3/6 calculations. A revised suite of thermodynamic datafiles (R19) was generated by D0OUT incorporating the aqueous-acid transfers.

4) 1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment). Work continued measuring electrical resistivity as a function of moisture content of Topopah Spring Tuff samples from U3hg-1 and GU-3 holes at room temperature, using J-13 water as pore fluid. The electrical impedance and high frequency electromagnetic tomography used in the laboratory and the field to monitor the distribution of moisture content in the tuffaceous rock depend on accurate laboratory measurements for their calibration. The electrical conductivity of partially saturated rocks is largely dependent on saturation level, fluid conductivity, and temperature. Thus far, electrical conductivity as a function of moisture content has been determined during both imbibition and drying cycles at 20°C on tuff samples for Area 3 and Area 25 NTS, Nevada using distilled water. Results indicate an exponential dependence of conductivity on water content (Sw) for both imbibition and drying cases. Hysteresis between the imbibition and drying cycles is observed for both rock types. The imbibition curve is more conductive than the drying curve between 20 and 70% Sw. Possible explanations of the hysteresis are changing ionic concentration or conducting mechanism in the pore fluid with changing saturation levels. Additional experiments using J-13 well water as the saturating fluid do not show any departure from the curves determined with distilled water during the imbibition cycle up to 30% saturation. The established

curves have successfully been used to determine saturation levels of a core sample used in a flow test.

5) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** Calculations show that extending the model to more than 1 km below the water table does not affect the unsaturated zone (UZ) temperature on saturation distributions. Since the model assumes a perfect heat sink at its lower edge, a fast moving aquifer deeper than 1 km below the water table would not affect the UZ thermo-hydrological performance.

6) **1.2.2.2.5 (Characterization of the Effects of Man-Made Materials on Chemical & Mineralogical Changes in the Post-Emplacement Environment).** Investigation activities into the stability and reactivity of organic materials have been initiated:

1) Planning of the initial experimental phases has been completed.

2) Lab facilities are in the final stages of completion.

3) The first phase of database evaluation for organic compounds that are liable to be introduced into the ESF and the potential radioactive waste repository and for which the thermodynamic and kinetic properties are not well established has been completed.

7) **1.2.2.2.2 (Hydrologic Properties of the Waste Package Environment).** Analytical and model calculations have been conducted for areal mass loadings (AMLs) of 27.1, 49.2 (the SCP-CDR) value, and 154.7 metrics tons of uranium per acre (MTU/acre) and for a range of bulk permeabilities, k_b, between $10^{-18}m^2$ (1 microdarcy) and $8 \times 10^{-10}m^2$ (840 darcy). The threshold for large-scale, buoyant, gas-phase convection dominance of the hydrological performance is in the 10-20 darcy range for 27.1 MTU/acre, and in the 1-5 darcy range for 49.2 MTU/acre. For 154.7 MTU/acre thermal buoyancy influences, but does not dominate, hydrological performance for k_b <5 darcy. The signature for hydrological influence is a vertical asymmetry of the temperature profile. Thermal performance is significantly affected by buoyancy-driven flow for k_b values 5 to 10 times higher than the threshold stated above. Convection effects are a balance between buoyancy-driven flow and boiling-induced pressures. Because the SCP-CDR design is marginally boiling, it is more affected by convection than are the lower and higher AMLs.

1.2.1 SYSTEMS ENGINEERING

1.2.1.1 Systems Engineering Coordination and Planning

No significant activities.

1.2.1.5 Special Studies

W. Clarke, J. Blink, D. Wilder, W. Halsey and W. Lin attended a Thermal Goals meeting in Denver, CO on March 24. Six LLNL staff members will participate in the ongoing exercise to review thermal goals as part of the thermal loading system study.

1.2.1.6 Configuration Management

Affected document notices (ADNs) were completed for CRs 92/110 and 92/149. No LLNL-controlled documents are affected.

1.2.2 WASTE PACKAGE

1.2.2.1 Waste Package Coordination and Planning

W. Lin attended the (SOC) Sample Overview Committee meeting at NTS on March 3.

B. Viani participated in the March Geochemistry Integration Task (GIT) teleconference meeting which focused primarily on the upcoming colloid workshop at LANL.

1.2.2.2 Waste Package Environment

The Preliminary Near Field Environment Report, Vol. I and II, was approved by YMPO and will soon be available as an LLNL report. This completes Milestone T359.

W. Clarke, D. Wilder, W. Halsey, T. Buscheck, W. Lin, W. Glassley, J. Blink, S. Blair, J. Nitao and D. Chesnut participated in the Committee for the Advancement of Science at Yucca Mountain (Casy) meeting hosted by USGS in Denver, CO on March 24-25. The topic of discussion was the extended dry concept. T. Buscheck gave a presentation entitled "The Impact of Repository Thermal Load on Hydrothermal Flow". W. Glassley gave a presentation concerning geochemical processes in the altered zone; the emphasis of the presentation was on the nature of processes that can be expected and that these processes will occur regardless of thermal load. An important conclusion from that meeting is that in situ heater testing is critically needed in assessing the ability of the Yucca Mountain site to safely contain and isolate spent nuclear fuel (SNF).

D. Wilder and D. Chesnut met with R. Levich (YMPO), G. Gustafson (Sweden) and several Swedish students on March 2 at NTS to discuss the construction and grouting meeting to be held in Sweden on March 30-April 1.

D. Wilder and W. Glassley attended the Loma Prieta earthquake seminar in San Francisco, CA on March 22-23.

1.2.2.2.1 Chemical and Mineralogical Properties of the Waste Package Environment

Work on the New Zealand natural analog site continued, with a visit there the last week of March and the first week of April by two LLNL scientists to evaluate potential sites for conducting validation activities using EQ3/6.

Models of mineral evolution in the vicinity of waste packages were further developed. Consideration is being given to the development of a baseline set of

computations that will be used as a comparison for calculations involving flow and transport. The current calculations do not consider the role of moving water. Computations are also underway to further evaluate the effects of flow on the extent to which equilibrium may be achieved in the vicinity of waste packages.

A discussion was held to more fully coordinate activities between various project participants regarding coupling of geochemical and hydrological processes. A plan for experimental studies was developed that will address specific questions that relate to alteration associated with two-phase systems.

1.2.2.2.2 Hydrologic Properties of the Waste Package Environment

Study Plan 8.3.4.2.4.2, Rev. 0, "Laboratory Study of Hydrological Properties of the Near Field Environment" was reviewed at LLNL. The comment resolution is about 70% complete.

T. Quinn will be leaving her LLNL-YMP position as lead software engineer for V-TOUGH to accept a position as Division Leader in the Computations Department.

Model Calculations

T. Buscheck with the support of S. Daveler and T. Quinn continued analyzing the preliminary scoping calculations of the hydrothermal performance of the repository, using the new model which represents hydrothermal flow in the upper 1000 m of the saturated zone (SZ) as well as within the unsaturated zone (UZ). Calculations have addressed four general effects:

1) large-scale, buoyant, gas-phase convection,
2) the distance to the lower boundary in the UZ-SZ-repository-scale model,
3) binary gas-phase diffusion, and
4) the initialization of the model.

With respect to bulk permeability, k_b, and the impact that large-scale, buoyancy-driven gas-phase convection has on thermal performance and moisture redistribution, a wide range of k_b have been considered; from $1.9 \times 10^{-18} m^2$ (1.9 microdarcy) to $8.3 \times 10^{-10} m^2$ (840 darcy). This wide range was considered in order to examine when convective effects dominate repository-driven heat flow. Hydrothermal performance for the k_b values month were examined in the transition from intermediate to large values (1 to 40 darcy), particularly for low- to intermediate-areal mass loadings (AML) cases for which rock dry-out primarily occurs under sub-boiling conditions, including AMLs of 27.1 and 49.2 MTU/acre. Also considered were k_bs values of 1 and 5 darcy for a high AML (154.7 MTU/acre). The purpose was to identify the threshold k_b where large-scale, buoyant, gas-phase convection begins to dominate hydrological performance and the threshold k_b where this convection begins to dominate the thermal performance. J. Nitao also developed analytical expressions which determine these k_b thresholds.

For 27.1 MTU/acre (30-yr-old SNF) and an areal power density (APD) of 20 kW/acre), k_b values of $2.8 \times 10^{-13} m^2$ (280 millidarcy), $1.0 \times 10^{-11} m^2$ (10 darcy), $2.0 \times 10^{-11} m^2$ s (20 darcy), and $4.0 \times 10^{-11} m^2$ (40 Darcy) were considered. These values are well within the range of unpublished k_b values estimated by E. Weeks for the UZ.

Depending on the number of SNF assemblies per waste package (WP), local boiling conditions may persist for some time even though average temperatures are well below boiling condensate (~60°C). For k_b < 10 darcy, large-scale, buoyant, gas-phase convection does not significantly redistribute liquid saturations; however, significant refluxing occurs with buoyant vapor flow being balanced by condensate drainage. For a k_b of 10 darcy, condensate drainage cannot keep up with buoyant vapor flow, and regions of net dry-out and condensate buildup develop and persist for tens of thousands of years. With the use of the Equivalent Continuum Model (ECM) it cannot be determined whether this condensate flux results in nonequilibrium fracture flow down to the repository horizon. However, the potential for nonequilibrium condensate drainage exists even for situations which do not result in a noticeably redistribution of liquid saturation.

J. Nitao recently developed analytical expressions for repository-heat-driven hydrothermal flow. These expressions were used to determine the threshold k_b at which large-scale, buoyant, gas-phase convection begins to dominate hydrological performance for a range of AMLs. For an AML of 27.1 MTU/acre, the threshold k_b lies is in the range of 10 to 20 darcy. For an AML of 27.1 MTU/acre and a k_b of 20 darcy, model calculations show a persistent condensate buildup above the repository horizon for tens of thousands of years. Therefore, the analytical determination of the threshold k_b for repository-heat-dominated hydrological flow is corroborated by the model calculations.

With the analytical expressions, J. Nitao found that for a k_b which is approximately 5 to 10 times the threshold for repository-heat-dominated hydrological flow, convective effects begin to dominate the temperature distribution. For an AML of 27.1 MTU/acre and a k_b of 84 darcy, it was found that buoyant vapor flow has little effect on temperatures at the repository center but it begins to have a noticeable effect on far-field temperatures and repository edge temperatures. In general, convection on repository temperatures are first observed at the outer edge of the repository. For a k_b of 168 darcy, it was found that the far-field temperatures are significantly perturbed by convection effects; however temperatures at the repository center are very similar to those of conduction-dominated heat flow. For a k_b between 168 and 410 darcy, temperatures at the repository center depart significantly from conduction-dominated heat flow.

The analytical determination of the threshold k_b at which temperatures are significantly affected by convective effects is corroborated by the model calculations. The factor of 5 to 10 difference between the two different threshold k_b values indicates that in order for the hydrological (buoyant gas-phase) flow system to dominate heat flow generated by the repository, the repository-generated heat flow must have had a dominant impact on the hydrological flow system, including both liquid-phase and gas-phase flow. In general, more will be known about the repository temperatures than any other aspect of the thermo-hydrological system. Moreover, the magnitude of buoyant convective effects required to dominate the thermal performance at the repository horizon will be associated with a dramatic increase in liquid saturation above the repository and resultant condensate drainage and episodic infiltration flow at the repository horizon.

For the reference SCP-CDR thermal loading case 49.2 MTU/acre AML, (10-yr-old SNF and an APD of 57 kW/acre), k_bs of $2.8 \times 10^{-13} m^2$ (280 millidarcy), $10^{-12} m^2$ (1 darcy), $5.0 \times 10^{-12} m^2$ (5 darcy), $10^{-11} m^2$ (10 darcy), and $4.0 \times 10^{-11} m^2$ (40 darcy) were considered. The large-scale buoyant gas-phase convection occurring in the 1 darcy case reduces the duration of the boiling period, t_{bp}, from 666 yr to 618 yr, relative to the 280 millidarcy case. The peak temperature at the center of the repository, T_{peak}, is only reduced from 100.3 to 100.0°C and t = 1000 yr, the temperature at the center of the repository is not affected. For the 5 darcy case, the effect of buoyant convection is to reduce t_{bp} to 565, T_{peak} is only reduced to 99.4°C, and t = 1000 yr, the temperature at the center of the repository is not affected. For the 10 darcy case, t_{bp} is reduced to 417 yr, T_{peak} is only reduced by 1.1°C, and t = 1000 yr, the temperature at the center of the repository is only reduced by 0.2°C. The large-scale buoyant gas-phase convection becomes more pronounced for the 40 darcy case, reducing t_{bp} to only 173 yr, reducing T_{peak} to 98.2°C, and t = 1000 yr, the temperature at the center of the repository is reduced by 5.1°C. B. Ross has conducted a calculation for a case with nearly the same AML (47.5 MTU/acre), with the primary differences being that he assumes 30-yr-old SNF, an APD of 35 kW/acre, and a k_b of 50 darcy. At t = 1000 yr, Ross found that buoyant gas-phase convection reduced the temperature at the center of the repository by approximately 9.5°C, relative to the conduction-only calculation. When one takes into account that the Rayleigh number for the Ross calculation is approximately 25% greater than that applicable to the LLNL calculation, the two models are seen to be in reasonably good agreement. Moreover, the shape of the temperature curves predicted by the two different models are very similar.

For an AML of 154.7 MTU/acre, increasing k_b from 280 millidarcy to 1 darcy does not affect t_{bp} (11,446 yr). The effect of large-scale, buoyant gas-phase convection has a minor effect on the 5 darcy case, reducing t_{bp} by 3.3% to 11,067 yr relative to the 280 millidarcy case. In contrast for the SCP-CDR thermal load, increasing k_b from 280 millidarcy to 5 darcy has the effect of decreasing t_b by 15.2%. The greater sensitivity of the SCP-CDR case to this range in k_b is due to two effects. Because temperatures never significantly exceed boiling, small changes in temperature result in larger changes in t_{bp}. In general, thermal buoyancy occurs because elevated temperatures lighten the column of gas which is within the footprint of the repository. The cooler column of gas outside of the repository footprint is denser and therefore has a larger pressure at a given depth below the repository horizon. Consequently, cooler denser gas moves in, displacing the warmer less dense gas column. In addition to this thermal buoyancy effect, boiling raises pressures in the dry-out zone. This boiling-generated gas-phase pressure buildup increases with AML. This boiling-generated pressure buildup opposes the thermal buoyancy for some period of time. For the SCP-CDR, thermal loading boiling effects are somewhat limited in space and time, resulting in less suppression of thermal buoyancy than for a thermal loading with a thick, persistent boiling zone. Both analytical analyses and model calculations show that the hydrological impact of buoyant vapor flow is maximized for the SCP-CDR thermal load.

J. Nitao's analysis showed that for the SCP-CDR thermal load, the threshold k_b at which repository heat dominates long-term hydrological performance is in the range of 1 to 5 darcy. Below this range of k_b, model calculations also show that t_{bp} is not affected by large-scale, buoyant, gas-phase convection. The ECM model

calculations also show in the 1 to 5 darcy range that large-scale, buoyant vapor flow will result in a very large buildup in liquid saturation above the repository horizon persisting for 100,000 yr. (The ECM cannot model non-equilibrium drainage of this fluid). Persistent buoyant vapor flow and condensate drainage may result in nonequilibrium fracture flow at the repository horizon for tens of thousands of years. This repository-heat-driven condensate flux is potentially orders of magnitude greater than the infiltration of meteoric water. Using the ECM and the unpublished UZ k_b data of E. Weeks, the condensate flux is orders of magnitude greater than infiltration fluxes that would be associated with pluvial conditions. It is possible that the rate limiting consideration for buoyant vapor flow may be the size of the rock matrix blocks and the gas-phase permeability of those blocks. LLNL is developing a dual porosity approach which will enable examination of the sensitivity of buoyant vapor flow to the matrix properties and condensate drainage.

The large-block test will provide critically important data of two-phase flow effects between fractures and matrix blocks. It is also critically important that in situ heater tests be conducted under sub-boiling conditions to determine the potential for nonequilibrium condensate drainage under low to medium AMLs and to better understand the post-boiling-period thermo-hydrological performance for high AMLs. Because of the magnitude of these potential repository-heat-driven effects and the impact of these effects on thermal loading decisions, it is imperative that the in situ heater tests be conducted as soon as possible.

LLNL's UZ-SZ-repository-scale calculations have assumed a constant temperature and constant pressure boundary 1 km below the water table. Calculations were repeated for AMLs of 27.1, 49.2, and 154.7 MTU/acre with a model in which the fixed temperature and pressure boundary is 7 km below the water table. Both models (1-km-thick and 7-km-thick SZs) yielded exactly the same thermo-hydrological performance in the UZ. It has been speculated that the lower paleozoic carbonate aquifer may have a very large lateral component of flow which would result in it acting as a temperature sink. The model results indicate that if this aquifer is located 1 km or more below the water table then it will have no effect on thermo-hydrological performance in the UZ. Further calculations will be investigated at what depth below the water table an aquifer which acts as a heat sink, would have an effect on the thermo-hydrological performance of the UZ.

In order to look at the effect of what is called "enhanced" binary vapor diffusion, several model calculations were repeated with different values of the tortuosity factor, t, for binary gas diffusion. Most of LLNL's previous calculations assumed a t of 0.2. Recently calculations considered a t of 1.0 for AMLs of 27.1, 49.2, and 154.7 MTU/acre and found that it had a negligible effect on temperatures at the repository edge and center. At the repository center, re-wetting back to ambient saturation was slightly enhanced, but re-wetting at the repository edge was somewhat retarded. In general, increasing t has a minor effect on stabilizing large-scale, buoyant vapor flow.

Most of LLNL's UZ-SZ-repository-scale calculations utilized a model which was based on a one-dimensional initialization. These calculations were repeated in which two-dimensional (R-Z) initialization for 10,000 yr before the introduction of

repository heat was tested. No difference was found in thermo-hydrological performance between the one- and two-dimensional initializations.

Laboratory Experiments

Work continued measuring electrical resistivity as a function of moisture content of Topopah Spring Tuff samples from U3hg-1 and GU-3 holes at room temperature, using J-13 water as pore fluid. The electrical impedance and high frequency electromagnetic tomography used in the laboratory and the field to monitor the distribution of moisture content in the tuffaceous rock depend on accurate laboratory measurements for their calibration. The electrical conductivity of partially saturated rocks is largely dependent on saturation level, fluid conductivity, and temperature. Thus far, electrical conductivity as a function of moisture content has been determined during both imbibition and drying cycles at 20°C on tuff samples for Area 3 and Area 25 NTS, Nevada using distilled water. Results indicate an exponential dependence of conductivity on water content (Sw) for both imbibition and drying cases. Hysteresis between the imbibition and drying cycles is observed for both rock types. The imbibition curve is more conductive than the drying curve between 20 and 70% Sw. Possible explanations of the hysteresis are changing ionic concentration or conducting mechanism in the pore fluid with changing saturation levels. Additional experiments using J-13 well water as the saturating fluid do not show any departure from the curves determined with distilled water during the imbibition cycle up to 30% saturation. The established curves have successfully been used to determine saturation levels of a core sample used in a flow test.

Work continued to investigate the different imbibition rates of water into a rock sample when the sample is either in a vapor environment or in liquid water. It was found that nucleation has no effect on the moisture retention in a capillary tube.

Work continued on an experiment to determine the effect of fracture surface coatings on the imbibition of water into the matrix. Eight Topopah Spring Tuff samples machined from outcrops from Busted Butte were prepared for this purpose. The determination of the mineralogy of the coating material, the pore–size distribution in the coating layers, and the porosity of the samples are in process.

Sample preparation for determining the moisture retention curve and one-dimensional imbibition at high temperatures continued. Work will soon start to prepare a fractured Topopah Spring Tuff sample from G-4 hole for a fracture healing study.

Meetings and Publications

The paper by T. Buscheck entitled "Repository-Heat-Driven Hydrothermal Flow at Yucca Mountain: Analysis and Testing" is in internal and YMPO review. After YMPO approval, it will be submitted to the Radioactive Waste Management and Nuclear Fuel Cycle Journal.

The abstract by J. Roberts and W. Lin entitled "The Effects of Water Saturation and Water Chemistry on the Electrical Conductivity of Topopah Spring Tuff" was approved by YMPO and will be presented at the American Geophysical Union meeting in Baltimore, MD on May 24-28.

1.2.2.2.3 Mechanical Attributes of the Waste Package Environment

Initial scoping calculations were performed for the Large Block Test (LBT) using two different codes, FLAC a finite difference code and FRACROCK a boundary element code. A third code was acquired: HEFF, a boundary element, thermomechanical code.

Work started on the procurement and calibration of laboratory equipment for laboratory testing of fracture properties and rock damage analysis and for calibration of the LBT.

1.2.2.2.4 Engineered Barrier System (EBS) Field Tests

Study Plan 8.3.4.2.4.4, "Engineered Barrier System Field Tests" has completed internal technical review, and will be sent to YMPO next month.

S. Blair, J, Blink, W. Lin, and D. Wilder attended an ESF test consolidation meeting in Las Vegas with LANL, the M&O, YMPO and SNL on March 17.

Large Block Test (LBT)

The Scientific Investigation Plan for Large Block Testing of Coupled Thermal-Mechanical-Hydrological-Chemical Processes, SIP-NF-2, Rev. 0, completed internal review and was submitted to YMPO for approval. Internal QA grading for the LBT has been completed. W. Simecka (YMPO) signed the initiation form for the Test Planning Package. R. Oliver (LANL TCO) initiated contacts with SAIC and REECo to obtain environmental clearance and site clearing necessary to finalize the location of the LBT.

The preliminary moisture content of some small pieces of Topopah Spring Tuff from the Fran Ridge outcrop has been determined to be about 20 and 50%, with the smallest samples having the lowest moisture content. Work will continue to refine the moisture content determination. This information will be used in the design of the Large Block Tests.

The design of the loading frame has been finalized. Mechanical Engineering Department personnel are preparing fabrication drawings. A SANL has been issued for the procurement of SNL's service for cutting the block(s).

J. Blink, W. Lin, and D. Wilder met with the M&O at NTS on March 16 to discuss issues related to the LBT.

1.2.2.2.5 Characterization of the Effects of Man-Made Materials on Chemical & Mineralogical Changes in the Post-Emplacement Environment

Investigation activities into the stability and reactivity of organic materials have been initiated:

1) Planning of the initial experimental phases has been completed.
2) Lab facilities are in the final stages of completion.
3) The first phase of database evaluation for organic compounds that are liable to be introduced into the ESF and the potential radioactive waste repository and for which the thermodynamic and kinetic properties are not well established has been completed.

The white paper entitled "Chemical and Mineralogical Concerns For The Use Of Man-Made Materials In The Post-Emplacement Environment", by A. Meike, has been released as an LLNL report.

A letter has been sent to J. Younker (M&O) describing the man-made materials task in order to open a dialogue to pursue potential interfaces with activities being conducted by M&O.

Revision of the draft Man-made Materials Study Plan 8.3.4.2.4.5, continues.

1.2.2.3 Waste Form and Materials Testing

1.2.2.3.1 Waste Form

1.2.2.3.1.1 Waste Form Testing - Spent Fuel

Revision 7 of the PNL QA plan was sent to LLNL for review and concurrence.

R. Fish (M&O) visited LLNL on March 23.

Spent Fuel Dissolution

The low-oxygen UO_2 dissolution experiments that are a part of the LLNL test matrix are continuing at LLNL. The very-low (0.2%) oxygen, room-temperature runs were finished this month. The equipment for the remaining low-oxygen runs has been installed in another laboratory and experiments will begin shortly.

An analysis of the test matrix from PNL's spent fuel dissolution tests shows a uranium dissolution dependence primarily on temperature and oxygen concentration. Carbonate concentration is less important. Existing data from LLNL's UO_2 dissolution tests show a similar relationship. The data from PNL and LLNL show pH as an insignificant factor under the alkaline conditions of these test matrices. Dissolution data under acidic conditions should be different, if only because of solubility differences.

The flow-through dissolution tests at PNL on ATM-106 fuel (PWR fuel with burnup ~48 MWd/kgM and fission gas release ~18%) in both oxidized (O/M ~2.4) and

unoxidized forms are in progress. Another specimen of ATM-106 fuel was converted to U_3O_8 by heating in air overnight at 425°C. Flow-through dissolution tests on this material will be started as soon as characterization work has been completed using x-ray diffraction (XRD), scanning electron microscopy (SEM) and surface area measurement.

W. Gray gave a presentation on spent fuel dissolution for the EBS meeting held March 31-April 1 at PNL.

Spent Fuel Oxidation

R. Einziger gave a presentation on spent fuel cladding and fuel oxidation for the EBS meeting held March 31-April 1 at PNL. R. Stout and W. Halsey (LLNL) attended the meeting. A preliminary model is being formulated to relate cladding failure with the rate of oxidation front propagation, with the time to clad splitting initiation, and with the amount of fuel oxidized to U_3O_8 as a function of container atmosphere and temperature. Results of the calculations will be reported next month.

Dry Bath Testing

Test instructions were prepared for initiation of the 255°C drybath test at PNL. A number of the samples of fuel at 130°C in bath 5 will be examined by ceramography and XRD to make sure there are no unanticipated results. Some of the samples from the drybath will be removed into drybath 7 running at the same temperature; other samples will be removed from the test completely and saved in stainless steel pipes for possible future use. After drybath 5 is completely empty, it will be operated at 255°C for a few weeks to determine its temperature stability. If the bath proves stable, it will be loaded with samples per the test plan addendum which was approved by LLNL and incorporated into Activity Plan D-20-45.

Thermogravimetric Apparatus (TGA)

B. Hanson, an OCRWM fellow from UC Berkeley, has joined the program to conduct fuel oxidation studies on the TGA and complete his Ph.D. dissertation. He is currently reviewing the oxidation literature, reading QA procedures and completing his required safety training. His first lab work will be to get the mothballed TGA's back into calibrated working condition and install the new data acquisition system. His first milestone is to prepare a test plan addendum for the TGA.

Materials Characterization Center (MCC) Hot Cell Activities

A meeting was held to brief DOE-RL on the status of disposal of the excess spent nuclear fuels currently occupying space in the PNL Bldg. 324 hot cells. PNL is currently identifying which fuel samples will be needed for OCRWM research activities.

1.2.2.3.1.2 Waste Form Testing - Glass

D-20-27 Unsaturated Testing of WVDP and DWPF Glass

The N2 tests (SRL actinide-doped glass) continue with no sampling period occurring this month. These tests have been in progress for 364 weeks. The N3 tests (ATM-10, a West Valley actinide-doped glass) continue and have been in progress for 282 weeks.

A validated model for predicting borosilicate glass dissolution rates must successfully simulate results from a variety of test types. This is being done for the SRL-202 glass using results from closed system tests with surface area to volume (SA/V) ratios from 10 to 20,000/m and from flow-through tests with varying flow rates. Results from measurements of surface charge, atomic electron microscopy (AEM) of reacted surface layers, and nuclear magnetic resonance (NMR) spectra of reacted and unreacted glasses also help constrain the model. The kinetic model has been modified to relate the surface charge rather than pH using data from the surface titrations. The form of the affinity term in the rate equation has been modified to better predict long-term reaction rates in high SA/V tests.

The abstract by W. Bourcier, S. Carroll, B. Phillips (LLNL), J. Bates and W. Ebert, (ANL) entitled "Modeling 202-SRL Glass Dissolution: Combined Constraints from Varying SA/V, Flow-Through, Surface Titration, AEM, and NMR Experiments" was approved by YMPO and will be presented at the American Ceramic Society meeting in Cincinnati, OH, April 18-22 .

1.2.2.3.2 Metal Barriers

D. McCright met with R. Fish and K. McCoy from the M&O on March 23-24 to discuss the status of the Metal Barrier work. Technical activities, schedules, and projected budgets were discussed. At the meeting, it was agreed that the present Scientific Investigation Plan (SIP) for this task is out-of-date. The present SIP dates from 1989 and reflects the interest of the YMP at that time to focus on a thin-walled container fabricated from a single material, which is the YMP Conceptual Design (CD). Since that time, other design concepts have been introduced, and these other designs involve materials not currently being considered for the YMP-CD. The SIP therefore needs revision to incorporate activities to support designs that will be considered during the Advanced Conceptual Design (ACD) phase. A draft of the revised SIP is planned for submission to YMPO in August 1993.

D. McCright has been in contact with D. Diercks and J. Bates from ANL to restart work on crack propagation under YMP sponsorship. The work had been sponsored by the YMP during the 1998-91 period, but budget reductions in 1991 forced curtailment of YMP sponsorship. The work at ANL originally included slow strain rate tests and crack propagation tests on the conceptual design candidate materials to determine their relative stress corrosion cracking resistance under repository-relevant conditions. The resistance of Alloy 825 tested under creviced conditions by the slow strain technique in simulated J-13 well water was an important reason why this material was recommended for additional study during ACD. It was felt that

this combination of conditions represented a very aggressive environment for the alloy. In the course of running the crack propagation tests, Alloy 825 did not show any indication of crack growth (the specimens were pre-cracked) after more than two years of exposure. Resumption of support for these tests is important for determining the long term resistance of corrosion resistant materials, used as single containment barriers or as part of a multiple barrier design. A statement of work was received from ANL and is being evaluated. Funding for the ANL subcontract work will be in a separate PACS account. It is anticipated that formal resumption of this work will occur in May.

Installation of crack growth measurement equipment in a new laboratory at LLNL is proceeding. Mechanical installation is complete and electrical installation will be completed during April. Procurement of the thermogravimetric system, placed on the YMP capital equipment purchase list for FY93, is still held up pending release of the funds.

Work on the degradation modes of iron and steel under YMP repository relevant conditions is continuing.

J. Mitchell is writing a "position paper" on the degradation of nuclear waste containers under "wet" and "dry" scenarios for the potential Yucca Mountain repository. R. Van Konynenburg is providing assistance. This paper will help support decisions on thermal loads for waste package designs.

R. Van Konynenburg is organizing the fall Materials Research Society (MRS) symposium on the Scientific Basis of Nuclear Waste Management to be held in Boston, MA in late November 1993. The call for papers has been mailed to 2500 scientists world-wide and funding requests have been submitted to DOE and NRC.

1.2.2.3.3 Other Materials

This WBS element has not been funded in FY93.

1.2.2.3.4 Integrated Testing

1.2.2.3.4.1 Integrated Radionuclide Release: Tests and Models

<u>Determination of Elemental Profiles in Rocks, Minerals, and Glasses using the Ion Microscope</u>

Initial secondary ion mass spectroscopy (SIMS) analysis of clinoptilolite samples was completed. Additional samples are currently being treated with chloride salts for subsequent SIMS analysis. Natural (untreated) samples of clinoptilolite were mounted in epoxy and examined by scanning electron microscopy (SEM). These samples will be used to provide base line composition data using the electron microprobe and SIMS.

X-ray analysis of various size fractions of clinoptilolite samples to be used in cation exchange experiments was completed. A protocol for separation of relatively pure clinoptilolite is being developed.

Interactions of Actinide-bearing Solutions with Rock Core Samples

Flow tests on the saw-cut fractured rock were begun using filtered Milli-Q deionized water. The automated balance and data collection system is operational. Changes to the data collection program will be made to facilitate tracking instantaneous flow rates.

1.2.2.3.4.2 Thermodynamic Data Determination

The status of NEA activities was reviewed, an update was provided to A. Simmons (YMPO), and plans were made for FY94-95 activities.

1.2.2.3.5 Nonmetallic Barrier Concepts

This WBS element has not been funded in FY93.

1.2.2.4 Design, Fabrication, and Prototype Testing

1.2.2.4.3 Container/Waste Package Interface Analysis

This WBS element has not been funded in FY93.

1.2.3 SITE INVESTIGATIONS

1.2.3.1 Site Investigations Coordination and Planning

This WBS element has not been funded in FY93. LLNL should be added to the list of participants for this WBS element in the WBS Dictionary.

1.2.3.2 Geology

1.2.3.2.1.2.1 Natural Analogue of Hydrothermal Systems in Tuff

This WBS element has not been funded in FY93.

1.2.3.4 Geochemistry

1.2.3.4.2 Geochemical Modeling

At the direction of R. Dyer (YMPO), Version 7.1 of EQ3/6 was provided to Dr. H. Nitsche at LBL.

Preparation was begun of a Version 7.2 package. Version 7.2 is designed to be compatible with both SPARC workstations and 486 PCs. This version incorporates changes required to allow EQ3/6 to run on the 486 PC. One bug in EQ6 was found

using the Lahey PC Fortran compiler. A local tolerance parameter in the pre-Newton-Raphson optimization model had the same name as a global tolerance parameter. The much tighter global value was being used in this module, causing a small loss of overall computing efficiency. Version 7.2 also addresses the few other bugs that have been reported in Version 7.1. One problem was that it was assumed that species names would be unique through the first 18 characters. This is not sufficient to discriminate among the end-members of the hydrated clinoptilolite solid solution, causing related calculations to be incorrect. The independent software verification effort found a discrepancy between the equations given in the EQ3NR manual for certain Jacobian matrix elements and the corresponding programming, which was found to be not up-to-date. Testing with the test library shows a very slight improvement in convergence properties with the programming corrected. A write format error in the EQ6 pickup file (reported by W. Murphy of CNWRA) was fixed. This affected the fixed fugacity option, causing the possible loss of a minus sign when this file is read as an input file. Some minor port-related problems (reported by T. Scandora of ANL) were also fixed. Work on the major codes was essentially completed this month. Version 7.2 will be available for distribution in April on floppy disks in both UNIX and DOS formats.

The review of Rev. 0 of the "Software Design Documentation for EQ3/6, Version 8" was completed, and this document was approved. Hands-on development of Version 8.0 will commence immediately upon the completion of the Version 7.2 package.

1.2.3.10 Altered Zone Characterization

YMPO has notified LLNL of its decision to fund this WBS element with FY92 underrun funds. These funds were furnished to LLNL in an Approved Financial Plan (AFP) in early April.

1.2.5 REGULATORY

1.2.5.1 Regulatory Coordination and Planning

This WBS element has not been funded in FY93. LLNL should be added to the list of participants for this WBS element in the WBS Dictionary.

1.2.5.2 Licensing

1.2.5.2.2 Site Characterization Program

Two Study Plans were sent to LLNL for review, and reviewers were assigned.

Rev. 1 of LLNL Study Plan 8.3.4.2.4.3, containing minor typographic and reference list changes were issued by YMPO.

1.2.5.3 Technical Data Management

1.2.5.3.4 Geologic and Engineering Materials Bibliography of Chemical Species (GEMBOCHS)

Development continued of a WINDOWS/4GL (mouse-driven) version of D0OUT. This program facilitates interactive point-and-click generation of thermodynamic datafiles for EQ3/6, GT, and other geochemical modeling packages. Beta testing of the prototype version of this code led to the conception of several significant enhancements; these are now being incorporated.

At the request of T. Wolery, three organic acids [formic acid(aq), propanoic acid(aq), and butanoic acid(aq)were transferred from the non-basis to the auxiliary basis set of aqueous species in the SUPCRT92 and composite data subsets of GEMBOCHS. This transfer permits specification of the concentrations of these acids as input parameters for EQ3/6 calculations.

D0OUT was used to generate a revised suite of thermodynamic datafiles (DATA0 suite R19) that support the EQ3/6 geochemical software package. These new datafiles incorporate the aqueous-acid transfer noted above. The new files were piped through EQPT to generate the corresponding DATA1 suite, which was then transferred to s60:/dberror/data0, where it can be accessed by local users of EQ3/6.

Fine tuning continued on the CNGBOCHS package.

J. Blink attended the Technical Data Working Group meeting in Las Vegas on March 4.

1.2.5.3.5 Technical Data Base Input

YMPO transferred an additional $60K into this WBS element. $10K will be used to fund R. Silva's participation in the Solubility Working Group. The remainder will be used to input backlogged data.

1.2.5.4 Performance Assessment

1.2.5.4.2 Waste Package Performance Assessment

W. Halsey and J. Blink met with J. Younker, A. Van Luik, R. Andrews, S. Trimishra (M&O) and J. Boak (YMPO) in Las Vegas on March 9 to discuss LLNL and M&O workscopes in PA. The meeting continued via conference call on March 15.

1.2.9 PROJECT MANAGEMENT

1.2.9.1 Management and Coordination

1.2.9.1.2 Technical Project Office Management

J. Blink attended the Quarterly Project Management meeting dry run in Las Vegas on March 4. W. Clarke and J. Blink attended the TPO meeting in Las Vegas on March 10. W. Clarke, J. Blink, D. Wilder and W. Lin attended a meeting with T. Sullivan, C. Newbury and A. Simmons in Las Vegas on March 16 to discuss the interface between LLNL's workscopes in WBS elements 1.2.2 and 1.2.3. J. Blink attended the Infrastructure Reduction Analysis Team (IRAT) meeting in Las Vegas on March 5.

S. Lundeen was appointed as LLNL's member on the Software Advisory Group (SAG), replacing T. Quinn who has accepted another LLNL assignment.

W. Clarke presented an overview on the Yucca Mountain Project to the Kiwanis Club of Danville, CA on March 4.

J. Blink judged the science fair at Armagosa Valley School (K-8) on March 2. He presented a hands-on science program to a kindergarten class at Griffith Day School and a fourth grade class at Crestwood Elementary School in Las Vegas on March 12. He also presented a hands-on demonstration of nuclear science to two fifth grade classes from Charlotte Hill Elementary School at the Yucca Mountain information office on March 18. In the first half of the fiscal year, he has provided hands-on science programs for over 2400 students and over 120 adults.

J. Blink was a tour guide to Yucca Mountain for eighteen members of the LLNL College Intern Program on March 3 and ten people from the University of Colorado on March 8.

J. Blink attended a meeting in Las Vegas on March 16 chaired by T. Kaish (M&O) to plan Boy Scout Merit Badge Workshops sponsored by YMPO.

1.2.9.2 Project Control

1.2.9.2.2 Participant Project Control

The February FTE/cost report was submitted to YMPO. The February actual schedule progress and costs were submitted via PACS workstation. Variance analysis explanations were developed for several P&S accounts for activity undertaken in February. The Cost Plan was updated to include February actuals. This is an internal report.

The FY95 Field Work Proposal (FWP) was completed. This annual planning document is a DOE requirement placed on the entire laboratory and is submitted directly to DOE through the San Francisco Field Office (SAN). YMPO is not directly

involved. This year's submission covered FY94-95. Total budget requirements by year are:

1) FY94 - $12 million, and
2) FY95 - $15 million.

Little progress has been achieved in the effort to automate transfer of data between laboratory financial systems and the PACS workstation. The FTE calculation module is 80% complete. The remaining modules are labor dollars and other direct charges.

A SANL was prepared for a Technical Services Agreement with SNL for the Large Block Test specimen preparation. An additional SANL is being prepared for ANL to perform crack growth studies.

A Change Control Notice was prepared to increase the FY93 Metal Barriers P&S account by $100,000 provided by FY92 carryover funds.

D. Rainey (SAIC) has accepted a position with the M&O and will be leaving LLNL on April 2. Her position will be covered temporarily by a Project Control technician.

Two positions were posted:

1) A Project Control Coordinator to assist in the development and maintenance of the PACS database; and
2) an Engineering/Scientific Coordinator to provide planning and programmatic/ technical support for the Technical Area Leaders.

It is anticipated that both positions will be filled by May 1.

J. Blink contacted members of the M&O and YMPO to determine FY94 initial budget estimates.

1.2.11 QUALITY ASSURANCE

1.2.11.1 Quality Assurance Coordination and Planning

Several applicants were interviewed for the LLNL-YMP QA Manager position. A candidate has been selected, and an offer is in preparation.

LLNL provided input to T. Statton (M&O) for the FY94 Annual Plan for Site Characterization. WBS elements 1.2.2.1, 1.2.2.2, 1.2.2.3.4, 1.2.3, 1.2.5.1, 1.2.5.2 and 1.2.5.3 were included in the submission. A courtesy copy was provided to H. Benton (M&O). Similar input is being prepared for H. Benton for the remaining elements of WBS 1.2.2.3 and 1.2.2.4.

The PNL Quality Assurance Plan (PNL-MA-70) (WTC-018, Rev. 7) for the Geologic Disposal Support Project for the YMP was reviewed, and comments were forwarded to the PNL Project Manager.

Grading reports for the five activities (LBT-01 through -05) of the Large Block Testing of Coupled Thermal-Mechanical-Hydrological-Chemical Processes were

reviewed, and the resulting grading determinations were submitted to the LLNL-YMP Leader for approval.

1.2.11.2 Quality Assurance Program Development

Work continues at LLNL to develop those changes to internal procedures that have been identified as necessary to fully implement the QARD.

1.2.11.3 Quality Assurance Verification

Actions have been prepared to close CARs YM-92-064, YM-92-065 and YM-93-017. The first two, dealing with M&TE, will be treated together, while the third, dealing with Grading Reports, is separate. YMQAD verification of the corrective actions is scheduled for early April.

1.2.11.3.1 Quality Assurance Verification - Audits

No significant activities.

1.2.11.3.2 Quality Assurance Verification - Surveillance

Surveillance S93-04 (Training and Qualification of Personnel currently assigned to the LLNL-YMP) was conducted. The Surveillance Report was issued on March 18.

1.2.11.4 Field Quality Assurance/Quality Control

This WBS element has not been funded in FY93.

1.2.11.5 Quality Assurance - Quality Engineering

No significant activities.

1.2.12 INFORMATION MANAGEMENT

1.2.12.2 Records Management

1.2.12.2.2 Local Records Center Operation (LRC)

Two new revisions and one change notice were issued by Document Control.

1.2.12.2.3 Participant Records Management

A total of 139 items were logged into the LLNL-YMP tracking system. This includes nine records/records packages that were processed through to the CRF. Ten action items were closed.

1.2.12.2.5 Document Control

LLNL received no funding under this WBS. Work performed to complete LLNL's obligation in this WBS is funded under WBS 1.2.12.2.2.

1.2.13 ENVIRONMENT, SAFETY AND HEALTH

1.2.13.1 Environment, Safety and Health Coordination and Planning

Changes were submitted to the PEARL directory; these changes update LLNL-YMP personnel and phone entries.

1.2.15 SUPPORT SERVICES

1.2.15.2 Administrative Support

The guidance letter for input to PR 8, Site Characterization Progress Report: Yucca Mountain, Nevada, was received by LLNL on March 3. LLNL's input to PR 8 was sent to YMPO on March 25.

1.2.15.3 Yucca Mountain Site Characterization Project (YMP) Support for the Training Mission

Sixteen different self-study assignments were issued, and 53 people were trained to these assignments. Currently, there are 69 participants on the project who are to be trained and/or tracked.

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IN REPLY REFER TO:

WBS: 1.2.9.2.2
QA: N/A

I-340501 BAA

April 13, 1993

4/13/93

Carl P. Gertz, Project Manager
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P.O. Box 98608
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SUBJECT: U.S. Geological Survey Yucca Mountain Project Monthly Summary for March 1993

Dear Carl:

In compliance with Yucca Mountain Project monthly reporting procedures, following is the YMP USGS input for March 1993. If you have any questions, please contact Raye Ritchey at (303)236-0517.

WBS 1.2.1 - SYSTEMS ENGINEERING

1.2.1.6 - Configuration Management

Development of Configuration Management Guidelines for the YMP-USGS program was begun, and a flow chart of proposed Configuration Management Plan activities was developed.

WBS 1.2.3 - SITE INVESTIGATIONS

1.2.3.1 - Site Investigations Coordination and Planning

All USGS and LBL summary account schedules were statused. The hydrologic investigations program (HIP) reports that two HIP accounts showed relatively small negative schedule variances, neither of which have any significant long-term impact on major milestones, and which can probably be made up during FY 1993. Negative schedule variances are approaching $20K for two other summary accounts; these are being investigated to determine what sort of corrective action might be necessary to avoid significant impacts later in FY 1993 or in FY 1994. Nine summary accounts showed cost variances greater than $25K, most resulting from administrative delays in the execution of pending contracts and in the filling of vacancies. The largest cost variance, +$133K, in the LOE account for "Percolation in the UZ, Surface Based Testing", resulted from three critical vacancies not being filled until the February-March timeframe.

The Executive Subcommittee of the Committee for the Advancement of Science at Yucca Mountain (CASY) organized a symposium on thermal-loading effects that was held in Denver March 24-25, 1993. Over 100 people attended the symposium, with over half being non-USGS technical people working on the Yucca Mountain Project.

USGS Principal Investigators met with the YMP performance assessment group.

Information was exchanged on what performance assessment needed from site characterization, and what geologic and hydrologic information the USGS had generated that would be of use to performance assessment.

1.2.3.2.2.1.1 - Surface and Subsurface Stratigraphic Studies of the Host Rock and Surrounding Units

Staff supporting surface and subsurface stratigraphic studies completed detailed technical changes on the 1:6000 scale geologic cross sections depicting the north ramp, south ramp, and main Topopah-level drift alignments. Changes in the technical details of the cross sections and the TDIF process were expedited to get this data released for YMP distribution. The sections will be published as a USGS open file report. Three drill holes were completed during March. NRG-6 reached a total depth of 1100 feet, NRG-3 a total depth of 330 feet, and UZ-16 reached 1686 feet. Core from NRG-3 has not been made available for examination. In UZ-16, preliminary lithologic identification indicates tuffaceous rocks of Calico Hills from 1201 feet to 1485 feet, and the Prow Pass Member of the Crater Flat Tuff from 1485 feet to 1686 feet. Downhole video logs were made of NRG-2 from 174 feet to 215 feet, and of UZ-16 from 74 feet to 1602 feet, but analysis in the laboratory has not begun.

Isotope and geochemistry group work in support of stratigraphic studies focused on an intense effort to prepare and analyze a suite of 40 samples of the Tiva Canyon from Antler Ridge in support of studies aimed at delineating offsets associated with the Ghost Dance fault zone. Geochemical results show a distinct, systematic variation of trace element concentration with stratigraphic position. A first-order geochemical break, particularly evident for Sr, Ba, Ti, and Zr, can be resolved within approximately one meter and may be viewed as a geochemical marker horizon to provide independent evidence corroborating the subtle physical and mineralogical variations being used to determine stratigraphic position.

1.2.3.2.2.1.2 - Structural Features within the Site Area

Staff supporting the geologic mapping of zonal features continued mapping fractures in Split Wash, and worked on the detailed stratigraphy in preparation for a tour. Snow covered the outcrops, as well as the majority of the north-facing slopes, making mapping and stratigraphic work difficult. Reconnaissance mapping in the rocks of Calico Hills along the north flank of Yucca Mountain showed variations in the stratigraphic section that will compared with sections exposed in upper Paintbrush Canyon and Fortymile Wash. Staff completed mapping of the East of Beatty Mountain 7.5 Quadrangle.

Mapping continued along the Ghost Dance Fault, with mapping of new areas cut back in order to focus on detailed descriptions and analysis of the local stratigraphy within the study area. Draft descriptions of stratigraphic discriminators are complete and in review. A suite of samples was collected at intervals along the Ghost Dance Fault and up the south flank of Antler Ridge for chemical analysis and petrographic study, which are in progress.

Staff supporting surface fracture network studies mapped an additional cell at P2001, while waiting for construction crews to prepare the north ramp portal area. Comparison of February and March graphics presents incremental progress. Two possible "shears" can be interpreted by general fabric orientation and character. These trend in a NW direction. The northernmost shear is southwest of the north test pit; the other is immediately north of the south test pit.

In support of geologic mapping of the ESF, staff completed geologic mapping of the north ramp portal for the ESF. Plan-view mapping of the exposed geology in the area, and six traceline surveys were completed. Additional samples were taken of fracture fillings and submitted to the SMF. Mapping of the portal revealed the presence of a previously unmapped north-trending fault

east of the portal face. The fault appears nearly vertical and with throw down to the east. Staff met with Project personnel to discuss plans for the upcoming starter tunnel excavation. Plans call for three-shift-per-day excavation and shotcreting each round. This schedule will have significant impact on the underground mapping; round-the-clock mapping crews will be required during round-by-round application of shotcrete.

1.2.3.2.6.2.1, .2, .3 - Soil and Rock Investigations

YMPO has redefined responsibilities under WBS 1.2.3.2.6.2. These studies will be transferred to Sandia National Laboratory through a transition, utilizing support from USGS staff. Change Control actions are in progress for necessary revisions to funding, schedules, and other appropriate documents.

1.2.3.2.5.5.2 - Characterization of Igneous Intrusive Features

Staff supporting heat flow studies report that no field measurements have been carried out. No new holes have been made available, and none of the WT holes have been reconfigured. Also, there are some software QA issues outstanding that preclude obtaining qualified data. A proposal was developed for fast-track resolution of outstanding software QA issues.

1.2.3.2.8.3.1 - Relevant Earthquake Sources

In support of the characterization of the 10,000 year cumulative slip earthquake, a contract was put in place for an expert from the USGS Geologic Division to work with and advise Yucca Mountain Project staff. Discussions were initiated of alternative ways to analyze deterministic seismic hazard methodology. QA training, and a field trip to familiarize participants with Yucca Mountain and the tasks to be performed, were conducted. Participants examined most trench excavations and reviewed preliminary findings at each trench.

1.2.3.2.8.3.3. - Ground Motion from Regional Earthquakes and Underground Nuclear Explosions

A team of four experts has been assembled to evaluate and choose appropriate models for ground motion at the Yucca Mountain repository. This team is scheduled to convene a conference in May to prepare a study plan. The planned finish for this study may be delayed because personnel working on the study must wait for the NRC to develop guidelines for evaluating ground motion models.

1.2.3.2.8.4.1 - Historical and Current Seismicity

Staff recorded data from the SGBSN for all of March, except for about 20 hours due to a disk problem. Develocorders provided backup during downtime. No events were missed. UNR completed the earthquake bulletin through March 27, 1993. Four temporary stations were deployed near Beatty, NV to reverse a refraction line under Yucca Mountain to constrain crustal velocities in the vicinity of Yucca Mountain. The microwave telemetry station at Slide Mountain was upgraded. Analysis was completed on the cluster test to close out the Little Skull Mountain data recording experiment. Routine focal mechanism determinations for Little Skull Mountain events were begun.

1.2.3.2.8.4.2 - Location and Recency of Faulting Near Prospective Surface Facilities

The activity to excavate/log/study extensions of Trench A-3 did not start as planned in February and, due to time and funding constraints, the trench may not be studied this year. In October-November, 1992, additional excavations and study of the area near the proposed ESF were required on the basis of prior work. This, plus planned work, had to be completed so that construction activities for the ESF could occur as scheduled, resulting in an increased

rate of spending. In addition, trench priorities have changed. Recently obtained geophysical data indicate that a fault may be present in the middle of Midway Valley. The location of a trench(s) across this possible fault will depend on the final geophysical interpretation and other information such as geologic mapping. Based on these considerations, priorities for excavation activities are being re-evaluated within the context of this study and within the scope of other trenching activities planned by the USGS for FY 1993.

1.2.3.2.8.4.3 - Quaternary Faulting within 100 km of Yucca Mountain

Two trench sites have been identified for evaluation of the Bare Mountain fault zone. Documents were prepared to obtain necessary clearances. An archeology clearance has not been granted for trench BMT-1 (Tarantula Canyon site); excavation and analysis are delayed until April. Input was provided into revision of the existing test planning package for evaluation of the Bare Mountain fault zone, required due to the selection of soil test pit sites and identification of two additional trench sites along the fault zone.

Isotope and geochemistry group work in support of tectonic studies focused on thermoluminescence and U-series dating of pedogenic deposits offset by Quaternary fault movement. This included processing U and Th chemistry on a suite of samples from Busted Butte, and Trenches 14c and 14d, as well as determining moisture contents on thermoluminescence samples from Midway Valley and Stagecoach Road, and preparing these samples for gamma- and delayed-neutron-counting.

1.2.3.2.8.4.5 - Detachment Faults

In support of the evaluation of the Miocene-Paleozoic contact at the Calico Hills, additional compilation of field work continued. Field work commenced in support of the evaluation of postulated detachment faults in the Beatty-Bare Mountain area. Geologic field mapping is being conducted at the north end of Bare Mountain and the south end of Crater Flat. The structure of the area also is being examined to determine the nature of the Miocene extension.

1.2.3.2.8.4.6 - Quaternary Faulting within the Site Area

Field work to collect data for the Quaternary fault map was completed and compiled on 1:12,000 scale orthophoto overlays. The final map at 1:24,000 scale, along with its accompanying report, will not be submitted for USGS review on schedule, due to the Principal Investigator being diverted, at DOE request, to work on the erosion topical report.

Cleaning and flagging of identified stratigraphic contacts and structures was completed on exposure #4 on the west side of Busted Butte. The cleaned wall was photographed stereographically in preparation for mapping. Trenches T-8 and CF-1 were rephotographed and surveyed in preparation for photogrammetric logging.

1.2.3.3.1.1.1 - Precipitation and Meteorological Monitoring for Regional Hydrology

The month of March was dry until the last week, a distinct change from the previous three months and a complete reversal of the wet March of 1992. Only one major storm series hit the western U.S. during the month. Rainfall at Yucca Mountain averaged over 3/4 inch from storms on March 26-28, resulting from a sharp upper level trough of low pressure off the coast of northern California. All data collected using the local storage gage network from January 1, 1990 through March, 1993, was compiled into a data base for statistical and geostatistical analysis of storm events. Approximately 50 significant storms are included in this data base. This information will be useful for developing isohyetal mappings of storms as well as stochastic precipitation models needed for the analysis of natural precipitation.

1.2.3.3.1.1.2 - Runoff and Streamflow

Progress has been delayed in the reduction of FY 86-89 surface water data due to extensive field activities associated with the regional streamflow network caused by numerous storms during January and February. Runoff which occurred on the Nevada Test Site during the month of March was a direct result of snowmelt which had accumulated during the January and February storms. Several measurements of streamflow were obtained at a proposed gaging site on Stockade Wash at Buckboard Mesa Road. These measurements, along with a surveyed point of zero flow will be used to develop a rating to define the stage discharge relationship. Gene Ryder (DOE) was contacted several times regarding permits for three new stream gage sites scheduled to be installed this year. A backlog of work, compounded by a shortage of manpower, has prevented any action being taken on these sites. Work has been rescheduled for early April.

1.2.3.3.1.1.3 - Regional Ground-Water Flow System

The Fortymile Wash recharge data report is behind schedule due to time needed to document ongoing recharge events during FY 93. Time has been spent mapping the extent of surface-water runoff flows, collecting and processing water quality samples, measuring water-level responses in wells, measuring changes in unsaturated zone moisture content through neutron logging, and documenting and communicating field results.

1.2.3.3.1.1.4 - Regional Hydrologic System Synthesis and Modeling

Simulations were run which examined the removal of the barrier to ground-water flow responsible for representing the large hydraulic gradient north of Yucca Mountain. Mass balances typically were 5 to 6 orders of magnitude smaller than the maximum specified fluxes within the model indicating excellent mass balance. A run was made to obtain steady state heads after 20,000 years; maximum difference between initial and final heads was 0.01m.

1.2.3.3.1.2.1 - Unsaturated Zone Infiltration

In support of surficial materials testing, four mapping/sampling transects of selected washes were conducted. In each transect, water content samples were collected at selected locations. Quick draw tensiometer readings were obtained at each of the locations, and a preliminary depth to bedrock map for each wash was constructed.

Staff from the natural infiltration project conducted field visits to visually assess overland flow and runoff from precipitation events. Neutron logs from the 24 new neutron holes were plotted and received preliminary analysis. Several locations show evidence of historical differences in climate, as well as differences due to topographic position. UZ-16 was logged using the large neutron tool to provide the surface based boreholes project with information on the water table. The logs were run in the uncased borehole, and will provide information to evaluate whether the dual-spaced tool can be used in a larger, uncased hole and if it is field calibrated using the core sample volumetric water contents. The calibration using the standards results in a very flat curve with very little resolution.

The artificial infiltration project reports that three ring infiltrometers and water storage tank systems were installed inside the larger infiltration ring at neutron access hole N-85. The infiltrometer and water storage system performance was outstanding. Infiltration rates, infiltration capacity, and saturated hydraulic conductivity were calculated for each of the rings following completion of the infiltration study. The prototype ponding/infiltration study was conducted at N-85. A total of 13,000 gallons of water infiltrated through the surface soil from March 9 until March 24. Neutron logs were taken every hour for the first 60 hours and then at selected time intervals for a total of 350 hours. These neutron logs showed the

various stages of wetting front as the water moved through the various stratigraphic units. By neutron logging every hour during the first 60 hours, a detailed picture of the wetting front was obtained. The logging interval for the next 290 hours detected the pulses and surges of the wetting front as it advanced downward. The wetting front reached a depth of 5.4 meters and the volumetric water content of the alluvial profile increased by approximately 15 percent throughout the infiltration region.

1.2.3.3.1.2.3 - Percolation in the Unsaturated Zone, Surface-Based Study

In support of matrix hydrologic properties testing, matrix permeability measurements have been completed on 23 runs of samples from the Prow transect, and data interpretation was finished on 16 of these. Moisture characteristic curve measurements in the chilled mirror CX-2 psychrometer are continuing on samples of fine soil and coarse fragments, as well as mixtures composed of varying mixtures of coarse and fine fractions.

DOE/YMPO has approved termination of Integrated Data Acquisition System software, and conversion to a PC-based system. The new data acquisition program is ready for testing. Two support programs were written and tested.

1.2.3.3.1.2.4 - Percolation in the Unsaturated Zone - ESF Study

An experiment was repeated on one fractured core where the water flow rate through a fracture at different pressures was measured. The repetition was required to verify effects of barometric pressure fluctuations on water flow rate through fractures observed in a previously conducted experiment. Results indicated that, as the barometric pressure rises, flow rate increases, and vice versa. This effect will be studied and included in the analytical report. Another factor that appeared to significantly affect the hydrologic properties of the water flow through the fractured sample was bacterial and algae growth. Bacteria does occur in the unsaturated zone; however, the types and concentrations in the Yucca Mountain region have been studied thoroughly. Further information regarding this effect will be reported next month.

1.2.3.3.1.2.9 - Site Unsaturated Zone Modeling and Synthesis

Numerical modeling was initiated in February to investigate to what extent the results of recently published thermal loading calculations are sensitive to the use of an effective continuum approximation for liquid, vapor and heat flow in thermal loading simulations intended to look at the effects of repository heat. Models were constructed using both an effective continuum approximation and a true dual-porosity approach to see if the high rates of condensate generation and dry-out predicted by the effective continuum approximation are significantly lowered by considering the finite amount of time required for liquid within the matrix blocks of a fractured medium to move to the fracture walls. A comparison of the models showed that, for the matrix hydrologic parameters and fracture spacing assumed in the calculations, the two approaches yielded nearly identical results. Further sensitivity analyses are necessary to determine what combination of matrix properties, fracture spacing and heat load cause the results of the two methods to deviate significantly.

1.2.3.3.1.3.1 - Site Saturated Zone Ground Water Flow System

Staff from the site potentiometric-level evaluation project report that work on the 1990-1991 water-level data report is still behind schedule, due to factors such as last year's delays in evaluation and reduction of the data (due to addressing effects of earthquakes on water levels and producing associated reports); recent problems of losing steel tapes in wells, and jammed packers; writing criteria letters; getting data into ADAPS, and access problems with ADAPS. Anticipated completion is May 30, 1993. The report "Water levels in continuously monitored wells in the Yucca Mountain area, Nevada" received USGS approval; DOE concurrence had been received in January.

The report "Earthquake-induced water-level fluctuations at Yucca Mountain, June, 1992, received USGS approval.

Staff supporting the testing of c-hole sites with conservative tracers report that a tracer mixing tank will be required at the surface during tracer tests at the c-holes. The completion date for construction of the tank has been delayed from April 1, 1993 until September 30, 1993. The tracer tests, for which the tank is needed, are not scheduled to begin until October 1, 1994.

1.2.3.3.1.3.2 - Saturated Zone Hydrochemistry

B. Steinkampf participated in a YMP/Geochemical Integration Team meeting to formulate plans for studies designated as needed to address post-emplacement geochemical aspects of coupled geochemical/hydrological processes that likely will occur as a result of the perturbation of the thermal and geohydrologic regimes at and in the vicinity of the repository block.

1.2.3.6.2.1.2 - Paleoclimate Study of Lake, Playa and Marsh Deposits

Plans to collect cores continue to be delayed because of the above normal rainfall in the region, making it impossible to access some of the dry lakes and playas that will be cored. The major coring activity, scheduled to begin in February, tentatively has been rescheduled for mid-April.

1.2.3.6.2.2.1 - Quaternary Regional Hydrology

Staff evaluating past discharge areas finalized preliminary vegetation maps worked on a report for regional vegetation mapping Death Valley region. A field trip has been scheduled to field check resulting density and land cover classes. A field trip was conducted where six sites were collected for complete water analysis. A well in the California Valley near Tule Spring was sampled for water level, water chemistry and Sr ratios. Saratoga Springs and Triangle Spring in Death Valley National Monument (DVNM) were collected for ostracodes and Sr 86/87 ratios. Eight samples were collected from wells in the town of Amargosa Valley for Sr 86/87 ratios. One well in the southern Pahrump Valley and two small springs in DVNM were sampled for Sr 86/87 ratios.

Isotope and geochemistry group work in support of past discharge studies included work with isotopic tracers in natural ground water systems, as well as dating of past discharge deposits. Spring waters in the northwest Spring Mountains have elevated $^{87}Sr/^{86}Sr$ ratios which reflect the local Precambrian aquifer host rock, and provide a source for the high $^{87}Sr/^{86}Sr$ end member observed in the southeastern-most discharge sites along the Ash Meadows spring line. A major collection trip provided water samples from the northern Mojave Desert, Amargosa Farms area, Bullfrog Hills and southern Death Valley, which should fill important gaps in the ground water Sr and U isotopic analysis. preliminary results from a tufa deposit stratified within fine-grained marsh deposits in Pahrump Valley suggest a U-series age of 9.4 ky which is consistent with detailed ^{14}C dates obtained from the same section. Additional attention also was given to defining ages and associated errors of samples from the palustrine deposits near the southern end of Crater Flat more rigorously by additional analyses and statistical reassessment of existing data.

In support of calcite silica studies, staff spent 12 days at and around the Nevada Test Site measuring concentrations of soil gas CO_2, and collecting soil profiles and soil gas profiles for measurement of the stable isotopic compositions of H_2O and CO_2. Approximately 250 samples of soil, soil gases, and soil carbonate were collected during the trip. Staff collected samples of calcite and opal from fracture coatings and lithophysal cavities of the upper lithophysal zone of the Tiva Canyon from the excavation at the site of the north ramp borehole. These samples will be very useful for comparison with the data from the trenches in the area (especially 5, 14, and 14d). Forty two analyses were performed of calcite sampled from USW GU-3, and nine of calcite

sampled from UE-25 A#5, completing reconnaissance analysis of both cores. The data from GU-3 were remarkably consistent down to nearly 1200 feet, with $d^{13}C$ and $d^{18}O$ values very similar to those of the pedogenic calcrete calcite found on Yucca Crest. The influence of the soil geochemical environment apparently extended much deeper at the southern end of Yucca Mountain, possibly due to a lesser influence of the 10.5 ma hydrothermal system related to the Timber Mountain event.

Isotope and geochemistry group work in support of calcite-silica studies included completion of Sr isotopic analyses of Paleozoic limestones and dolomites from inaccessible areas on Nellis Air Force Base. Most rocks have $^{87}Sr/^{86}Sr$ ratios typical of Paleozoic marine carbonates. Scoping studies continued in developing methods for analyzing U and Th isotopes by mass spectrometry. This technique will provide a means of dating of small calcite samples available from drill core. Investigations into the feasibility of determining ^{90}Sr concentrations in soils and vein carbonates were conducted. This Sr isotope, derived from above-ground nuclear testing, may provide a tracer with geochemical affinities to calcite which can be used for studies of pedogenesis and infiltration along fast pathways.

1.2.3.7.2.1 - Natural Resource Assessment

An additional 15 sonic logs from Railroad Valley were digitized, allowing computation of accurate depth versus time curves for key exploration wells along seismic reflections lines near the prolific Grant Canyon oil field. To date, 35 wells have been digitized.

WBS 1.2.5 - REGULATORY

1.2.5.3.5 - Technical Data Base Input

Thirty-nine TDIFs were received into the PDA. In addition to the new entries, many TDIFs were corrected. Three additional FTEs were assigned to this task, as a technical data support group.

1.2.5.4.4 - Site Performance Assessment

Water retention curves from the fault fill in Trench 14 are being determined using the CX-2. A rock core with fracture filling has been sliced in thin layers to determine the alteration from the fracture into the bulk rock away from the fracture. The thin slices are being used to determine porosity, bulk density, grain density and water characteristic curves. Similar whole rock cores are being used to measure imbibition properties of the fracture coating and the unaltered rock core.

1.2.5.4.7 - Supporting Calculations for Postclosure Performance Analyses

A presentation of the current data set for measuring thermal effects on rock properties was given at the CASY symposium by A. Flint. Although the paper was withdrawn from the IHLWC, Flint was asked by IHLWC organizers to give an informal presentation on the results; organizers feel that this issue needs to be discussed in a timely manner due to the current considerations on a high temperature repository.

WBS 1.2.9 - PROJECT MANAGEMENT

1.2.9.2.2 - Project Control

A process to implement an internal cost/schedule change control system was begun. Procedures are being developed to monitor changes to the baseline budget and schedules.

A data base to track USGS milestones was developed to generate a report

depicting milestone satisfaction criteria, level, responsible staff, baseline data, planned date, and actual completion date.

WBS 1.2.11 - QUALITY ASSURANCE

1.2.11.1 - Quality Assurance Coordination and Planning

All USBR Quality Management Procedures and the USBR Quality Assurance Program Plan were deleted in accordance with CAR 92-07.

1.2.11.2 - Quality Assurance Program Development

A draft matrix for the DOE QARD was completed indicating which requirements already are met by the USGS' present program, which requirements are not applicable, and which requirements require changes to the USGS program. This process identified 15 existing QMPs requiring revision, 4 QMPs to be developed, and 7 QMPs requiring modification.

1.2.11.3 - Quality Assurance Verification

Audit USGS-93-06, an internal audit of six SCP activities was conducted, resulting in one audit finding and eight audit observations.

The Audit Report for USGS-93-07, an external audit of vendor Campbell Scientific, Inc. was completed, recommending retention of the vendor on the Approved Suppliers List.

Audit USGS-93-08, an internal programmatic audit of criteria 3, 4, 7, 17, and verifications of several deficiency documents, was submitted.

Special Investigative Reviews of AFR-9203-01, AFR-9205-03, and NCR-92-24 were completed. Closure of four deficiency documents was recommended.

Supplier evaluations USGS-93-E12 of Hewlett Packard, and USGS-93-E13 of MKS Instruments, Inc. were conducted and reported, recommending their retention on the Approved Suppliers List. An evaluation of vendor EG&G Geometrics, USGS-93-E14, was conducted, and a report issued recommending expansion of their approved services. Supplier Evaluation USGS-93-E15 of Ruska Instruments Corp. was completed and a draft report written.

Surveillance USGS-93-S03 of USGS work at borehole UZ-6 was conducted; no problems were found.

1.2.11.5 - Quality Assurance - Quality Engineering

Reviews and/or resolution of comments were completed for eight QMP modifications.

Work was coordinated with USGS Project Control, M&O, and SNL personnel to complete the draft YMPO required Transition Plan for transitioning work under WBS elements 1.2.3.2.6.2.1, 1.2.3.2.6.2.2, and 1.2.3.2.6.2.3 from the USGS to SNL.

Approximately 45 Software Documents were received, reviewed, and/or processed by the SCM Coordinator in accordance with QMP-3.03, R3.

WBS 1.2.12 - INFORMATION SYSTEMS

1.2.12.2.2 - Local Records Center Operation

Two hundred sixty-eight individual records and 132 criteria packages were received into the LRC. One record required QA designation changes, and 36 packages (26 percent) required corrective actions. Seventy three individual records and 103 criteria packages (3,817 pages); nine publication packages and

no data packages (1,114 pages); and no current cited references; four backlog publications, four other records packages, and 45 backlog cited references for a total of 1,177 pages were transmitted to the CRF. No corrective actions were requested of the USGS, making the accuracy rate 100 percent.

A meeting with Project Office staff was productive in getting access to DOE/YMP computer services needed for LRC activity support.

1.2.12.2.5 - Document Control

Ten Quality Management Procedures and Modifications, and nine Technical Procedures, were distributed. USGS procedure QMP-5.01, R3, Preparation and Control of Drawings, was rescinded.

The ten remaining USBR QMPs were rescinded. There no longer are any USBR controlled documents in effect on the Yucca Mountain Project.

WBS 1.2.13 - ENVIRONMENTAL

1.2.13.4.7 - Water Resources Monitoring

Ground water levels were measured at 26 sites; discharge was measured at one flowing well; ground water data collected during February were checked and filed; historical ground water data for four wells were entered into the data base; reported elevations of land surface, reference points, and measurement points of three wells were verified with surveying equipment; four electric water tapes were calibrated; equipment calibration was checked at well JF-3.

WBS 1.2.15 - TRAINING

YMP-USGS personnel were scheduled and classroom announcements were distributed for eight classroom sessions. Mass reading assignments were distributed for five QMPs; reading assignments were distributed for nine technical procedures; and reading assignment instruction was waived for seven modifications.

Four GERT sessions were held in Denver, with 101 YMP-USGS personnel attending. One session of GET, with 14 attendees, was held.

Sincerely,

Raye E. Ritchey

for Larry R. Hayes
Technical Project Officer
Yucca Mountain Project
U.S. Geological Survey

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