Basalt Waste Isolation Program Quarterly Report

**April 1, 1979
through
June 30, 1979**

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Director, Basalt Waste
Isolation Program**

July 1979

Prepared for the United States
Department of Energy
Under Contract EY-77-C-06-1030

Rockwell International

**Rockwell Hanford Operations
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ABSTRACT

During the quarter, progress was made in all areas of the Basalt Waste Isolation Program. In the Geosciences, Hydrology, and Engineered Barriers areas, work continued on schedule aimed at being able to make a site selection decision in 1981, as scheduled. Emphasis continued to be placed on geologic mapping studies, on hydrologic data gathering, and on definition of waste/basalt interactions and needed engineered barriers. Progress at the end of the quarter on the Near-Surface Test Facility was approximately on schedule and the rate of work was accelerating to better than scheduled due to some equipment improvements and tunnel design modifications. In the Engineering Testing area, design work, test planning, and fabrication of heaters and auxiliary equipment continued on schedule.

In the Repository area, an Architect/Engineer Evaluation Board was formally designated by the U. S. Department of Energy-Headquarters during October 1978. The evaluation board will select an architect/engineer for repository conceptual design with an option for follow-on Title I, Title II, and Title III engineering services. Selection will be completed by October 1979. Questionnaire information was received from a number of interested architect/engineer firms by the U. S. Department of Energy-Richland Operations Office and has been evaluated. Onsite visits with the qualified firms were completed during April 1979. In addition, repository preconceptual design studies continued on schedule with emphasis on compilation of repository functional design criteria by July 1979, and the repository preconceptual design report in September 1979.

Sixteen documents were issued during the quarter. These documents are listed at the end of this report.

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INTRODUCTION

In February 1976, the U.S. Energy Research and Development Administration (currently the U.S. Department of Energy) expanded the commercial radioactive waste management programs and established the National Waste Terminal Storage Program. Its mission was to provide multiple facilities in various deep geologic formations within the United States. The Office of Waste Isolation was established within the Union Carbide Corporation-Nuclear Division to provide program management of the National Waste Terminal Storage Program. The overall program consisted of investigating a number of geologic rock types to determine their suitability for terminal storage of radioactive waste. Basalts, such as the Columbia Plateau basalts, which underlie a large portion of the Pacific Northwest and the Hanford Site, were selected for initial geologic reconnaissance. Atlantic Richfield Hanford Company was asked in May 1976, by the Office of Waste Isolation, to plan and execute a geologic exploration of Columbia Plateau basalts to determine the feasibility of utilizing those formations as a site for terminal storage of commercial nuclear waste.

In September 1977, the National Waste Terminal Storage Program was restructured. While emphasis was still on a salt repository, additional funds were given to support investigations of two U.S. Department of Energy sites--Hanford and Nevada. The Hanford program is presently the responsibility of the U.S. Department of Energy-Richland Operations Office. Rockwell Hanford Operations (successor to Atlantic Richfield Hanford Company) is the prime contractor responsible for this work. The Basalt Waste Isolation Program within Rockwell Hanford Operations has been chartered with the responsibility of conducting these investigations. The investigations are presently aimed at assessing the feasibility of utilizing basalts as a possible rock type for nuclear waste storage. As recently noted in a report by the Interagency Review Group (Report to the President by the Interagency Review Group on Nuclear Waste Management, October 1978, TID-28817 [Draft]), once feasibility is established at various sites, the U.S. Department of Energy will select a site for construction of a repository. The present basalt studies are not to imply that a commitment has been made to select a basalt site as a repository location.

The overall program is divided into the following areas:

- Systems Integration;
- Geosciences;
- Hydrology;
- Engineered Barriers;
- Near-Surface Test Facility;
- Engineering Testing;
- Repository.

A summary of major program accomplishments during the reporting period follows.

SYSTEMS INTEGRATION

The objective of Systems Integration is to integrate all activities leading to the identification, qualification, and licensing of a site and a repository for nuclear waste within Columbia River Basalt. The scope of work includes reviewing of research, test, and design activities, providing computer models, trade studies, data analyses and interpretation, and establishing the technical bases and criteria for site selection, licensing, and the design of the repository and ancillary facilities and functions. The Systems Integration Program is divided into three major activities: (1) Project Management; (2) Systems Integration; and (3) Safety and Environmental Documentation. During the third quarter of fiscal year 1979, work has progressed in all three activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Systems Integration end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

SYSTEMS INTEGRATION

Technical Criteria

The technical requirements to qualify a potential nuclear waste repository in basalt are being analyzed and reviewed by Rockwell Hanford Operations and other waste management offices and projects.

A study to estimate allowable seismic loadings for key subsurface repository structures has been initiated. Background research and a work plan have been completed.

The Basalt Waste Isolation Program has participated in several meetings and reviews of preliminary National Waste Terminal Storage criteria prepared by the Office of Nuclear Waste Isolation. These include site selection criteria, systems performance criteria, glossary of quality assurance terms, and others.

Preliminary studies have been performed to: (1) identify the major factors involved in establishing a repository site size; and (2) update reference waste characteristics and the reference forecast of quantities to be stored.

Systems and Test Analysis

The work is continuing on the development of a potential test program for assessing underground conditions in a deep horizon selected as a repository site. The purpose of such testing is twofold. First,

penetration of the candidate horizon would allow actual verification of the geologic, hydrologic, and thermal properties as previously determined by deep core holes in the surrounding candidate horizon because of the need to maintain the integrity of the repository horizon. The second purpose is to verify repository construction operations activities, such as shaft sinking and grouting techniques, remote handling systems, tunnel boring equipment, and emplacement and retrievability equipment.

Site Evaluation

The siting study is aimed to identify suitable repository sites within the Hanford Site. Work done outside this area is at present being used to assist in the identification of a site at Hanford.

Progress made this quarter, relating to the identification of a repository site on the Hanford Site, included:

1. Screening guidelines were reviewed and applied to the Pasco Basin area;
2. Candidate areas, subareas, and candidate localities were identified in the Pasco Basin; no obviously superior site localities were found outside the Hanford site;
3. A subsurface area of over 300 square miles within the Hanford Site potentially suitable for a repository was tentatively identified;
4. Five preliminary candidate localities, based on available surface and subsurface area, were identified ranging from about 10 to 50 square miles within the Hanford Site.

Engineering Model Development

Work in this area supports three activities: (1) conceptual repository design; (2) the Near-Surface Test Facility; and (3) computer code development. In the conceptual repository design area, the studies have been undertaken with respect to the specific characteristics of the borehole liner and the interaction between liner, backfilling material, between liner and rock, and the rock itself. Other studies have been undertaken with respect to the preconceptual repository design utilizing horizontal canister layout between groups as opposed to previously modeled vertical borehole placement. Pre-analysis of the test program at the Near-Surface Test Facility indicated possible changes to the proposed spent fuel test layout. Code development work has been mainly concerned with the liner studies and with debugging some of the computer codes used over the course of the year's work. Work has been accomplished in the following specific areas.

1. Modeling of Canister Hole Lining and Its Interaction with Rock and Backfill--Preliminary analysis for canister hole lining design has been performed assuming an isotropic stress boundary around the hole. This study was extended to consider non-isotropic stress boundary conditions, which will more closely represent the in situ

stress field. A two-dimensional explicit finite difference code, STEALTH2D, was used. This is being modified to incorporate the failure model into the code and to consider the influence of the biaxial stress boundary.

2. Analysis of the Horizontal Canister Borehole Concept--The present Basalt Waste Isolation Program repository preconceptual design utilizes essentially horizontal boreholes for the emplacement of the waste, as opposed to the vertical boreholes considered in previous modeling studies. A semi-analytical model, SYM3D, which approximates canisters by a series of point heat sources distributed along the center line of the canisters was used to model the horizontal configuration. Studies made show that the semi-analytical model is a suitable approximation for scoping studies involving horizontal placement.
3. Review the Effect of Uniform Heat Generation by a Waste Canister--Most modeling activity to date has assumed heating to occur uniformly over the full length of the canister. However, in an actual canister containing spent fuel, the active elements are concentrated within the central one-third of the total length. Studies were undertaken to evaluate the consequences of this assumption. The air gaps, the liner, and the associated outer casing in the canister will serve to spread the non-uniform heating.
4. Effect of Air Gaps on Canister in Rock Conditions--A study was made of the effect of an air gap on the canister and rock conditions. It was observed that the thermal properties of the canister control the canister temperature and had little effect on the rock temperature. Similarly, basalt temperature seemed to be relatively independent of the thickness of any air gap between the heat source and the solid basalt. These scoping analyses consider only conductive heat transfer across the air gap and ignored radiative and convective heat transfer processes and gamma radiation.
5. Pre-Analysis of Phase I Tests (Electric Heaters)--As part of the Phase I analysis, investigations were made of the temperature histories at points in which measurements are to be made in the test facility as well as other predictions at points defined by the location of stress-measuring devices.
6. Pre-Analysis of Phase II Tests (Spent Fuel)--As part of the Phase II pre-analysis, studies were made related to the spacing of the spent fuel tests in order to assure independent operations. Other factors considered were the specific effect of replacing some of the fuel canisters in the heated areas by electric heaters. Consideration was also given to the level of power to be applied to the peripheral electric heaters in light of uncertainties as to the level of temperature to be achieved. The question of preheating of the test facility was also considered.
7. Data Transfer Procedures--Work was undertaken to coordinate data transfer activities between the University of Minnesota and Rockwell Hanford Operations. Preliminary data formats were established.

8. Explicit Finite Difference Models--An explicit finite difference code, STEALTH, has been used for the examination of rock failure around the canister borehole. The failure model developed for STEALTH is to be included within a special-purpose, explicit finite difference model for analysis of the coupled fluid flow heat transfer and stress analysis.
9. Displacement Discontinuity Models--A program developed at the University of Minnesota (SALTY) was used to study the effects of the repository on the interbed typically existing above and below the component basalt in which the repository would be sited. Since SALTY was developed utilizing heat sources located directly below the rooms, an incorrect stress displacement field would result in heat sources between the rooms as in horizontal placement in canisters. Modifications were undertaken to correct this problem.
10. Code Documentation--A set of typical problems for proving runs against which codes can be checked is being assembled. These problems will encompass the canister, room, and regional scales appropriate for the design of the nuclear waste repository.

SAFETY AND ENVIRONMENTAL DOCUMENTATION

A new Office of Licensing was established to deal with regulatory requirements related to licensing of a deep underground waste repository. The new office will maintain a relatively small staff and will depend on other functional organizations for input to licensing documents. Plans and schedules were prepared by the Office of Licensing for a Preapplication Site Review Report, which can be used in the U.S. Department of Energy site selection process.

GEOSCIENCES

The Geosciences Program conducts geologic and geophysical studies that gather basic data on local and regional geology which aid in the identification of criteria and development of techniques for selecting potential repository sites. The studies emphasize reconnaissance field work in that portion of the Columbia Plateau underlain by Columbia River Basalt and detailed field work within the Pasco Basin of the Columbia Plateau where the Hanford Site is located.

The Geosciences Program is divided into four major activities: (1) Project Management; (2) Geology; (3) Geophysics; and (4) Seismic Monitoring. During the third quarter of fiscal year 1979, work has progressed in all four activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Geosciences end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

GEOLOGY

Geologic studies for the Basalt Waste Isolation Program are designed to gather the data required for selection and evaluation of potential repository sites in Columbia River Basalt. Work during fiscal year 1979 includes reconnaissance work in the Columbia Plateau region and detailed work in the Pasco Basin.

Integration of results of geologic activities to date for preliminary site characterization is planned for completion by September 1979 and is the primary goal of present work. The integration is necessary for preliminary site characterization by the Basalt Waste Isolation Program and for planning future work. The results of the integration effort are to culminate in a report tentatively entitled "Summary of Geologic Studies in the Columbia Plateau." This report is to emphasize geologic and geophysical findings regarding the structure and stratigraphy of the Columbia River Basalt in the Pasco Basin subsurface, and is to contain sections on regional geology, seismicity, and tectonics. The first draft of the report is about 80 percent complete. Required fiscal year 1979 field work for the report is complete and nearly all technical personnel have been involved in the preparation of this report since May 15, 1979.

Regional geologic mapping is being conducted to develop an understanding of the stratigraphic, structural, and tectonic setting of the Columbia Plateau (Figure 1). U.S. Geological Survey personnel, under the auspices of the regional geology effort, have essentially completed mapping of the Columbia River Basalt within Washington (scale: 1:250,000). Mapping of the Columbia River Basalt (scale: 1:250,000) is 50 percent complete in Idaho and 50 percent complete in Oregon.

FIGURE 1. The Columbia Plateau.

The Washington State Department of Natural Resources Division of Geology and Earth Resources has completed 95 percent of the reconnaissance mapping of the late Cenozoic sediments of the Columbia Plateau, Washington (scale: 1:250,000). Compilation of fiscal year 1979 mapping and revisions to previously compiled mapping will be completed by August 1979. Information to accompany the geologic map of the late Cenozoic sediments in Washington has been received from the Washington State Department of Natural Resources Division of Geology and Earth Resources and reviewed by Rockwell Hanford Operations.

The regional geologic mapping effort is supported by remote sensing studies being conducted by Pacific Northwest Laboratory. Pacific Northwest Laboratory completed a preliminary photolineament map (scale: 1:250,000) based on an interpretation of enhanced Landsat imagery and on input provided by field geologists. High-quality U-2 photography (flown during fiscal year 1978 and received during the first quarter of fiscal year 1979) has been used to refine approximately 50 percent of the preliminary Landsat photolineament map of the Columbia Plateau, Washington.

A report has been completed by the Oregon State Department of Geology and Mineral Industries entitled "Annotated Bibliography of the Geology of the Columbia Plateau (Columbia River Basalt) and Adjacent Areas of Oregon," and is available as RHO-BWI-C-30. Bibliographic coverage of the entire Columbia Plateau (Washington, Oregon, and Idaho) has now been provided.

Surface geologic mapping of the Pasco Basin has been conducted to provide information that can be combined with results from borehole studies and geophysical surveys to improve our understanding of the stratigraphy and structure of the Pasco Basin subsurface. Surface geologic mapping of Columbia River Basalt and post-Columbia River Basalt sediments was completed on schedule during the third quarter of fiscal year 1979 and the results were compiled at a scale of 1:62,500 for inclusion in the integration report as a colored, 12-sheet set. Preparation of the index map and explanations and descriptions of rock units for this map have been completed. Also, sheet layout, color markings, and line work are complete for all sheets. All sheets are in the proofing stage, and several sheets have passed final proofing prior to printing.

Structural mapping by Rockwell Hanford Operations' geologists has resulted in the interpretation of a low-angle thrust fault on the south limb of the Umtanum anticline. At Priest Rapids Dam, the thrust overrides the core of the fold and overturned layering occurs on the north limb. Current interpretation suggests as much as 1.2 miles of crustal shortening, a larger amount of shortening than had been previously thought. The thrust fault is presently being evaluated further and traced eastward from the McCoy Canyon slide block to determine its extension into the Hanford Site subsurface. The Umtanum Ridge anticline is thus structurally more complex than previously known. Current structural interpretations for the central Hanford subsurface are being evaluated as a result of these new findings.

Borehole studies and subsurface mapping are proceeding at an accelerated pace now that surface mapping has been completed. Preliminary structure contour maps have been prepared for the following horizons: (1) top of basalt; (2) top of the Wanapum Basalt; and (3) top of the Grande Ronde Basalt. Preliminary isopach maps have been prepared for the following intervals: (1) Saddle Mountains Basalt; (2) Wanapum Basalt; and (3) Sentinel Bluffs sequence. Current plans are for these maps to be included in the integration report.

Examination of old well records for the Rattlesnake Hills gas field resulted in the discovery of a borehole (Walla Walla Number 6) drilled to a total depth of 3,660 feet, which would indicate that it penetrated the Umtanum unit. After a surface search, the apparent site for this well was located. The casing is in good condition at the ground surface and work is under way to determine if the well can be cleaned and logged. If this can be done, additional subsurface stratigraphic control can be obtained for the southwest Pasco Basin between the Rattlesnake Hills and Cold Creek syncline without the expense of drilling a new borehole.

A stratigraphic summary section has been prepared for the intermediate depth "DB" core holes. The basalt units that were penetrated by the core holes are identified on this section. Stratigraphic interpretation of the late Cenozoic sediments is being completed for all deep core holes drilled to date by the Basalt Waste Isolation Program and the "DB" core holes. Basin-wide cross sections of the late Cenozoic sediments and basalt are being prepared for inclusion in the integration report.

Paleomagnetic analyses of the Ringold Formation have been completed and a report on the magnetostratigraphy has been received from Woodward-Clyde Consultants. These studies included a detailed paleomagnetic section of the Ringold type locality at the White Bluffs, selected samples from existing core wells on the Hanford Site, and reconnaissance sections from Lind Coulee near Moses Lake, and Taunton, Washington. The detailed paleomagnetic section at the White Bluffs locality showed approximately 65 feet of normally polarized sand and silt above the conglomerate facies. The remainder of the section, above the normal magnetozone, is of reversed polarity. This, along with paleontological data, suggests a Gilbert age (less than 3.4 million years before present) for the Ringold Formation at the White Bluffs.

GEOPHYSICS

Investigations by the Basalt Waste Isolation Program geophysical staff are currently under way on 3 of 7 selected sites in the Pasco Basin. The sites currently being studied are Areas Numbers 2, 3, and 7 (see Figure 2). The specific goals of these surveys are to study the nature of geologic anomalies located by seismic reflection surveying in Areas Numbers 2 and 3 and by geologic mapping in Area Number 7. The data are to be used as input to the year-end geologic integration report.

FIGURE 2. Seismic surveying map.

Work in the remaining areas has temporarily been halted until the high-priority areas are complete. Work in Area Number 1, Saddle Mountains, is complete and the data have been integrated into the geologic mapping effort.

Seismic surveying of approximately 87 line miles has been completed (Figure 2). Onsite analysis and field interpretation performed by Seismograph Service Corporation have allowed refinement of the depth to basalt map. The final subcontractor-supplied information report from this work will be delivered by mid-July.

The data obtained from magnetotelluric surveys conducted during the first portion of this fiscal year are undergoing evaluation and integration. Preliminary interpretations show the same basic geoelectric units as interpreted during the 1978 surveys. Deviations from the originally mapped structures and depths of the various units have been noted, but are probably due to the increased number of data points in surveys conducted this year. These data are currently being integrated with other geophysical data to permit a more detailed interpretation of the Pasco Basin subsurface.

Single-level aeromagnetic surveying has been completed over approximately 600 square miles of the Pasco Basin. The data from this survey are presently undergoing interpretation; however, preliminary results indicate that aeromagnetic surveying will be a valuable aid in interpreting the subsurface geology.

SEISMIC MONITORING

Regional seismic monitoring by the University of Washington continued during the third quarter with some improvement in the network. Digital computer recording will soon be implemented, a step that will permit quicker and more detailed analysis of data as well as allow more recording space for any additional stations. Five new stations are being installed in the eastern foothills of the Cascade Range and monitoring in the High Cascade Range will be undertaken, thus providing better data on Cascade Range events and possibly on crustal thickness changes between western and eastern Washington.

An area northeast of Lake Chelan has been a new locus of activity with several events, including a magnitude 4.0 event with several aftershocks. The Saddle Mountains were relatively quiet compared with recent quarters. On April 7, 1979, an earthquake between magnitude 3.5 and 4.0 occurred at a depth of 1.2 to 3.1 miles southwest of Walla Walla. This event was close to the coordinates given by the National Oceanic and Atmospheric Administration for the magnitude 5-3/4 Milton-Freewater earthquake of July 15, 1936 and was the first event recorded in this area since the deployment of the eastern Washington array.

Information to status the seismic monitoring in the Columbia Plateau and region was reviewed. Emphasis was placed on details of the history of earthquake monitoring in Washington, Oregon, Idaho, and Montana.

HYDROLOGY

The Hydrology Program provides hydrologic criteria and evaluation techniques by which potential repository sites can be identified and evaluated. Study of the ground-water regime underlying the Columbia Plateau is important, since the ground-water pathway probably affords the fastest avenue of contact between repository-stored wastes and the biosphere. Thus, hydrologic studies have emphasized the development of a large data base in order to characterize the ground-water system underlying the plateau, and modeling of the flow system needed to evaluate the potential for radiocontaminant transport to the biosphere. The hydrologic studies include reconnaissance regional studies over the Columbia Plateau and intensive local studies within the Pasco Basin where the Hanford Site is located. The Pasco Basin contains the greatest accumulation of basalt rock found on the Columbia Plateau. The Hydrology Program is divided into four major activities: (1) Project Management; (2) Hydrology; (3) Testing Support; and (4) Drilling Support. During the third quarter of fiscal year 1979, work has progressed in all four activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Hydrology end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

HYDROLOGY

Regional hydrologic studies during the third quarter included a continued update of the ground-water data base for the Columbia Plateau. The Washington State Department of Ecology, Washington State University, Century West Engineering, and Pacific Northwest Laboratory are assisting in this effort.

The ultimate goal of the fiscal year 1979 regional hydrology effort (on the Columbia Plateau, and more specifically within the Pasco Basin) is to develop a broad data base for synthesis and interpretation in fiscal year 1980.

Additional data obtained this quarter in support of the regional data base development are:

1. An annotated bibliography of the hydrologic properties of the Columbia River basalts was submitted by the Washington State Department of Ecology;
2. Information on the hydrostratigraphy of the Columbia River basalts was submitted by Washington State University;
3. Digital terrain magnetic tapes for the Columbia Plateau were obtained from the National Cartographic Information Center; this data base

provides the capability to construct topographic maps of the region from these tapes using in-house computer facilities;

4. Preliminary hydrologic data maps for the Columbia Plateau were obtained from Pacific Northwest Laboratory; the type of data plotted on these maps includes average annual precipitation, runoff, pan evaporation and lake evaporation, evaporation pan coefficients, hydrologic sub-basin, and a base map; percent frequency histograms by sub-basin and areas of sub-basin showing the distribution of the above parameters were also received;
5. Century West Engineering submitted information characterizing the quality of the existing hydrologic data base and ranking the quality of the available information; a preliminary conceptual model of the Columbia Plateau is being developed from these data;
6. The ground-water data base for 13 counties within the Columbia Plateau was obtained in digital tape form from the U.S. Geological Survey; the data have been loaded into the Pacific Northwest Laboratory UNIVAC system for program use;
7. Work continued at Pacific Northwest Laboratory on Columbia Plateau land use classification using remote imagery; irrigation-derived recharge and discharge areas are identified.

Pasco Basin hydrologic studies have been progressing steadily. One conceptual ground-water model developed consists of three flow systems: (1) local; (2) intermediate; and (3) regional. In brief summary, the local system is the shallowest with young (<2,500 years before present) ground waters and low total dissolved solids. Its recharge originates within the Pasco Basin with discharge to local springs, streams, and to the Columbia River. The intermediate system lies beneath the local system and contains older ground waters (2,500-15,000 years before present) with increased total dissolved solids. The regional flow system is stratigraphically the deepest. Its ground waters are greater than 15,000 years old and have the largest concentrations of total dissolved solids.

A preliminary model calculation was made using the Rockwell Hanford Finite Element (RHAFE) code to gain some initial insight into the basalt ground-water flow system. This initial model computation assumed the intermediate and regional systems as a single layer, and utilized composite heads (i.e., individual aquifers were not identified). The primary purpose of this preliminary model run was to establish the initial areal model boundaries and finite element network, and to debug the model input. Work is now progressing on expanding the model to include multiple basalt aquifers, and best estimates of individual aquifer head distributions.

Members of the hydrology staff, along with other U.S. Department of Energy contractors made presentations at U.S. Department of Energy-Headquarters in Germantown, Maryland. This meeting was an information exchange between the U.S. Department of Energy's Division of Waste Isolation and members of the California Energy Resources Conservation and Development Commission. The California delegation was particularly

interested in methods of verifying the various models to be used in the Federal Commercial Nuclear Waste Isolation Program. The Rockwell Hanford Operations' participants presented the preliminary Pasco Basin conceptual hydrologic model and numerical model methodology with emphasis upon techniques of in situ verification. The value of age dating of ground-water samples at various locations as an independent check of the ground-water models was emphasized by Rockwell Hanford Operations.

Two major reports on the Pasco Basin were issued this quarter. "Geophysical Logging and Hydrologic Testing of Deep Basalt Flows in Rattlesnake Hills Well Number One" (available as RHO-BWI-ST-1) presents the testing and logging conducted in the deepest borehole to date in the Pasco Basin (10,665 feet).

The primary conclusions of this report are:

1. The regional flow system in basalts of the Grande Ronde Formation have approximately twice as many dense flows (greater than 50 feet thick) than the intermediate flow system in the overlying Wanapum Formation;
2. Low-density zones are not dependent upon the thicknesses of the underlying denser basalts;
3. Calculations of hydraulic conductivity for both high- and low-density basalts are very low, ranging from 1.7×10^{-7} to 4.7×10^{-9} centimeters per second.

"A Survey of the Groundwater Geology and Hydrology of the Pasco Basin, Washington" (available as RHO-BWI-C-41) presents one conceptualization of the hydrology of the Pasco Basin. The primary conclusions of this report are:

1. A regional flow system carries connate water that underflows the Pasco Basin;
2. Local flow systems discharge meteoric water to the local springs and streams;
3. Intermediate flow systems are recharged in regions beyond the Pasco Basin.

TESTING SUPPORT

Exploration Data Consultants, Inc., Denver, Colorado conducted geophysical logging in Boreholes DC-2-A-2, DC-4, DC-5, DC-6, DC-7, and DC-8. Obstructions caused by caving sand prohibited completion of this task in DC-4 and DC-5 below 2,680 feet from the ground surface. Exploration Data Consultants, Inc. is to be remobilized to complete logging in DC-4 and DC-5 after the boreholes at this depth have been stabilized.

Washington State University ran spinner survey logs in DC-2-A-2, DC-6, DC-7, and DC-8 to identify zones of vertical fluid movement within the boreholes. Upward fluid movement was apparent in DC-6 from 3,500 feet to surface (<2 gallons per minute). No fluid movement was detected in DC-2-A-2 and DC-7.

Pacific Northwest Laboratory ran a neutron-neutron log in Borehole DC-2 from 3,100 feet to the surface to determine changes in porosity in support of hydrologic sampling interval selection.

The fiscal year 1979 hydrologic testing services contract was awarded to Science Applications, Inc. Hydrologic testing of the Grande Ronde Basalt was initiated in DC-6, DC-7, and DC-8. Initial testing of static water pressure and ground-water sampling at selected horizons have started.

Schaefer Well Service, Inc., Victoria, Texas commenced operations on May 5, 1979 with the hydrologic workover rig. Initial work consisted of repairing and cleaning out existing boreholes. The workover rig is presently assisting Science Applications, Inc. with their hydrologic testing activities in existing boreholes.

DRILLING SUPPORT

The fiscal year 1980 drilling program was submitted to the program office as part of a special report discussing the relationship between the drilling and hydrologic testing effort for the next fiscal year. Statements of work and purchase requisitions have been forwarded to the Material Function for procurement. Approximately 12,000 feet of core drilling is planned as follows:

1. DC-12 and DC-15 to 4,500± feet each;
2. DC-14 to 2,500± feet;
3. DC-7 deepened from 4,099 feet to 5,000 feet;
4. DB-15 deepened from 900 feet to 1,900± feet;
5. DH-18 and DH-19 shallow core recovery from Ringold Formation in support of paleomagnetic studies.

The contract for cable tool drilling the entrance holes for DC-14, DC-15, and DH-18 was awarded to Hatch Drilling Company, Pasco, Washington.

ENGINEERED BARRIERS

The primary goal of the Engineered Barriers Program is to specify a set of multiple barriers--engineered and natural--that will ensure that nuclear materials emplaced in a repository in basalt do not exceed acceptable rates of release to the biosphere. Key activities are the definition of repository conditions under planned operating and potential accident scenarios, review and development of information relevant to radionuclide transport, and the development of data necessary to define safe disposal of wastes in a repository in basalt. The key activities of the program are concerned with definition of the need for and specification and testing of natural and man-made materials which can be used to plug boreholes in basalt and which can be used as an overpack to surround nuclear waste forms and containers. The Engineered Barriers Program is divided into three major activities: (1) Project Control; (2) Multiple Barrier Studies; and (3) Borehole Plugging. During the third quarter of fiscal year 1979, work has progressed in all three activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Engineered Barriers end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

MULTIPLE BARRIER STUDIES

The emplacement of nuclear wastes in a deep geologic repository may cause both physical and chemical changes to the existing geologic environment. This activity examines the nature of such changes and attempts to identify the chemical and physical stability of the proposed barriers to the transport of radioactive contaminants. The activity looks at four potential barriers: (1) the waste forms; (2) the rock; (3) the container; and (4) the backfill. To assess the effectiveness of such a multiple barrier system, one examines the potential occurrence of chemical reactions both at the canister (phase transformations, dissolution) and away from the canister (solution/precipitation and sorption/desorption).

Characterization of the secondary minerals in core sections from DH-4, DH-5, and DC-6 has been completed. In addition, the volume estimates of the secondary mineral phases present in vesicles and fractures have been completed. These minerals have formed as a result of the reactions between basalt and ground water. The types of secondary minerals observed in vesicles and fractures of Columbia Plateau basalt and their sequence of crystallization allow determination of chemical reactions which have taken place. This information also allows estimations of the historic compositions of the ground water. Samples from DH-4 (2,438 to 4,362 feet), DH-5 (2,616 to 2,831 feet), and DC-6 (1,978 to 4,323 feet) have been examined by petrographic microscopy, electron microprobe, X-ray diffraction, scanning and transmission

electron microscopy, and energy dispersive X-ray spectroscopy. Data from these examinations are used as input to the thermodynamic modeling of the chemical reactions of basalts in the Columbia Plateau.

The results show that clay is typically the first member of a layered sequence of secondary minerals to form in both fractures and vesicles. In other samples, the initial phase in the vesicles and fractures was clinoptilolite. The second layer of secondary minerals in a large percentage of the fractures and vesicles was also clinoptilolite. A third layer of secondary minerals where it exists is typically silica or a clay.

In most layering sequences of secondary mineralization of the vesicles and fractures, the order of deposition appears to be:

Since the ground-water chemistry is dominated by the basalt chemistry, the type of secondary mineral being deposited in a fracture or a vesicle is controlled by the chemical composition and crystalline form of the basalt. Therefore, one should expect chemical independence among the members of a layered sequence of secondary minerals.

A revision to the Tardy and Garrel's method has been developed to estimate thermodynamic properties of clay. The method allows calculation of free energies of formation of clay minerals exclusive of exchangeable cations. These thermodynamic properties are required for modeling the evolution of secondary mineral assemblages in Columbia River basalts and the chemical perturbations expected by the introduction of selected radionuclides to the ground-water system.

Additional thermodynamic data have been incorporated into the EQ3/6 computer code data base. These include equilibrium constants for aqueous species and minerals containing uranium, plutonium, fluorine, strontium, barium, and cesium. Tests of the code with the expanded data base to evaluate equilibrium conditions in selected systems have been successful.

Collection of reference materials from the Near-Surface Test Facility has been completed. Approximately 25 pounds of secondary minerals were obtained from a single large vug exposed during the mining of the heater room. A few pounds of secondary minerals from a number of other smaller vugs were also collected. Approximately 200 pounds of Pomona basalt were also collected from freshly mined basalt. These materials are now being prepared for use as reference materials for Multiple Barriers activity experimentation.

Hydrothermal interactions of basalt have continued with simulated nuclear waste forms in ground-water solutions similar to those found in

Columbia River Basalt. The formation of mineral-like phases containing fission product elements from reactions with basalt during the thermal period of the repository provides additional barriers to the transport of radionuclides from the canister to the biosphere.

Hydrothermal interactions of basalt from DDH-3, Pacific Northwest Laboratory 76-68 Glass, and stainless steel at 300 degrees centigrade, 300 bars for 6 months have been shown to yield analcite ($\text{NaAlSi}_2\text{O}_6 \cdot \text{H}_2\text{O}$) as one of the alteration products. Two additional minerals which appear to be single phases have been isolated, but have not yet been identified. Similar experiments on DDH-3 basalt and simulated spent fuel have yielded phases whose X-ray diffraction patterns are similar to those of $\text{Nd}_5\text{Mo}_3\text{O}_{16}$. Reaction of a standard basalt sample (BCR-1) and supercalcine under the same conditions produced an alteration product which was identified as a member of the pollucite ($\text{CsAlSi}_2\text{O}_6 \cdot \text{H}_2\text{O}$) analcite solid solution series. Hydrothermal interaction between $\beta\text{-UO}_3$ and BCR-1 basalt has also been observed in experiments at 300 bars. Radiating yellow crystals with a needle-like habit occurred both in and on the basalt matrix. These needles consisted of two phases: (1) zeophyllite [$\text{Ca}_4\text{Si}_3\text{O}_7(\text{OH})_6$]; and (2) a phase similar to haiweeite [$\text{Ca}(\text{UO}_2)_2\text{Si}_6\text{O}_{15} \cdot 5\text{H}_2\text{O}$]. Zeophyllite is a layered structure phase which appears to result from the alteration of basalt.

Research aimed at understanding radionuclide sorption on basalt and basalt secondary minerals has continued. In two series of room temperature sorption experiments with Umtanum basalt at 23 degrees centigrade with different experimental conditions, similar K_d values for strontium and cesium were obtained. The experimental differences included radionuclide concentration, basalt weight to solution volume ratio, and agitated sample versus non-agitated. For experiments which lasted approximately 40 days, K_d values of 3,000-3,500 milliliters per gram + 200 milliliters per gram were obtained for ^{137}Cs ; while ^{85}Sr gave K_d values of about 105 milliliters per gram. Similar experiments on "Flow E" basalt gave ^{137}Cs K_d values of 600 milliliters per gram, about 20 percent that which is observed in Umtanum Basalt. Strontium-85 K_d values for these experiments were about 90 milliliters per gram.

Preliminary adsorption values for strontium and cesium have been obtained for 20-50-mesh Umtanum basalt equilibrated for 20 days at 150 degrees centigrade under 68 bars N pressure. Adsorption coefficients of about 100 milliliters per gram were observed for ^{137}Cs and ^{85}Sr in these experiments. Although similar sorption experiments with plutonium, iodine, and selenium have been run, interpretation of the results has been very difficult due to the high sorption of plutonium and selenium on the walls of the Inconel pressure vessels. Very little sorption of iodine was observed on basalt, and none was sorbed by the pressure vessel walls.

BOREHOLE PLUGGING

The objective of the borehole plugging activity is to devise a plugging system to seal boreholes, shafts, and tunnels leading from a repository in basalt. The plugging system consists of materials, machines, placement techniques, and instrumentation.

The scope of work for the present study included: (1) description of characteristics of plug system components; (2) a description of the plug environment; (3) an assessment of the effect of the plug environment on the components of the plug system; (4) the selection of candidate plug materials and machinery; (5) the development of geochemical and physical testing programs; and (6) the development of a quality assurance program and procedures.

Initial work involved a description of the plugging environment where data were collected on various aspects of the geologic environment and projected conditions of the plug environment for a repository in a Columbia River Basalt flow. Although available data are incomplete, geotectonic characteristics considered and evaluated thus far included stratigraphy, geologic structure, faults, regional subsidence, the region stress field, and earthquake potential. Physical characteristics included the physical properties of basalt, ranges in physical properties, fracturing, the hydrogeology of geologic formations in the Columbia Plateau, ground-water flow patterns, hydraulic characteristics, the projected hydraulic regime of the repository, temperature, and pressure. Chemical characteristics included the geochemistry of ground water, Eh and pH conditions at depth, secondary minerals (as fracture and vesicle filling in basalt), and the significance of the boiling point at repository depths.

This preliminary characterization provided the principal parameters for selection of candidate plug materials, which must be physically and chemically compatible with this environment. Construction of the repository may significantly modify some environmental parameters (such as fracture patterns, ground-water composition, local stress fields, wall rock permeability, etc.). The initial plug system design must be flexible enough to accommodate changes in environmental parameters as work progresses and as additional data become available.

The selection of candidate plug materials is one of the most critical steps in the development of a borehole plug system. Materials to be used in plugs influence (and are influenced by) the selection of potential placement machinery and plug designs. Depending on the final selection of materials, some plug systems may or may not be feasible to construct, and existing placement equipment may have to be redesigned or new machinery developed to handle the combination of materials under consideration for plugs. In general, no single material will satisfy all the requirements of plug design in the geologic environment.

A screening process was used to select candidate plug materials. This process ranked materials on the basis of their compatibility with the probable plug environment, a documented history of survival through time, data availability on their properties, and an evaluation of a selected mix of their chemical and physical properties. Although objectivity was sought during this screening process, many aspects of the process were essentially subjective in nature, and some critical decisions were influenced by the investigators' combined years of experience and personal bias. However, at all times, a rational and reasonable approach was the goal of this process.

The preferred and possible materials identified for a borehole plug are listed below.

<u>Preferred Materials</u>	<u>Possible Materials</u>
Basalt	Salt
Smectite Clay Bentonite	Serpentinite
Clinoptilolite	Shale
Mullite or Steatite Ceramic	Vermiculite
Portland Cement	Talc
Types II and V	Phillipsite
Hydrothermal Cement	
Type V + Quartz	
Grey Expansion	
Portland Pozzolan Cement	
Aggregate (Hanford Site)	
Gravel	
Sand	
Silt	

In addition to these materials are potential additives which would be considered as a minor component in a multi-material plug to achieve a specific desired physical or chemical effect in the overall performance of the plug and plug system.

Potential plug placement was selected on the basis of a literature review, compatibility with the plug environment, compatibility with the list of preferred candidate plug materials, an evaluation of the capabilities of existing construction and mining machinery, and a tabulation of available commercial and research equipment. A description of the performance characteristics of a quantitative rating factor keyed to various levels of performance within each range was prepared. Evaluation criteria, the candidate machinery list, and a matrix format were then used to complete comparative rating scores for each candidate machine, and total scores thus derived were compared to form a list of preferred candidate machinery.

The major conclusions from this indicate that it appears feasible to design a plug system that will satisfactorily seal man-made openings of a nuclear waste repository in Columbia River Basalt flows. Also, it appears that a plug system can be designed using natural and manufactured materials and can be emplaced with existing placement machinery and/or modifications of that machinery.

NEAR-SURFACE TEST FACILITY

The Near-Surface Test Facility is a multipurpose test facility for in situ testing in basalt. The Phase I (Electric Heater) and Phase II (Radioactive Material) tests to be conducted in the facility are designed to:

1. Qualify basalt as a repository medium;
2. Provide the basis of design for key repository elements;
3. Demonstrate placement, storage, and retrieval of spent fuel canisters in an underground basalt environment;
4. Demonstrate spent fuel monitoring capability in an underground basalt environment.

The Near-Surface Test Facility is located on the west end of Gable Mountain on the Hanford Site near Richland, Washington. When completed, the facility will consist of approximately 3,300 feet of underground workings including access tunnels, test rooms, and a computer room. Phase I is to develop the electric heater test portion of the facility so that testing may begin in 1980. Work on Phase II is scheduled for completion in 1981.

The program is divided into nine major activities: (1) Project Management; (2) Design - Phase I; (3) Construction - Phase I; (4) Safety and Environmental Analysis - Phase I; (5) Decommissioning - Phase I; (6) Design - Phase II; (7) Construction - Phase II; (8) Safety and Environmental Analysis - Phase II; and (9) Decommissioning - Phase II. During the third quarter of fiscal year 1979, work has progressed in five of these activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Near-Surface Test Facility design and construction end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

DESIGN - PHASE I

The previously reported Phase I redesign effort to relocate the computer facility outside the tunnel continues. This design effort is on schedule and will be completed before July 27, 1979. Title III support continues for Construction - Phase I activities.

DESIGN - PHASE II

With the completion of Title I and Title II design for Phase I in prior quarters, the Near-Surface Test Facility design effort is now concentrated on Phase II.

The Phase II facility conceptual design report was completed on schedule and transmitted to the U.S. Department of Energy-Richland Operations Office. This report provides the necessary system design descriptions, trade studies, special requirements, and cost estimate to proceed directly to Title II design. The Title II design for this effort is scheduled to start in the next quarter.

The Phase II functional design criteria were transmitted to the U.S. Department of Energy-Richland Operations Office on June 22, 1978 for review and approval. This revision incorporated changes developed during the conceptual design study. Security and access road requirements were revised.

The bottom loading transporter Title I design was completed by Atomics International on May 1, 1979. The Title II design effort for the bottom loading transporter continues. This work is being done by Rockwell Hanford Operations. Title II bottom loading transporter layout drawings have been completed and reviewed by cognizant personnel. Comments have been incorporated and final approval is in process.

The Request for Directive Authorization B-300b, Modification Number 3 was submitted to the U.S. Department of Energy-Richland Operations Office. This modification requests the additional funds to complete Phase II design and construction.

CONSTRUCTION - PHASE I AND PHASE II

Underground construction and core drilling is 85 percent complete and is on schedule. Facilities construction is 2.5 percent complete against a scheduled 4.0 percent.

The following progress and achievements have been accomplished this quarter.

<u>Description</u>	<u>Status Date</u>
Complete Extensometer Room	April 9, 1979
Complete Tunnel Number 1	April 13, 1979
Complete Heater Test Room	May 21, 1979
Complete Raise	May 22, 1979
Complete West Transfer Room	June 19, 1979
Complete East Transfer Room	June 30, 1979

<u>Description</u>	<u>Status Date</u>
Complete Spent Fuel Test Room	June 30, 1979
Complete Foundation and Slab for Computer Enclosure	June 30, 1979
Complete Outside Electric Conduit	June 30, 1979
Drill 686 Feet of Core Hole	June 30, 1979

The tunnel and excavation portion of the project is complete, except for some minor items and cleanup. Progress was good this last quarter due to the quality of the rock.

The drilling subcontractor has provided templates to increase the efficacy of the drillers. This allows for a much quicker "set-up" time for the drill on each hole and greatly reduces the possibility of an error in location setup.

ENGINEERING TESTING

The objectives of the Engineering Testing Program are to fabricate, procure, and install equipment and instrumentation to obtain test data during Near-Surface Test Facility operations. The test data will be used to establish engineering feasibility of constructing a repository in basalt and repository design.

Rock testing and other miscellaneous special studies are also included as part of this program to assist in meeting the Near-Surface Test Facility objectives. Test articles will include both electric heaters and spent fuel. The Engineering Testing Program is divided into four major activities: (1) Project Management; (2) Engineering Studies; (3) Phase I; and (4) Phase II. During the third quarter of fiscal year 1979, work has progressed in four of the activities.

PROJECT MANAGEMENT

The Project Management activity is responsible for the management of the Engineering Testing end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

ENGINEERING STUDIES

Laboratory testing of basalt samples is continuing at the Colorado School of Mines' Earth Mechanics Institute. The fiscal year 1979 effort is aimed at gathering material property data of deep underground basalt flows.

The study completed in the second quarter of fiscal year 1979 by the Colorado School of Mines included physical property tests performed on core under varying ambient conditions from DC-6. Samples were taken from the Umtanum flow at depths ranging from 3,030 to 3,260 feet. Further tests this fiscal year will also be in the same flow at approximately the same range of depths, but at two different locations (DC-4 and DC-8). The physical property test results will be compared to determine if the properties vary significantly from one location to another in one basalt flow.

The most significant conclusions from the test results are:

1. There is some agreement between the results of the current investigation and last year's results; for example, the uniaxial compressive strength at room temperature 22.97 ± 13.01 kips per square inch for DC-6 core, compared to 25.69 ± 14.78 kips per square inch for near-surface basalt tested last fiscal year;
2. Temperatures of 500 degrees centigrade appear to reduce the rock compressive strength by approximately 50 percent over the room temperature strength;

3. Density measurements correlated well with compressive strength, Young's modulus, Poisson's ratio, and hardness. As the rock density increases, the compressive strength, Young's modulus, Poisson's ratio, and hardness also increase;
4. Increasing the confining pressure from 0 to 3,000 pounds per square inch will increase the compressive strength by 50 to 100 percent.

Variations in the rock density from sample to sample and the large number of different tests make it difficult to conclude any statistical trends at this time. However, some areas which suggest possible trends are:

1. Acoustic velocities are effective in characterizing the elastic properties of basalt, but may be limited in application over distance due to the transmission-interfering effects of joints;
2. Thermal expansion measured significantly higher for the deep flow basalts than was measured for the near-surface basalt tested in 1978; a consistent non-linearity at 100 to 150 degrees centigrade was noted that did not show up in the 1978 testing or in the calibration samples; this non-linearity in thermal expansion may be due to dewatering, but has not been verified.

Figure 3 shows failure stress plotted against confining pressure, Table 1 presents typical values for thermal expansion, and Tables 2 and 3 show strength properties as a function of confining pressure and temperature, respectively.

PHASE I

Phase I provides the design, procurement, fabrication, calibration, installation, checkout operation, and analysis of the heater test engineered equipment in the Near-Surface Test Facility. Phase I is subdivided into the following subactivities: (1) Heaters and Controllers; (2) Rock Instrumentation; (3) Data Acquisition System; (4) Site Characterization; (5) Test Engineering Support; (6) Equipment Installation; and (7) Operation. During this quarter, work has progressed in six of the seven subactivities.

Heaters and Controllers

An acceptance test procedure for testing operability of main and peripheral heater controllers for Phase I was prepared, approved, and released. Fifty percent of the controllers, four main and five peripheral, were tested and accepted. Acceptance test procedures for main and peripheral heaters were also prepared and released. These procedures specify tests at power levels anticipated for in situ operation.

During fabrication and subsequent testing of the heater controllers for Full-Scale Heater Test Number 1 and Full-Scale Heater Test Number 2,

FIGURE 3. Failure stress versus confining pressure.

TABLE 1. Thermal expansion obtained on Umtanum core samples taken at various depths from DC-6

<u>DEPTH</u> <u>(ft)</u>	<u>DENSITY</u> <u>(g/cc)</u>	<u>TEMP. RANGE</u> <u>(°C)</u>	<u>EXPANSION COEFFICIENT</u> <u>(x 10⁻⁶ in/in -°C)</u>
3,148.8	2.63	23-572	7.37
3,163.9	2.79	25-393	10.77
3,182.9	2.66	64-640	8.04
3,253.0	2.57	25-508	11.16
3,256.3	2.49	20-546	10.48
3,256.3	2.49	20-576	10.11
3,256.3	2.49	18-548	11.00 (saturated)

TABLE 2. Strength properties of intact core as a function of confining pressure

	<u>DENSITY</u> <u>(gm/cc)</u>	<u>TEST</u> <u>CONDITIONS</u>	<u>FAILURE</u> <u>STRESS</u> <u>(ksi)</u>	<u>YOUNG'S</u> <u>MODULUS</u> <u>(10⁻⁶)</u>	<u>POISSON'S</u> <u>RATIO</u>
MEAN VALUES AND STANDARD DEVIATIONS AT EACH PRESSURE	2.77	hot/cool	39.12	8.17	.260
	±.03		±13.10	±1.86	±.186
	2.80	50 psi	56.47	13.40	.272
	±.03		±8.97	±1.01	±.036
	2.56	2,500 psi	47.19	6.10	.240
	±.40		±31.70	±5.66	±.052
	2.54	5,000 psi	31.92	3.01	.240
	±.23		±10.88	±1.74	±.096
	2.80	7,500 psi	103.71	11.08	.239
	±.02		±21.61	±1.16	±.052

TABLE 3. Strength properties of intact core
as a function of temperature

	<u>DENSITY</u> <u>(gm/cc)</u>	<u>TEST</u> <u>CONDITIONS</u>	<u>FAILURE</u> <u>STRESS</u> <u>(ksi)</u>	<u>YOUNG'S</u> <u>MODULUS</u> <u>(10⁻⁶)</u>	<u>POISSON'S</u> <u>RATIO</u>
MEAN VALUES AND STANDARD DEVIATIONS AT EACH TEMPERATURE	2.79	20°C wet	41.06	18.89	.386
	<u>±.01</u>		<u>+20.86</u>	<u>+6.48</u>	<u>±.169</u>
	2.54	20°C dry	22.97	8.42	.386
	<u>±.21</u>		<u>+13.01</u>	<u>+8.54</u>	<u>±.190</u>
	2.11	150°C	6.67	2.16	.347
	<u>±.04</u>		<u>+0.79</u>	<u>+0.75</u>	<u>±.147</u>
	2.34	300°C	15.83	2.74	.300
	<u>±.42</u>		<u>+10.55</u>	<u>±.75</u>	<u>±.029</u>
	2.56	500°C	17.57	3.87	.207
	<u>±.39</u>		<u>+5.72</u>	<u>±.87</u>	<u>±.112</u>

several changes were identified to facilitate fabrication and operation of the controllers. These changes have been incorporated into the Time-Scaled Heater Test controller design. Seattle Electronics Corporation of Seattle, Washington was awarded the contract for fabrication and assembly of the Time-Scaled Heater Test controllers.

Criteria for the design of a dewatering and desteaming system for heaters and instruments were prepared and issued for design action. Design effort is ongoing for this system.

A market survey of boroscope manufacturers was initiated to identify a boroscope which will function in the high-temperature environment of the heated boreholes.

Fabrication of two main heaters and nine peripheral heaters was completed. Radiographs of thirteen main heater elements showed faulty welds at the terminal wire junctions in eight elements. Rockwell Hanford Operations' quality assurance representatives worked closely with the supplier, Pacific Chromalux Corporation, Ogden, Utah, to assure preparation of an acceptable rework procedure and followed up to observe rock operations and complete necessary qualification inspections. Seven of the eight elements passed inspection after rework. The eighth element must be reworked or replaced due to a poor weld. Sufficient elements are now available to assemble main heaters for Full-Scale Heater Tests Numbers 1 and 2 and to provide 50 percent spares for replacement.

Preparations have been completed for final assembly and testing of all Full-Scale Heater Tests Numbers 1 and 2 heaters and for simulating an in situ installation.

Rock Instrumentation

The design of the rock instrumentation system for Full-Scale Heater Test Number 1 was completed. Included in the design was the incorporation of larger diameter boreholes (A_x) for the U.S. Bureau of Mines' borehole deformation gage and IRAD Manufacturing Company's vibrating wire stressmeter gage.

Foundation Sciences, Inc. was awarded the contract option for design of the rock instrumentation for Full-Scale Heater Test Number 2. Delivery of the Full-Scale Heater Test Number 2 system is scheduled for October 30, 1979.

Foundation Sciences, Inc. has completed the extensometer anchor creep test on the Terrametrics Model HG Anchor. The anchor did not exceed the maximum creep allowed of 0.02 millimeter.

The following tests were initiated during the quarter:
 (1) extensometer direct current linear differential transformer calibration; (2) long-term (30 days) electronic stability test of the extensometer direct current linear differential transformer at 400°C; and (3) long-term electronic stability test of IRAD Manufacturing Company's gage at 200 degrees centigrade.

Thermocouples for the Full-Scale Heater Test Number 1 rock instrumentation system were X-rayed and calibration checked. Each thermocouple has been permanently identified, logged, and packaged for assembly.

Installation procedures were written and have been approved for installation of the extensometer, U.S. Bureau of Mines'/IRAD Manufacturing Company's gage, and thermocouple assemblies.

Trips were made to Lawrence Berkeley Laboratory, Lawrence Livermore Laboratory, and Sandia Laboratory to review the rock instrumentation design for Full-Scale Heater Test Number 1 and generic problems associated with design, installation, and operation of the instrument types.

Design changes made as a result of these meetings were:

1. Thermocouple assemblies were redesigned to allow for individual replacement of thermocouples after installation in the event of instrument failure;
2. Provisions to allow the use of a portable thermocouple at each thermocouple assembly were incorporated;
3. Room temperature vulcanization (silicone rubber) potting of the extensometer terminal board was added to eliminate moisture problems;
4. Silicone rubber was used as a moisture barrier in the instrumentation cable on the U.S. Bureau of Mines' gage as the cable egresses from the gage body.

Data acquisition interface cabinets and components were received and the wiring and assembly of the cabinets and termination drawers are in progress.

Data Acquisition System

The data acquisition computer system consisting of a Data General M/600 computer and peripherals was installed and tested at the Skypark terminal on schedule. The data acquisition system data loggers have been ordered and installation is proceeding on schedule. The data acquisition system was designed so that the majority of hardware could be purchased off the shelf. The onsite-fabricated material consists of the data communications cables that connect terminals and data loggers to the computer.

The software for the data acquisition system is being developed using the Boeing Computer Services Seattle systematic software development and maintenance methodology. A one-week systematic software development and maintenance course presented by a Boeing Computer Services' consultant was attended by Basalt Technical Systems staff members. The systematic software development and maintenance standards and procedures are being used for data acquisition system software development to minimize software errors and assure complete software documentation.

The executive application software design was completed which coordinates the data acquisition system user routines, acquired and developed routines in the system library, and automatic data collection and analysis routines. The top level of the executive application software was fabricated using the Data General Advanced Operating System executive software with minimum additional development for the applications unique to the Near-Surface Test Facility.

The data acquisition system data collection and analysis application software is being designed and integrated with the executive application software using systematic software development and maintenance methodology. Typical examples are routines to communicate with data loggers and routines to provide the user-specific graphics output and user reports.

Specifications for graphics, predicted data, and offsite data analysis have been prepared and are in the review and approval cycle.

Site Characterization

Pre-test geologic site characterization is required to characterize the structural and physical composition of the rock mass before testing, so that changes resulting from the heating and testing can be easily identified and allow comparison of the Near-Surface Test Facility geologic conditions that prevail at the site picked for a repository.

This characterization will be accomplished by detailed geologic mapping, instrument borehole core logging, impression packer mapping of selected boreholes, and laboratory testing of the physical properties of the rock.

Geologic mapping, current with excavation, consists of maps at a scale of 1:20 and detailed line maps. The 1:20-scale maps describe the rock mass mineralogy, fabric, and structure in detail. The detailed line maps are taken at frequent intervals and provide statistical data for the analysis of local joint patterns, joint aperture, and infilling materials.

A detailed line map was made on the north wall of the extensometer room prior to shotcreting. A similar map was made on the north wall and selected sections of the south walls of the heater test room. A detailed map of the heater test room floor will be made prior to installation of the heaters.

Photographic documentation, prior to the application of shotcrete in the access tunnels and test room will supplement the geologic maps.

Impression packer mapping, to provide a 360-degree wall impression of the joints, will be done in the heater holes and selected monitor holes. These impression sleeves will be compared with the borehole core and will be used for comparison in the post-test characterization. Bids are currently being evaluated for this work.

The borehole coring program has begun and lithologic and structural core logs are current with the drilling. Detailed fracture data logs will be prepared on the oriented three-inch (NX) core at a later time.

It was determined that the seismic velocity surveys, moisture measurements, and permeability measurements as needed for the Near-Surface Test Facility were state-of-the-art testing and would not provide accurate data. Consequently, the geophysical testing contract was cancelled.

Test Engineering Support

The instrument layout drawings for Full-Scale Heater Tests Numbers 1 and 2 and the Time-Scaled Heater Test of Phase I were modified during the second quarter of fiscal year 1979. These changes reduced the number of instrument holes slightly and moved some of the holes to avoid the high probability of holes intersecting during the drilling process. Also, the stress and monitoring holes were increased in size to utilize a standard drill size and ease instrumentation installation.

Operation

Planning inputs for the facility and operating schedule were updated during this report period. Reviews were also provided for project prints, specifications, and acceptance test procedures. Coordination effort was also supplied for the occupancy at the Near-Surface Test Facility Gable Mountain trailer village, scheduled for August 1979.

Procedures for operation of the data acquisition system and an operating plan are in progress.

Inputs were received from Hanford Environmental Health Foundation, Inc. on Near-Surface Test Facility first aid and emergency medical requirements and from the Rockwell Hanford Operations' Health, Safety and Environment Function on the Near-Surface Test Facility safety requirements during operation of the test facility.

PHASE II

Phase II, as currently defined, will employ canistered spent fuel and electric heaters to evaluate the thermomechanical response of basalt. Phase II is subdivided into the same subactivities as listed in Phase I plus spent fuel preparation. Efforts this quarter were directed primarily toward spent fuel preparation.

Spent Fuel Preparation

During April 1979, Rockwell Hanford Operations' personnel recommended a revised scope for the Phase II test plan which was subsequently approved by the U.S. Department of Energy. Under the revised scope, the number of spent fuel canisters was reduced from 20 to 12 by replacing the 2 canisters at each end of each linear array with electric heaters. Also, a spare canister hole will be instrumented to provide redundant data in the event that instrumentation problems occur in the single canister array.

The U.S. Department of Energy assigned the Office of Nuclear Waste Isolation the responsibility for activities associated with procurement, transportation, characterization, packaging, and delivery of the spent fuel canisters to the Near-Surface Test Facility. Basalt Waste Isolation Program personnel will monitor Office of Nuclear Waste Isolation activities and schedules to ensure conformance of the delivery of spent fuel when required at the Near-Surface Test Facility site.

The Office of Nuclear Waste Isolation designated the Westinghouse Advanced Energy Systems Division as the contractor to design and fabricate the generic spent fuel canisters with site-specific design changes incorporated for each waste isolation program. Since the Basalt Waste Isolation Program will be the first program to use the Office of Nuclear Waste Isolation canister, current planning calls for this unit to match the needs of the Basalt Waste Isolation Program.

The canister designer, Westinghouse Advanced Energy Systems Division, has undertaken a design study with associated testing for the initial Office of Nuclear Waste Isolation generic canister. On June 21, 1979, a conceptual design review meeting was held at Westinghouse Advanced Energy Systems Division, resulting in the adoption of a preliminary canister design. The canister, as presently conceived, will have an outside diameter at 12.75 inches and an overall length not to exceed 178 inches. The canister will utilize an ellipsoidal cap on both the top and bottom. The top cap will be adaptable to several pintle configurations by means of an adapter plate. A preliminary design review on the canister is scheduled in the first quarter of fiscal year 1980 and final design review during the second quarter of fiscal year 1980.

Initial canister drop tests have been conducted to verify bottom end design which have resulted in the ellipsoidal configuration being the reference design. The possibility of using a reverse dish configuration on the bottom end cap is also being investigated.

A study on the use of the Fort St. Vrain shipping cask as a shipping container for spent fuel canisters to the Near-Surface Test Facility was completed during April 1979. The results of the study indicate that this cask should carry an encapsulated pressurized water reactor fuel assembly, but the cask would require modification at the cost of approximately \$400,000. Since the present spent fuel package will fit into the National Lead Industries' cask, the Fort St. Vrain unit will not be utilized at the Near-Surface Test Facility.

The present Basalt Waste Isolation Program schedule for the Near-Surface Test Facility calls for the delivery of the first spent fuel canister on February 28, 1981. The delivery of the next three spent fuel canisters is scheduled from September 1, 1981 to October 6, 1981, with the last eight canisters to be delivered from April 6, 1982 to July 20, 1982.

REPOSITORY

The objectives of the Repository Program are the design and construction of a repository in Columbia River Basalt for the storage and eventual disposal of nuclear waste and spent fuel. The Repository Program is divided into seven major activities: (1) Project Management; (2) Engineering Support; (3) Repository Design; (4) Long-Lead Procurement Support; (5) Construction-Manager Selection; (6) Construction; and (7) Site-Specific Tests. During the third quarter of fiscal year 1979, work was conducted only on the first two activities.

PROJECT MANAGEMENT

The Project Management activity is responsible for the management of the Repository end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

ENGINEERING SUPPORT

The Architect-Engineer Evaluation Board continued the selection process directed to the award of a contract for architect-engineer services for repository conceptual design, with an option for follow-on Title I (preliminary) design, Title II (detailed) design, and Title III engineering services. During the period May 19 through 30, 1979, the board visited the home offices of the six firms deemed most qualified. The architect-engineer contract is scheduled to be in place in October 1979.

Repository preconceptual design studies leading to a preconceptual design report are being conducted by Vitro Engineering, J. F. T. Agapito and Associates, and Rockwell Hanford Operations. The design effort has been divided into the following seven tasks:

- Task I - Overall Repository Preconceptual Design (Rockwell Hanford Operations);
- Task II - Surface Facilities (Vitro Engineering);
- Task III - Shafts (J. F. T. Agapito and Associates);
- Task IV - Subsurface Facilities (J. F. T. Agapito and Associates);
- Task V - Waste Handling System (Rockwell Hanford Operations assisted by Vitro Engineering);
- Task VI-A - Surface System (Vitro Engineering);
- Task VI-B - Subsurface Systems (J. F. T. Agapito and Associates).

During the report period, the technical studies for each task were completed and draft system design descriptions were prepared. The design that has evolved includes the following significant features: five access shafts; a central shaft pillar area separated from the canister storage rooms by the low-level waste and experimental chambers; horizontal canister storage holes with each hole containing six canisters; and early backfill of canister storage rooms.

The repository preconceptual design will be based on this design and will consist of three parts:

1. Part I - System Design Description (Reactor Development Technology Standard F1-2T format)

Technical description,
Drawings and sketches,
Trade studies;

2. Part II - Integrated Schedule for Repository Design and Construction

Engineering for conceptual, Title I, Title II, and Title III design,
Major advance procurements;

3. Part III - Preliminary Repository Cost Estimate

The cost estimate will be summarized in the same work breakdown used in the design description and in the schedule. Backup data will be submitted to justify the estimated costs.

The repository functional design criteria were submitted June 22, 1979 for the U.S. Department of Energy-Richland Operations Office review and approval. The repository conceptual design plan and architect-engineer work statement were started during the period.

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