WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #:

DOCUMENT: Russell, C.E., 1987, Hydrogeologic Investigations of Flow in Fractured Tuffs, Rainier Mesa, Nevada Test Site. Unpublished M.S. Thesis, Dept. of Geoscience, University of Nevada, Las Vegas.

REVIEWER: Williams & Associates, Inc., James L Osiensky

DATE REVIEW COMPLETED: May 31, 1988

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review presents a Master of Science degree level investigation of the hydrogeology of Rainier Mesa. The report presents many hypotheses and data to explain the conditions observed during the investigation. Although the report contains useful information, additional data are needed to interpret the hydrogeology in sufficient detail to form a defensible conceptual model of the hydrogeology of Rainier Mesa, particularly if inferences are to be made that pertain to the transfer of information to the conceptual models of Yucca Mountain.

BRIEF SUMMARY OF DOCUMENT:

According to the report under review, the objective of the research was to investigate hydrogeologic processes which occur within Rainier Mesa. The research was designed to evaluate 1) the origin of seep waters, 2) average groundwater velocity, 3) periodicity of hydraulic responses, 4) total groundwater flux through Rainier Mesa, 5) percentage of precipitation that enters the ground as recharge, 6) period of principal recharge, 7) extent of mixing between fracture reservoirs, and 8) the effects of a nuclear test on groundwater chemistry and groundwater discharge. In order to evaluate the average velocity of groundwater flow, two tracer studies that utilized four different tracers were conducted on top of Rainier Mesa. In addition, the stable isotopic ratios between precipitation at the top of Rainier Mesa and the discharge at the Rainier Mesa tunnel seeps were evaluated. Several tritium samples also were taken in order to estimate the age of the groundwater. According to the report, the "hydraulic response time" was evaluated by examining the precipitation data and groundwater discharge records. In addition, the total flux of groundwater which passes through Rainier Mesa was estimated quantitatively by monitoring the total discharge from U12n Tunnel for a nine month period. According to the report, the discharge data from the U12n Tunnel together with humidity measurements in the tunnel and the surrounding environment, and the flux of air circulated through the ventilating system were used to estimate to total groundwater discharge from the tunnel.

According to the report, the period of principal recharge was estimated by comparing the stable isotopes in groundwater seeps to the corresponding isotopic ratio of the seasonal precipitation. The author of the report also attempted to evaluate the extent of mixing between fracture reservoirs by examining the seasonal and spatial variance in the chemistry and isotopic signatures of the various seeps within the tunnels. The author also evaluated the effects of an underground nuclear test on selected discharges.

According to the report, two tunnels were utilized during the investigation (U12n and U12e). Hydrologic data were collected in three drifts (U12n.03, U12n.05, and U12n.10) within Tunnel U12n; hydrologic data also were collected at the portal entrance to the tunnel. According to the report, access to the U12e Tunnel was prohibited; however, the portal itself was monitored.

Two tracer tests were conducted on Rainier Mesa. During the first test, "yellow" dye and fluorescene dye were applied behind berms to facilitate infiltration of the dyes. According to the report, activated charcoal and cotton dye receptors were emplaced within the U12n.03, U12n.05, and U12n.10 adits. The dye sampling locations were monitored monthly. The second tracer test consisted of the application of solutions of lithium bromide and Tinopal 5BM (a concentrated optical brightner) directly to surface fault traces and fractures on the surface of Rainier Mesa. The optical brightner was monitored by use of cotton receptors; water samples were collected on a bi-weekly basis from both the (e) and (n) tunnels for lithium bromide concentrations. Water samples taken from Rainier Mesa were analyzed for deuterium, oxygen-18, tritium, gross chemistry, lithium bromide and fluorescent dye concentrations.

The report concludes that fluctuations in discharge of seeps that occur within the tunnels monitored suggest that recharge to the groundwater flow system occurs on an annual basis. The report also concludes that isotopic data for precipitation on Rainier Mesa and for water discharging from seeps within the tunnels support the hypothesis that discharge is derived from recent precipitation events.

The author of the report attempted to evaluate fracture interconnection within Rainier Mesa by analyzing the extent of mixing between the .03 and .05 drift seeps. The gross chemistry of the two seeps, and the isotopic ratios were used to evaluate the extent of mixing between the two drift seeps. Chemistry of the water from the U12n.03 and U12n.05 drifts reportedly are very similar. In order to investigate the chemistry of the two seeps further, the isotopic ratios of the two seeps were examined. The author of the report concludes that the difference in the isotopic ratios between the two seeps suggests that the fracture reservoirs are poorly connected between the two seeps; this observation suggests further that the similar geochemistry of the water actually is due to similar geochemical processes rather than by mixing of the two waters.

The author of the report attempted to evaluate the hydraulic response for Rainier Mesa. The "hydraulic response" to a given precipitation event constitutes an increase in discharge from the system that results from an increase in hydraulic head caused by recharge from a precipitation event. The author used a precipitation record for the period of September 1, 1983 to August 31, 1986. Discharge data were obtained in the U12n.03 and U12n.05 drifts and the U12n portal. The discharge data for the 03 and 05 drifts extend from September 27, 1985 to August 31, 1986; the discharge data for the portal extend from December 4, 1985 to August 31, 1986. According to the report, the period of hydraulic response was estimated by averaging the 03, 05, and portal discharge records from suspected recharge events using a simple average response technique. The occurrence of the hydraulic response for each recharge event measured during the investigation proved to be approximately 120 days after the recharge event.

Several methodologies reportedly were used in order to estimate the groundwater travel time through Rainier Mesa. The first method consisted of tracer studies using yellow and fluorescene dyes, and lithium bromide (an optical brightner). None of these tracers was detected within the tunnel system. The second method consisted of water quality sampling for tritium concentrations. The author found that tritium contamination by nuclear testing precluded the use of tritium to age date the water from the drifts. The third method consisted of the evaluation of isotopic signatures of precipitation and the groundwater seeps. However, according to the report, the results of the isotopic analyses were not statistically significant.

The author of the report attempted to evaluate the effects of nuclear testing on groundwater discharge and chemistry within Rainier Mesa. A two-fold increase in groundwater discharge from the 05 drift seep was observed shortly after the nuclear test. The "bomb pulse" (period of increased discharge due to the nuclear test) lasted for 18 days. The report indicates also that an increase in the total dissolved solids of the seep waters occurred during the bomb pulse. During the bomb pulse, anomalously high concentrations of sulfate were detected in the discharge waters. The significance of this occurrence is unknown; however, the most plausible reason proposed for this occurrence is the existence of relict water that is high in sulfate which exists in the formation from the time of deformation.

The author of the report presents the following conclusions:

1. The hydrogeology of Rainier Mesa is dominated by fracture flow through the majority of formations.

2. The source of water observed at the tunnel seeps is recent precipitation.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OFR-80-569

DOCUMENT: Winograd, I.J., and Doty, G.C., 1980, Paleohydrology of the Southern Great Basin, With Special Reference to Water Table Fluctuations Beneath the Nevada Test Site During the Late(?) Pleistocene. USGS Open File Report 80-569, Reston, VA.

REVIEWER: Williams & Associates, Inc., James L. Osiensky

DATE REVIEW COMPLETED: April 13, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review presents an evaluation of the origin of caliche and tufa deposits, and calcitic veins within outcrops of the lower carbonate aquifer and within alluvium and lake bed deposits. The report presents interpretations of these deposits with respect to past and future water level changes due to pluvial conditions. Interpretations presented in the report suggest that water levels in the lower carbonate aquifer may have been as much as 50 m higher during the late (?) Pleistocene than they are at present. Under these conditions, discharge from the lower carbonate aquifer is believed by the authors to have occurred at distances as much as 14 km northeast of the present discharge area in Ash Meadows. Interpretations presented in the report are based on a reconnaissance level investigation of the locations of caliche and tufa deposits, and calcitic veins. The report is significant from the standpoint that it provides evidence of potential changes in the groundwater flow systems in the vicinity of the Nevada Test Site during past pluvials.

BRIEF SUMMARY OF DOCUMENT:

The report under review presents an evaluation of evidence that suggests that water levels in the vicinity of the Nevada Test Site were at significantly higher altitudes during the late

Pleistocene than at the present. According to the authors, the purposes of the report are:

1. To demonstrate why knowledge of the altitude of past-water tables is important for a critical evaluation of the Nevada Test Site (NTS) as a potential repository for (high level wastes) and (transuranic wastes); and

2. To present and discuss the results of the reconnaissance of modern and fossil spring deposits which, coupled with hydrogeologic considerations, provide evidence pertinent to the magnitude of the water-table rises and changes in length of ground-water flow path during the Pleistocene, and particularly during Wisconsin time.

The report under review discusses briefly the possible effects of pluvial related rises in the potentiometric surface in the "lower carbonate aquifer." The possible effects that are listed include:

1) A significantly reduced distance of groundwater flow from the Nevada Test Site to points of natural discharge.

2) The utility of the unsaturated zone as a waste disposal environment may be reduced.

3) Increased recharge during pluvial environments would result in increased groundwater velocities and shorter residence times for any dissolved radionuclides.

Figure 2 of the report suggests that a rise in the potentiometric surface of 40 to 50 m could result in discharge from the lower carbonate aquifer about 14 km closer to Frenchmen Flat than the present discharge area in Ash Meadows. A rise in the potentiometric surface of 150 m could result in natural discharge from the aquifer 21 km closer to Frenchmen Flat.

According to the report, the method of investigation was based on the assumption that natural discharge from the lower carbonate aquifer would have occurred at higher altitudes during periods of higher potentiometric surfaces during past pluvials. It was assumed further that evidence of these past discharge areas would exist in the form of spring and spring-related deposits.

The primary evidence for groundwater discharge from the lower carbonate aquifer at higher altitudes than at present exists in the form of caliche and tufa deposits and calcitic veins. The term caliche in the report under review refers to calcium carbonate deposits of pedogenic (or soil) origin; the term calcrete is used to describe the well indurated calcium carbonate deposits found in arroyos; the term tufa in the report under review

> "refers to calcium carbonate deposits which display fossilized vegetative mass similar to those forming at modern springs or which comprise strata which field relations clearly demonstrate have originated from spring discharge."

The report notes that for the purpose of this investigation, only morphologic distinctions were made to distinguish between tufa, caliche and calcrete deposits. No petrologic, mineralogic, or stable isotopic criteria were used to distinguish between the deposits. Figures 4 through 23 of the report constitute photographs of the spring deposits of the Ash Meadows and Death Valley region.

According to the report, calcitic veins, and in one location, the strandlines marking former water tables provide potential evidence of pluvial groundwater discharge areas. According to the report, at least some of the calcitic veins mark avenues of fossil groundwater flow. The report suggests that direct evidence for a higher water table in the lower carbonate aquifer is present on the walls of Devil's Hole. Notches on the walls of this cavern provide evidence that water levels as high as 6 m above the 1966 (prepumping) level occurred sometime in the past.

For the purpose of the present evaluation, the authors of the report limited their reconnaissance investigation to an altitude range between 720 and 940 m. According to the report, tufa deposits were found between the altitudes of 720 and 760 m (as much as 40 m above the highest modern water level of 719 m in Devil's Hole). The report notes that the most prominent of the observed fossil tufas occurs at an altitude of 742 m on top of a butte northeast of Fairbanks Spring. Calcitic veins which fill fractures in lake beds, and/or alluvium were found to exist between the altitudes of 720 and 770 m to the north and northeast of Ash Meadows. Table 1 of the report describes selected calcitic veins in the Ash Meadows area. In addition to the calcitic veins, a dense travertine deposit occurs at altitudes as high as 790 m.

According to the report, the absence of tufa deposits in the vicinity of the ridges of paleozoic rock northeast of Ash Meadows between the altitudes of above 760 and 940 m can be interpreted in the following ways:

1) All the pluvial springs northeast of Ash Meadows emerged from sediments on the valley floor rather than from sediments adjacent to or from carbonate rock comprising the low ridges

of the area; subsequent alluviation buried all traces of such springs and their deposits.

2) The spring mounds and related deposits of pluvial age were deposited along the periphery of carbonate rock knolls and ridges but they have all been eroded or buried.

3) The pluvial groundwater has had a relatively low content of dissolved calcium, magnesium, and carbonate species and thus formed no significant tufa deposits.

4) Extensive deposition of strataform tufa requires a marsh or lake environment; a setting which never existed above 790 m northeast at Ash Meadows.

5) The pluvial water tables were never markedly higher than present water tables.

Of these five possible explanations for the absence of tufa deposits between the altitudes of about 760 and 940 m the authors believe that the fifth explanation is the most reasonable. They suggest that discharge from the Ash Meadows groundwater basin during the Late (?) Pleistocene occurred at altitudes as much as 40 m higher than the highest modern water level (719 m in Devil's Hole).

The authors conclude that most of the calcitic veins that exist between the altitudes of 720 and 770 m are related to fossil groundwater discharge. The data suggest that fossil groundwater discharge may have occurred at attitudes up to about 50 m above the 1966 water table in Devil's Hole (719 m). According to the report, the vein data suggest that pluvial discharge occurred at higher altitudes than modern discharge at Ash Meadows and at distances as much as 14 km up the hydraulic gradient.

The report notes that climate induced water level changes of meters to tens of meters would be expected in areas up the hydraulic gradient from Devil's Hole; however, water level declines in the regional discharge area in the vicinity of Devil's Hole are not easy to explain. The report suggests two possible explanations for the 6 m to 15 m decline in the water level within Devil's Hole. One possible explanation that is presented in the report is that the water level in Devil's Hole remained relatively constant while a ridge of carbonate rock was uplifted 15 m over a period of a few tens of thousands of years to over 100,000 years. Another possible explanation presented in the report is that the 6 to 15 m decline in the water level within Devil's Hole, and possibly the cessation of spring discharge at some of the mapped calcitic veins and tufa sites was "due to the initiation or increase of flow at the site of Crystal Pool and Big Spring in response to faulting or to orifice enlargement." The report notes also that combinations of both of the above mentioned hypotheses are possible.

Table 2 of the report under review presents factors that affect the altitude of the potentiometric surface in the lower carbonate aquifer beneath Frenchman Flat during the late (?) Pleistocene or during pluvials that may occur in the future. Table 2 also presents order of magnitude changes which the authors consider to be plausible during Wisconsin time. Table 3 of the report presents postulated late (?) Pleistocene and future water-level changes in the lower carbonate aquifer beneath central Frenchman Flat. The authors of the report consider cases 1 and 2 of Table 3 to reflect the most likely situation during Wisconsin time and perhaps during future pluvials. Cases 1 and 2 suggest that 1) recharge to the lower carbonate aquifer during Wisconsin time was two times the modern recharge rate, 2) transmissivity of the aquifer was the same as at present or as low as 0.5 times the present value, and 3) the past and future groundwater base level is 719 m. According to the authors of the report, the combination of factors presented in Cases 1 and 2 suggest a water level rise on the order of 6 to 20 m in the lower carbonate aquifer during future pluvials.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The primary significance of the report under review is its relation to potential travel time calculations in the saturated zone at the Nevada Test Site. The report is limited to the evaluation of potential water level changes within the Ash Meadows groundwater basin during the Pleistocene and pluvials that may occur in the future. The report under review does not include an evaluation of potential water level changes in the tuff aquifers beneath Yucca Mountain.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review presents the results of a reconnaissance level investigation of caliche and tufa deposits, and calcitic veins primarily between the altitudes of 720 and 940 m. The evaluation of water level changes was limited to the Paleozoic carbonate rocks that comprise the lower carbonate aquifer. A unique interpretation of the origin of the caliche and tufa deposits, as well as the origin of the calcitic veins, is not possible based on the data collected during the investigation. Much more detailed information is needed to delineate the factors responsible for the formation of the deposits and calcitic veins. The report under review is valuable with respect to facilitating an understanding of potential increases in recharge during pluvials that might occur in the future.

SUGGESTED FOLLOW-UP ACTIVITIES:

Future reports which contain additional data (i.e., age dates for the caliche and tufa deposits and the calcitic veins) should provide useful information. No follow-up activities are suggested for the paper under review.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OF-80-826

DOCUMENT: Analysis of Thermal Data from Drill Holes UE25a-3 and UE25a-1, Calico Hills and Yucca Mountain, Nevada Test Site. J.H. Sass, A.H. Lachenbruch, and C.W. Mase, U.S.D.I. Geological Survey, 1980.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: May 28, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

Temperature profiles were measured in borehole UE25a-3 in Yucca Mountain and borehole UE25a-3 in the Calico Hills. The profiles showed that upward or downward water flow below the water table in Yucca Mountain is probable but it is not possible to determine whether the flow is in the borehole or in the rock. Some of the variations in the temperature profile may be due to variations in the heat conductivity of the formation. No statement is made concerning vapor flux in the unsaturated zone.

BRIEF SUMMARY OF DOCUMENT:

This document reports on temperature profiles measured in borehole UE25a-1 in Yucca Mountain and borehole UE25a-3 in the Calico Hills stratigraphic unit. In Yucca Mountain the apparent heat flow above the water table is upward, while below the water table a possible indication exists of upward or downward water movement within the hole and possibly within the rock. The temperature profile within hole UE25a-1 shows a definite curvature below the water table which indicates an almost certain upward flow of water within the hole or within the rock. Since a definite indication of vertical water movement is present, the authors analyzed the data from both a conductive and a convective standpoint. However, thermal conductivities in this borehole were not measured. Thermal conductivities for hole UE25a-3 were measured on saturated cores of the Calico Hills unit. The linear segments of the temperature profiles were analyzed from the standpoint of conductive heat flow. The conductivity used was either the harmonic mean of the measured conductivities within that segment or an estimate based on measurements of the Calico Hills unit in other locations.

A one-dimensional upward or downward diffusion flow model was used to calculate seepage velocity for the nonlinear temperature distribution segments. The authors state, however, that it is impossible to determine whether the upward flow is in the rock or within the borehole. In one section of borehole UE25a-1, the temperature profile is wavy, which suggests zones of both upward and downward water movement. As stated by the authors, however, the possibility of variations in thermal conductivity also exists. The authors present considerable discussion of the regional temperature distribution and point out that lateral variations such as that which occurs between these two holes (UE25a-3 and UE25a-1) is characteristic of the Nevada Test Site. This large variation in heat flow between holes 1 and 3 could suggest the presence of a more deeply seated hydrothermal convective system with net upward heat flow beneath the Calico Hills and a net downward flow beneath Yucca Mountain. The authors do not draw any conclusions concerning the flow of water in the unsaturated zone in either hole. As stated previously, evidence of downward flow in hole 1 is present; however, this downward flow could constitute circulation in the hole rather than in the formation because the data base cannot differentiate between the two.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

This report has been used as evidence that vapor flow may occur in the unsaturated region of Yucca Mountain. We find nothing in this report from which to draw such conclusions. The only evaluation of water movement concerns the saturated flow region.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

This report does not provide information to lead to any conclusion concerning vapor movement within or beneath Yucca Mountain.

SUGGESTED FOLLOW-UP ACTIVITIES

At the time the conceptual model report (Montazer and Wilson, 1984) was reviewed, we were uncertain about the significance of the vapor movement in their conceptual model. After reviewing this report it appears that the concept of vapor movement is even more uncertain than we have suggested in our previous review.

WMGT DOCUMENT REVIEW SHEET

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A one-dimensional upward or downward diffusion flow model was used to calculate seepage velocity for the nonlinear temperature distribution segments. The authors state, however, that it is impossible to determine whether the upward flow is in the rock or within the borehole. In one section of borehole UE25a-1, the temperature profile is wavy, which suggests zones of both upward and downward water movement. As stated by the authors, however, the possibility of variations in thermal conductivity also exists. The authors present considerable discussion of the regional temperature distribution and point out that lateral variations such as that which occurs between these two holes (UE25a-3 and UE25a-1) is characteristic of the Nevada Test Site. This large variation in heat flow between holes 1 and 3 could suggest the presence of a more deeply seated hydrothermal convective system with net upward heat flow beneath the Calico Hills and a net downward flow beneath Yucca Mountain. The authors do not draw any conclusions concerning the flow of water in the unsaturated zone in either hole. As stated previously, evidence of downward flow in hole 1 is present; however, this downward flow could constitute circulation in the hole rather than in the formation because the data base cannot differentiate between the two.

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SUGGESTED FOLLOW-UP ACTIVITIES

At the time the conceptual model report (Montazer and Wilson, 1984) was reviewed, we were uncertain about the significance of the vapor movement in their conceptual model. After reviewing this report it appears that the concept of vapor movement is even more uncertain than we have suggested in our previous review.

ATTACHMENT F:SUMMARY OF GEOLOGIC DATA FOR TEST WELLS UE25a-4, -5, -6 and -7

Spengler, R.W., and Rosenbaum, J.G., Preliminary interpretations of geologic results obtained from boreholes UE25a-4, -5, -6 and -7, Yucca Mountain, Nevada Test Site, U.S. Geological Survey Open-File Report 80-929; 33 p.

Test wells UE25a-4, -5, -6, and -7 were installed during 1979 to provide structural and stratigraphic information in the southern portion of the four northwest-trending washes near Yucca Mountain. The four holes were cored to depths of 152, 148, 152 and 152 meters respectively, and cased 21-36 m below ground. Well A-7 is intentionally inclined 26° to the southwest. The stratigraphic units cored in each well are the Tiva Canyon, Yucca Mountain, Pah Canyon, and Topopah Spring members of the Paintbrush Tuff Formation.

Oriented core techniques were applied on nearly 43 percent of the total 481 m cored for the purposes of investigating the spatial relationships of faults or fracture zones. Examination of the foliation planes in the cores indicated an obvious preferred alignment for fractures within each hole. However, some orientations deviated from the dominant cluster. Paleomagnetic directions from samples of the core segments were utilized to quantify core misorientation. This problem was corrected by reorienting the cores before measurements of fracture orientation.

Observation of the variations in the thickness as observed in the cores indicates no major or abrupt structural change between the wells. Formation thickness shows only a gradual thinning in a southeasterly direction. The base of the Tiva Canyon member strikes northeasterly and dips gently east and southeast in the northern area of the test site.

A change in the strike directions is observed between the wells to the south. Most of these measurements agree with those made on eutaxitic structure of the foliation planes as seen in cores. Discrepancies of foliation attitudes from test well a-6 suggest structural block rotation. The absence of detectable vertical offsets suggest rotational movement. The densely welded zones of the Topopah Spring show a high incidence of fracturing. Shear fractures occur only in wells a-4 and -7. Those from a-4 are within the interval 398 to 496 m below ground surface and strike northwesterly, dipping about 75° to the southwest.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OF-80-941

DOCUMENT: Hagstrum, J.T., Daniels, J.J., and Scott, J.H., 1980, Interpretation of Geophysical Well-Log Measurements in Drill Hole UE25a-1, Nevada Test Site, Radioactive Waste Program: USGS Open-File Report 80-941, 32 p.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: July 15, 1986

ABSTRACT OF REVIEW: **APPROVED BY:** Roy E Williams

The report under review presents a preliminary interpretation of the geophysical logs recorded in test hole UE25a-1. Geophysical logs recorded in the test hole include resistivity, density, neutron, gamma-ray, induced polarization, and magnetic susceptibility. Interpretation of the well logs by the authors was facilitated by a computer program designed to interpret well logs individually or simultaneously. No details of the program are given. The primary emphasis of the report is the interpretation of lithologic variations within the tuff units penetrated by test hole UE25a-1.

BRIEF SUMMARY OF DOCUMENT:

The purpose of the report under review is to present an interpretation of the lithologic character of the tuff units penetrated by test hole UE25a-1 from geophysical log measurements. The geophysical logs recorded for the test hole include resistivity, density, neutron, gamma-ray, induced polarization, and magnetic-susceptibility. According to the report, because of the subjective nature of geophysical log interpretation, consistent interpretations of the well logs were facilitated by a computer program designed to interpret well logs either individually or simultaneously. No details of the program are presented.

Test well UE25a-1 was drilled and cored to a depth of 762 m. The purpose of the test hole was to investigate the stratigraphy, structure, mineralogy, petrology, and physical properties of the Paintbrush tuff, the tuffaceous beds of Calico Hills, and a portion of the lower member of the Crater Flat tuff.

Zones of zeolitization, silicification, and calcitization occur within the tuffs penetrated by the test well due to alteration by groundwater. The groundwater level presently is at 469 m in test hole UE25a-1; however, the report notes that alteration related to groundwater saturation occurs up to 80 m above this level.

The geophysical well logs for drill hole UE25a-1 are presented in Appendix A of the report. According to the report, initial interpretation of the geophysical logs is based on geologic observations by Spengler (1979) and Sykes and others (1979). According to the report, a computer program was written to synthesize a consistent interpretation of well log data. The program "assigns particular lithologies for those depth intervals that contain one or more geophysical well log measurements within specified value ranges."

According to the report, degree of welding is correlative with density obtained from neutron logs in the lower portion of the test hole. Because of this fact, "value ranges for the degree of welding (Table 1 of the report) were selected subjectively for these logs to best match the welded zones described by Spengler (1979)." According to the report, the low density values for the densely welded rock in the top portion of the hole are due to borehole wall instability caused in part by the extensive fracturing of these units. In addition, the neutron response values are consistently high due to the absence of groundwater in the upper part of the test hole. The report notes that inconsistencies occur in the response values for gamma-ray, resistivity, and magnetic-susceptibility logs. Because of these inconsistencies, the value ranges were selected subjectively by the authors based on the largest groups of units within a log that gives similar values.

According to the report, densely welded sections of the Tiva Canyon and Topopah Spring Members give gamma-ray measurements of 128.2 to 152.7 cps and 103.8 to 140.5 cps, respectively. The densely welded sections of the Crater Flat tuff give gamma-ray measurements of 79.4 to 103.8 cps. The report attributes these variations in response values to the fact that the fine-grain devitrification products of the Paintbrush tuff units are 40 percent richer in potassium feldspar than the Crater Flat tuff units. The report suggests also that the spherulitic textures are more prevalent in the Paintbrush tuff.

Magnetic susceptibility values are moderate to high for the densely welded Paintbrush tuff sections. However, magnetic susceptibility values are low for the Crater Flat tuff. The report suggests that the differences may be related to the variation of magnetite in the initial composition of magma or that the lower values may be an indication of the degree of oxidation of magnetite to hematite.

According to the report, it was necessary to interpret several well logs simultaneously to best characterize the rock encountered by the geophysical probes. The computer program uses several digitized well logs in the corresponding value ranges subjectively assigned to a particular lithology. The report notes that due to the problems encountered in logging the upper portion of test hole UE25a-1, only the logs for the lower part of the hole are considered in the multiple log analysis.

Figure 8 of the report shows the initial results of multiple log interpretation combining density and neutron logs. Figure 9 of the report presents the results of the computer analysis which assigned depth ranges to the value ranges of those existing possibilities in an individual well log. According to the report, Figure 9 is a preliminary interpretation and should be augmented by a geologist's field log, drillers records, and the detail of the original geophysical well log measurements.

According to the report, notable differences between the resistivity and IP response values exist between densely welded zones of the Prow Pass Member and the Bullfrog Member of the Crater Flat tuff. The density, neutron, gamma-ray, and magnetic susceptibility response values are consistent between these units. The report suggests that the Bullfrog Member probably contains a higher concentration of a low-resistivity polarizable mineral than the Prow Pass Member. In addition, the report suggests that hematite could cause some of the IP responses seen in the Bullfrog Member.

Lower density, neutron, and magnetic susceptibility response values occur in the non welded units than in the welded units. According to the report, the tuffaceous beds of the Calico Hills appear to be the least indurated interval and show the lowest density in neutron values. Resistivity, gamma-ray, and magnetic susceptibility response values also are low for the non welded units; these low values suggest a relatively high porosity and low concentrations of potassium rich minerals and magnetite.

The report presents the following conclusions:

1. Interpretation of geophysical well logs from test hole UE25a-1 was hampered by incomplete log coverage and the complex response of some well logs.

2. The IP measurements did not correspond consistently to any single mineral expected to give a high response.

3. More mineralogic and petrologic work is needed to clarify the causal elements of well-log response in welded tuffs.

4. Future studies must include laboratory physical properties measurements to link the mineralogic and petrologic work to the geophysical well log measurements.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents interpretations of the geophysical logs recorded for test well UE25a-1. The geophysical logs are interpreted primarily with respect to the major lithologic variations. The interpretations presented in the report may be of value in the detailed evaluation of the hydrogeologic characteristics of the tuff units in the vicinity of test hole UE25a-1.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review is limited with respect to characterizing the hydrogeology in the vicinity of test hole UE25a-1 because of the uncertainties involved in the interpretation of the geophysical logs. The report is useful with respect to the identification of major lithologic units. However, additional data are needed to improve the reliability of the interpretations presented in the report. In addition it should be noted that most borehole geophysical logs are not designed for use above the water table.

SUGGESTED FOLLOW-UP ACTIVITIES

Information presented in the report under review may become important with respect to detailed characterization of the hydrogeology in the vicinity of test hole UE25a-1. No follow-up activity is suggested unless additional data become available to improve the reliability of interpretations of the geophysical logs.

REFERENCES CITED:

Spengler, R.W., Muller, D.C., and Livermore, R.B., 1979, Preliminary Report on the Geology and Geophysics of Drill Hole UE25a-1, Yucca Mountain, Nevada Test Site: USGS Open-file Report 79-1244, 43 p.

Sykes, M.L., Heiken, G.H., and Smyth, J.R., 1979, Mineralogy and Petrology of Tuff Units from the UE25a-1 Drill Site, Yucca Mountain, Nevada: Los Alamos Scientific Laboratory Informal Report LA-8139-NS, 76 p.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS/[illegible]-OFR-80-963

DOCUMENT: Christensen, R.C., and Spahr, N.B., 1980, Flood Potential of Topopah Wash and Tributaries, Eastern Part of Jackass Flats, Nevada Test Site, Southern Nevada. USGS Water Resources Investigations, Open File Report 80-963, Lakewood, CO.

REVIEWER: Williams & Associates, Inc., James L. Osiensky

DATE REVIEW COMPLETED: January 20, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review describes the flood potential of Topopah Wash and its tributaries in the eastern part of Jackass Flats. Estimates of the characteristics of the 100-year flood, 500-year flood, and the maximum potential flood are presented. The report indicates that flooding during the 100-year flood would be relatively insignificant compared to the 500-year flood and the maximum potential flood. The discharge capacities of all channels except for Topopah Wash and some channels in the upstream reaches of a few tributaries would be exceeded during the 500-year flood. The maximum potential flood would inundate most of the study area. In addition, severe erosion in channels and floodplains would occur in parts of the study area during the 100-year flood; erosion would be more widespread during the 500-year flood and during the maximum potential flood.

BRIEF SUMMARY OF DOCUMENT:

The report under review describes the potential for flooding of Topopah Wash and its tributaries in the eastern part of Jackass Flats. The flood potential of these drainages was evaluated for the 100-year flood, the 500-year flood, and the maximum potential flood.

The headwaters area of Topopah Wash is located along the southern part of Shoshone Mountain. Topopah Wash is an ephemeral stream which drains southward through Jackass Flats to its confluence with the Amargosa River. Topopah Wash is the primary drainage channel in the eastern part of Jackass Flats. Tributary channels to Topopah Wash drain the southeastern part of Shoshone Mountain. These channels converge into two main tributaries before entering Topopah Wash.

According to the report, the characteristics of the stream channels in the study area range from the well defined channel of Topopah Wash which is about 600 feet wide and more than 13 feet deep, to a swale like tributary channel which is 150 feet wide and less than 1 foot deep. According to the report, most low water channels in the study area consist primarily of sand and gravel with scattered cobbles of various sizes.

Hydrologic analyses were performed by the authors of the report to estimate the 100-year, 500-year, maximum potential floods in the study area. The procedure used to estimate the characteristics of the 100-year and 500-year discharges in the study area was based on a regional analysis of streamflow records. According to the report, an analysis of regional streamflow records was used to define the characteristics of the 100-year flood and 500-year flood because the following data are not available specifically for the study area: 1) the rate at which rainfall will infiltrate into the ground, 2) the channel-routing losses, and 3) the calibration of the rainfall-runoff model. Table 1 of the report presents the estimated floodflow characteristics for the 100-year flood for selected stream sites on Topopah Wash and its tributaries. The estimated floodflow characteristics for the 500-year flood are presented in table 2 of the report.

The flooding history of Topopah Wash is not known. According to the report, data from maximum floods that have been observed on other streams having similar flood potentials provide the best estimate of maximum potential flooding in the study area. Figure 6 of the report presents an envelope curve for maximum potential discharge versus drainage area for a five state region in which Topopah Wash is located. The estimated maximum potential discharges for selected stream sites in the study area are based on figure 6 of the report. Table 4 of the report lists the maximum potential discharges for the selected stream sites.

The hydraulic characteristics of the stream channels in the study area were evaluated to estimate the potential flood depths in the channels for the 100-year flood, 500-year flood, and the maximum potential flood. According to the report, these estimates were based on natural flow conditions and the estimated discharges listed in tables 1, 2, and 4 of the report.

Flood depths for selected locations along Topopah Wash and its tributaries were estimated for the 100-year flood, 500-year flood, and the maximum potential flood by using a form of the Manning equation. The form of the Manning equation used for the estimates is as follows:

$$Q = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

where:

- Q = discharge, in cubic feet per second, for a given flood depth;
- n = Manning roughness coefficient, based on field observation of channel and floodplains;
- A = area of cross section, in square feet, for a given flood depth;
- R = hydraulic radius, in feet, which is the ratio of the area to the wetted perimeter of the cross section,
- S = the friction slope, approximated by streambed slope determined from topographic contours which is shown on Plate 1 of the report.

It should be noted that the Manning roughness coefficient controls the velocity of flow within the channel. Thus, estimated flood depths are controlled to a large degree by the value of roughness coefficient chosen. According to the report, roughness coefficients for the main channels were estimated to range from 0.030 to 0.050; floodplain roughness coefficients were estimated to range from 0.038 to 0.055 for all floods. Manning roughness coefficients were chosen by engineering judgment and based on observations of the channels and floodplain areas. No field measurements were made of streamflow velocities at different discharge rate to estimate roughness coefficients.

Approximate areas that would be inundated by the 100-year flood, 500-year flood, and the maximum potential flood were estimated by relating predicted discharges to the existing channel characteristics. These areas are shown on Plate 1 of the report. Estimated maximum flood depths for the 100-year flood would average about three feet in the main channels and would range in depth from one foot in the upstream reaches of several tributaries to 9 feet at the mouth of tributary 1. According to the report, "the 500-year flood would exceed the discharge capacities of all channels except for the channel of Topopah Wash and the channels in upstream reaches of a few tributaries. The maximum potential flood would inundate most of the study area: exceptions would be areas between Topopah Wash and tributaries 1.1.1 and 2, and between upstream channel reaches of some of the other tributaries." The report notes that water flowing at a velocity in excess of 7 feet per second will cause erosion in channels consisting of sand, gravel, and cobbles. Severe erosion of channels and floodplains would occur in parts of the study area during the 100-year flood, and would be more widespread during the 500-year flood and the maximum potential flood.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review discusses flood potential of Topopah Wash and its tributaries in the eastern part of Jackass Flats. The report presents estimates of the characteristics of the 100-year flood, 500-year flood, and the maximum potential flood in these drainages. The report is significant with respect to the potential locations of access facilities to a repository in Yucca Mountain. Yucca Mountain itself is not within the study area; the analysis presented in the report is applicable to the reach of Topopah Wash and its tributaries that are present within Jackass Flats.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review presents estimates of flood potential within Topopah Wash and its tributaries in the eastern part of Jackass Flats. The primary limitation of the report is that actual flood data for the study area are not available. A procedure using a regional analysis of streamflow records was used to estimate the characteristics of the 100-year flood and the 500-year flood within the study area. The characteristics of the maximum potential flood were estimated from selected, maximum observed flood peaks as of 1974 at 883 stream sites throughout the conterminous United States. These stream sites are believed by the authors to have similar flood potential to Topopah Wash. Another limitation of the report is that a form of the Manning equation was used to estimate flood depths for the 100-year flood, 500-year flood, and the maximum potential flood. Solution to the Manning equation for the conditions of Topopah Wash and its tributaries is based on an estimate of the Manning roughness coefficient and the energy gradient within the stream. The Manning roughness coefficient and the energy gradients of the streams that were selected for the analysis are based on subjective judgment of the characteristics of the dry stream beds.

SUGGESTED FOLLOW-UP ACTIVITIES:

No follow-up activities are suggested.

GEOTRANS COVER LETTER OF 84/07/12

ATTACHMENT E: SUMMARY OF GEOPHYSICAL INTERPRETATIONS FOR TEST WELLS UE25a-4,-5,-6,-7

Daniels, J.J., Scott, J.H., Hagstrum, J.T., 1981 Interpretation of Geophysical Well-Log Measurements in Drill Holes UE-25a-4,05,-6 and -7, Yucca Mountain, Nevada Test Site. U.S. Geological Survey Open-File Report 81-389, 28 pp.

In the summer of 1979 four exploratory holes (UE25a-4,-5,-6, and -7) were drilled and cored on the northwestern edge of Yucca Mountain. The four wells penetrate the Tiva Canyon, Yucca Mountain, Pah Canyon, and Topapah Spring members of the Paintbrush Tuff Formation at depths of 138, 133, 123, and 143 m, respectively. It should be noted that these depths are not consistent with Spengler, R.W., and Rosenbaum, J.G.

The geophysical surveys which were conducted and interpreted on the wells include resistivity, density, neutron, gamma-ray, induced polarization, and magnetic susceptibility. The purpose of these surveys was to investigate the physical properties of the pyroclastic deposits.

The introduction of drilling fluids into the unsaturated rocks inhibited interpretation of the geophysical well log surveys. Other physical properties such as interstitial fluids, borehole conditions, degree of saturation, volume of rock penetrated by the signals, etc. influence the well log measurements. Since resistivity and neutron measurements can only be performed in saturated media, the logs show only that portion of the hole where standing water could be maintained. Graphic well-logs have been provided for all of the geophysical surveys.

Within the Topopah Spring Member more highly welded tuffs and possibly a vitrophyre have produced high resistivity values. Logs for wells a-5 and -6 exhibited areas of high resistivity at the top of the Topopah Spring and relatively low resistivities at the base.

The degree of welding and percent of vitrophyre is proportional to the density. Thus, a decrease in degree of welding with the presence of highly altered units will decrease the detected density. Higher density values interpreted within the Topopah Spring member are found to be consistent with high resistivity values. Lower resistivity values for the same member in well A-4 corresponds to lower density values and a high degree of fracturing. The lower density measurements agree with the observed physical characteristics for each unit.

The response of the neutron probe is proportional to the degree of welding in saturated material and inversely proportional in unsaturated material. The low neutron-count near the bottom of A-6 (Topopah Spring Member) indicates interconnected cavities.

Gamma log measurements indicate the abundance of potassium related to post-emplacement chemical alteration. Within the Topopah Spring member, gamma signatures are correlatable between the four wells. Above the Topopah, response is approximately the same for only wells A-6 and A-7. The logs indicate large differences between wells 4, 5, and 7. The induced polarization logs are not discussed because of the unreasonably high and questionable values observed.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OF-81-615

DOCUMENT: Daniels, J.J., Scott, J.H., and Hagstrum, J.T., 1981, Interpretation of Geophysical Well-Log Measurements in Drill Holes UE25a-1, -5, -6, and -7, Yucca Mountain, Nevada Test Site: USGS Open-file Report 81-615, 29 p.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: July 15, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

The report under review presents interpretations of geophysical wells logs recorded for test wells UE25a-4, UE25a-5, UE25a-6, and UE25a-7. Resistivity, density, neutron, gamma-ray, induced polarization, and magnetic-susceptibility well logs were recorded for these test wells. The geophysical logs for the four test holes are interpreted primarily with respect to identifying the major lithologic features penetrated by the boreholes.

BRIEF SUMMARY OF DOCUMENT:

The purpose of the report under review is to present interpretations of borehole geophysical logs recorded in test wells UE25a-4, UE25a-5, UE25a-6, and UE25a-7. Resistivity, density, neutron, gamma-ray, induced-polarization, and magnetic-susceptibility logs were recorded for these test wells. According to the report, interpretation of the well log measurements was facilitated by use of a computer program designed to interpret well logs. Details are not given.

Test wells UE25a-4, UE25a-5, UE25a-6, and UE25a-7 were cored to depths of 138 m, 133 m, 127 m, and 143 m, respectively, on the northeastern flank of Yucca Mountain. Test well UE25a-7 is the only hole that is not vertical. This test well was drilled at an angle of 26 degrees from the vertical.

According to the report, each geophysical log is affected by the physical properties of the rock, the interstitial fluid of the formation, the conditions in the borehole (fluidity and rugosity), the volume of rock investigated by the probe, the vertical resolution of the probe, and the design characteristics of each probe. The report notes that interpretation of the lithologies was complicated by the unsaturated condition of the rocks. According to the report, the fluid level could not be maintained at the land surface in any of the test wells. Resistivity and neutron logs are presented only for that portion of the test wells below which a "standing" water level could be maintained.

According to the report, the resistivity of ash flow tuffs should be a function of welding, devitrification, and void space in the rocks; resistivity in saturated welded tuffs should increase with the degree of welding and decrease with the degree of devitrification and the amount of void space (including fractures). Figures 3, 4, 5, and 6 of the report, respectively, present the resistivity logs for test wells UE25a-4, UE25a-5, UE25a-6, and UE25a-7. According to the report, high resistivity values that occur in the Topopah Spring Member represent welded tuffs; however, a high resistivity zone at the top of the Topopah Spring Member and a low resistivity zone at the base of the Topopah Spring Member cannot be explained by variations in the degree of welding. The report suggests that a possible cause for the high resistivity zone at the top of the Topopah Spring Member may be a vitrophyre. Low resistivity values at the bottom of drill holes UE25a-5 and UE25a-6 may be caused by a lithophysal zone. The report suggests also that variations in the degree of welding that cannot be detected in the drill core may affect the resistivity.

Density logs indicate that non-welded and highly altered units have low bulk densities. Densely welded units have high bulk densities. Figures 7, 8, 9, and 10, respectively, present the density logs for drill holes UE25a-4, UE25a-5, UE25a-6, and UE25a-7. The report suggests that the high density values in the Topopah Spring Member can be interpreted consistently as being caused by the presence of welded tuffs. The report suggests also that an increase in the density near the top of the Topopah Springs Member probably is caused by the vitrophyre indicated on the lithologic log. The density logs for the Topopah Spring Member indicate that the highest and lowest bulk densities occur in test well UE25a-5 and UE25a-4, respectively.

The neutron logs for test wells UE25a-4, UE25a-5, UE25a-6, and UE25a-7 are shown in figures 12, 13, 14, and 15, respectively. It is noteworthy that these neutron logs show and inverse relationship between the degree of welding and the neutron count rate. According to the report, when the neutron well log interpretations are based on this inverse relationship they correspond closely to the lithology as interpreted from core. However, the report notes that a constant value for degree of fluid saturation in each of the formations must be assumed in order for this interpretation to be valid. According to the report, potassium bearing minerals are common in both primary and secondary crystalization regimes in welded tuffs. Therefore, the gamma-ray logs indicate the relative abundance of potassium. Figure 16 of the report presents the gamma-ray logs for the four test wells. According to the report, the gamma-ray signatures for the Topopah Spring Member are correlatable between each of the four drill holes. The lowest intensity gamma-ray measurements occur in test well UE25a-5. The report suggests that if the amount of potassium is related to post-emplacement chemical alteration, then the logs suggest that the degree of alteration between the drill holes may be significant.

The induced polarization (IP) logs for the test wells are shown in Figure 17 of the report. According to the report, a high IP response in volcanic rocks may be caused by cation enriched clays, zeolites or sulfides. The report suggests also that in some cases iron oxide minerals may influence the IP response. According to the report, the IP values are unreasonably high and the usefulness of the logs themselves is questionable. The report suggests that the IP logs apparently were influenced by the invasion of drilling fluid into the unsaturated volcanic rocks.

Magnetic susceptibility logs for the four test wells are shown in Figure 18 of the report. According to the report, these logs are discussed in another paper by Hagstrum and others (1980).

The report under review presents the following conclusions:

1. Interpretation of the borehole geophysical well logs for the four test holes was complicated by the absence of 100 percent fluid saturation. Most geophysical logs are not designed for use in the unsaturated zone.

2. Partial fluid saturation levels caused direct correlation between neutron response and porosity, rather than the usual inverse relationship.

3. The partially saturated rocks caused abnormally high IP values.

4. The density and resistivity logs indicate that near surface fracture zones are least likely to be present near drill hole UE25a-5.

6. Additional mineralogic and petrologic work is needed to interpret the geophysical logs in more detail.

7. Laboratory physical-properties measurements are needed to link the mineralogic and petrologic work to the geophysical well log measurements.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents interpretations of geophysical logs recorded for test wells UE25a-4, UE25a-5, UE25a-6, and UE25a-7. The report is significant primarily with respect to understanding the lithology and possibly the hydrostratigraphy penetrated by the test wells. The interpretations presented in the report appear to be valid. Therefore, the information presented in the report may become important with respect to understanding the hydrogeologic characteristics in the vicinity of the test wells.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review presents reduced (in scale) copies of lithologic logs and geophysical logs recorded for the four subject test holes. The report primarily is an interpretation report and is not intended to present field data. The logs presented in the report do not allow evaluation of "minor features" that may be of hydrogeological significance. However, presentation of the actual well logs is not the intended purpose of this report. The interpretations presented in the report more or less must be accepted to be accurate and valid.

SUGGESTED FOLLOW-UP ACTIVITIES

The interpretations presented in the report under review may become significant as the hydrogeology of the Yucca Mountain area is evaluated in greater detail. However, if this information becomes significant, it would be necessary for the NRC to obtain copies of the original well logs for independent evaluation.

REFERENCES CITED:

Hagstrum, J.T., Daniels, J.J., and Scott, J.H., 1980, Analysis of the Magnetic Susceptibility Well Log from Drill Hole UE25a-5, Yucca Mountain, Nevada Test Site: USGS Open File Report 80-1263, 33 p.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OFR-81-1220

DOCUMENT: Lachenbruch, A.H., 1981, Temperature Effects of Varying Phase Composition During the Steady Vertical Flow of Moisture in Unsaturated Stratified Sediments. U.S.G.S. Open-file Report 81-1220, 11 p.

REVIEWER: Williams & Associates, Inc., George L. Bloomsburg

DATE REVIEW COMPLETED: January 20, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review considers the possibility that fluid phase changes may produce heat sources and sinks when water flows out of coarse grained into fine grained materials or vice versa. The magnitude of heat flux caused by phase changes is determined without knowledge about whether such changes actually occur. In the final analysis the report concludes that heat flow due to phase changes would be insignificant at the value of water flux to be expected in Yucca Mountain.

BRIEF SUMMARY OF DOCUMENT:

The author discusses the possibility that heat flux may be produced by phase changes during steady downward flow under unsaturated conditions. It is known that under unsaturated conditions a change of saturation level and absolute pressure in the water will occur when water flows from coarse grained rocks into finer grained rocks. The author suggests that this change of capillary pressure may cause a change in the proportion of the mass flow in the liquid phase relative to the properties of mass flow in the vapor phase. This argument leads to the conclusion that condensation will occur and a resulting heat source will form at the top of a fine grained material, while vaporization will occur and a heat sink will form at the bottom of a fine grained material. No explanation is given in the report for the cause of condensation and vaporization.

The author calculates the magnitude of the temperature gradient which could develop for a certain downward seepage velocity; he then shows that this temperature change may be an order of magnitude larger than the natural thermal gradient. The equation for the gradient includes a coefficient (λ) which is the ratio of the mass of water which condenses or vaporizes to the mass of water flowing downward. The author assumes that this coefficient is 1.0; however, it actually could be zero and it certainly would be a very small number. He also suggests that the direction of very small steady unsaturated flows perhaps could be determined from a superficial examination of the temperature profile of a core. He explains, however, that whether it is reasonable to expect appreciable changes in phase composition in steady unsaturated flows in bedded tuffs is not known; however, the temperature profiles at the Nevada Test Site contain anomalies that might be explained by the effects of changes in phase composition.

The differential equation that governs heat flow is developed and the rate of the change of the thermal gradient is given as a function of the water flux and the thermal gradient. The author eventually develops an estimate of a "scale length" for the case where transport is predominantly in the liquid phase as well as when the flow is predominantly in the vapor phase. In the case of a Darcian liquid flow rate of one millimeter per year the governing stratum thickness is 10 km. This deduction means that conductive heat flow across a stratum will be uniform unless the stratum thickness is at least 10 km. This conclusion indicates that the entire analysis is of little importance because no strata in Yucca Mountain are 10 km in thickness.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

This report has little importance to the NRC Waste Management Program.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report considers insignificant factors with no reason presented for the occurrence of condensation and vaporization.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OFR-81-1337

DOCUMENT: Anderson, L.A., 1981, Rock Property Analysis of Core Samples from Calico Hills UE25a-3 Borehole, Nevada Test Site, Nevada. U.S. Geological Survey, Open-file Report 81-1337, Denver, 29 p.

REVIEWER: Williams & Associates, Inc., James L Osiensky

DATE REVIEW COMPLETED: December 15, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

The report under review presents results of rock property measurements of core samples from borehole UE25a-3. Borehole UE25a-3 is located approximately 12 km east of Yucca Mountain within the Calico Hills. The borehole was drilled to a depth of 771.2 m into Unit J and possibly Unit I of the Eleana Formation. The purpose for drilling borehole UE25a-3 was to obtain rock property data to evaluate the potential suitability of the Eleana Formation in the Calico Hills as an underground repository for nuclear wastes. Core samples from the borehole were measured for density, porosity, resistivity, induced polarization, compressional sonic velocity, and magnetic properties. The report is not significant with respect to the local geology and hydrogeology in the vicinity of Yucca Mountain. However, some of the data presented in the report may be of value with respect to understanding the regional geology and hydrogeology of the Nevada Test Site.

BRIEF SUMMARY OF DOCUMENT:

The report under review describes measurements taken on core samples from borehole UE25a-3 located in the Calico Hills, approximately 12 km east of Yucca Mountain. Forty-nine core samples were collected as part of a large scale site evaluation program to identify potentially suitable underground repositories for radioactive waste products.

-ehole UE25a-3 was drilled to a depth of 771.2 m. The borehole etrates into Unit J and possibly Unit I of the Eleana rormation. According to the report, Unit J persists to a depth of 720.6 m. Below this level the hole penetrates marble that tentatively has been identified as Unit I of the Eleana Formation.

According to the report, the samples that were believed to be representative of the significant lithologic variations within major stratigraphic units were selected from the core. These samples were "labeled for identification, wrapped in heavy aluminum foil, and coated with beeswax to preserve, as nearly as possible, the in-situ conditions of the rock." The samples were shipped to the USGS laboratory in Denver where they were trimmed to uniform length and measured for electrical resistivity, induced polarization, porosity, bulk density, compressional seismic velocity, and remnant and induced magnetization. Page 3 through 10 of the report describe the laboratory procedures followed for sample measurement.

Table 1 of the report lists the values of electrical resistivity and induced polarization for natural state and saturated samples. Resistivities at 100 hertz (Hz) for natural state and resaturated samples are plotted in Figure 5 of the report with respect to depth of origin. According to the report, rapid changes in resistivity within the borehole reflect the high degree of stratification of the rock column. Resistivity and induced polarization data obtained on saturated samples with a Huntec receiver are plotted against depth on Figure 6 of the report.

Natural bulk density, saturated bulk density, dry bulk density, grain density, and porosity (calculated from density in volume determinations) were measured from samples of the cores. Table II lists these data plus the measured values of compressional sonic velocity. Figure 7 of the report shows bulk density values for core samples plotted as a function of depth. According to the report, the graph of natural bulk density probably reflects the manner with which textural changes occur within the penetrated rock section.

Grain densities of the three argillite subunits are described as being relatively uniform; the report suggests that variations in the grain densities reflect subtle differences in the composition of the argillites. The report notes that the effect of compositional variations on the bulk density of the argillites is negligible compared to the effect on the porosity.

Figure 8 of the report presents porosity and compressional sonic velocity values for borehole samples plotted as a function of depth. According to the report, the velocity shows an inverse dependence on porosity; grain size, lithification, and chemical composition also influence the seismic velocity.

According to the report, magnetic susceptibility and remnant magnetization measurements were made on as many samples as possible following their removal from their protective coating. Figure 9 and Table III present plots and tabulated results, respectively, of these measurements. The report notes that major gaps in the data plot of Figure 9 represent sections of core that disintegrated during handling.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review represents a data interpretation report of rock property measurements of core samples from borehole UE25a-3. The report is not significant with respect to the local geology and hydrogeology in the vicinity of Yucca Mountain. However, the report may be of value with respect to understanding the regional geology and hydrogeology of the Nevada Test Site. Data presented in the report are specific to the Eleana Formation in the Calico Hills.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review contains no significant problems, deficiencies or limitations. The report is a data interpretation report describing the results of rock property analyses of core samples from borehole UE25a-3.

SUGGESTED FOLLOW-UP ACTIVITIES:

No follow-up activities are suggested.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OFR-81-1338

DOCUMENT: Anderson, L.A., 1981, Rock Property Analysis of Core Samples from the Yucca Mountain UE25a-1 Borehole, Nevada Test Site, Nevada. U.S. Geological Survey, Open-file Report 81-1338, Denver, 36 p.

REVIEWER: Williams & Associates, Inc., James L Osiensky

DATE REVIEW COMPLETED: December 15, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review is a data interpretation report. Core samples from borehole UE25a-1 on Yucca Mountain were measured for bulk density, porosity, resistivity, induced polarization, compressional sonic velocity, hydraulic conductivity, magnetic susceptibility, and remnant magnetization. This report presents valuable information with respect to the rock properties of the Topopah Spring Member on the eastern edge of Yucca Mountain. Rock property measurements were taken on 59 core samples from the borehole.

BRIEF SUMMARY OF DOCUMENT:

The report under review is a data interpretation report of rock property measurements on core samples from borehole UE25a-1. The borehole was drilled to a depth of 762 m; it penetrates the Tiva Canyon and Topopah Spring Members of the Paintbrush Tuff, the tuffaceous beds of Calico Hills, and the Prow Pass and Bullfrog Members of the Crater Flat Tuff. Fifty-nine core samples were obtained from borehole UE25a-1. Borehole UE25a-1 is one of a series of test holes drilled on the Nevada Test Site to help evaluate potentially suitable strata for an underground repository for nuclear waste. Borehole UE25a-1 is located on the eastern edge of Yucca Mountain

According to the report, core samples were selected so as to be representative of major lithologic variations within the principal stratigraphic units. Core samples were brought to the USGS laboratory in Denver for measurement of electrical resistivity, induced polarization, porosity, bulk density, compressional sonic velocity, hydraulic conductivity, remnant magnetization, and magnetic susceptibility. According to the report, the results of the measurements are to be used for the interpretation of in-hole and surface geophysical surveys, and to provide a means for rock property characterization beyond conventional borehole techniques.

Pages 3 through 9 of the report describe the laboratory procedures used for sample measurements. The results of electrical resistivity and induced polarization for natural state and saturated samples are listed in Table I of the report. Resistivity values measured at 100 Hertz (Hz) are plotted with respect to depth in Figure 5 of the report. Values of porosity and compressional sonic velocity for borehole samples are plotted as a function of depth in Figure 6 of the report. Comparison of Figures 5 and 6 shows that there is an inverse relationship between resistivity and porosity throughout essentially the entire measured section.

According to the report, the resistivity of the Topopah Spring Member generally is high; this is true particularly within the lower two-thirds of the unit showing an inverse correlation with porosity. The report suggests that spherical cavities within specific intervals of the Topopah Spring Member influence the resistivity values strongly. According to the report, resistivities measured in the tuff beds of Calico Hills are appreciably lower than most tuffs of the Topopah Spring Member. The report suggests that the higher porosity of the tuff beds of Calico Hills is the primary reason for the lower resistivity values.

According to the report, resistivity values of samples from the Prow Pass Member of the Crater Flat Tuff vary as a function of changes in texture, the degree of welding, and the intensity of silicification. The report notes, however, that porosity variations are responsible principally for the resistivity changes observed within the Crater Flat Tuff. Resistivity and induced polarization data obtained from resaturated samples are plotted against depth in Figure 7 of the report. The lowest induced polarization values were measured near the base of the tuffaceous beds of Calico Hills. The highest induced polarization values were measured in samples from the Bullfrog Member of the Crater Flat Tuff. The report notes that no obvious explanation exists for the high induced polarization values measured for samples from the Bullfrog Member.

Table II of the report lists measured values of natural bulk density, saturated bulk density, dry bulk density, and grain density. The values of dry bulk density, saturated bulk density, and dry bulk density are plotted against depth in Figure 8 of the report. Sonic compressional velocity data, hydraulic conductivity data, and porosity data (calculated from density and volume determinations) are listed in Table III of the report.

Compressional sonic velocities along with the porosity are plotted as a function of depth in Figure 6 of the report. This figure illustrates the inverse relationship between porosity and sonic velocity. The highest sonic velocities occur within the densely welded tuffs of the Paintbrush Tuff. However, according to the report, acoustic attenuation is apparent near the top of the Topopah Spring Member where cavities within the welded tuff constitute as much as 30% of the bulk volume of the rock.

Intrinsic permeability values (microdarcies) for the samples are listed in Table III of the report. Figure 4 of the report shows a diagram of the stainless steel hydraulic conductivity cell used to measure permeability of the samples. According to the report, gaps in the permeability data are due to sample losses that occurred during the reshaping of poorly welded samples. The report notes also that some samples were unsuitable for measurement because of large lithophysal cavities. A general increase in permeability with depth was measured in the tuffaceous beds of Calico Hills.

Values for magnetic susceptibility, remnant magnetization, induced magnetization, remnant vector inclination, and Koenigsberger ratio are listed in Table IV of the report. Remnant and induced magnetic values are plotted in Figure 9 of the report. This figure shows a dramatic decrease in rock magnetization at the contact of the Paintbrush Tuff and the tuffaceous beds of Calico Hills. The report notes that beneath the Topopah Spring Member, the magnetic properties of the rock are so variable that recognition of formation contacts on the basis of magnetics becomes virtually impossible.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review is a data interpretation report of rock property measurements on core samples from borehole UE25a-1 on Yucca Mountain. The report is significant with respect to the NRC Waste Management Program because it presents useful rock property data of the Topopah Spring Member.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review contains no significant problems, deficiencies or limitations. The report is a data interpretation report that presents important data with respect to the properties of the Topopah Spring Member.

SUGGESTED FOLLOW-UP ACTIVITIES:

Data reports of this kind should be reviewed so the NRC can keep current records of the data available. This document constitutes a potentially important source of data on the rock properties of the Topopah Spring Member.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OFR-81-1349

DOCUMENT: Spengler, R.W., Byers, F.N., Jr., and Warner, J.B., 1981, Stratigraphy and Structure of Volcanic Rocks in Drill Hole USW-G1, Yucca Mountain, Nye County, Nevada. USGS Open-file Report 81-1349, Denver.

REVIEWER: Williams & Associates, Inc., James L Osiensky

DATE REVIEW COMPLETED: October 6, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review presents significant stratigraphic and structural data on the volcanic rocks penetrated by drill hole USW-G1. The report contains a significant amount of data pertaining to fractures observed in core from the drill hole. These data are described from a geologic view point; however, the data may be very useful in helping to formulate conceptual models of flow in the unsaturated and saturated zones at Yucca Mountain.

BRIEF SUMMARY OF DOCUMENT:

The report under review describes the stratigraphic and structural characteristics of volcanic rocks penetrated by drill hole USW-G1. The purpose of the report is to present information on the thickness, lateral extent, correlation, and structural characteristics of volcanic rocks penetrated by drill hole USW-G1.

Drill hole USW-G1 was cored continuously to a depth of 6,000 feet between March and August, 1980. According to the report, several factors were used to help select the location for the drill hole. These factors are: 1) The drill hole site was located near an inferred structural zone. 2) The drill hole was located to avoid an east-west-trending magnetic high over Calico Hills which extends westward over most of northern Yucca Mountain. 3) The steep local gravity anomaly over most of northern Yucca Mountain suggests that a greater thickness of tuffs occurs over that area.

According to the report, circulation of drilling fluid was poor to nonexistent during most of the coring operation; drilling fluid losses averaged about 20,500 gallons per day (gpd) throughout the entire length of the hole. According to the report, most of the drilling fluid was lost within the Topopah Spring Member.

The rock units penetrated by the drill hole consist of rhyolitic ash flow tuff, one interval of volcanic breccia of dacitic composition, and subordinate amounts of fine- to coarse-grained volcaniclastic rocks. Table 2 of the report lists the stratigraphic units penetrated by the drill hole. Figure 3 of the report presents the results of an Eastman Whipstock Gyroscopic Survey. According to the gyroscopic survey, the drill hole deviates 475 feet south and 400 feet west of its original surface location. Table 3 of the report presents a detailed lithologic log of the drill hole. According to the lithologic log, the Tiva Canyon Member is the only member of the Paintbrush tuff that is not present in the immediate vicinity of the drill hole. Table 4 of the report presents x-ray analyses of selected samples from drill hole USW-G1. Table 5 of the report presents chemical analyses of selected tuff samples from the Crater Flat tuff and flow breccia in the drill hole.

The structural characteristics of the core were evaluated by the authors of the report. A total of 5,513.7 feet (96.6%) of the core were recovered from the drill hole. According to the report, 21% of the recovered core was wrapped in heavy gauge aluminum foil, labeled, and sealed with bees wax to preserve "in situ" moisture content of the core. The remaining 4,353.9 feet of core were evaluated for structural features which include layering attitudes, evidence of faulting, frequency of occurrence and inclinations of shear fractures and joints, and types of fracture coatings. Approximately 11% of the core was collected using oriented coring techniques. According to the report, "figure 6 shows the location of stratigraphic intervals where meaningful measurements were taken."

Fractures observed in the core were divided into joints and shear fractures for descriptive purposes. According to the report, a total of 61 shear fractures were recognized in the core between depths of 324.8 and 5,468.4 feet. The report suggests that most shears are associated preferentially with particular rock types as well as with conspicuous fault zones. Figure 7 of the report presents structural diagrams that show the inclinations of shear fractures.

A total of 528 joints was identified in the core. The data suggest that, in general, the greatest number of joints occurs in densely welded ash flow tuffs. According to the report, pronounced joint development is confined largely to the Topopah Spring Member and the Tram unit. It should be noted, as mentioned previously, that the Tiva Canyon Member is not present in drill hole USW-G1. Figure 9 of the report shows the inclination of joints, and types of fracture fillings within the core.

According to the report, about 88% of the joint and shear surfaces show evidence of at least a partial coating of secondary minerals. Approximately

40% of the fractures are described as "healed." According to the report, in decreasing order of abundance, the types of fracture coatings observed are silica, manganese and iron oxides, calcite, and clay. Fracture coatings were absent along 12.3% of the examined fractures; most of these fractures occur within the Topopah Spring Member and the flow breccia.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents significant information with respect to the stratigraphic and structural characteristics of the volcanic rocks in the vicinity of drill hole USW-G1. The information presented in the report may become very valuable with respect to the detailed characterization of Yucca Mountain as a potential repository site. The fracture data presented in the report are described primarily from a geologic view point; however, the information may help to improve conceptual models of flow in the unsaturated zone and the saturated zone.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review is typical of most USGS reports. The primary limitation of the report is that the USGS typically does not present all of the data collected for a specific test hole or well within a single report. Usually it is necessary to obtain several different documents to develop a complete picture of the hydrogeology in the vicinity of the test hole. For example, stratigraphic and structural data may be presented in one report while the hydrogeologic testing data and geophysical logs are presented in separate reports. This type of data report may prove to be very useful to the NRC Waste Management Program. Data presented in the report may be very useful in helping to interpret hydrogeologic test data.

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FILE: 3001.5, 413.2

DOCUMENT: Monfort, Mary E. and J. R. Evans, 1982, Three-dimensional Modeling of the Nevada Test Site and Vicinity from Teleseismic P-wave Residuals, U.S.G.S. Open-File Report 82-409

REVIEWER: M. Pendleton

DATE REVIEW COMPLETED: 3/29/83

DATE APPROVED:

BRIEF SUMMARY OF DOCUMENT:

This report summarizes the results of a regional teleseismic P-wave relative residual study in the vicinity of the Nevada Test Site. The large scale spacing of the seismic array precluded detailed analysis of crustal velocity structure beneath the Yucca Mountain site. The available data does, however, provide insight into the complexity of some regional structures. In the southern Nevada region, certain characteristics of the velocity structure were observed: 1) a low velocity body in the upper crust near the Miocene Timber-Mountain-Silent Canyon Caldera complex (50 km north-east of Beatty, Nevada), 2) a low velocity body near the south-west corner of the Nevada Test site, 3) a low velocity body 81 to 131 km deep centered approximately 30 km north of Las Vegas, and 4) an increase in travel time from west to east across the study area.

SIGNIFICANCE TO THE NRC MANAGEMENT PROGRAM:

Teleseismic P-delay data and 3-dimensional damped-least-square inversions of these data are summarized in this report. The current data do not resolve the upper crust beneath Yucca Mountain, and because of the widely spaced stations, anomalous bodies less than 35 km wide may not have been detected. No major mantle low-velocity anomaly was detected given the limitations of the present data. Tectonic interpretations of the teleseismic P-delay data are not included in the report but will be published at a later date. These interpretations will be reviewed, as appropriate, if they are used to support tectonic models of the region.

ACTION TAKEN:

A copy of this report was given to Paul Prestholt, WMHT and A. Murphy, RES.

FOLLOW-UP ACTIVITY:

NONE

DesireeM 83/04/05

OF 82-457

INFORMATION TO APPEAR ON DOCUMENT REVIEW SUMMARY SHEET*

DOCUMENT: Volcano-Tectonic History of Crater Flat, Southwestern Nevada, As Suggested by New Evidence From Drill Hole USW-VH-1 and Vicinity. USGS Open File Report 82-457. By W. J. Carr.

DATE REVIEW COMPLETED: 7/14/82

REVIEWER: W. R. Rehfeldt

SIGNIFICANCE OF INFORMATION TO NRC PROGRAM:

Volcanic hazard studies, being conducted as part of the NNWSI, are attempting to assess the risk of disruption of a waste repository within the NTS by future volcanic activity. The presence of Quaternary volcanism within 12 miles of the Yucca Mountain site area underscores the need for a thorough study as required in 10 CFR 60.

ACTION RECOMMENDED:

None.

ACTION TAKEN:

None.

REFERRED TO (FOR INFO):

Name	Pages
N/A.	

SUMMARY OF DOCUMENT:

See Attached.

Distribution: WM-82-445
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WMHL r/f
JBMartin
REBrowning
MJBell
RRBoyle
WRRehfeldt & r/f
HJMiller
JOBunting

*If an item is not applicable to a particular review, write N/A next to the item.

SUMMARY OF DOCUMENT:

The report provides a summary of recent subsurface investigations conducted in Crater Flat, relative to the exploration and technical evaluation of the Yucca Mountain area at the NTS. As part of the investigation, a 2,501-ft hole, designated USW-VH-1, was drilled in central Crater Flat. The primary objectives of the hole were to aid volcanic hazard assessment in the Crater Flat area, and to provide subsurface hydrologic information for that area. More specifically, the geologic purpose was to determine whether additional basalt flows or other evidence of late Cenozoic volcanism is present in central Crater Flat.

The volcanic rocks are of particular interest because they include the units that are now under consideration as the repository host rock -- the Bullfrog and Tramm members of the Crater Flat Tuff formation. Drill hole USW-VH-1 has added to evidence that suggests that Crater Flat is the source area for some or all of the members of the Crater Flat Tuff.

Evidence from the drill hole indicates that the Bullfrog member is quite thick at Crater Flat, and, when correlated with a large aeromagnetic anomaly which occurs in the same area, suggests a resurgent dome structure within a caldera collapse area.

None of the units of the Crater Flat Tuff are believed to have originated from the repository site area on Yucca Mountain because all of the units are not unusually thick according to drill hole logs in that area.

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WMHT DOCUMENT REVIEW SHEET

FILE: 3001.5, 413.2

DOCUMENT: "Snyder, D.B. and Carr, W. J., 1982, Preliminary Results of Gravity Investigations at Yucca Mountain and Vicinity, Southern Nye County, Nevada, U.S.G.S. Open-file Report 82-701.

REVIEWER: M. Pendleton DATE REVIEW COMPLETED: 2/9/83

BRIEF SUMMARY OF DOCUMENT: DATE APPROVED: RB 2/15/83

Data from 1257 gravity stations in the vicinity of Yucca Mountain were used to generate a residual gravity map of the area. The results of this work provide some preliminary interpretations of the geometry of the rock units adjacent to and beneath Yucca Mountain including an approximation of the topography of the Paleozoic surface underlying the thick tuff sequence at Yucca Mountain. Gravity anomalies support inferred structures interpreted from geologic mapping and drill hole data.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

A preliminary three dimensional model of the subsurface geology in the vicinity of Yucca Mountain was developed from the gravity data. This model will serve to focus additional investigations and data collection at Yucca Mountain to refine the interpretation of the subsurface structure in the area and to limit uncertainties in the interpretation of the geometry of rock units in the vicinity of the proposed geologic repository at Yucca Mountain. Significant preliminary interpretations are:

- The gravity low beneath Crater Flat and western Yucca Mountain is interpreted to be an extensive tuff-filled depression in the Paleozoic surface. This is consistent with the concept that Crater Flat is the source area for the Crater Flat Tuff with a possible resurgent dome in southern Crater Flat.

- The gravity saddle dividing Crater Flat along an east-west trend may indicate the presence of two collapse calderas in Crater Flat. The northern section of the gravity low may represent an older caldera filled with pre-Crater Flat tuff.

- The north-east trending gravity high extending from the Eleana Range through Calico Hills and Busted Butte is interpreted to be a structural high in the Paleozoic surface.

- The gravity saddle between Busted Butte and Calico Hills may be an extension of a north-west trending shear zone identified in

Yucca Wash or a north-south trending burried fault in the Jackass Flats area. It may also represent a structural contact between Paleozoic carbonates at Striped Hills and argillite (Eleana Formation) if the pre-Tertiary rocks beneath Busted Butte correlate with the Paleozoic carbonates. Siltstone fragments in the Prow Pass and Bullfrog members of the Crater Flat Tuff suggest that Tertiary tuffs at the eastern end of Yucca Mountain are underlain by argillite.

- Gravity data do not resolve the possibility of an east-west trending intrusive loacted beneath the northern section of Yucca Mountain and Crater Flat.

- East-west trending profiles across Yucca Mountain, constructed from modeling calculations locate several inferred faults cross-cutting the Yucca Mountain block.

ACTION TAKEN:

A copy of this report was transmitted to Ernst Zurflueh (RES) for technical review of the geophysical techniques and interpretations. The results of his review are attached. Copies of this report were also given to Peter Ornstein, Mark Logsdon and Paul Prestholt.

FOLLOW-UP ACTIVITY:

Additional field data that refine/revise this preliminary gravity model will be reviewed during the NTS Geologic Stability workshop.

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 9 1982

MEMORANDUM FOR: Martha Pendleton, Geologist
High-Level Waste Technical Development Branch
Division of Waste Management, NMSS

FROM: Ernst Zurflueh, Geophysicist
Earth Sciences Branch
Division of Health, Siting, and
Waste Management, RES

SUBJECT: REVIEW OF USGS OPEN-FILE REPORT #82-701, GRAVITY
AT YUCCA MTN.

The gravity map presented in this report was produced by using a density of 2.0 g/cm^3 for Bouguer corrections. The resulting map is much more satisfactory than an earlier one which used a density of 2.67 g/cm^3. That density did not correspond to actual rock densities and therefore produced anomalies related to topography.

The interpretation of the map described in the report is quite reasonable in general, although it is not a complete interpretation. The outlines of rock bodies shown on the map and used in 3-d modeling are suitable. Some possible faults are indicated in the cross sections resulting from model calculations. However, a more comprehensive interpretation of the map might show that there are locations other than those shown on cross sections where faulting could be inferred.

Subsurface steps shown in cross section C-C[1] are questionable because they do not correspond to the measured gravity profile. Also, figure 12 shows that details of the model calculations can be fairly insignificant. The main point to keep in mind, in this respect, is that calculation of depths to the bottom of the tuff is very uncertain. Very similar models could be constructed that have markedly different depths to the base of the tuff.

Ernst Zurflueh

Ernst Zurflueh, Geophysicist
Earth Sciences Branch
Division of Health, Siting, and
Waste Management, RES

OF 82-973

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WMHT DOCUMENT REVIEW SHEET

FILE: 3001.5, ~~3109.4~~ 413.2

DOCUMENT: Sass, J. H. and Lachenbruch, A. H., 1982, Preliminary Interpretation of Thermal Data from the Nevada Test Site, U.S.G.S. Open-File Report 82-973

REVIEWER: M. Pendleton DATE REVIEW COMPLETED: 2/3/83

BRIEF SUMMARY OF DOCUMENT: DATE APPROVED: 2/15/83

Thermal data from 60 wells in the vicinity of the Nevada Test Site were analyzed to evaluate the implications of the data with regard to regional heat flow. In addition, because thermal measurements are sensitive to hydrologic processes, thermal data from 16 wells in the vicinity of the Yucca Mountain Site were analyzed to determine the implications of this data with regard to vertical groundwater flow. At Yucca Mountain, thermal measurements in wells deeper than 1 kilometer appear to indicate downward movement of groundwater. Seepage velocities in the range of 1-10 mm/year were calculated.

SIGNIFICANCE TO THE WASTE MANAGEMENT PROGRAM:

Preliminary interpretation of thermal data at Yucca Mountain supported a concept of downward percolation of groundwater through the unsaturated and saturated zones. Analysis of additional data were used to test this hypothesis. Among the wells in the vicinity of Yucca Mountain, only Ue17e, drilled in argillite of the Eleana Formation, was completed with the proper techniques (annulus blocked with grout) to provide good data to evaluate the thermal effects of groundwater flow. In the other wells, the investigators had to distinguish between flow in the formation and flow in the annulus of the well. While it is possible, according to the authors, to distinguish between the two types of flow, uncertainties in the interpretation exist in all wells except Ue17e. Thus, the locally lower heat flow measurements still are only suggestive of downward water movment in the vicinity of Yucca Mountain.

ACTION TAKEN:

A copy of this report was given to Ernst Zurflueh for technical review. The results of this review are attached.

FOLLOW-UP ACTIVITY:

None

W&A COVER LETTER OF 84/09/07.
THIS REVIEW IN CONJUNCTION WITH
JULY 1984 DATA REVIEW IN DENVER.

Review of Well H-1, Data Report

Rush, F.E., W. Thordarson, and Laura Bruckheimer, 1983, Geohydrologic and Drillhole Data for Test Well USW H-1, Adjacent to Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-file Report 83-141.

This review covers the above document in combination with raw data observed at the Data Review Session for NTS held at the U.S.G.S. offices in the Denver Federal Center on July 25, 1984.

This document presents data collected to determine hydraulic properties of the rocks penetrated in test well USW H-1. The report contains data on drilling operations, lithology, borehole geophysics, hydrologic monitoring, core analysis, ground water chemistry, and pumping and injection tests for this well. This review will concentrate on the pumping and injection tests (slug tests). The well is located in Nye County, Nevada, approximately 140 km northwest of Las Vegas. It is located in an easterly draining canyon of Yucca Mountain, northwest of Jackass Flats. The well was drilled to a total depth of 1,829 m on November 22, 1980. The well was drilled with rotary drilling equipment using air, detergent and water for chip removal.

The report contains data on 48 core samples that were removed from the unsaturated and saturated zones. Measurements included density, matrix porosity, pore saturation, and pore water content. Horizontal and vertical saturated hydraulic conductivity measurements were made on samples from the saturated zone. The hydraulic conductivities for the saturated zone ranged from 10^{-4} to 10^{-7} m/day. Matrix porosity ranged from 20 to approximately 30 percent, although a few samples fell outside this range. The tests show that the matrix permeability is several orders of magnitude lower than the permeability values determined from the slug tests and pumping tests discussed below.

The borehole flow survey log presented in the report indicates that the well has three major producing zones. These zones are located between depths of 572 m (the water table) and 655 m, between 690 m and 700 m, and between 740 m and 790 m. These were the zones that received primary attention during pump testing in particular. The borehole flow survey graph presented in the report is not consistent with the borehole flow survey data presented in the raw data file. According to the data file the borehole flow survey was conducted throughout the length of the hole but only the upper 1,000 m of hole data are presented in the subject report. No explanation is given.

Both the report under review and the data presented in the file indicate that the head distribution in the borehole increases vertically with depth. The water level for the depth zone 572 to 688 m above sea level is 729.9 m above sea level. The head reading for the depth zone 1,112 to 1,115 m above sea level is 780.8 m above sea level.

Drawdown and recovery tests were conducted for the interval 570 m to 688 m before casing was set. Two additional pumping tests were conducted between the depths of 687 m and 1,829 m after casing was set to 688 m. Drawdown test data were plotted in the form of drawdown versus time after start of pumping on semilog paper. Recovery test data were plotted with residual drawdown against time on semilog paper. The number of pumping test curves and recovery curves reported in the document under review is in agreement with the number of tests reported in the raw data file. The only difference between the pump test data in the raw data file and the pumping test data in the document under review is that the raw data file contains the drawdown data for well G-1 due to the pumping of well H-1; the report under review makes no reference to this curve. The semilog graphs of drawdown versus time and recovery data versus time should be amenable to analysis by the Jacob straight-line method.

Data for six injection tests for packed-off intervals between depths of 687 m and 1,829 m are presented in the report under review. The ratio of hydraulic head at a given time to initial hydraulic head is plotted against time since injection began. The number of injection (slug) tests in the raw data file is not equivalent to the number of injection tests presented in the report under review. Inspection of the list of tests included in the raw data file reveals that 17 injection tests were attempted in this interval. Of the 17 tests, one test was considered too short for analysis; three tests were not used because the tool failed; two tests were not used because of packer failure; three tests were listed as no good without explanation; and two tests were listed as good with questions. These reasons account for the presentation of only six sets of test results in the document under review. Twenty-nine other tests were either attempted or conducted in well H-1. These tests consisted of swabbing tests and shut-in tests. Shut-in tests are not defined in either the data base or the document. However, the test list in the data base for well H-1 indicates that some of the shut-in tests were considered to be good. Jim Robison's explanation for the shut-in test is that the tubing is evacuated and the shut-in tool opened in order to watch the pressure change as a consequence of opening the tubing to the formation pressure. Alternatively the tubing is evacuated and the tool closed in order to watch the pressure build up between the packers. In any case the decision was made to use only the injection slug tests for which the data are reported in the review. Apparently this was somewhat of an arbitrary decision, but it explains the presentation of only six tests in the document under review.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OFR-83-321

DOCUMENT: Muller, D.C., and Kibler, J.E., 1983. Commercial Geophysical Well Logs of the USW G-1 Drill Hole, Nevada Test Site, Nevada. USGS Open-file Report 83-321.

REVIEWER: Williams & Associates, Inc., James L. Osiensky

DATE REVIEW COMPLETED: February 18, 1987

ABSTRACT OF REVIEW: **APPROVED BY:** Roy E Williams

The report under review presents a brief description of the geophysical logs recorded in saturated and unsaturated portions of drill hole USW G-1. The authors of the report suggest that the geophysical logs are of good quality; however, the logs are of limited usefulness for stratigraphic correlation due to the similar responses of the different tuff units penetrated by the borehole. The usefulness of the logs as lithologic indicators within the bore hole are limited to zones of welding in the tuffs, and to "noisy" density, caliper, and neutron traces in the lithophysal zone in the Paintbrush tuff. The report is of very limited significance to the NRC Waste Management Program at the present time.

BRIEF SUMMARY OF DOCUMENT:

The report under review presents a very brief description of the commercial geophysical well logs that were recorded for drill hole USW G-1. The geophysical logs were recorded during six periods of logging during and after completion of drilling. Table 1 of the report presents a summary of the logging operations. Plates 1 and 2 of the report are graphs of the geophysical logs compared with the lithology, stratigraphy, fracturing, and core index. Plates 1 and 2 are not included in the photocopy of the report that is available to Williams and Associates, Inc. for review.

According to the report, its purpose is to document the geophysical log data for drill hole USW G-1 and to present the log data in a usable form for use by other investigators. The authors of the report note that some data are missing on Plates 1 and 2. Data gaps on Plates 1 and 2 indicate that either no data were obtained in that interval, or that the data that were obtained were "discarded due to poor quality." Some of the missing data are the result of the unsuccessful attempt to record geophysical logs in the unsaturated portion of the hole by filling that portion of the hole with viscous mud.

Pages 1 through 6 of the report present very brief descriptions of the geophysical logs recorded for drill hole USW G-1. These logs include caliper, gamma-ray, spontaneous potential, resistivity, neutron, density, velocity, porosity, and calculated logs. These descriptions include a discussion of the principles and applications of each log. The authors of the report reached the following conclusions:

1. The geophysical logs recorded in drill hole USW G-1 generally are of good quality.

2. The usefulness of the logs as lithologic indicators is limited primarily to the identification of welded zones, and the lithophysal zone in the Paintbrush tuff.

3. The physical properties of the tuffs above the Tram unit are quite variable whereas the Tram and tuff of Lithic Ridge are more uniform and predictable.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents a brief discussion of the geophysical well logs recorded for drill hole USW G-1. The descriptions of the geophysical logs presented in the report probably will be of little value to the NRC Waste Management Program. The authors of the report conclude that the usefulness of the geophysical logs as lithologic indicators is limited primarily to identification of welded zones in the tuffs and seemingly noisy density, caliper, and neutron traces in the lithophysal zone of the Paintbrush tuff. While the actual geophysical logs eventually may become very significant to the NRC Waste Management Program, the report under review probably will be of relatively minor value.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The primary limitation of the report under review is that the descriptions of the geophysical logs are very brief. In addition, the authors of the report note that the logs are of limited usefulness as lithologic indicators.

SUGGESTED FOLLOW-UP ACTIVITIES:

No follow-up activities are suggested.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OF-83-475

DOCUMENT: Permeability and Pore Fluid Chemistry of the Bullfrog Tuff in a Temperature Gradient: Summary of Results. J. Byerlee, C. Morrow and D. Moore, U.S.D.A. Geological Survey.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: May 28, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

Permeability and water chemistry changes associated with water flowing through heated samples of the Bullfrog Member of the Crater Flat tuff were investigated. Small cylindrical samples with a heating element in the center were used for the experiment. Water flowed radially due to a small pore pressure gradient. The pressure gradient was assumed to be constant, which is not a valid assumption. This assumption will result in a slightly incorrect value of permeability. A significant change of permeability occurred over time. The project was conducted under saturated conditions which is not applicable to the proposed repository location.

BRIEF SUMMARY OF DOCUMENT:

This report investigates the permeability and fluid chemistry of water that was forced to flow through heated samples of the Bullfrog Member of the Crater Flat tuff. Cylindrical samples, 7.62 cm in diameter and 8.89 cm long with a 1.27 cm diameter hollow borehole in the middle were used in the experiment. A coiled resistance heater was placed in the borehole to produce a temperature gradient between the center and the outside of the core. Water flowed radially through the tuff from the center toward the outside in response to a small, imposed pore pressure gradient. For the calculation of permeability, the authors used the Darcy equation, but the pressure gradient in the radial direction was assumed to be constant. This assumption is not valid for radial flow. The measured permeability of two out of three samples decreased with time. The maximum permeability measured was 10 microdarcies while the minimum was about .5 microdarcy.

The mineral-fluid interactions seemed insufficient to account for the high concentrations of dissolved material contained in the room temperature fluids. A rapid decrease in concentrations of many of the dissolved species suggests also the removal of a finite amount of readily leached material rather than continuous mineral reaction. The permeability tests showed that a significant decrease in permeability occurred with time compared to that measured in some other rocks. This characteristic is desirable because it may prevent downward percolating groundwaters from accumulating around the canisters. However, in the proposed repository the pore matrix will be unsaturated; these samples were tested under saturated conditions.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

Useful data probably are presented in this paper concerning the effect of heated water on the permeability of the porous matrix. The data may be useful in the design of the waste repository.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

A limitation of this work is that it was conducted under saturated conditions whereas the repository in Yucca Mountain will be under unsaturated conditions. Another deficiency in the experimental work was that the pressure gradient during radial flow was assumed to be constant; this assumption will produce an incorrect value of permeability.

SUGGESTED FOLLOW-UP ACTIVITIES

No follow-up is necessary.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-OF-83-475

DOCUMENT: Permeability and Pore Fluid Chemistry of the Bullfrog Tuff in a Temperature Gradient: Summary of Results. J. Byerlee, C. Morrow and D. Moore, U.S.D.A. Geological Survey.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: May 28, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

Permeability and water chemistry changes associated with water flowing through heated samples of the Bullfrog Member of the Crater Flat tuff were investigated. Small cylindrical samples with a heating element in the center were used for the experiment. Water flowed radially due to a small pore pressure gradient. The pressure gradient was assumed to be constant, which is not a valid assumption. This assumption will result in a slightly incorrect value of permeability. A significant change of permeability occurred over time. The project was conducted under saturated conditions which is not applicable to the proposed repository location.

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The mineral-fluid interactions seemed insufficient to account for the high concentrations of dissolved material contained in the room temperature fluids. A rapid decrease in concentrations of many of the dissolved species suggests also the removal of a finite amount of readily leached material rather than continuous mineral reaction. The permeability tests showed that a significant decrease in permeability occurred with time compared to that measured in some other rocks. This characteristic is desirable because it may prevent downward percolating groundwaters from accumulating around the canisters. However, in the proposed repository the pore matrix will be unsaturated; these samples were tested under saturated conditions.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

Useful data probably are presented in this paper concerning the effect of heated water on the permeability of the porous matrix. The data may be useful in the design of the waste repository.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

A limitation of this work is that it was conducted under saturated conditions whereas the repository in Yucca Mountain will be under unsaturated conditions. Another deficiency in the experimental work was that the pressure gradient during radial flow was assumed to be constant; this assumption will produce an incorrect value of permeability.

SUGGESTED FOLLOW-UP ACTIVITIES

No follow-up is necessary.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT: Claassen. H.C.. 1983. Sources and Mechanisms of Recharge for Groundwater in the West-Central Amargosa Desert. Nevada--A Geochemical Interpretation: U.S.G.S. Open-file Report 83-542. Denver. 61 p.

REVIEWER: Williams and Associates. Inc.

DATE REVIEW COMPLETED: February 28. 1986

ABSTRACT OF THE SUMMARY: APPROVED BY:

The report under review presents data and interpretations which suggest strongly. that overland flow of snowmelt and storm runoff may be a primary source of recharge to the tuff aquifers in the vicinity of the west-central Amargosa Desert. Geochemical interpretations are used to support the conclusions. Recharge is believed to be concentrated in the major stream drainages. The report contains no major problems or deficiencies. The report is very significant with respect to the development of conceptual models for the saturated zone in the vicinity of the Nevada Test Site.

BRIEF SUMMARY OF DOCUMENT:

The purpose of the report under review is to present supporting data for and interpretations of a hydrogeochemical model of groundwater flow in the vicinity of the Nevada Test Site. The report utilizes geochemical concepts to estimate ground water sources and pathways of groundwater movement in the west-central Amargosa Desert in southern Nevada. Geochemical data are combined with hydraulic data in an attempt to explain the sources and mechanisms of recharge to the groundwater flow systems in the west-central Amargosa Desert.

The report incorporates water quality data collected by the U.S.G.S. in 1971. 1974. and 1979. Additional water quality data collected by other agencies and not published previously are included in Table 1 of the report. Groundwater chemistry data can be interpreted to indicate that groundwater in the west-central Amargosa Desert can be divided by composition into: 1) groundwater originating from reaction with tuffaceous rocks or tuffaceous valley fill, 2) groundwater that has reacted primarily with carbonate rocks or carbonate valley fill, and 3) groundwater that has reacted with the mixed lithology of carbonate and tuffaceous material. The report notes that carbonate derived waters that enter a region of tuffaceous valley fill (or vice-versa) are indistinguishable in composition from those waters resulting from reaction in the valley fill deposits of mixed lithology. This fact complicates the interpretation of the groundwater chemistry data in the vicinity of the Nevada Test Site. Another factor that complicates the interpretation of the geochemical data is the existence of Quaternary playa deposits within the area of investigation. Maps showing the concentrations of sodium, calcium, bicarbonate and sulfate, are shown in Figures 4 through 7 of the report.

The report suggests that the compositions of groundwater in the tuffs of the Nevada Test Site are due primarily to the formation of montmorillonite and clinoptilolite. Composition of the groundwater in the tuffs depends on the quantity of clinoptilolite precipitated relative to the quantity of montmorillonite. According to the report, greater percentages of sodium in the groundwater are associated with greater clinoptilolite/montmorillonite ratios.

Recharge water (i.e., infiltrating precipitation or surface runoff) that reacts with vitric tuff would result in the precipitation of montmorillonite and clinoptilolite in varying quantities, depending on the lithology and flow path. According to the report, sodium probably would comprise more than 70% of the three major cations (sodium, calcium, and magnesium) in recharge that occurs through the rocks in the highlands north of the study area. However, the compositions of most of the groundwater in the Amargosa Desert (sodium, calcium, and magnesium) in tuffaceous valley fill are inconsistent with the expected composition of recharge water entering aquifers of the rock types that exist to the north. This fact suggests that the water in the tuffaceous valley fill in the Amargosa Desert was <u>not</u> derived from recharge in the highlands to the north. The report suggests that a reasonable alternative is that surface runoff recharges the valley fill directly.

Winograd and Thordarson (1975) suggested that a potentiometric high in the vicinity of the intersection between the gravity fault and the Spector Range thrust fault was due possibly to a breach of the confining properties of the Gravity fault along the Ash Meadows spring line. Geochemical data were used to evaluate whether groundwater that appears to be flowing from east to west across the Gravitv fault is derived from the unconfined (vallev fill) or the confined (lower carbonate) aquifer discussed bv Winoorad and Thordarson (1975). Water level data indicate that the potentiometric surface in the vallev fill is about 10 m lower than than in the underlving carbonate aquifers. These data indicate that the vertical component of the fluid potential gradient is upward in this area.

Accordino to the report, groundwater from well 17S/51E-23B mav be due to upward leakage from the lower carbonate aquifers; however, significant upward leakage and calcium carbonate precipitation cannot explain adequatelv the water qualitv of the other vallev fill derived samples. The report notes that much of the vallev fill from which these samples were obtained consists of limestone and dolomite. Therefore, the geochemical data cannot be interpreted uniquely. However, accordino to the report, three possible mechanisms can explain the water qualitv data in the vicinitv of the potentiometric high. 1) Upward leakage of ground water from the lower carbonate aquifer mav occur into the vallev fill. This water is believed to be mixed with water that has been recharged into the vallev fill directlv. 2) Upward leakage from a carbonate aquifer mav occur and react with rock fragments, including evaporites, in the vallev fill. 3) Water mav recharge primarilv through the vallev fill and reside therein. The report suggests that the mechanism that best explains the water qualitv data in the vicinitv of the potentiometric high is upward leakage from the lower carbonate aquifer into the vallev fill deposits in combination with water that has been recharged directlv into and is now resident in the vallev fill.

Figures 4 through 7 of the report present water qualitv maps in the studv area. Contours of equal concentrations of sulfate, bicarbonate, calcium and sodium indicate that the best qualitv water exists within the central portion of the studv area (i.e., a trough in the contours). The report suggests that the water within these troughs originated as local surface runoff. The report suggests also that infiltration of this runoff occurred primarilv in the vicinitv of present-dav drainagewavs and that reaction with vitric tuff resulted in the observed water qualitv. This interpretation is plausible.

The water qualitv maps suggest that large chemical gradients exist between the vallev fill containing principallv carbonate detritus near the Amargosa River and the vallev fill to the northeast, in the central part of the studv area. Accordino to the report, the vallev fill in the central part of the studv area is presumed to be principallv tuffaceous. In order to explain the water qualitv data, the report presents the hvpothesis that a greater number of floods which result in recharge occur in Fortv Mile Canvon than in the Amargosa River. If this hvpothesis is correct a greater fraction of runoff recharge would occur in the tuffaceous valley fill than in the valley fill containing carbonate detritus. This hypothesis could explain the large hydrochemical variations that exist in the study area. However, the report notes that additional data are necessary to explain the occurrence of groundwater with higher TDS along the upstream reach of the Amargosa River than along the downstream reach.

According to the report, the potentiometric surface in the valley fill along the Amargosa River suggests that subsurface groundwater flow parallel to the river is possible. The report suggests that groundwater may flow from the valley fill in Oasis Valley, near Beatty, Nevada, into the valley fill in the upstream reach of the Amargosa Dessert. However, the groundwater chemistry data are difficult to interpret. The report suggests that two mechanisms may account for the groundwater quality along the upstream reach of the Amargosa River: 1) recharge of surface runoff or 2) underflow of groundwater from Oasis Valley. The report notes that the groundwater chemistry along the downstream reach of the Amargosa River can be explained only by recharge of surface runoff. Therefore, the author of the report favors this mechanism as the dominant source of recharge along the entire reach of the Amargosa River.

Figure 14 of the report presents a map of unadjusted carbon-14 age dates of groundwater in the vicinity of major surface drainageways. The map indicates that the youngest ages are located in or near present-day drainageways. The present-day drainageways are assumed to correlate with the paleodrainageways. Based on this assumption, the distribution of groundwater ages supports the conclusion that a primary source of recharge is overland flow in the drainageways.

It is important to note the absence of groundwater dates older than 17,000 years before present in the tuff aquifers. The report offers three possible explanations for the absence of groundwater ages greater than 17,000 years before present: 1) The relatively young groundwater ages are an artifact of well completion and location. 2) Groundwater velocity is sufficient to have moved the older groundwater beyond the study area. 3) Snowfall earlier than about 20,000 years before present was insufficient to produce snowmelt recharge, whereas subsequent climatic conditions caused such recharge. The author of the report favors the third explanation.

An interesting contradiction exists between the chemical data and the isotope and hydraulic data with respect to Ash Tree Spring. Ash Tree Spring is located approximately in line with the trend of other tuff derived water samples from the central part of the study area (the trough in the water quality maps). However, the carbon-14 age of this water is 15,900 years before present. This age is significantly older than the upgradient groundwater in most other parts of the valley fill downgradient from Forty Mile Canyon. In addition, the water level altitude of the spring is approximately 21 m higher than the water levels in wells within 1 km of the spring. According to the report, the nearest wells also contain water of very different chemistry than water from Ash Tree Spring. The author offers the following two explanations for these contradictions in the data: 1) Water level altitude at Ash Tree Spring reflects recharge in the valley fill at a time when the land surface was higher than it is today. Subsequent erosion or subsidence left the aquifer material of Ash Tree Spring topographically higher than the surrounding valley fill. Flow from the spring represents draining of the aquifer. 2) Recharge to Ash Tree Spring originates from a different source than the source that recharged valley fill to the northwest.

SIGNIFICANCE TO THE NRC WASTE MANAGEMENT PROGRAM:

The report under review presents very significant data and interpretations with respect to conceptual models of groundwater flow in the vicinity of Yucca Mountain. The report is significant with respect to understanding the mechanisms of recharge to the tuff aquifers. Most of the interpretations presented in the report are supported by groundwater chemistry data, groundwater isotopic data, and hydraulic head and gradient data. The information and interpretations presented in the report are very significant with respect to the development of conceptual models for the saturated zone at Yucca Mountain.

The sources of groundwater recharge indicated by Claassen (1983) are taken into account by USGS papers dealing with this subject published after 1983 (e.g., Czarnecki and Waddell, 1984; and Czarnecki, 1984). However, potential recharge along Forty Mile Wash and Forty Mile Canyon are not mentioned in the draft EA or by Rice (1984). This is a serious deficiency in the report by Rice (1984). Claassen (1983) is referenced in Chapter 6 of the draft EA; however, Claassen (1983) is referenced as a source of groundwater chemistry data only. No interpretations of the data are presented in the EA.

PROBLEMS, DEFICIENCIES, OR LIMITATIONS OF REPORT:

The report under review contains no significant problems, deficiencies, or limitations. Most interpretations presented in the report are supported by groundwater chemistry data.

groundwater isotopic data, and hydraulic data. The data base is not sufficient to explain fully all of the conditions observed within the study area. However, this is not a deficiency of the report. The author offers alternative explanations to explain the occurrence of apparently anomalous conditions whenever the data base is inadequate to support a unique interpretation.

SUGGESTED FOLLOW-UP ACTIVITY:

The groundwater chemistry data and interpretations presented in the report are important with respect to supporting or disproving potential conceptual models of groundwater flow in the vicinity of Yucca Mountain. We believe that any conceptual models developed for the saturated zone in the vicinity of the Nevada Test Site should agree with the interpretations presented in the report or should offer alternative interpretations of the data.

REFERENCES CITED:

Winograd, I.J., and Thordarson, William, 1975, Hydrogeologic and Hydrochemical Framework, South-Central Great Basin, Nevada-California, with Special Reference to the Nevada, Test Site: USGS Prof. Paper 712-C, 126 p.

Czarnecki, J.B., and Waddell, R.K., 1984, Finite-Element Simulation of Ground-Water Flow in the Vicinity of Yucca Mountain, Nevada-California. USGS Water Resources Investigations Report 84-4349, Denver, 38 p.

Czarnecki, J.B., 1984, Simulated Effects of Increased Recharge on the Ground-Water Flow System of Yucca Mountain and Vicinity, Nevada-California. USGS Water Resources Investigations Report 84-4344, Denver, 33 p.

GEOTRANS COVER LETTER OF 85/04/21

ATTACHMENT E: SUMMARY OF GEOLOGIC INFORMATION FOR TEST WELL USW G-2.

Maldonado, Florian, and S.L. Koether, 1983, Stratigraphy, Structure, and Some Petrographic Features of Tertiary Volcanic Rocks at the USW G-2 Drill Hole, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey, Open File Report 83-732, 83 pp.

USW G-2 is a continuously cored drill hole located at Yucca Mountain in southwestern Nevada, Nevada State coordinates N237,385 m and E170,841 m. Drilling began March 25, 1981 and was completed October 11, 1981 to a total depth of 1830.6 m below ground. Air foam and polymer mud were used as the circulating media. Surface casing was set at 88.2 m; core sizes were 9.75 cm in diameter from 88.3 to 1438.5 m in depth and 7.3 cm, from 1438.5 to 1830.6 m in depth. The drill hole had a maximum drift angle less than 5° and deviated 15.2 m south and 75.3 m west.

USW G-2 is one of several deep boreholes drilled for the purpose of characterizing the rock units of the Yucca Mountain Area. Consequently, data from USW G-2 is compared to that obtained from boreholes USW G-1, USW H-1, UE25b-1H, and UE25a-1. For instance, westward drift was prevalent in each of these deep boreholes; this drift could be structurally related. The regional faulting of the area dips predominantly to the west.

Stratigraphically, the borehole penetrated 1830.6 m of Tertiary volcanic strata comprised of abundant silicic ash-flow tuffs, minor lava and flow breccias, and volcaniclastic rocks. The following units were penetrated in descending order: (1) Paintbrush Tuff including Tiva Canyon and Yucca Mountains Members, Pah Canyon, and Topopah Spring Members; (2) tuffaceous beds of Calico Hills; (3) Crater Flat Tuff including Prow Pass and Bullfrog Members, and Tram Unit; (4) rhyodacitic lava and flow breccia; (5) tuff of Lithic Ridge; (6) bedded and ash-flow tuff; (7) rhyolitic, quartz latitic, and dacitic lava and flow breccia; (8) bedded tuff, conglomerate, and ash-flow tuff; (9) older tuffs.

The following observations were made while comparing the units of USW G-2 with the equivalent units of the other deep boreholes: (1) thickening of the Paintbrush Tuff Members and the tuffaceous beds of Calico Hills toward the northern part of Yucca Mountain; (2) thickening of the Prow Pass Member and the Tram Unit; (3) thinning of the tuff of Lithic Ridge; (4) the presence of approximately 280 m of lava and flow breccia not previously penetrated in any other borehole; (5) the presence of an ash-flow tuff unit at the bottom of USW G-2 which has not been previously intersected and which is apparently the oldest unit penetrated to date in the Yucca Mountain Area. Explanations for the preceeding observations on thicknesses of the units are primarily related to their location relative to source area. Exceptions to this generalization are the thinning of the Yucca Mountain and Bullfrog Members. The thinning of the Yucca Mountain Member may be paleotopographically and/or structurally related; the Bullfrog Member, is related partially to structure.

Petrographic observations to be noted are the following: lavas characterized by a rhyolitic top and a dacitic base, indicating reverse compositional zoning; the presence of hydrothermal mineralization in lavas; the presence of resorbed quartz in the lower tuffaceous beds of Calico Hills, the Prow Pass, and Bullfrog Members. The authors suggest that the origin of the resorbed phenocrysts are either from high pressure zones within the magma or from magma which was unsaturated by water.

The fractures tabulated were predominantly open and high angle (40° to 90°); however, it was noted that some of the open fractures might have been previously closed but opened during drilling. The types of fractures identified include both tectonic fractures and cooling joints.

Cooling joints are considered high angle, short in length, and rarely intersect each other. Although the intensity of tectonic fractures varies, a high intensity is typically correlated to a higher degree of welding and presence of lithophysal, vitrophyre, and/or silicified zones. Cooling joints appear in devitrified lava, flow breccia, and bedded tuffs.

Numerous fault zones were identified in USW G-2 particularly within the lithophysal zone of the Topopah Spring Member and below the tuffaceous beds of Calico Hills. Also, noted were a substantial increase in shear fractures below the tuffaceous beds of the Calico Hills. Fault zones were characterized by the presence of slickensides, fault breccia, clay gouge, broken core, and/or missing strata. Faults were identified as being predominantly high angle (greater than 40°) with vertical and lateral components. The high angle of the faults is in agreement with the general regional structural fabric of the area.

Two major faults which intersect the ground surface were located within the borehole. One fault is located 824.2 m below ground, strikes northwest, and dips 55° southwest. This fault places the nonwelded to partially welded tuffaceous beds of Calico Hills against the densely welded to moderately welded unit of the Prow Pass Member with approximately 20 m of displacement. The other fault is located 1424 m below ground, strikes northwest, and dips 65° southwest. This fault displaces the tuff of Lithic Ridge. Another fault which does not intersect the ground surface is located between the two major faults. This fault is located 1015 m below ground and is estimated to be offset 50 m within the Bullfrog Member.

W+A COVER LETTER OF 84/9/7.
THIS REVIEW IN CONJUNCTION WITH
JULY 1984 DATA REVIEW IN DENVER.
PREVIOUS W+A REVIEW OF OFR 83-853
DATED 84/04/09.

Well USW H-5

Bentley, C.B., J.H. Robinson and R.W. Spangler, 1983, Geohydrologic Data for Test Well USW H-5, Yucca Mountain Area, Nye County, Nevada: U.S.G.S. Open-file Report 83-853.

Well H-5 was drilled to a total depth of 1,219 m on June 23, 1982. Geophysical logs were run in test hole H-5 to define lithology, correlate with logs of nearby wells and collect data on porosity in fractures, obtain fluid levels, locate casing perforations in cement, and guage the diameter of the well.

Hydrologic Testing and Water Sampling, Pumping Tests

Drawdown and recovery tests were conducted in conjunction with four pumping periods, after test well USW H-5 had been drilled to its total depth, cased to 790 m and casing perforated below 707 m. Data plots of the drawdown and recovery tests for the third pumping period, and for the recovery test for the fourth pumping period are presented in figures 4 through 6 in the published document. Drawdown data for pumping periods 1 and 2 are not presented in the published document, presumably because * they do not form a straight line or smooth curve as shown in the raw data file. The semi-log plot of drawdown data for pumping period 1 showed that drawdown did not begin until approximately .7 minutes into the test. Water levels decreased at a consistent slope until approximately one minute at which time the slope of the data changed. The slope flattens out until approximately 40 minutes into the test. At that time the data steepens for another 10 minutes and then flattens again until the end of the test at 100 minutes. Overall there are four changes in slope during the duration of the pumping test. A semi-log plot of drawdown data for pumping period 2 indicates that drawdown from approximately .15 minutes until .5 minutes formed a curvalinear line; from .5 minutes to the end of the test at approximately 55 minutes the curve is a fairly straight line and analyzable.

Figure 4 of the published report is a graph of water level drawdown against time for pumping test 3. The depth of interval is from 707 to 1,219 m. This curve is a semi-log graph of water level drawdown in meters versus time after pumping started in minutes. The semi-log plot of the data forms a curvalinear line with the shape very similar to the Theis curve. Unfortunately, this is a semi-log plot.

Figure 5 of the published document is a water level recovery graph for pumping test 3. The depth interval is from 707 to 1,219 m. Again it is a semi-log plot of residual drawdown in meters versus time after pumping stopped in minutes. The semi-log plot again forms a curvalinear line very similar in shape to a Theis curve.

Figure 6 of the published document is a water level recovery graph for pumping test 4. The depth interval is from 707 to 1,219 m. Figure 6 is a semi-log graph of residual drawdown in meters versus time after pumping stopped in minutes. Again the graph forms a curvalinear line with a shape very similar to the Theis type curve.

Packer Injection Test

Packer injection tests were conducted by using inflatable packers to isolate test zones; tests were performed at intervals where hole size and configuration allowed setting of the packers. Water was injected into the interval between two packers or between one packer and the bottom of the hole. Decline of hydraulic head with time was monitored in the isolated interval. Eleven tests were conducted in test well USW H-5 for the intervals between 790 and 1,219 m. Injection curves are plotted in figures 9 through 19 of the published document. The ratio of hydraulic head after injection (H_t) to initial hydraulic head (H_o) is plotted against time since injection began. Semi-log graphs of the water level data for the injection tests form fairly smooth curvalinear curves for figures 9 through 14. Water level data presented in figures 15 and 16 form distorted curvalinear curves on semi-log plots. The reason for the distortion is not explained in the published document. However, the distortions could be attributed to the high initial head during the tests which may have opened fractures within the formation. Water level data presented in figure 17 also are distorted but not to the same degree as figures 15 and 16. Water level data presented in figures 18 and 19 form smooth curvalinear curves.

Note: Figure 7--Borehole flow survey 1 showing percent of total pumping rate produced by intervals. This figure shows that the interval between 700 and 800 m produces most of the water pumped from the well. The interval from 800 to approximately 1,100 m produces much less water. This is probably the reason why the data plots for figures 4, 5, and 6 form curvalinear curves rather than straight line plots for the pump tests.

Well G-1

The drilling polymer used for G-1 had a higher viscosity than the formation water so the results of testing in G-1 are questionable. Seventeen injection tests, fifteen swapping tests, and thirteen shut in tests were attempted in G-1. Four of the injection tests were considered successful by the USGS. Five swapping tests were noted as "OK". Six shut in tests were noted as "OK".

GEOTRANS COVER LETTER OF 84/03/22 GEOTRANS

ATTACHMENT A: SUMMARY OF THE GEOHYDROLOGIC DATA FOR TEST WELL USW H-5

Bentley, C.B., J.H. Robison, and R.W. Spengler, "Geohydrologic data for test well USW H-5, Yucca Mountain Area, Nye County, Nevada," U.S. Geological Survey Open-File Report 83-853, 34 pp., 1983.

Drilling of H-5 was completed on June 23, 1982 to a total depth of 1,219 m. H-5 is located on the Crest of Yucca Mountain at N 766,643 and E 558,943 (Nevada State Coordinate System Central Zone) at an elevation of 1,478.5 meters above sea level. The hole, drilled with air foam by Fenix and Scisson, Inc., has a vertical deviation of less than 2°. The hole is constructed with 4 borehole diameter changes (91.4, 66.0, 37.5, 22.0 cm) and 3 casing diameter sizes (76.2, 40.5, 27.3 cm). The casing has been perforated in the lower portions between a depth of 707 and 790 meters. According to the lithologic log (determined from rock-bit cuttings and seven sidewall core samples), this hole penetrates the stratigraphic interval from the Tiva Canyon member of the Paintbrush Tuff through the Tram unit of the Crater Flat Formation. The hole bottoms out in the dacite lava beds of the Lithic Ridge Tuff. A number of borehole geophysical surveys were conducted upon portions of the test hole. No results of these surveys were presented.

A hydrologic testing program, including two borehole flow surveys, four aquifer tests, and eleven slug injection tests, were completed for the test hole. Of the four pump tests conducted, only one test was of sufficient duration to adequately stress the aquifer system. The interval of testing was between a depth of 707 and 1219 meters. The slug injection tests were performed primarily within the Tram Unit and Bullfrog Member. Four of the eleven tests exhibit unusually shaped trends when compared to the expected analytical solution type curve. Six of the eleven tests were conducted over the same stratigraphic interval. Graphical data are presented on all tests except the first two aquifer tests; no tabular data are given. The borehole-flow surveys showed that about 90 percent of the production in the well is contributed by the zone between 707 and 820 meters below land surface. This is within the Bullfrog Member of the Crater Flat Tuff Formation. Eighteen sporadic water level measurements were reported with this publication. The measurements reported were basically taken during the hydrologic testing program and span the time interval between June 14 and July 25, 1982. Some water elevations were associated with pumping tests and obviously do not represent a static water level and/or shut-in potential level. Those water elevations, taken over discrete test hole intervals (as might be derived from packer installation before a slug injection tests), range from 773.6 to 774.5 meters below ground level. These water-level data suggest little or no vertical gradient, but the packer method of hydraulic isolation within the borehole is susceptible to many possible failures/leaks because of this fracture-dominated flow regime.

Two composite water samples collected after well completion contained 206 and 220 mg/L of dissolved solids. Sodium and bicarbonate were the predominant dissolved anion and cation. The concentration of dissolved silica was 48 mg/L in both samples, which is a relatively large concentration for most natural waters, but not unusual for a siliceous tuff. No other interpretations of any data were present in this report.

H-5
OFR 83-853

WILLIAMS & ASSOCIATES, INC.

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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

April 9, 1984
Contract No. NRC-02082-046
Communication No. 40

Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Jeff:

This letter constitutes my response to your request to review a document entitled "Geohydrologic Data for Test Well USW H-5, Yucca Mountain Area, Nye County, Nevada". The report is identified as U.S. Geological Survey Open-file Report 83-853. It was written by C.B. Bentley, J.H. Robison, and R.W. Spengler.

The subject report presents the lithology of the well as determined from rock bit cuttings and sidewall core. The well penetrates predominantly ash flow tuffs that have experienced varying degrees of welding, alteration, and zeolitization. The report contains a summary of geophysical logs but no geophysical logs. The summary is not interpretive in nature. No core was collected from the hole because the drilling technique did not permit it. The well was drilled with a rotary bit using water, air, and foam to recover the cuttings. A few side hole cores were taken but their limited number does not contribute significantly to the interpretation of the lithology throughout the hole. The total depth of the hole was 1,200 meters.

Four time drawdown type pump tests were conducted on the hole. However, pump test No. 3 is the only one that is usable. The report contains time drawdown data in the form of a semi-log plot for pump test 3, as well as a recovery semi-log plot. The authors did not derive a transmissivity or storativity value from he curves but this could be done with relative ease. We will proceed to do so, If you so desire. The curves are not particularly anomalous.

Injection tests also were run on various intervals in the hole after the intervals had been isolated with inflatable packers. The report presents the curves of head at time t over initial head versus time over each of the intervals tested. No transmissivity values were obtained from these curves either. Some of the curves appear to be rather anomalous but others would lend themselves to analysis for the purpose of determining a value of transmissivity.

Perhaps the most interesting information in the report consists of the borehole flow surveys. They show that about 90 percent of the water in the well during pumping was contributed by the zone between depths of 707 and 820 meters below land surface. These depths are essentially from the water table to a depth f about 113 meters below the water table. Consequently even though the saturated portion of the hole extended between depths of 704 meters and 1,200 meters, the aquifer consisted essentially of only the upper 115 meters of the saturated section. These data reflect a conceptual model of ground water flow in welded tuff that we have discussed previously. Specifically that conceptual model is based on the fact that the welded tuff at the Nevada Test Site is particularly heterogeneous. The heterogeneity probably will make difficult the definition of aquifers and their continuity among drill holes.

If you have any questions about these comments, please call.

Sincerely,

Roy E. Williams

Roy E. Williams
Ph.D. Hydrogeology
Registered in Idaho

:W:sl

xc: Appropriate NRC Offices
M.D. Miffline

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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

April 12, 1984
Contract No. NRC-02-82-046
Communication No. 42

WM Record File B-7377 | WM Project 11
Docket No.
PDR ✓
LPDR N
Distribution:
POHLE
(Return to WM, 623-SS) 15

Mr. Jeff Pohle
Division of Waste Management
Mail Stop SS-623
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Jeff:

This letter constitutes my response to your request to review a document entitled "Chemical Composition of Groundwater and the Locations of Permeable Zones in the Yucca Mountain Area, Nevada." The document is identified as USGS-OFR-83-854. It is dated 1983.

The report describes the results of chemical sampling and borehole surveying of 10 wells in the vicinity of Yucca Mountain. The wells sampled and surveyed are VH-1, H-1, H-4, H-5, H-6, G-4, UE-25b tic tac toe diagram 1, UE-29a tac tac toe diagram 2, J12, and J13. The V well, the H wells, and UE-25b tic tac toe pattern 1 are located on or immediately adjacent to the block.

Samples were obtained for water quality analysis during pumping of water from the entire well bore (open hole) except for the case of well UE-25b tic tac toe pattern 1. The chemical compositions of the water from the open holes are similar among wells. The sample obtained from the packed off interval in UE-25b #1 is not significantly dissimilar from the samples that were obtained from the entire open hole in the same well, except for temperature which is 1.2 degrees higher in the packed off interval. The report states that additional data are to be collected that will facilitate comparison of water quality among vertically discrete zones that have been packed off prior to sampling. These data could be very helpful in the delineation of zones that are hydraulically connected from one well to another. I suggest, however, that the probability of successful differentiation of this type is low. The concentrations of all dissolved constituents exept silica are low enough to preclude the existence of a significant source that might affect separately one or more of the isolated permeability zones. Nevertheless, statistical analysis of data from vertically isolated sampling points should be attempted when these data become available.

Paragraph 2 on page 3 of the report states that "The bottom 9 meters of casing penetrating the saturated zone was cemented. That part of the saturated zone penetrated by casing was perforated." Figure 3 illustrates this procedure. I do not understand why the bottom 9 meters of the casing were cemented when the casing above the cement was perforated. Perhaps the perforations were installed subsequent to cement. The borehole survey log for well H5, shown on figure 6, suggests that the only aquifer in the hole is transected primarily by the portion of the hole that contains the perforated casing. The borehole survey logs constitute the most interesting data in the report. These logs identify the zones which produce the majority of the water in each of the holes. Borehole survey logs are shown for wells UE-25b #1, H-1-H-4, G-4, H-5, and H-6. These are the wells that are located near the periphery of the Yucca Mountain exploratory block. The surveys show that fluid production in most of the wells is from a few discrete permeable intervals. The exceptions are wells H-4 and H-5. In well H-4 the majority of the fluid production came from the upper half of the borehole. The inflow was about uniformly distributed. In well H-5 fluid production came from the upper half of the Bullfrog Member of the Crater Flat tuff. H-5 is the well discussed earlier relative to the necessity for perforating the casing.

The borehole flow surveys constitute the basis for the information presented in figure 11 of the report. Figure 11 is entitled "Vertical distribution of permeable zones in selected wells in the Yucca Mountain area." The figure shows which formations contain permeable zones and where in the formations the zones are located. The figure indicates that the permeable zones are not consistent with respect to the formation in which the zone is located. For example, wells H-1, H-5, and H-6 contain permeable zones in the Bullfrog Member of the Crater Flat tuff. Well J13 and well G-4 contain no permeable zones in this unit. In well J13 the Topopah Spring Member of the Paintbrush tuff is the only major aquifer in the well. None of the other wells are even saturated in this member. The data in figure 11 demonstrate the complexity of attempting to design a drill and test program in this environment. It appears that the design of a drill and test program may have to rely heavily on single hole tests. Unfortunately, several of the wells contain permeable zones that are located immediately below the water table. Most single hole hydraulic tests were not designed for water table use. This observation is supported by the statement on page 16 of the subject report. That statement is "Little or no well to well correlation of permeable zones with lithology exists. However, permeable intervals commonly occur near the water table surface regardless of the geologic unit."

This completes my remarks. I would add only the fact that the borehole surveys clearly are a valuable tool in delineating zones of high permeability within the Yucca Mountain type of hydrogeologic environment. The point made previously with respect to the occurrence of aquifers near the water table in most of the wells is highlighted further by the borehole flow surveys. On the basis of the graphs presented, it would be advisable to design hydraulic testing programs that incorporate unconfined methods.

This concludes my remarks. If you have any questions please call.

Sincerely,

Roy

Roy E. Williams
Ph.D. Hydrogeology
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REW:sl

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M.D. Mifflin

ATTACHMENT A: DATA SUMMARY OF U.S.G.S. OPEN-FILE REPORT 83-854

Benson, L.V., J.H. Robinson, R.K. Blankennagel, and A.E. Ogard, 1983, Chemical Composition of Ground Water and the Locations of Permeable Zones in the Yucca Mountain Area, Nevada.

Analyses of 17 water samples pumped from ten different wells are presented together with flow surveys of six of the ten wells. The ten wells are all located within seven miles of the Yucca Mountain exploratory black. The wells were drilled with foam, using local ground water from well J-13 or, in the case of well H-6, from well VH-1. The wells were fully cased from the ground surface to the water table, below which perforated casing extends 50 to 90 m.

The water sample analyses represent 15 previously unpublished samples taken from December 1980 to December 1982 and two analyses included for comparison from Claassen (1973). The samples are all composite samples with the exception of a sample from a 12 meter interval isolated by inflatable packers in well VE-256#1. Two composite samples representing different intervals are presented for well H-1. The later sample was taken after the well had been cased and then deepened an additional 1100 m. Samples were taken after the wells had been pumped for 2 to 13 days until temperature, specific conductance, and pH became relatively stable and the concentration of lithium, included in the drilling fluid as a tracer for all wells except H-1, approached background levels. Samples were analyzed using previously documented U.S. Geological Survey analytical procedures.

Examination of the major ions plotted as equivalent fractions on trilinear diagrams indicate the waters are all of a strongly sodium bicarbonate type. The samples exhibit a small, but perhaps significant degree of variability. The samples show the greatest disparity in their sodium and bicarbonate concentrations, uncorrected carbon 14 ages, and isotopic compositions. The wells which are most anomolous are J-12, J-13, H-4, H-6, VH-1 and VE-29a#2. There are serious discrepancies in the report between the description of the anomolies given in the text and the values given in the figures and table. Following the values from the figures and table, VE-29a#2 is isotopically heavy, not light, with respect to del-oxygen 18 and del-deuterium and H-4, H-6, and VH-1 are characterized by high, not low, concentrations of sodium, bicarbonate, sulfate and fluoride. Cause and significance of the observed inhomogeneities is not discussed in the report. Although speculative because of the sparsity of data points and unknown vertical influences, possible causes of the chemical variability are apparent and will be evaluated and presented for internal discussion in a forthcoming report.

Borehole-flow surveys are presented for all wells within a mile of the Yucca Mountain exploratory block. The surveys were performed using iodine 131 as an injected tracer as described in Blankennagel (1967). The surveys are shown graphically as depth versus percent of total flow, where the percent of total flow is cumulative from the bottom of the well. The horizontal and step like nature of the curves indicate that fluid production is from discrete permeable intervals. Borehole surveys are discussed for those wells not graphically represented. The majority of wells show flow as being from only a few permeable intervals. The exceptions, H-4 and H-5, do have a step like nature indicating that though the intervals are more numerous, they are still discrete. Well to well correlation of the permeable zones show that permeable intervals occur near the water-table surface. In addition, although the report does not mention the relationship as significant, more then half of the ten wells have a permeable zone in the Bullfrog Member of the Crater Flat Tuff. No other well to well correlations are evident nor are the permeable zones correlated with water chemistries.

W+A COVER LETTER OF 84/09/07.
THIS REVIEW IN CONJUNCTION
WITH JULY 1984 DATA REVIEW
IN DENVER.

Review of Well UE-25b #1

Lobmeyer, D.H., M.S. Whitfield, Jr., R.R. Lahoud, and Laura Bruckheimer, 1983, Geohydrologic Data for Test Well UE-25b #1, Nevada Test Site, Nye County, Nevada, U.S.G.S. Open-file Report 83-855.

This document presents the data base for the hydrogeologic testing conducted on test well UE-25b #1. The well is located in Nye County, Nevada, approximately 145 km northwest of Las Vegas on the Nevada Test Site. The well is located in a major wash which trends northwest from 40 Mile Wash on the east flank of Yucca Mountain. During the hydrogeologic testing program, well UE-25a #1 was used as an observation well. This well is located 107 m south-southwest of well UE-25b #1 in the same wash. The total depth of well UE-25b #1 is 1,220 m. The well was drilled with air rotary and foam. Initially the hole was drilled to a depth of 579 m and tested. Subsequently the hole was enlarged, cased and deepened to 1,220 m. The second episode of testing was conducted shortly after deepening. The third episode of testing utilized packers to determine the vertical head distribution for the four most productive zones. The well penetrates the usual sequence of alluvium, Paintbrush tuff, and Crater Flat tuffs. According to the report, the Topapah Springs Member of the Paintbrush tuff, the Bullfrog Member and the Tram Member of the Crater Flats tuff are the most indurated tuffs in the section. Presumably this means they also are the most fractured.

The report contains a section describing the hydrologic properties of core samples obtained from the hole. The tests on the core samples were performed by Sandia National Laboratory. Matrix porosity was measured on 127 core samples from the interval 589 to 1186 m. According to the data presented in the report, the percent porosity is in the order of 23 to 27 percent in the Bullfrog Member and in the upper portion of the Tram Member. Porosity decreases to 10 percent or less in some portions of the Tram Member and in about 20 percent of the Prow Pass Member. Only limited porosity measurements were taken above the Prow Pass Member of the Crater Flats tuff.

Geophysical logs were used to help select hydraulic test intervals. These logs included the down hole televiewer, the SP log and the temperature log.

Water level observations and measurements were made during drilling, during hydraulic testing and after testing was completed. The purposes of the measurements were: 1) to locate possible perched water in the unsaturated zone, 2) to determine depth at which water saturation occurs, and 3) to determine hydraulic heads in the well for specific zones (vertical distribution of hydraulic head). The four most productive zones as identified by tests between packers and by borehole geophysical logs were between the depths of 546 to 583 m, 585 to 622 m, 789 to 826 m, and 848 to 884 m. The water level measurements for these intervals were respectively, 471 m below land surface, 471.3 m below land surface, 471.5 m below land surface and 471.4 m below land surface. These data indicate that the vertical component of the potential gradient is very nearly zero in this well.

The document lists 24 separate tests that were conducted in borehole UE-25b #1. Most of the tests were labeled injection tests, but three of the tests were pumping tests. Most of the injection tests were conducted between straddle packers. All three of the pumping tests were conducted across the open hole without packers. As discussed previously herein, some confusion exists with respect to the term injection tests. The U.S.G.S. is using the term to be synomynous with a slug test. This test is accomplished by opening the tool between two packers or between one packer and the bottom of the hole to a column of water reaching land surface in the tube that connects the tool to the land surface. The decay of the head in the tube is measured by the falling water level or by falling pressure as the water flows into the portion of the section that is being tested between the packers. These tests should not be confused with the standard term injection test which usually means pumping water into a packed off zone either under constant head or at a constant injection rate. This distinction is important because the methods of analysis of the two types of tests are completely different. The radius of the tubing in which the water level was measured as it was allowed to fall was .031 m in all cases. The data are plotted as the ratio of remaining hydraulic head to the original head (h/h_o) against the log of time on semilogarithmic paper. The method of analysis of these data requires that the resulting curve be matched against a family of type curves published in Water Resources Research by Papadopolus, Bredehoeft and Cooper in 1973. The article is entitled "The Analysis of Slug Test Data". The curves for all the tests are presented in the report under review. In my opinion, only a few of the test results will match a type curve closely. Most of the data definitely do not constitute textbook cases.

The pump tests that were conducted at the site were conducted over the interval 471 to 1,220 m. The first test stressed the aquifer at 13.4 l/sec. The relatively low rate was a consequence of the limitations of the pump (15 l/sec). A second pumping test was conducted after the importation of a larger pump. This test pumped the system at 32 l/sec, but the rates ranged from 26.5 to 36.8 l/sec. The third test stressed the system at 35.8 l/sec. As stated previously, well UE-25a #1 was used as an observation well during the pumping tests. This observation well responded to both test 2 and test 3 (the higher pumping rate tests); however the response was so slight that data may be difficult to analyze. They cannot be analyzed at the scale on which they are plotted in this document. In my opinion the test data from the first pumping test cannot be analyzed. The curves contain fluctuations that preclude the application of standard curve matching techniques. With the data available in this report it is not possible to speculate on the causes of the anomalous drawdown data. The drawdown and recovery curves for the second pumping test are more standard in shape; they can be analyzed. However the drawdown data in particular reflect the influence of boundaries. The drawdown data for the third pumping test also can be analyzed, but these data also reflect the influence of boundaries. Recovery data were not taken for the third pumping test because the recovery data for the second pumping test were considered adequate for purposes of hydraulic property determination.

The borehole flow survey for well UE-25b #1 shows the influence of the aforementioned four permeable zones. The graph shows that the productive portions of this borehole are separated by very tight rock. The aforementioned pumping tests were conducted throughout the entire open hole; consequently, the borehole flow survey graph may explain the barrier boundaries that are reflected by the pumping test data. But other hydrogeologic explanations probably can be defined as well.

With the exception of the confusion over the definition of an injection test (versus slug test) it seems to me that this report is written clearly and accurately. I can see no reason to question the test results aside from the fact that the injection tests perhaps may not match appropriate type curves very well.

ATTACHMENT B: SUMMARY OF THE GEOHYDROLOGIC DATA FOR TEST HOLE UE-25b#1

Lobmeyer, D.H., M.S. Whitfield, Jr., R.R. Lahoud, and L. Bruckheimer, 1983, Geohydrologic data for test well UE-25b#1 Nevada Test Site, Nye County, Nevada: U.S. Geological Survey, Open-File Report 83-855, 48 pp.

This test well is located within a canyon informally known as Drill Hole Wash. The borehole was drilled and tested in a staged approach. Drilling started on April 3, 1981 and was completed to a depth of 579 m below ground. Hydrologic pump testing was completed on this upper interval and the borehole extended to a final depth of 1,220 m below ground. The drilling operations utilized a rotary method with air-foam circulating medium. Drilling methods were appropriate for the geologic conditions. Stabilization methods using cement were utilized in the interval between 337 to 366 m below ground. This interval is within the lower one third of the Topopah Spring Member. The borehole consists of four hole diameter reductions (telescoped) at depths ranging from 914 to 216 mm. The hole is fitted with casing with appropriately cemented intervals and perforated at .23 m intervals from 407 to 588 meters below ground surface. Below a depth of 311 meters, the hole is uncased.

Stratigraphically, the borehole penetrates units from the Tiva Canyon Member of the Paintbrush Tuff down to the Lithic Ridge Tuff. The lithologies consist of variably welded ashflow and bedded tuffs below depths of 45 m. The upper most 45 meters of the strutum hole consists of alluvium.

A total of 141 cores were taken over the depth interval of 589 to 1,186 meters for the determination of selected physical properties. It should be noted that only one core sample was taken from the unsaturated zone. Physical property tests were performed by two DOE contractors, Sandia National Laboratories, and Holmes and Navier Materials Testing

Laboratory. Each core, on the average, represents 4.7 meters of the units penetrated. Detailed results of porosity determinations are graphically displayed. Raw data measurements are unreported. Throughout the interval, porosities range from approximately 7 to 33 percent but generally are less than 25. The Prow Pass Member exhibits a bimodal distribution in response to the welding characteristics of the formation. As expected, an inverse relationship exists between porosity and degree of welding. Variations in porosity of the Bullfrog and Upper Tram Members are less than the Prow Pass averaging approximately 22 percent. The Middle portions of the Tram exhibit a decrease in porosity to approximately 7% at a depth of 1,000 m below ground. The Lower Tram Unit exhibits gradual increases and decreases with depth in porosity. This alternation results in a maxima (25%) being observed at approximate depths of 1100 and 1175 meters and a minima (7%) at 1140 meters below ground. Core descriptions also identified 6 major zones of shear fractures suggesting structural deformation within the stratigraphic section penetrated by the borehole. These zones of shear fractures are concentrated within the Prow Pass Member (depth of 620 m), the Bullfrog Member (depth of 815 m) and the Tram Member (depths of 960, 1020, 1075, and 1125m) of the Crater Flat Tuff Formation.

Water level measurements taken at selected depth intervals suggest negligible vertical flow components. These observations were made in the four most productive intervals of the penetrated units during borehole flow surveys. Static water level was reported to be 471 meters below ground. No time dependent observations were reported.

The hydrologic testing program performed on the test hole consisted of two borehole flow surveys, four pumping tests, and twenty-one slug injection tests. Borehole flow surveys exhibited four productive zones, a total of 49 percent of the production originated from the Bullfrog Member at depths of 820 m and 875 m below ground level. Approximately 40 percent of the production originated from the lower most Calico Hills and the Prow Pass Member at a depth between 550 and 620 meters below ground. Distribution of relative high yield zones can be correlated with zones of increase shear fractures and/or lithologic contacts and the presence of bedded tuffs.

Three pumping tests were completed on the interval from 471 to 1,220 meters below ground at discharge rates ranging from 13.4 to 35.8 liters per second. Two of the tests were conducted with observation wells using test well UE-25a#1. Both drawdown and recovery measurements were observed for pumping tests ranging from 4,320 to 12,960 minutes. No data analysis or supporting measurements are reported;, only, graphical displays of time versus drawdown or recovery are presented.

Approximately one-third of the slug injection tests were conducted upon the Calico Hills Tuffaceous Beds with an additional third, on the Bullfrog Member. No data analysis are presented. The graphical displays exhibit some large deviations from the expected type curve.

W+A Cover Letter of 84/09/07
This review in conjunction with
July 1984 data review in Denver.

Review of Well H-6, Data Report

Craig, R.W., R.L. Reed and R.W. Spengler, 1983, Geohydrologic Data for Test Well USW H-6, Yucca Mountain Area, Nye County, Nevada: U.S.G.S. Open-file Report 83-856.

This review covers the above document and the raw data base as examined at the NTS data review session held in Denver, Colorado on July 23-27, 1984. The document under review presents the results of two pumping tests, water level measurements, tests on core samples, a borehole flow survey, packer-injection tests (actually slug injection tests), and chemical analysis of water for borehole H-6.

Analysis of core consisted of measurement of density, matrix porosity, pore saturation, hydraulic conductivity, and pore water content. A total of 67 m of core were collected in the depth interval 333 to 1,220 m. A total of seventeen segments of core were collected. The document does not contain any of the results of the analysis of core.

According to the report, two pumping tests were conducted in the well. Drawdown and recovery analysis were applied to the results. However, Jim Robison revealed that additional tests have been conducted since the report was completed. The results of these tests were not available. The two tests described in the report covered two productive intervals identified on the borehole flow survey log. These intervals extended from the water table at approximately 525 ft to approximately 780 ft. The results of the tests are presented in the form of semilog graphs of drawdown versus time and residual drawdown versus time. The Jacob straight line method of analysis should be applicable to both sets of curves. However, breaks in the curve indicate that a log-log plot of the data would fall beneath the Theis curve at later times. Transmissivity values are not calculated in the report. They have been calculated in the data file but I have agreed not to comment on them. Some of the curves in the data file are presented in the form of log-log plots of drawdown against time for the lower zone extending from approximately 635 m to 780 m. A packer was set approximately at 780 m and at approximately 625 m in order to conduct a pumping test of the lower productive zone. The resulting curves suggest that this zone is leaky for one reason or another. More than one explanation for the apparent leakage is possible. In this context the term leaky must be used with disgression.

During the first pumping test of the entire section, the pumping rate was 28 l/sec for 4,822 minutes. This test was ended prematurely by mechanical failure of the pump. Consequently no recovery data were obtained. Pumping test 2 was run for 2,226 minutes at a pumping rate of 27 l/sec. However, no data are available for the period 116 to 1,789 minutes because the monitoring instrument was removed to allow access for the borehole flow survey tool. A complete recovery curve was obtained. The data should facilitate the assignment of transmissivity values to the entire section of 2,525 m and 800 m.

The borehole flow survey can be used to divide the transmissivity among the two aforementioned permeable depth intervals in the hole. The tests mentioned above that were run subsequent to the preparation of the report under review can be used to check these procedures. The question raised by the three sets of tests is how to interpret the apparent leaky characteristics of the two aquifers in combination or of the lower aquifer. The leaky lower aquifer would make the combined test appear to be leaky even if the upper aquifer is not leaky. None of the tests display the characteristics of delayed yield. Consequently the system must be acting as a confined system.

The packer injection tests were conducted in the well to obtain transmissivity values for the relatively low permeability zone between depths of 803 m and 1,200 m. As explained previously the packer injection tests are in reality slug injection tests that should be analyzed by the Papadopolus-Bredehoeft-Cooper methods. Slug injection tests for the seven intervals are shown in the report. These tests are identified as test 1 in the depth interval 581 to 607 m, test 2 in the depth interval 606 to 640 m, test 7 in the depth interval 835 to 869 m, test 8 in the depth interval 871 to 1,220 m, and test 10, depth interval 1,155 to 1,220 m. Data are plotted in the form of standard slug tests coordinates of H/H_o versus time. Several of the curves probably will not fit type curves very well. Two of the curves (test 7 and test 8) have anomalous humps that should be explained in some manner.

The raw data base examined at the workshop indicates that ten slug injection tests were performed on well USW H-6. Comparison of the report with the data base reveals that test 9, test 6 and test 5 were not used in the report. Examination of the field data suggest that test 5 was not used in the report because it was not run for a sufficient length of time. The total length of the test was 3.9 minutes. The reason for the length of the test is not obvious. Apparently test 6 was not used because the shut-in test following the slug injection test revealed that something had gone wrong with the system. Test 9 was not used because the curves revealed that something had malfunctioned.

ATTACHMENT C

Summary of Geohydrologic Data for Test Well USW H-6

Craig, R.W., R.L. Reed, and R.W. Spengler, 1983, Geohydrologic data for test well USW H-6, Yucca Mountain area, Nye County, Nevada: U.S. Geological Survey Open-File Report 83-856, 35 p.

Test well H-6 was drilled to a depth of 1220 m and encountered ash-flow tuffs and lava beds associated with the Lithic Ridge Tuff. The hole is located west of the fault scarp of the Yucca Mountain Repository Block to determine if the geohydrologic conditions as found in the test wells east of the scarp are similar. Drilling operations resulted in a 1.5° maximum hole deviation (16 m from vertical) with no unusual drilling problems except the loss of circulation at a depth of 1120 m. Cores totaling 67 m were taken from the depth interval between 333 and 1220 m below ground level. The cores were submitted for determination of bulk density, matrix porosity, pore saturation, and pore-water content. Core recovery was calculated to be 92%. No core analysis on hydrologic parameters was reported in this report.

A lithologic description of the units penetrated was based upon core and rock-bit cuttings. The units are predominantly ash-flow tuffs and bedded tuffs except for the interval from 877 to 1126 m below ground. This interval is characterized by dacitic lava. The tuffs exhibit varying degrees of welding, mineralogical composition, and secondary alteration.

A similar range of geophysical surveys was conducted on the borehole as on the previously reviewed test wells. Again, only depth intervals were summarized with this report; no surveying results, geophysical log profiles, and/or additional data compilation were presented.

A hydrologic testing program was conducted on the test hole. Water levels taken sporadically over a two-month period exhibited a static water level at approximately 780 m above sea level. These water levels were derived during various log surveys and pumping tests. It should be noted that most water level measurements were taken over a rather large test hole interval (525 to 1220 m below ground).

Two single well pumping tests were performed. The first pumping test was conducted over the entire interval of the hole for a pumping period of over 4,000 minutes. This test was ended prematurely due to mechanical failure and resulted in obtaining no water level recovery data with the test. The test exhibited approximately 18 m of drawdown after pumping at a 28 l/sec discharge rate. The second pumping test exhibited 11 m of drawdown at a rate of 27 l/sec for 2,226 minutes of discharge. Semi-logarithmic data plots of drawdown versus time show multisloped lines characteristic of fracture-dominated systems.

No quantitative analyses are presented with the report. Nine packer injection surveys were conducted on the stratigraphic unit below the Prow Pass Member penetrated by the test hole. Data plots of the results are provided without quantitative analysis. Six of the nine tests were conducted within the Bullfrog and Tram Members.

One borehole flow survey was completed on the hole. The survey results indicate that 90% of the production originates from two distinct intervals. These intervals are from 616 to 631 m and 777 to 788 m below ground level. The two production intervals are located within the Bullfrog and the Tram Members, respectively. No measurable flow was detected below 803 m.

A composite water sample was taken near the termination of pumping test 2. The uncorrected Carbon-14 age of the water is 14,600 years b.p. Inorganic water quality analyses exhibit concentrations typical of a sodium bicarbonate water. Total dissolved solids concentration was 263 mg/l.