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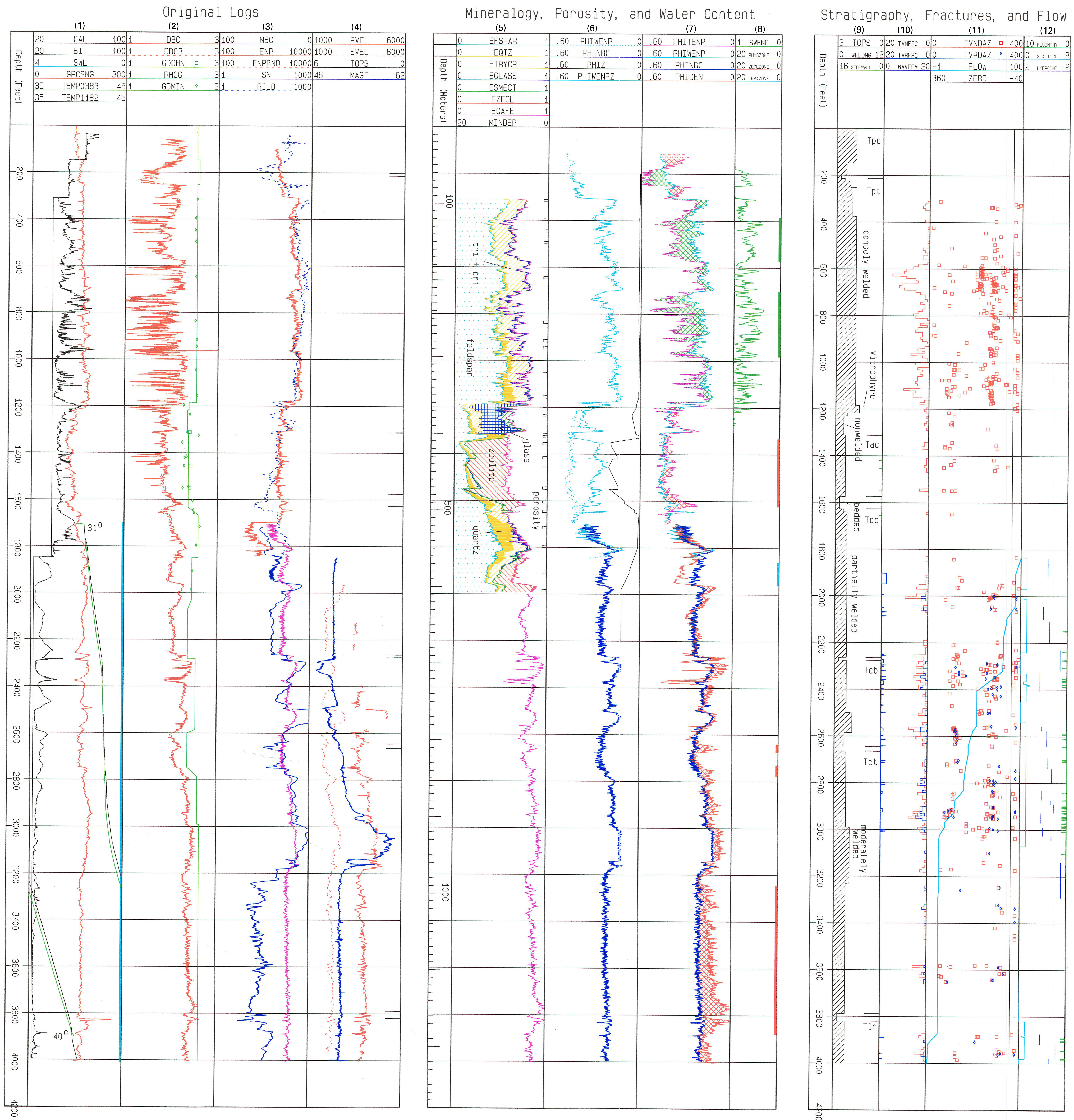
USW H-4



Petrophysical Properties, Mineralogy, Fractures, and Flow Tests in 25 Deep Boreholes at Yucca Mountain, Nevada

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BOREHOLE USW H-4, YUCCA MOUNTAIN, NEVADA

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Borehole H-4 was completed in June, 1982 to a total depth of 4000 feet. The hole was rotary drilled using air foam consisting of air, detergent, and water (Whitfield et al., 1984). A few sidewall cores were obtained as indicated by ticks labelled sidewall in column 9. Depth on the plot is measured along hole, and has not been corrected for deviation. Hole deviation is slight, (Plate 11 in Nelson and others, 1991): at a true vertical depth of 3979.4 feet, the measured depth is 3980 feet and the horizontal offset is 43 feet.

Original logs in columns 1-4, acquired between April 1, 1982 and May 10, 1982, were described and presented by Nelson and others, 1991. Two temperature logs (Sass and others, 1988) obtained in November 1982 and March 1983 also appear in column 1.

Mineralogy in column 5 is derived from X-ray diffraction data by Bish and Chipera (1989). Their data have been converted to volume percent, combined with porosity, and in several places extrapolated to boundaries inserted where marked changes in log response occur.

Estimates of total water content in column 6 are derived from the epithermal neutron log (phiwenp) and thermal neutron log (phinbc). Between 1698 and 1841 feet phinbc can be compared with phiwenp. Structural water phiz is estimated from mineralogy and subtracted from phiwenp to form an estimate of water in pore space, phiwenpz.

Porosity (phitenp, phiden) and water content (phiwenp, phinbc) are given in column 7. Phitenp and phiwenp were computed from epithermal neutron and density logs (Nelson, 1994). Phiden was computed from density log. Because there are no core-based constraints on rhog below 2000 feet, porosity phiden is less accurate below 2000 feet. Green hatching between the porosity and water content curves denotes air-filled porosity. Red hatching appears where water content exceeds porosity, often indicating the presence of zeolitic minerals.

Saturation (column 8) is computed as the ratio of phiwenp to phitenp from 100 to 1305 feet. The flags physzone and zeolzone (green and red bars in column 8) denote the presence of abundant lithophysae and extensive alteration, respectively. Their depth extent is taken from inspection of the green and red hatch areas in column 7 and from consideration of other logs, especially resistivity, sn. Separation of porosity and water content occurring at a zone marked invazone is attributed to invasion of air into formation during drilling. This zone is probably a high permeability zone.

Stratigraphic tops and degree of welding, given in column 9, are taken from Whitfield and others, 1984.

Disruptions in the sonic waveform log (wavefm, column 10) are often due to fractures or faults. Temperature gradient logs, dtmp, were not computed due to the pronounced isothermal zones separated by discrete temperature increases, as exhibited in column 1. Plots of individual fractures, column 11, observed on televiewer (tvrdaz) and television (tvndaz) logs are plotted to show the azimuth of the dip of each fracture. The same data are plotted as fracture density (tvrfrc, tvnfrc) in column 10. The televiewer log extends from 1825 to 3975 feet. Television log extends from 312 to 3980 feet with a gap from 1657 to 1830 feet due to foam on borehole wall.

A flow log (Whitfield and others, 1984) shown in column 11 was derived from tracer tests carried out during a pump test. Points of fluid entry (fluentry, column 12) were interpreted from a temperature log run during a pump test (Erickson and Waddell, 1985). Zones where tracer tests were carried out under static (nonpumping) conditions are indicated as stattrcr, indentations in these intervals occur where fluid entry or exodus was interpreted from progressive changes in tracer profiles. Hydraulic conductivity values (hydrcond) from a pumping test were prorated along the pumped interval on the basis of the flow log (Whitfield and others, 1985).

EXPLANATION OF CURVES AND SYMBOLS

Column 1
CAL Caliper in cm, black curve.
BIT Bit size in cm, black line.
SWL Static water level, vertical cyan bar.
TEMP Temperature in degrees C, two colors dated by month, year.
GRCSNG Gamma ray in API units, casing effect removed, red curve.

Column 2
DBC Density in g/cm3, red curve.
DBC3 Density bound in g/cm3, red dash curve.
RHOG Grain density in g/cm3, green curve.
GDMIN Grain density from mineralogy, green diamonds.
GDCHN Grain density from core, green squares.

Column 3
ENP Epithermal neutron in counts/sec, red curve.
ENPBND Epithermal bound, red dash curve.
NBC Thermal neutron log in porosity, magenta curve.
RILD Induction resistivity in ohm-m, blue dot curve.
SN Short normal resistivity, in ohm-m, blue curve.

Column 4
PVEL Compressional-wave velocity in m/s, red curve.
SVEL Shear-wave velocity in m/s, red dot curve
MAGT Total magnetic field in microTesla, blue curve.
TOPS Stratigraphic boundaries, black ticks.

Column 5 [shaded areas represent volume fractions]
EFSPAR Feldspar, blue dotted area to left-hand edge.
EQTZ Quartz, dark yellow area.
ETRYCR Tridymite + cristobalite + opal, light yellow.
EGLASS Glass, blue gridded area.
ESMECT Smectite + kaolinite, green slanted area.
EZEOL Clinoptilolite + mordenite + analcime, red slant.
ECAFE Calcite + hornblende + hematite + chlorite, magenta hatch.
Porosity Unshaded area to the right-hand edge.
MINDEP Depth of x-ray diffraction samples, ticks.

Column 6 [fractional volume of whole rock, increasing to left]
PHIWENP Water-filled porosity, from ENPBND and DBC3 logs, cyan dot curve.
PHIWENPZ Water-filled porosity, structural water removed, cyan curve.
PHIZ Structural water, black curve.
PHINBC Water content from corrected NBC, blue curve.

Column 7 [fractional volume of whole rock, increasing to left]
PHIWENP Water-filled porosity, from ENPBND and DBC3 logs, cyan curve.
PHITENP Porosity, from ENPBND and DBC3 logs, magenta curve.
(green hatch where PHITENP > PHIWENP, red where PHITENP < PHIWENP).
PHIDEN Porosity, computed from DBC3 log, red curve.
(red hatch where PHIDEN < PHINBC).
PHINBC Water content from NBC, blue curve.

Column 8
SWENP Water saturation, ratio of PHIWENP to PHITENP, green curve.
PHYSZONE Lithophysal zone, picked from logs, green bar.
ZEOLZONE Zeolitic zone, picked from logs, red bar.
INVAZONE Zone where air invaded the formation during drilling, cyan bar.

Column 9
TOPS Stratigraphic boundaries, black ticks.
WELDNG Degree of welding from core inspection, black slant.
SIDEWALL Location of sidewall samples, green ticks.

Column 10
WAVEFM Disruptions in sonic waveform log, blue ticks and bars.
TVRFRC Number of fractures per 10 feet, from televiewer, blue.
TVNFRC Number of fractures per 10 feet, from television, red.

Column 11
FLOW Flow log from tracer tests while pumping, cyan curve.
TVRDAZ Dip azimuth of fractures, from televiewer, blue diamonds.
TVNDAZ Dip azimuth of fractures, from television, red squares.
Undetermined azimuth is coded as 380 or 390 degrees.

Column 12
STATTRCR Intervals of tracer tests under static conditions, cyan lines.
FLUENTRY Points of fluid entry from temperature log during pump test, green.
HYDRCOND Hydraulic conductivity, in m/day, blue line.

Stratigraphic Names
[Unmarked ticks are bedded units]

-Paintbrush Group-
Tpc Tiva Canyon Tuff
Tpp Pah Canyon Tuff
Tpt Topopah Spring Tuff

Tac Calico Hills Formation

-Crater Flat Group-
Tcp Prow Pass Tuff
Tcb Bullfrog Tuff
Tct Tram Tuff

Tlr Lithic Ridge Tuff

NOTES

Date of last computation: October 1995
Plot Date: November 1995
Scientific Notebook: SN-0092

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