SCIENTIFIC NOTEBOOK #432e

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USFIC KTI

Volume V – PTn and PTn Analog

April 18, 2002 notebook submission
Volume V, Pages 6-8

PTn and PTn Analog Site

RF 6/1/01

Introduction

Flow through heterogeneous and fractured nonwelded tuff is the focus of volume II of sci ntbk 432. DOE uses flow through a homogeneous nonwelded tuff in dual-permeability (matrix and fracture continua) model simulation results to support temporal and spatial dampening of percolation pulse traversing the Tiva Canyon welded units above the PTn. Initial efforts will be to establish the basal Bishop Tuff (Bishop, California) as a reasonable analog to the PTn at Yucca Mountain. The more scientific interesting objective is to assess in the field and the laboratory the flow patterns and processes for water flowing through a fractured nonwelded tuff; in particular, analyze the fracture and flow variations as a function of the degree of welding (and other textural variations).

Collaborators are James Evans, Jason Heath, and Kelly K. Bradbury (Utah State University), Craig Forster (University of Utah – Salt Lake City), David Ferrill (CNWRA).

Initial Estimates of Hydraulic Properties of PTn

Calculation of PTn means, minimums, and maximums for measured and/or estimated (regression from porosity) was done using the deep borehole data from Flint (1998), which I have in electronic format. I sorted all the thermal-mechanical PTn units that are part of the hydrostratigraphic PTn, put the data into a separate file, and created a 2nd worksheet in that file using QuattroPro (version 8.0.0.611):

J:\HydroProperties\PTnFault\ptn.wb3 worksheet: "Avg by Unit"

Measurements were only made on some of the core samples; estimates for all other cores were based on regressions using porosity. The estimates are described in Flint (1998); i.e., they are not my estimates.

Avg Ks (m/s) of measured values	Avg Ks (m/s) of estimated values	unit	minimum of measured values	maximum of measured values
ERR	2.11695228567487E-07	pv2	ERR	ERR
2.9720206E-07	1.22946799255412E-06	pv1	1.06E-11	8.787E-07
4.41539333333333E-06	2.13641890338179E-06	Tpbt4	1.8E-10	1.1E-05
8.03124166666667E-07	8.18038682304171E-07	Tpy	1.92E-09	3.27E-06
2.51528571428571E-06	1.82277943498609E-06	Tpbt3	1.058E-06	7.3E-06
1.1173E-06	3.67884362989457E-06	Tpp	9E-08	1.742E-06
5.19707E-06	3.20480910714392E-06	Tpbt2	5.055E-07	1.31E-05

ERR means that there were no measured data for that unit (the Tiva Canyon basal vitric that grades from welded to nonwelded: pv3, pv2, pv1).

Reference:

Flint, L.E., 1998. Characterization of Hydrogeologic Units Using Matrix Properties, Yucca Mountain, Nevada, Water-Resources Investigations Report 97-4243, Denver, CO: U.S. Geological Survey.

Field Work at Bishop

6/30/01 RF

Field notebook #428 contains notes taken in the field during the June 12-14, 2001 initial scoping of the Bishop site, which is immediately north of the town of Bishop, CA. Three bucket infiltration tests were done to roughly estimate the saturated permeability of two of the nonwelded units [matrix supported ignibrite and pumice clast supported bedded (likely reworked) tuff]. The data was directly entered into a computer, and the file was imported to this scientific notebook.

Falling Head Bucket Tests in Bishop Tuff June 14/01

Test #1 - Falling Head Bucket Test at Quarry Site (see page 53 of Sci Ntbk #428).
Location: Lower Unit exposed Quarry Site. Fractures largely absent even though unit has fractures on south side of Quarry.
June 14/01

Time (hr:min:sec)	Del T (min)	Level #	Del h (cm)	Del Vol (cm^3)	q (cm/min)
10:01:00-		0	-	-	-
10:10:00	9:00	1	1.0	137.9	0.40
10:15:00	5:00	2	0.5	69.0	0.036
10:22:00	7:00	3	0.5	69.0	0.026
10:30:00	8:00	4	0.8	110.3	0.036
10:42:00	12:00	5	0.8	110.3	0.024
10:50:00	8:00	6	0.6	82.7	0.036
11:20:00	30:00	7	2.5	344.8	0.036
11:30:00	10:00	8	0.7	96.5	0.036

Reconnaissance K ~ 0.036 cm/min ~ 6 x 10^-4 cm/sec

Test #2 - Falling Head Bucket Test at Horton Cr. – Ash Fall Tuff , bedded, pumice clast supported.
Location: Upper part of lower unit (see page 54of Sci Ntbk #428).
June 14/01

Time (hr:min:sec)	Del T (sec)	Level #	Del h (cm)	Del Vol (cm^3)	q (cm/sec)
14:42:30-		0	-	-	-
14:43:00	0:30	1	1.0	137.9	0.012
14:43:30	0:30	2	0.5	69.0	0.0061
14:44:05	0:35	3	0.5	69.0	0.0052
14:44:50	0:45	4	0.8	110.3	0.0064
14:45:45	0:55	5	0.8	110.3	0.0053
14:46:45	1:00	6	0.6	82.7	0.0036
14:48:05	1:20	7	1.0	137.9	0.0045
14:49:25	1:20	8	0.7	96.5	0.0032
14:50:50	1:25	9	0.8	110.3	0.0034
14:52:00	1:10	10	0.7	96.5	0.0036

Reconnaissance K ~ 0.0036 cm/sec

Test #3 - Falling Head Bucket Test at Horton Cr. – massive, matrix supported ignimbrite.
Location: lower part of upper unit (see page 54of Sci Ntbk #428).
June 14/01

Time (hr:min:sec)	Del T (min)	Level #	Del h (cm)	Del Vol (cm^3)	q (cm/min)
15:30:20-	0		-	-	-
15:38:308:30	1		1.0	137.9	0.045
15:44:306:00	2		0.5	69.0	0.030
15:53:309:00	3		0.5	69.0	0.020
16:04:006:30	4		0.8	110.3	0.045
16:16:0012:00	5		0.8	110.3	0.024
16:26:0010:00	6		0.6	82.7	0.022
16:40:3013:30	7		1.0	137.9	0.027
16:54:0013:30	8		0.7	96.5	0.019
17:04:0010:00	9		0.8	110.3	0.029
17:14:0010:00	10		0.7	96.5	0.025

Reconnaissance K ~ 0.025 cm/min ~ 4 x 10^-4 cm/sec

Test Method

- excavate surface until into slightly moist zone
- flatten surface then cut 0.5" wide circular groove to fit bucket bottom
- use plumber's putty to seal bucket bottom into groove
- weight bucket and tamp down putty
- add about 10 cm water to bucket and monitor decline

Bucket Dimensions

- diameter at initial water level is 27 cm; at final level is 26 cm
- volume of water released with level decline computed using 26.5 cm
- bucket inside diameter at contact with formation
  - ~ 22 cm measuring only from putty seal to putty seal
  - ~ 24 cm measuring from rim to rim
- area of flow through bucket base computed using 22 cm diam
- Level Marks

	Cm from Top Mark	
Level #	Test #1	Tests #2, #3
0	0	0
1	1.0	1.0
2	1.5	1.5
3	2.0	2.0
4	2.8	2.8
5	3.6	3.6
6	4.0	4.0
7	6.5	5.0
8	7.2	5.7
9	-	6.5
10	-	7.2

Note that additional, intermediate level marks were added after Test #1

Note on calculations of saturated hydraulic conductivity (K) estimates:
Reconnaissance K estimates were made using Darcy's Law, assuming steady state saturated flow towards end of test, and assuming a unit vertical gradient

6/28/01

Locations of 8 stops during the Bishop field work (see field scientific notebook #428) of June 13-14, 2001are noted on the figure below:

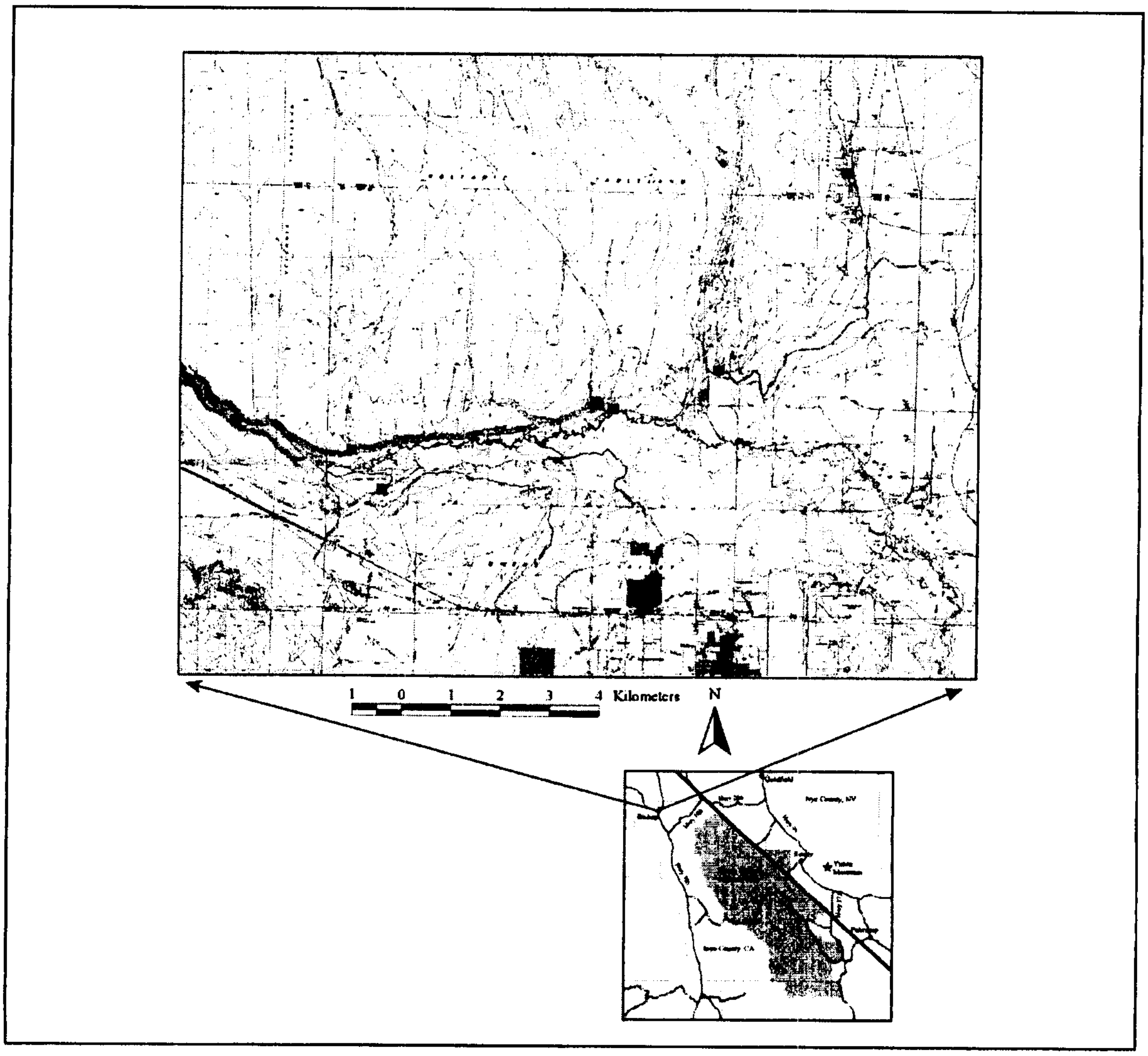

Table of saturated hydraulic conductivity values for the non- to partially welded Bishop Tuff, the nonwelded Paintbrush (PTn), and shardy base unit of the Tiva Canyon (TC)

	lithology	K_{sat}, cm/s	source
Bishop Tuff	nonwelded massive ignimbrite	$4x10^{-4}$, $4x10^{-4}$, $2x10^{-3}$	our field work, falling head range & disc infiltrometer
Bishop Tuff	pumice-rich airfall tuff	$4x10^{-3}$	our field work
Bishop Tuff	indurated (?) ignimbrite	$4x10^{-6}$ to $6x10^{-6}$	Tokunaga and Wan (1997)
Bishop Tuff	friable ash, pumice, tuff	$7x10^{-3}$ to $5x10^{-2}$	Hollet et al. (1991)
Tpbt4,3,2 (PTn)	bedded tuff	$6x10^{-4}$ (mean)	Flint et al. (1996)
Tpy (PTn)	Yucca Tuff	$2x10^{-5}$ (mean)	Flint et al. (1996)
Tpp (PTn)	Pah Canyon Tuff	$2x10^{-6}$ (mean)	Flint et al. (1996)
TC shardy base	upper ash flow	$2x10^{-5}$ (mean)	Rautman et al. (1995)
TC shardy base	lower ash flow	$1x10^{-2}$ (mean)	Rautman et al. (1995)
TC shardy base	basal pumice-rich airfall	$1x10^{-1}$ (mean)	Rautman et al. (1995)
pv1	basal Tiva Canyon tuff	$1x10^{-4}$ (mean)	Flint (1998)
Tpbt4	upper bedded unit	$2x10^{-4}$ (mean)	Flint (1998)
Tpy	Yucca Tuff	$8x10^{-5}$ (mean)	Flint (1998)
Tpbt3	middle bedded unit	$2x10^{-4}$ (mean)	Flint (1998)
Tpp	Pah Canyon Tuff	$4x10^{-4}$ (mean)	Flint (1998)
Tpbt2	lower bedded unit	$3x10^{-4}$ (mean)	Flint (1998)

References:

Flint, L.E., 1998. Characterization of Hydrogeologic Units Using Matrix Properties, Yucca Mountain, Nevada, Water-Resources Investigations Report 97-4243, Denver, CO: U.S. Geological Survey.

Flint L.E., A.L. Flint, C.A. Rautman, and J.D. Istok, 1996. Physical and Hydrologic Properties of Rock Outcrop Samples at Yucca Mountain, Nevada, Open-File Report 95-280, Denver, CO: U.S. Geological Survey.

Hollett, K. J., Danskin, W. J., McCaffrey, W. F., and Walti, C. L., 1991, Geology and Water resources of Owens Valley, California, U. S. G. S. Water Supply Paper 2370-B.

Rautman, C.A., L.E. Flint, A.L. Flint, and J.D. Istok, 1995. Physical and Hydrologic Properties of Outcrop Samples from a Nonwelded to Welded Tuff Transition, Yucca Mountain, Nevada, Water-Resources Investigations Report 95-4061, Denver, CO: U.S. Geological Survey.

Tokunaga, T.K. and J. Wan, 1997. Water film flow along fracture surfaces of porous rock, WRR, v. 33(6), pp. 1287-1295.

Volume V - PTn and PTn Analog Site **10/18/01** RF

HYDRUS2D (version 2.02) modeling of July 2001 field dye tracer tests

1. Include anisotropy to reproduce overall shapes of the entire cross-section.
2. Isolate the effect of fractures on flow by creating a small, idealized discrete feature grid that includes a couple fractures; this would reproduce the effect of enhanced flow caused by the constraining, low permeability fractures. Maybe also include clasts (low permeability pumice) to illustrate the shadowing. The discrete feature representation would assume heterogeneous, but isotropic properties.

There may be a problem with using HYDRUS2D for the discrete features because of smoothing caused by the FEM representation of HYDRUS2D. Grid refinement in HYDRUS2D will be the key. However, the caliche in fractures spreads into the matrix, therefore a smoothed contact is probably reality. To reduce smoothing, Multiflo could be used, with nodes shifted to near the contact.

Figure and tables of PTn and Bishop Tuff hydrologic properties for AGU poster were developed from our field and laboratory measurements (sci ntbk#428, 432, 476, 477), Flint (1998), Flint et al. (1995), and Rautman et al. (1995). The figure was created in worksheet "Analog Compare" of file: E:\Presentations\Fall_AGU2001\PTn-Analog\Kdata.xls.

Flint (1998) data (used geometric mean from table 7 of the report, used my extraction of minimum and maximum from Lorrie's database, E:\HydroProperties\PtnFault\PTn\ptn.wb3 using Quattro Pro version 8.0.0.709)

Table 4a and 4b of the AGU poster are contained in the worksheet "LabData-Dani" of the file: E:\Presentations\Fall_AGU2001\PTn-Analog\Kdata.xls. The field and laboratory parameter estimates come from Dani's notebook (#354) while the Guelph permeameter data was estimated in the Excel 97 SR-2 worksheet "July2001" of the spreadsheet file: E:\HydroProperties\PTn-Analog\infilt.xls. The procedure for analyzing the Guelph permeameter data is outlined in the instruction manual that comes with the Guelph permeameter.

The plot in figure 4b of the AGU poster was created in the worksheet "Gardner_vanGen" of the file: E:\Presentations\Fall_AGU2001\PTn-Analog\Kdata.xls. The parameter values for this plot come from Dani's laboratory estimates (sci ntbk#354).

Simulations

Three series (base names) were used here:

(i)	.\Hydrus2d\Bishop\unfract-?	Homogeneous or 2-layers; 750 nodes, 1392 elements
(ii)	.\Hydrus2d\Bishop\fract-?	Homogeneous or 2-layers, anisotropic; 750 nodes, 1392 elements
(iii)	.\Hydrus2d\Bishop\bishop-?	Discrete features for fractures

Table of Simulations: Properties, Initial and Boundary Conditions

	Pond Height, cm	Pond Width, cm	Initial Condition, cm	van Gen. α, cm^{-1}	Ksat, cm/min		comment
unfract-1				.0068			
unfract-2							
unfract-3							
unfract-4							
unfract-5							
unfract-6							
unfract-7							
unfract-8							
unfract-9							
fract-9				0.006			
Bishop-0							
Bishop-1							
Bishop-2							
Bishop-3							
Bishop-4							

Field values for saurated hydraulic conductivity were about 0.036 cm/min, lab values were around 0.0083 cm/min. The field values represent a volume more comparable to the grid scale of the simulations, but they also reflect the properties of the upper (near surface) texture. Hence, the field values may be an over-prediction of the properties of depths in the range of 25-125 cm, which covers most of the wetting front and dye plume.

The manual calibration process focused on the varying the initial condition and the hydraulic conductivity, anisotropy of unfractured tuff, and van Genuchten α; in order of importance to calibration. The primarily difficulty in the calibration was getting the lateral movement of water due to capillary drive to match the water/pressure head "plume" width. The focus was on matching the wet area of test. Matching the dye tracer plume width was considered secondary in this round of modeling, except to simulate some of the features of the dye tracer movement such as the separation from the fractures and promotion of movement in the matrix.

In the poster for Fall 2001 AGU, unfrac-9, frac-9, and Bishop-4 were used in the figures of the modeling section (section 6).

References

Flint, L.E., 1998. Characterization of Hydrogeologic Units Using Matrix Properties, Yucca Mountain, Nevada, Water-Resources Investigations Report 97-4243, Denver, CO: U.S. Geological Survey.

Flint L.E., A.L. Flint, C.A. Rautman, and J.D. Istok, 1996. Physical and Hydrologic Properties of Rock Outcrop Samples at Yucca Mountain, Nevada, Open-File Report 95-280, Denver, CO: U.S. Geological Survey.

Hollett, K. J., Danskin, W. J., McCaffrey, W. F., and Walti, C. L., 1991. Geology and Water resources of Owens Valley, California, USGS Water Supply Paper 2370-B, U.S. Geological Survey.

Rautman, C.A., L.E. Flint, A.L. Flint, and J.D. Istok, 1995. Physical and Hydrologic Properties of Outcrop Samples from a Nonwelded to Welded Tuff Transition, Yucca Mountain, Nevada, Water-Resources Investigations Report 95-4061, Denver, CO: U.S. Geological Survey.

Tokunaga, T.K. and J. Wan, 1997. Water film flow along fracture surfaces of porous rock, Water Resources Research 33(6), pp. 1287-1295.