308 --- Q200312100010
Scientific Notebooks No. 068: Stochastic Project: BIGFLO Modification and Simulations (03/08/1993 through 12/16/1996)

S149
R
150

129.162.50.12 — ASHOK PC

cf77 filename -o ex ← to compile on INEL CRAY

129.162.200.219 — DIV 20 IRIS

mail abagtzog@sisyphus
Subject: ...
:
CTRL D

mohanty@sebastian.cnwra.swri.edu

SUBJECT: BIGFLO MODS & SIMULATIONS

PROJECT: 20-5704-053 (STOCHASTIC)

Used by:

Ashok Nedungadi

All work conducted under the auspices of the Stochastic Project. Tasks described in Project Plan.

0 78910 13932 5

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[redacted]

BIGFLOW version 2.0 is used throughout

03/08/93

- In NLCOND : J1, J2, J3 & I1, I2, I3 are used inconsistently especially if J1 cells are active.
- In NLCOND : when ALFDEUV was changed to BTDEU, the code has become inflexible
  - For Vangenucht → need BTDEV
  - for other (as was) → need ALFDEU
  - Not using BTGM anywhere in code.

needs to be corrected if NLCOND is to be made flexible

NLAGA1
NLAGA2
NLAGA3

03/09 IN THETA30 : ACAP(N1, N2, N3)

However in SUBFLO

ACAP(N1CAP, N2CAP, N3CAP)

For LTRANS = 0 (Steady State)

N1CAP = 1

N2CAP = 1

N3CAP = 1

∴ IN NLCOND, when calling

THETA30 → ACAP(N1, N2, N3)

did this because ACAP was not being passed properly from THETA30 to NLCOND.

∴ NLCOND → ACAP(N1CAP, N2CAP, N3CAP)

because in the original code, ~~when~~ calling routine of THETA30 had ACAP(N1CAP, N2CAP, N3CAP)

This didnt work either.

ACAP defined correctly in THETA30 but when it is passed to NLCOND I get only ~~~~ "0" ???

NLAGA1, .. 3 = 0

NLCOND ← → THETA30

~~PROBLEM OF NPP1/NP1 needs to be corrected in all cases of NLCOND! Presently, only implemented for case (4).~~

NPP1 = Tot Nodes

NP1 = NPP1 - 1

N1 = NPP1 - 2

~~In THETA30 ACAP(J1, J2, J3) instead (J-1 ...)~~

ADDING ANOTHER 3D DIMENSION MOIST

VERIFICATION =

- w PORFLOW
- w OLD BIGFLO USING BEST GARDNER FIT TO THE VANGEN THAT WE ARE USING

HEAD_T1 → messed up

MIDFLOW VANGEN TRUE THEN
LD(50)+ = NPP1 × .. B
ELSE
(II) Don't add.

- VANGEN needs to be in a common block
- Also dont compute faces of TMOIST if VANGEN is false in THETA3Ø

To make the change to ABIG:
(To add): Do the following:

- LD(51) = LD(50) + NPP1 × NPP2 × NPP3 (reg array)

MMDIM = MMDIM + MPP1

03/10/93

From INPUT1 (VANGEN STYLE)

$K_{SAT} = 140$

$\alpha = 7.299 \cdot 10^{-2}$

$\theta_s = 0.3$

$\theta_r = 0.055$

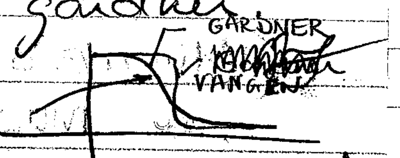
$\beta = 2.9227 \cdot 10^{-2}$

$n = 2.0304$

We used the above to calculate K(h) vangenuchten then fitted a straight line in semi-log scale to get the $\tilde{K}_s$ and $\tilde{\alpha}$. This was then inputted into BIGFLO with gardner.

Compared Results.

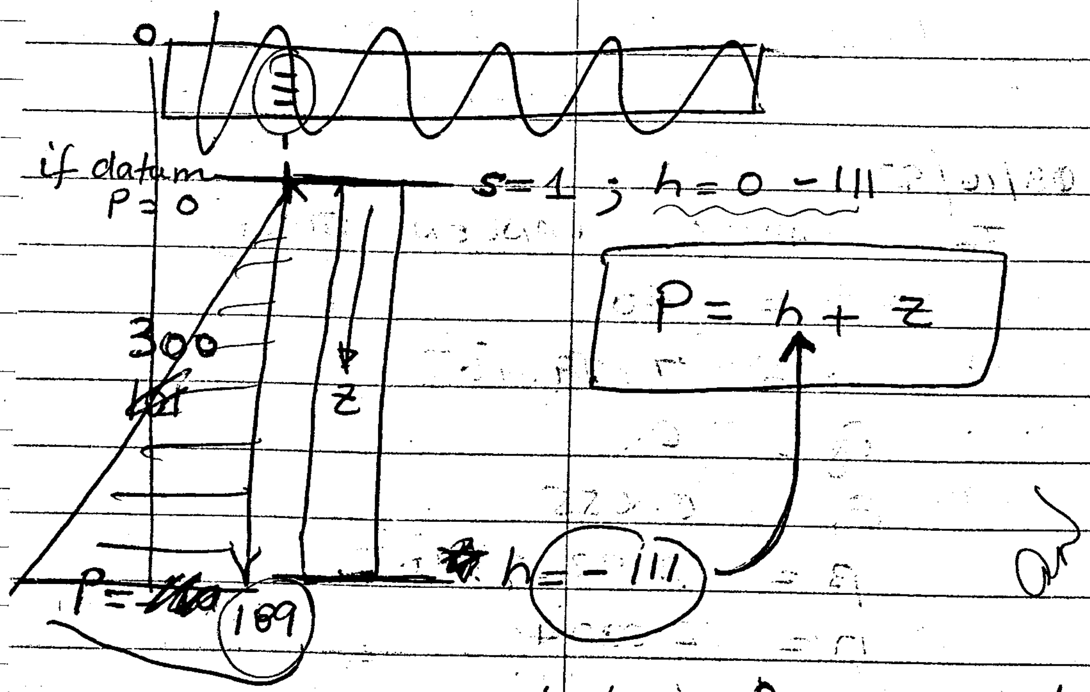
(OK)



NOT EXACT BUT BALL PARK (AVERAGE OK)

6 set termal/width=132/sn

Comparison w. PORFLOW
θ, K Vangenuchten-Mualem

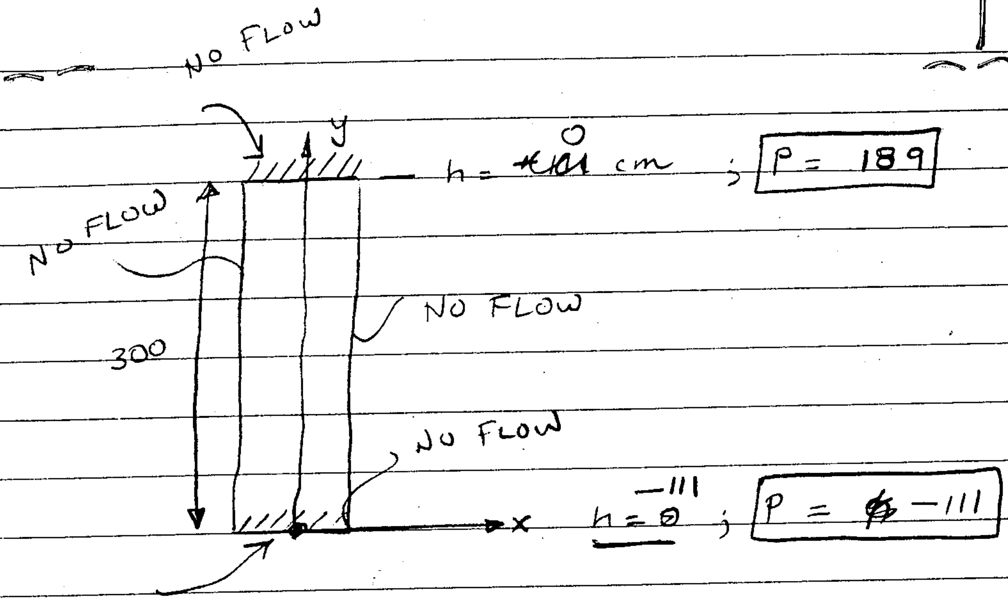


Initial P = grad.
BC P(z=0) = 0
P(z=300) = 189

Later:
Simple Source } comparing
Half Strip } Bigflow/porflow

(MULTIFLOW) VANWUTH
MULTI MUAL

7



Initial h = -111
throughout ✓ gradx = 0,
INITIAL p is -111 grady = 1

$= \frac{\theta_r}{\theta_s} = S_r$

$\frac{5.5 \cdot 10^{-2}}{0.3} = 0.1833$

effective porosity = θ_s ≠ S_r

θ_r = TOT POR - EFF. POROSITY

$\left.\begin{matrix}\theta_r \\ \theta_s\end{matrix}\right\} \rightarrow$ $S_{r\,porflow} = \frac{\theta_r}{\theta_s}$

8

$$S = \frac{\theta - \theta_r}{\theta_s - \theta_r}$$

$S_r =$ normalized

$$S^* = \frac{S - S_r}{1 - S_r}$$

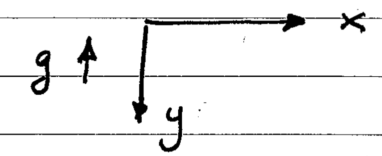
$$\hat{S}^*(h) = \frac{(S - S_r)}{(1 - S_r)}$$

$$S = \frac{\theta}{\theta_s}$$

AW

03/14/93

RAN PORFLOW 1D INFILTRATION WITH G = (0, -981, 0). IT SEEMED TO GIVE BETTER RESULTS. WE ALSO CHANGED OUR COORD. FRAME, K_s CONVERTED



TO .../sec TO MATCH WITH g UNITS IN m/sec^2 AND TIME WAS CHANGED FROM DAYS TO SECONDS.

THESE MODS PRODUCED BETTER RESULTS AND COMPARED WELL W. BIGFLOW

AW

BIG QUESTION: WHY DID G = (0, 981, 0) NOT WORK ALTHOUGH Y AXIS IS GOING DOWN!?

Because heads were such that we were forcing flow to take place in the opposite direction of gravity. Vertical infiltration takes places in the direction of gravity!

3/25/93

PORZDREAD:

So that PORZDREAD can process a porflow output file do the following:

(1) Remove initial "junk" from file

1st Line → I = 1 2 . . .
2nd Line X = 0.5 . . . .
Y UNODE . . . .

[

~~END needed~~
→ Empty line Needed
EOF

(2) Cutoff x must correspond to the number of grids along x, otherwise more nodes will appear with "ø" values!

4/1/93

To time ~~ex~~ programs:

Time ~~/~~ executable

5.97u	OVERHEAD	REALTIME	CPU %

↑ CPU Time in Sec

[Keep all except OUT10, OUTBAD]

OUT11, OUT12, OUT13
KTYM in OUT13

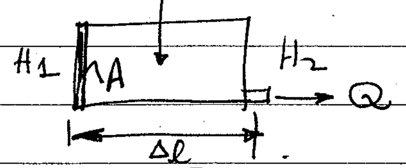
~~ACCES TO IWEL ARRAY~~

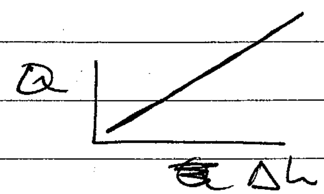
04/10/93

Real Space Renormalization Group Method

Effective properties

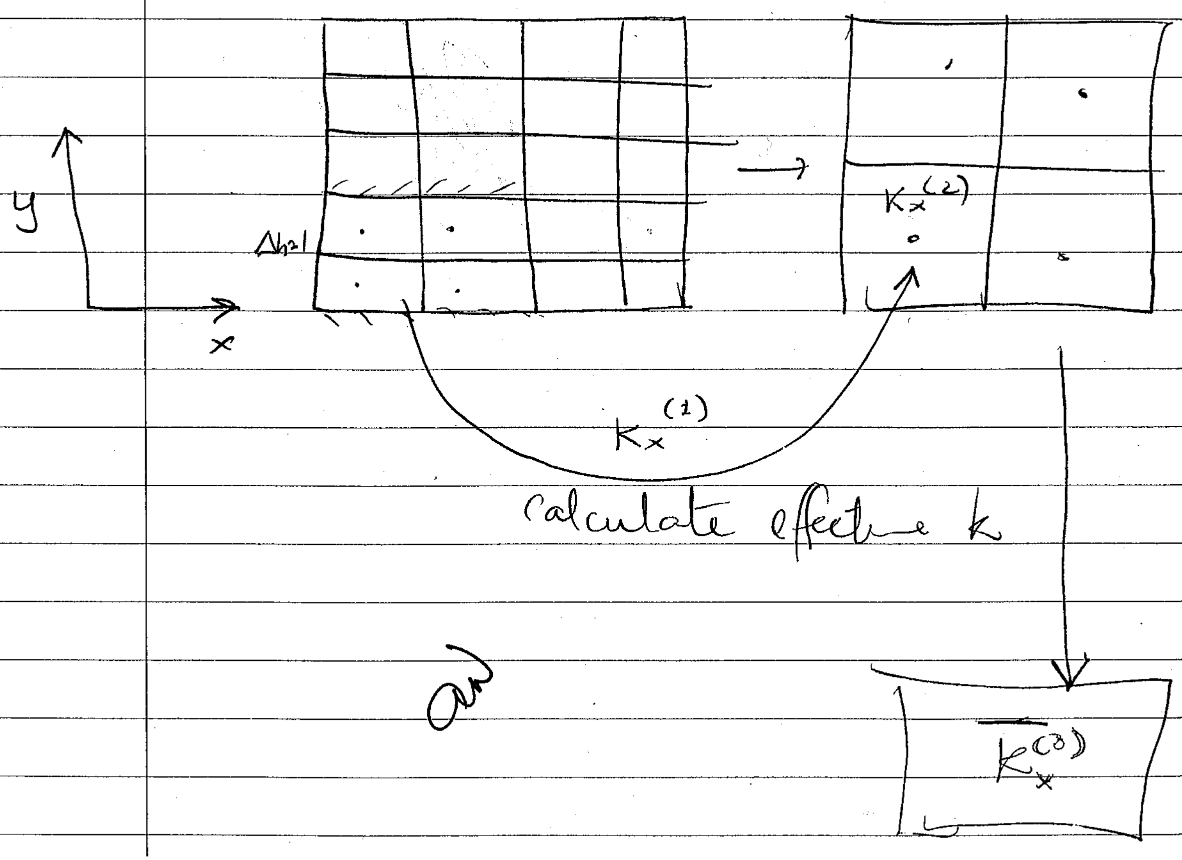
Saturated Core





$$Q = (K) \frac{\Delta h}{\Delta l} A$$

"average" value in core
~ effective



K is a tensorial Quantity

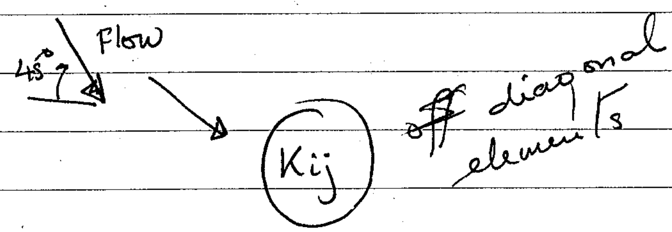
$$\underline{\underline{K}} = \begin{bmatrix} K_{11} & (K_{12}) \\ (K_{21}) & K_{22} \end{bmatrix}$$ symmetric

coupling

anisotropic $\Rightarrow K_{11} \neq K_{22}$

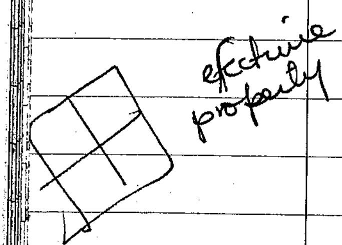
Typically $K_{ij}\ (i \neq j) = 0$

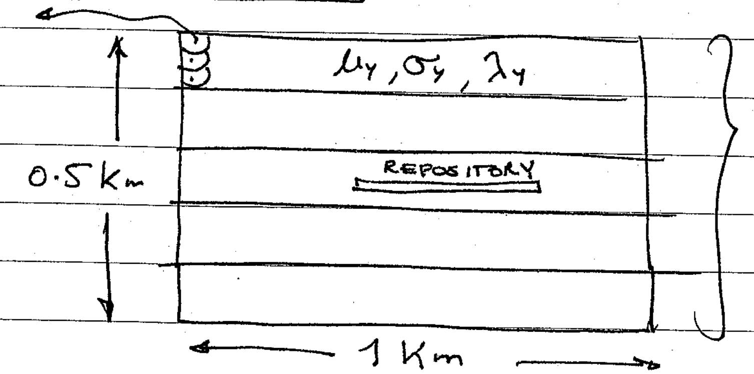
$$\underline{\underline{K}} = \begin{bmatrix} K_{11} & \\ & K_{22} \end{bmatrix} \left[\underline{\underline{I}}_{2\times 2} \right]$$



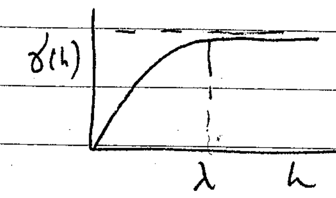
NON LINEAR FLOW / UNSAT FLOW

YUCCA Mnts





μ_y = mean ln(k)
σ_y = std (ln (k))
λ_y =



Assume ($\mu_y, \sigma_y, \lambda_y$) for each layer

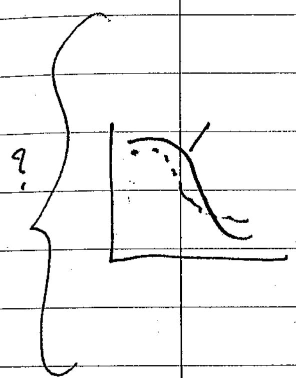
↓ CTURN,

α, β, K_{SAT} (STOCHASTIC)
θ_{SAT}

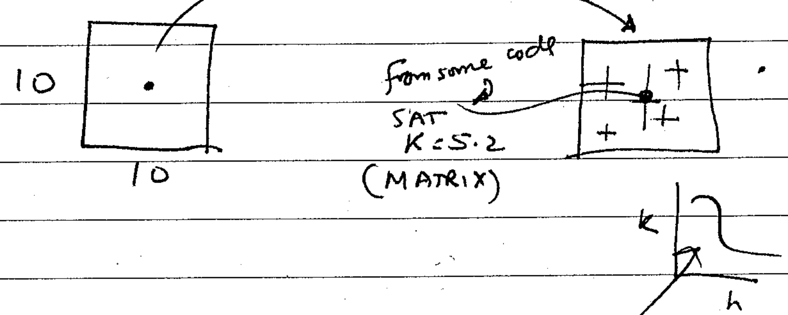
2D

1 Km ⇒ 100 cells
0.5 Km = 50 cells

for each 10 m × 10 m → conductivity } $\theta(h)$ curve } "Van Genuchten" properties



for each of the VG curves (β, n)
↓
fit for the best VG Curve
(IMSL) routines



Need: K_s
α
β
n = 4

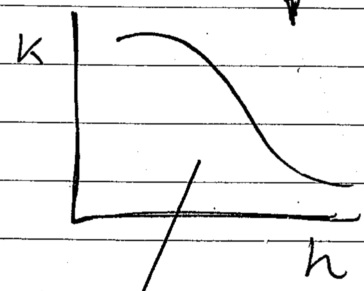
fit the best VG Curve and get ~~θ_s~~, β

for every 10x10 m, I will have a mean density and frequency of fractures.

- K_{sat}
- α
- β
- n const
- mean length of fracture
- frequency (isotropic)

(anticorrelated)

semi-analytic



after summer activity!

fit best β, θ_s for Van Genuchten

this is how the property of the 10x10 domain

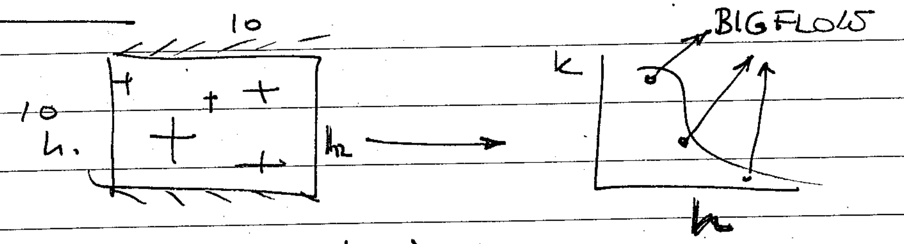
Water travel time uncertainty

Parameters Variability

↓ Multiple Simulations

Multiple transport paths and velocities

For now:

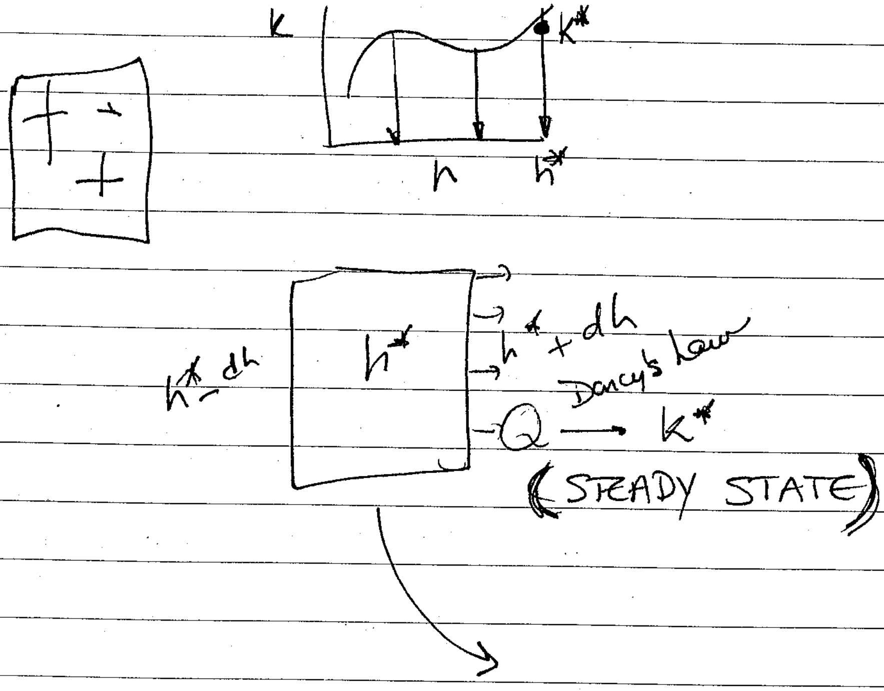


(Sisyphus)
semi
code — data
α, β, K_{sat} } in "BIGFLOW" format

INEL

NUMER / BIG / C1000

extract → OUT13
QAB



BIGFLO DATAFILES:

IN1
INPUT2
INPUT3
INPUT4
~~INPUT5~~ IN5
~~INPUT6~~ IN6
INPUT7
IN8
INPUT9

4/12/93

/semi/code

FRACGEN 4 } Random Fracture Generator
FRACGEN 5 }
FRACRG2D
FRACVAR 6

SEE README

RELPRMVG4 UNSAT COND FOR BINARY COND FIELD

4/15/93 f77 file.f -o ex.x

256 × 256 — nnx = 64, imult = 4 } 256

>> 1 input data interactive
>> 2 No of Realizations for variogram
>> .0025 horz frac density
>> 1 Frac. center distribution (random 0, expo 1 ← some difficult)
>> 2 { frac length distribution 0 1 2 }
>> .7 Vert frac Density (1) → for every vert fract ∃ a horz frac
(cluster center loc.
>> 0 { 0 .. fixed center; 1 ... random loc }
.
.
.
plot variogram

Recommended: Do NOT EXCEED 10% of
for VsC.

1 ← effective properties < 0 No / 1 yes
(SATURATED)

1 ← deter unsat cond < 0 / 1

(1) ∅ Ave. cond ? < 0 / 1

1 Superimpose Fract

Image

mag factor 7)

*. lis = OUTPUT FILES

OUTPT1. LIS ⇒ UNSAT (K/h)

OUTPT4. LIS ⇒ UNSAT (K/h)

SUEL SUE2 AVE (SUE1/SUE2) head θ Unsat K Ph

Unsat K phase II (Ave KI/KII) Unsat K PhI

K phase II KI/KII

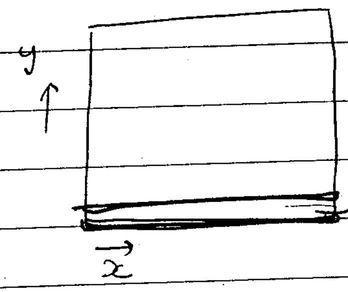
(Image of matrix & fracture)!

{ White → highest conductivity
{ Black – lowest

(NEED) OUTPUT2D.DAT – actual Matrix Kond. @ node.

↓ scaled 4 viccy

OUTPUT2D1.DAT



→ first blk in OUTPUT2D-DAT

FRACMAT.DAT

final composition of matrix & fracture SATURATED K @ node

FRAC1.DAT PORTION of field

FRAC2.DAT (?)

FRAC3.DAT (Same as FRAC1)

GARBAGE (DONT WORRY)

OUTPUT.LIS — (NOTHING IN IT)

OUTPT1.LIS

OUTPT2. LIS (nothing)
OUTPT3. LIS effective Sat Kond.

OUTPT4. LIS — Unsat K

OUTPT5. LIS (NOTHING)

DIST1. LIS output (Don't Worry)

Siel Soenvo head this here

dist2

relprmdist2 (dist2. lis)

4/15/93 CONTD
MODIFYING Fracvar?.f

relprmdist2 (fracmat.dat)
relprmdist1 (fracmat.dat)

15 — main (fracmat.dat) [unsat K]

unit 7 — main (frac1.dat)
relprmdist2 (head_d2.lis)

17 — fracvg2d1 (output3.lis)

unit 16 — main (frac2.dat)

unit 12 — main (frac3.dat)
relprmdist2 (BETA.DAT)

8 — relprmdist1 (dist1.lis)
relprmvg4 (outpt4.lis)

unit 11 — main (garbage)
RELPRMDIST2 (ALFA.DAT)

unit 9 — main (output.lis)

unit 10 — main (outpt1.lis)
fracvg2d1 (outpt5.lis)
RELPRMDIST2 (KSAT.DAT)

14 — main (outpt2.lis)

19 — main (output2d1.dat)

Running fracvar6

Inputs :

- >> 1 — User to input data interactively
- >> 2 — Number of Realizations
- >> 0.0025 — horz fracture Density
- >> 1 — fracture center distribution
- >> 2 — fracture length distribution
- >> 1 — Vert. fracture density
- >> 1 — cluster center location

Code OUTPUT

- >> ϕ — Plot Variogram
- >> 1 — Effective properties ?
- >> 1 — Determine unsat conductivity
- >> 1 — Distribution of Conductivity

.... Superimposing fracture on matrix ....

- >> 1 — Method A or B

iter Soemin seeavg hh θ rkurve

- >> 0 — Image of fracture network ?

following files were found to be empty :

outpt2.lis
output.lis
garbage.dat
~~[illegible]~~

QUESTIONS :

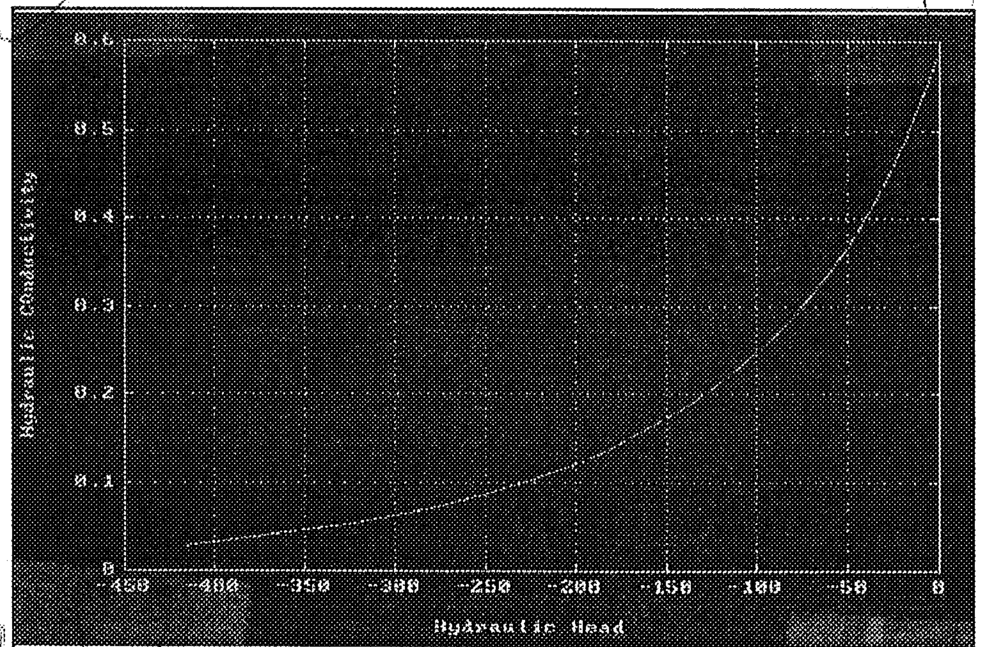
SUBROUTINE RESIZE → FORMAT (1X, 16F8.4) ?

(? ONLY 16 NODES IN X)

WRITE (19, 1ϕ1)

"OUTPUT2D1.DAT"

"HETEROGENEOUS MATRIX"



4/16/93 BIGFLO

4/16/93 BIGFLO

OUT 13 → STEADY STATE

∴ QA1 = QB1

$$Q_A = (q_F) A = \left(\bar{K} \frac{\Delta h}{\Delta l}\right) A \quad *$$

EXTRACT
OUT13
↓
(INDEX) (QAB) KSAT ... INPUT5

ER FOR ALFA (INPUT5), BETA(...)

for Header BIGFLOW ...

[IDNXX IDPTXX LFILXX ...
KTYMXX TYMXX
NXX1 NXX2 NXX3
DXX1 DXX2 DXX3
GRVX1 GRVX2 GRVX3
TXXM FXXDEV FXXL1 FXXL2 TXXL3
→ FKGM → FKDEV → FKL1 → FKL2 → FKL3

EMPTY LINE
[

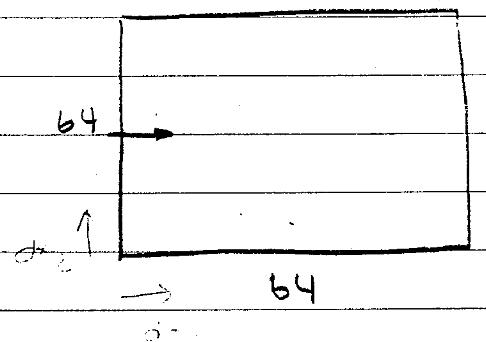
-200, -50, -100

RAN BIGFLOW FOR
AIN = -100
-98 -102
64×64×3

CP: 1248.245s / Wallclock: 2054.159s

FOR EXTRACT:
KTYM must be total
KTYM - 1 (from OUT 13)

BIGFLO → QFA1 • AREA1 = QA1



∴ comparing * :
@ -100 = h
$$QFA1 = \bar{K} \frac{\Delta h}{\Delta l}$$
$$\therefore \bar{K} = \frac{\Delta l \cdot QFA1}{\Delta h}$$
$$= \frac{64 \cdot 0.014}{4}$$
= 0.224

$$q_F = \frac{Q_{A1}}{A_1}$$

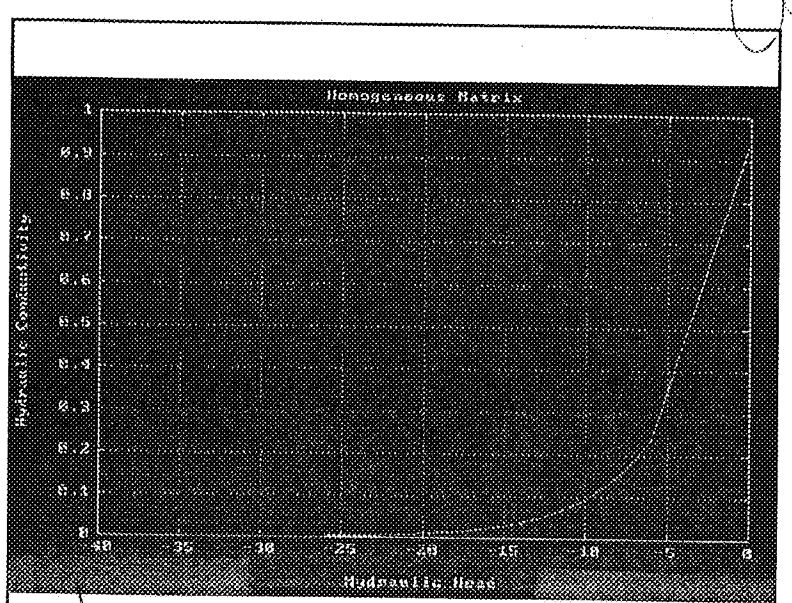
A = N2 * N3 * DX2 * DX3

$$q_F = K \frac{\Delta h}{\Delta l}$$

Q_{A1} = 0.88

$$q_{F1} = \frac{0.88}{192} = (4.583 \cdot 10^{-3})$$

→ Try a homogeneous matrix !!!
Method B



alfa1 } → fraction
Beta1 } (1)

Didn't do any further. Sita Kanta is still working on ~~the~~ the subroutine.

Homogeneous Method B

	h	K	
(1)	−5	·208	
(2)	−10	·074	(not completely steady state)
(3)	−15	·027	1804 CPU
(4)	−20	·0015	
(5)	−25	·003144	1831.75 CPU

homogeneous Method B

BIGFLOW SIMULATIONS

(1) h = −100 cm ⟶ $\bar{K}$ = 0.2240

(2) h = −50 cm ⟶ $\bar{K}$ = 0.3744

$\frac{.0237 * 64}{4}$

(3) h = −200 cm ⟶ $\bar{K}$ = 0.0835

$\frac{.00522 * 64}{4}$

(4) h = −300 ⟶ $\bar{K}$ = 0.0307

$\frac{.00192 * 64}{4}$

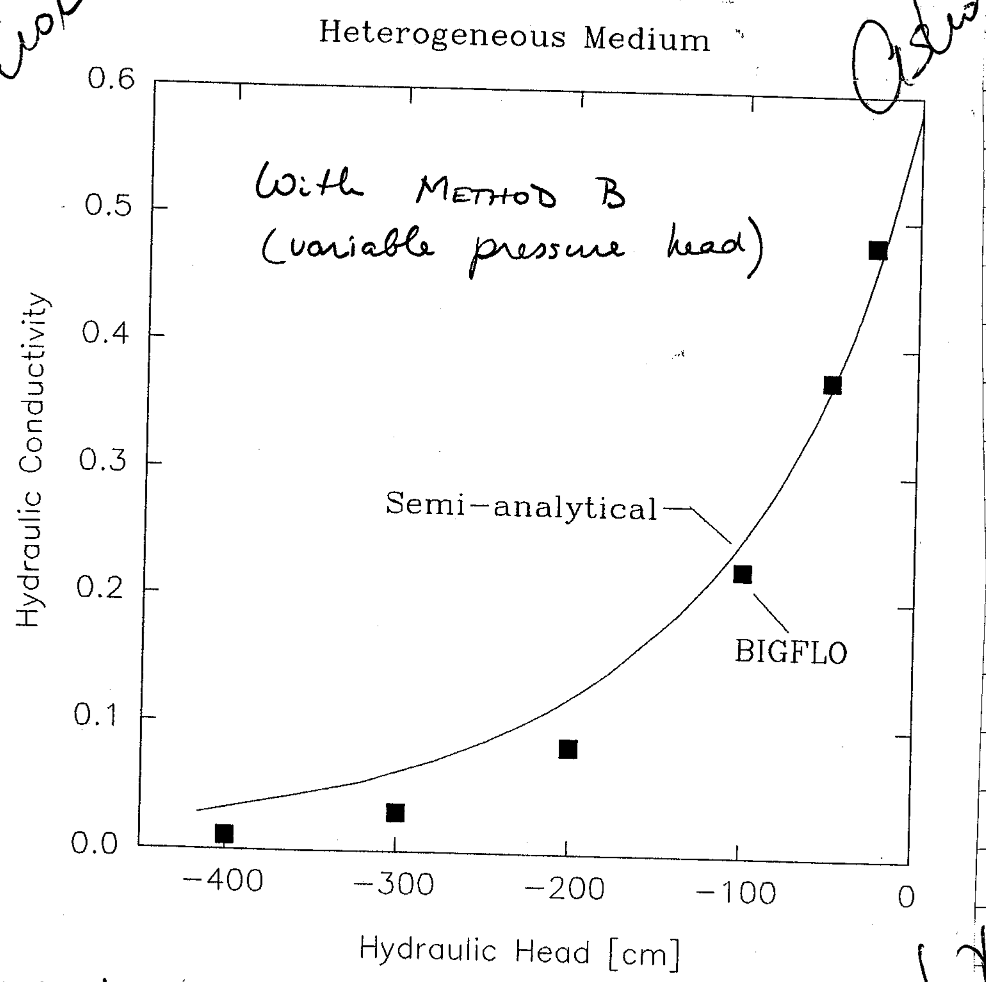
(5) h = −400 ⟶ $\bar{K}$ = 0.0113

$\frac{.000707 * 64}{4}$

(6) h = −~~85~~ ⟶ K = 0.48096

(.03006 * 64)/4

NOTICED:
The higher the suction, the faster BIGFLO converged.
i.e. The further away from h = 0, the more ~~iterations~~ time reqd ~~for~~ to converge.



4/30/93

~~Modifying~~ Mods to BIGFLO & FLOPROC to incorporate heterogeneous "n" when using Van Genuchten.

VGNMAT VGNDEV

NUAN1, NVAN2, NVAN3

INPUTIØ

TOT GRIDS ↓

M1 = NGRID1 − 2

MP1 = M1 + 1

MPP1 = M1 + 2 = NGRID1

Reading a PoREAD2D OUTPUT IN MATLAB

① (2) MAT
```
for j = 1:ny
    for i = 1:nx
        h(i,j) = mat((j-1)*nx + i, 3)
    end
end
```

② (Y vec)
```
for j = 1:ny
    for i = 1:nx
        tmp = mat((j-1)nx + i, 2)
    end
    Y(j) = tmp
end
```

③ (X vec)
```
for i = 1:nx
    x(i) = mat(i,1)
end
```


5/3/93 Printing from MATLAB

① print (within MATLAB)
② rename *.ps (mv *.ps → ?.ps) / remove *.met
③ lpqps ?.ps → (sends to printer)

5/5/93 TESTING heterogeneous "n"
Modification of BIGFLOW

ZONE 1	ZONE 2
$\beta = 0.05$	$\beta = 0.06$
$n = 3.872$	$n = 2.5$
$K_s = 1.112 \cdot 10^{-3}$	$K_s = 2.24E-5$
(NOT USED) → $\alpha = 0.1258$	$\alpha = 0.0839$

$\theta_s = 0.4411$
$\theta_r = 0.0189$

Timing BIGFLOW
⟹ 13347.9647 u 255.4118 s 4:19:34 87%

Timing PORFLOW
2460 u

5-10-93

Without any changes to new version of BIGFLOW (this version ~~[illegible]~~ is able to process variable "n") :

~~1305.348 CPU 22.5466s 23:58 92%~~

SIMULATION TIME 353 SEC

(1) → 623.65 CPU 11.868 11:22 93%

Changed SUBROUTINE THETA3Ø CASE (6) SO THAT IF STATEMENTS ARE OUTSIDE DO LOOPS ! BIG1.FOR → BIG1.EXE

(2) → 614.05 CPU 7.322 12:48 80%

Changed SUBROUTINE NLCOND CASE (2) SO THAT IF STATEMENTS ARE OUTSIDE DO LOOP ONLY FOR INTERNAL ~~X~~ NODES. BNDRY NODES OLD WAY

(3) 248.72 CPU 6.16s 6:15 67%

Changed NLCOND CASE (2) SO THAT IF STATEMENTS ARE OUTSIDE DO Loop ~~ONLY FOR I~~ FOR BNDRY NODES AS WELL

(4) 152.36 CPU 3.07 5:03 51%

(5) TOTAL SIMULATION NOW TAKES:

3419.35u 39.74s 1:49:03 52%

5-11-93

Comparing HEAD FILES concludes:

(1) There is a difference in the 5th digit after the comma!

H1 & HEAD_T1 ex: HEAD_T1 → -76.52801

H1 → -76.52800

(diff. H1)

(2) H2 & HEAD_T2 revealed same as above (diff. H2)

(3) H3 & HEAD_T3 had differences in the 2nd digit after the comma

ex: HEAD_T3 → -8.723324

H3 → -8.726127

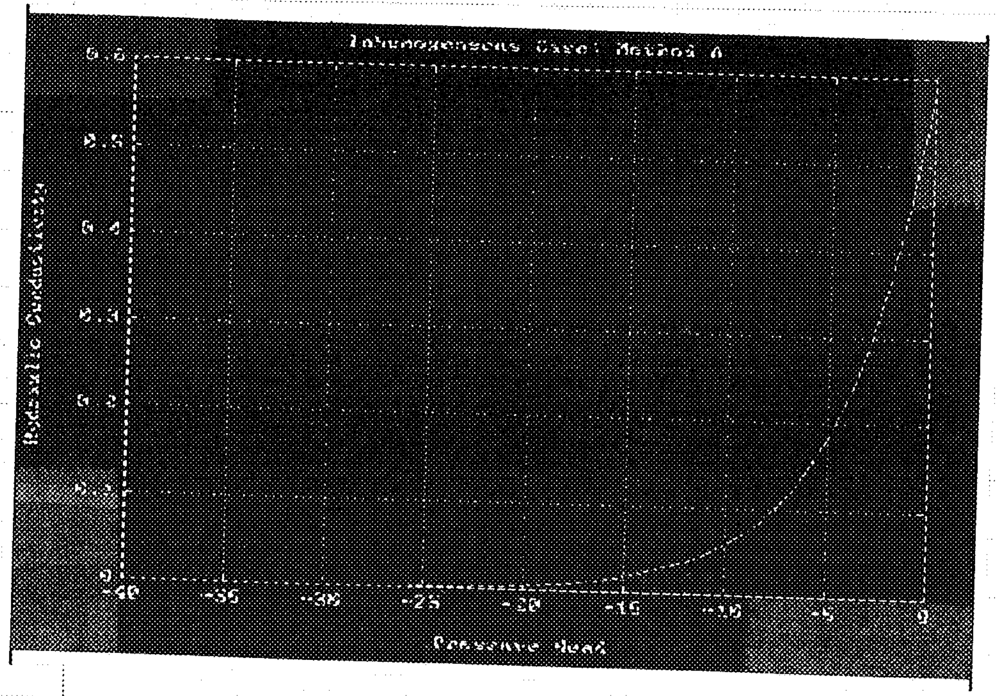
on (diff. H3)

(4) Differences between OUT13 & O13

NO

BIGVAR was run again and all files HEAD* ~~[illegible]~~ compared to same generated by BIG1 (version in which IF statements (5 loops) were outside DO loops)

Method A :
inhomogeneous



BIGFLO Simulations

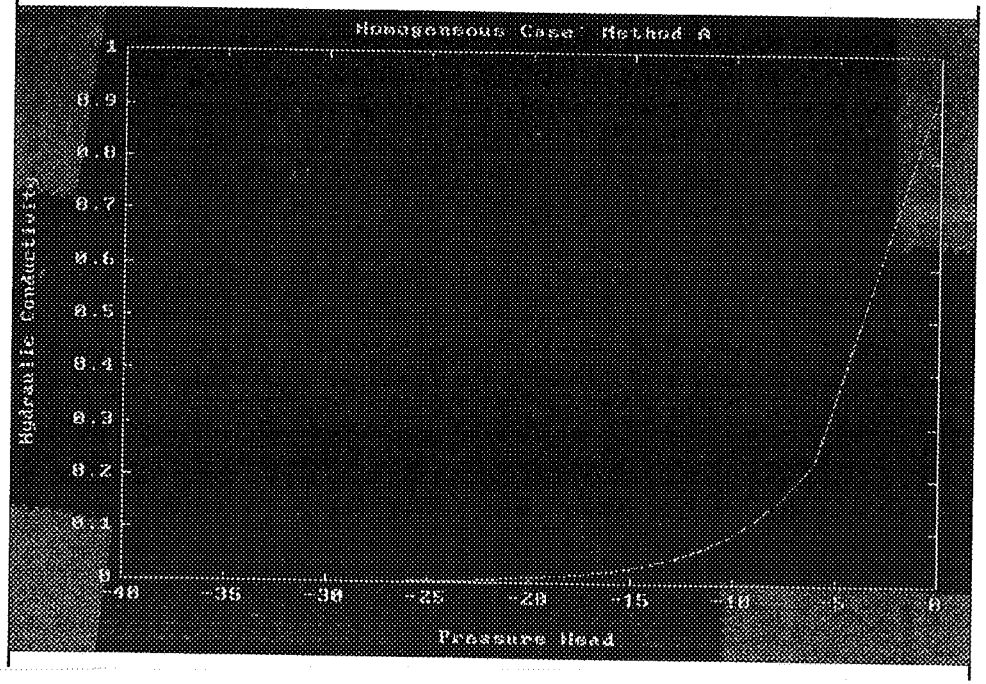
scaled α in fraction !

	h	K	K	
①	−5	0.2144	.093	1790 CPU
②	−10	0.077	.013	
③	−15	0.029	$1.82 \cdot 10^{-3}$	
④	−20	0.010	$2.58 \cdot 10^{-4}$	
⑤	−25	$3.33 \cdot 10^{-3}$		

⑤ @ h = −2 } 0.3088

same observation as Ⓐ

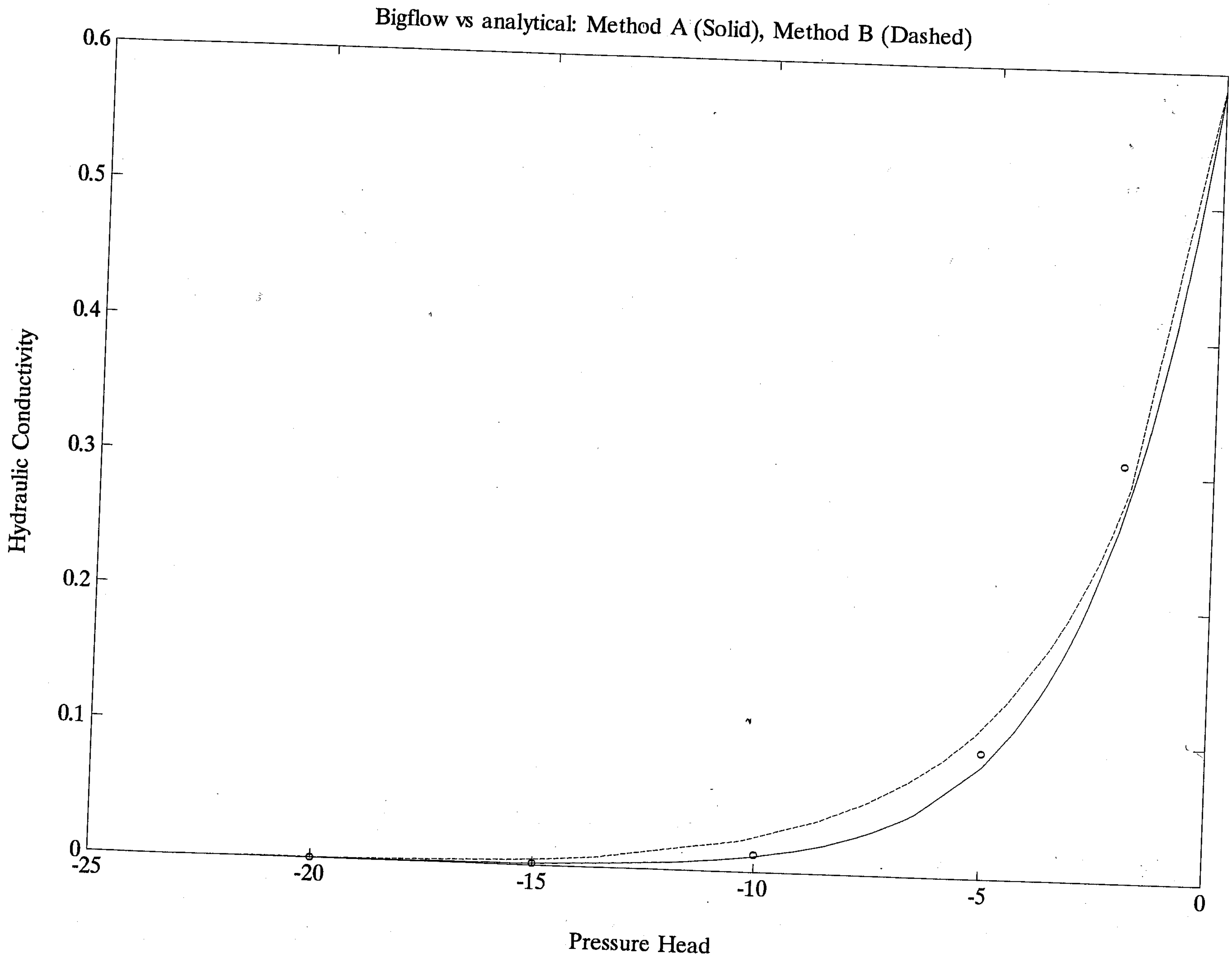
Method A
Homogeneous



BIGFLO Simulations

	h	K
①	−5	0.208
②	−10	0.0736
③	−15	0.0272
④	−20	9.6 E−3
⑤	−25	3.12 E−3

Ⓐ ← The further away from h = 0, the more ~~iterations~~ (time) req'd for steady state


Bigflow vs analytical: Method A (Solid), Method B (Dashed)
Hydraulic Conductivity
Pressure Head
0.6
0.5
0.4
0.3
0.2
0.1
0
-25
-20
-15
-10
-5
0

OW

5-26-93 REALISTIC DATA

Yucca Data [.5 fracture/m min ; average = 0.8 frac/m ; Max = 4.3 fract/m

fracture density in fracvan ?
~ No of centers per domain (tot No nodes)

Area fracture density

$.0025 \times (\sout{128}\ 64)^2 \approx \sout{40}\ 10$ centers ✓
check with number of centers ✓

If 128 × 128 domain = (10 m × 10 m)
then fracture aperture = ~~5cm~~ 7.8 cm

$$\frac{1}{128} \times 10\,m = 7.8\,cm$$

Length distribution:
Mean length ≈ 60 cm

int (nx * ny * xfrac) * (1 + ppp) = fracture density

xfrac: density of centers

ppp: vertical fractures density ~~(...)~~

For every center ∃ a horizontal fracture

$$\text{Linear density} \quad \sqrt{\frac{20}{L^2}} = \frac{4.47}{L} = 1$$

$\frac{1}{64} \times 4.5 \approx 7.0$ cm ← Length domain ← **L = 4.47**

fracture aperture

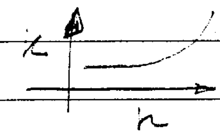
(1) fracture centers ?
"Put a cross "X" on center. Not necc

Key parameters of fracuar ?
. Length
. Isotropy of fracture → No crosses
. fracture density
. Isotropy of fracture length

. Begin with homogeneous
with average.
then heterogeneous.

6-7-93

xlmean } fr. domain
ylmean }



ppp = 0.5
Ratio of cond = 300
homogeneous

(2) Half as many [illegible] fractures.

(3) Reduce # of [illegible] frac.

(4) [illegible] of [illegible] frac.

6-15-93

xlmean = ylmean = 1.5
fractures not extending the
entire length.
(See readme file) 6/15/93

7-26-93

EXPT 1:

Effect of fractures on HOMOGENEOUS MEDIUM (Method A)

LONG FRAC	xfrac	Vol of fractures	
xlmean / ylmean } = .001	0	0	SOLID (A)
	.0025	16.97%	dashed (B)
	.025	57.28%	dotted (C)
	.25	68.68%	dash dot (D)

EXPT 2

Effect of Length HOMOGENEOUS MEDIUM (Method A)

xlmean // ylmean	xfrac	Vol	
(LONG) FRAC .001	0.0005	3.6%	(A)
(SHORT) FRAC 1.5	0.003	3.6%	(B)

EXPT 3

Effect of length on HET MED. (Method A) & B

Values Same as EXPT2

EXPT 4

Effect of heterogenity on conductivity with a fixed percentage of fracture Volume

Method B

IMULT = 1, 4, 64

Long fractures: xlmean = ylmean = 0.001

Imult	xfrac	Frac Vol
(A) (B) (C)	[illegible]	[illegible]
(1, 4, 64)	0.001	7.18%
(1, 4, 64)	0.002	13.62% ←
(1, 4, 64)	0.02	54.2%
(1, 4, 64)	0.25	68.18%

Same as above for SHORT FRACTURES

Method B ⇒ xlmean = ylmean = 1.5

maintaining above frac Volumes

	xfrac	Frac Vol
	0.005	7.18%
→	0.015	13.72%
	0.2	54.83%
	0.45	68.95%

14%

(xfrac = 0.05) short

long (0.002)

Het. — jmult = 1

Hom. — jmult = 64

$n, \theta_s, \theta_r, h_b$

Hom: short, long — Het: short, long

α.dat ; β.dat ; Ksat.dat

09/22/93 Negative α can result if

$K_s < 10^{-3}$ for α_{max} UVL

$K_s < 3.2E{-5}$ for $\alpha_{max} = 0.075$

$$\alpha = \alpha_{max} + s\,(\alpha_{min} - \alpha_{max})$$

$$s = \log\left(\frac{\delta_b}{K_s}\right) \Big/ \log\left(\delta_b / \sigma_a\right)$$

∴ Expect positive α only for ($\alpha_{min} \approx \alpha_{max}$) !

∴ Change α_{min} / ~~α_{max}~~ for different K_{sat} values.

$3.41 < \ln(1/K_s)$

$e^{3.41} < 1/K_s$ (6.88)

$K_s e^{3.41} < 1$

$K_s < \frac{1}{e^{3.41}}$

$K_s < 0.033$ for $\sigma_a = 0.1$

$K_s < 0.00103$ for $\sigma_a = 0.01$

15 BC	1249300
K2_16BC	249860
17	"
18	999440

ACT-5 — File path
default path

$$\alpha = \alpha_{max} + \frac{\log\left(\frac{\sigma_b}{K_s}\right)}{\log\left(\frac{\sigma_b}{\sigma_a}\right)} \left(\alpha_{min} - \alpha_{max}\right)$$

(1) $\alpha_{min} = 0.025$

$\alpha_{max} = 0.075$

$\sigma_b = 1$

$\sigma_a = .001$

$$\alpha = 0.075 + \frac{\log\left(\frac{1}{K_s}\right)}{\log(1000)} (-0.05)$$

$$\alpha = \left[0.075 + \log(1/K_s)(-7.24E-3)\right]$$

$$\alpha < 0 \rightarrow .075 - 7.24E-3 \log(1/K_s) < 0$$

$$.075 < 7.24E-3 \log(1/K_s)$$

$$10.36 < \log(1/K_s)$$

$$e^{10.36} < \frac{1}{K_s}$$

$$K_s \cdot e^{10.36} < 1$$

$$K_s < \frac{1}{e^{10.36}}$$

$$\boxed{K_s < 3.2E-5} \rightarrow \boxed{\alpha < 0}$$

②

$$\alpha = \alpha_{max} + \frac{\ln\left(\frac{\sigma_b}{K_s}\right)}{\ln\left(\frac{\sigma_b}{\sigma_a}\right)} (\alpha_{min} - \alpha_{max})$$

$\alpha_{min} = 0.025$

$\alpha_{max} = 0.075$

$\sigma_b = 1$

$\sigma_a = 0.1$ (0.01)

$$\alpha = 0.075 + \frac{\ln(1/K_s)}{\ln(1/0.1)} (-0.05)$$ (0.01)

$$\alpha = 0.075 + \ln(1/K_s)\,(-0.022)$$ (−0.0109)

$\alpha < 0 \Rightarrow [\,0.075 - 0.022 \ln(1/K_s)\,] < 0$ (−0.0109)

$0.075 < 0.022 \ln(1/K_s)$ (−0.0109)

$3.41 < \ln(1/K_s)$ (6.88)

$e^{3.41} < 1/K_s$ (6.88)

$K_s e^{3.41} < 1$

$$K_s < \frac{1}{e^{3.41}}$$

$K_s < 0.033$ — for $\sigma_a = 0.1$

$K_s < 0.00103$ — for $\sigma_a = 0.01$

45

γ γ̇

(2)

09/22/93

~~Clip xxlat(i,j) where it is read ∩ xxlat = threshold. Threshold calculated from pg 44.~~

$\sigma_b = 1$; $\sigma_a = .001$ ⇒ $\alpha_{min} < \alpha < \alpha_{max}$

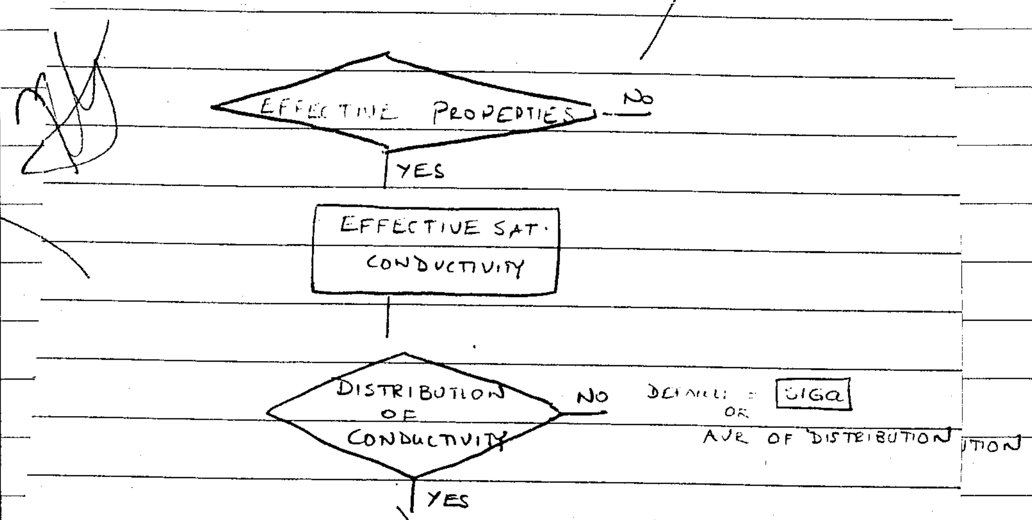
NOTE: ∴ K_s must be in the above range to get good positive values

- SENDING YEH ONLY HOMOGENEOUS FILES

Regenerate xxlat with values in between .001 & 1.

- Regenerate xxlat with mild/medium/high conductivity
- Try $\sigma_b \simeq 10^{-6}$. Something is hardwired
- As long xxlat is in between σ_a and σ_b, all *should* be ok ✓

AW



BIGELO Read format : 5 (1X, E14.7)
10(2X, F6.4)

10/16 Frachet* is indeed fravan(11).f
with imult = 1, nnx = 64

frehom* is fracvan11.f with
imult = 64, nnx = 1

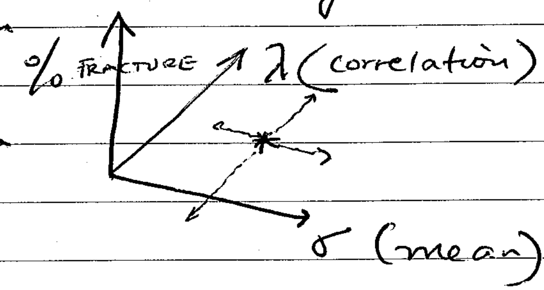
Xn=1.51

fracvan11.f divides all Ksat values
from output2d.dat by 1e4

∴ 1e4 ~~shift~~ multiply in
Sip2frac.

10/1 Duplicate graphs (results) for
heterogenous output2d_new.dat.
See expt 5 directory
Only imult = 1 investigated.
We will observe effect of
heterogenity / stochastisity &
stratification using TURNING BAND.

7, 14, 55, 69 {



See pg 43 for parameters for
long / short fractures.

EXPT 6 directory

	xfrac	xlmean	Fracture Vol %	Method A
long ←	0.0005	0.001	3.6 %	"
short ←	0.003	1.5	3.6 %	"

EXPT 7 directory
same as EXPT6 except Method
[B] instead of (A) !

11/9

EXPTS PERFORMED SO FAR:

→ $f = 3.6\%, 7\%, 14\%, 54\%$

→ short, long fracture (isotropic

xlmean = ylmean ← length, isotropic density) → always a cross, $rpp = 1.0$

→ hom, het matrix

$\frac{K^f}{K^m} = 1000$, $nmc^f = 25$, $nmc^m = 1$

$K_f^m = 1.0 = \sigma_b$

$K_G^m(\text{het}) = .001 = \sigma_a$

level of stochasticity ← $\sigma_x(\text{het}) = 0.75$

$\lambda_x(\text{het}) = \lambda_y(\text{het}) = 4$

$\Delta x = \Delta y = 1$

<u>Need to do:</u>

① het
$\frac{K^f}{K^m} = 1000$, $nmc^f = 25$
$nmc^m = 1$
$f = 7\%$ short fracture

② hom
$\frac{K^f}{K^m} = 1000$, $nmc^f = 25$
$nmc^m = 1$
$f = 7\%$, short fracture

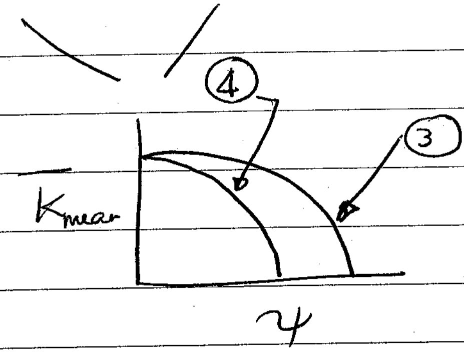
③ hete $K_G^m = 0.001$

$nmc^m = 1$	$nmc^m = 25$	$nmc^m = 25$
$nmc^f = 25$	$nmc^f = 25$	$nmc^f = ~~25~~\ 1$

Need an additional flag for $nmc > 1$

④ hete $K_G^m = 0.1$ (same as ③)

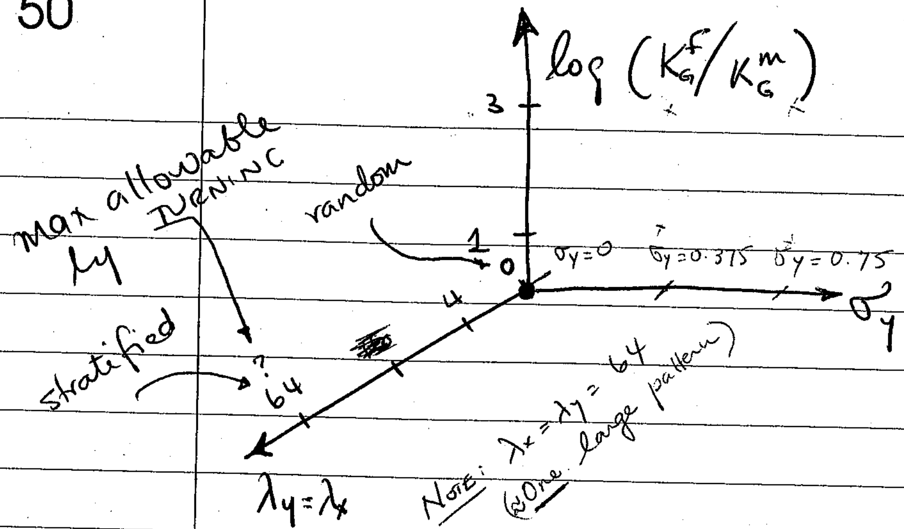
③ + ④



Effect of background & fracture network

⑤ $K_G^m = .001$, $\sigma_y = \begin{cases} 0.33 \\ 0.50 \\ ~~0.9~~ \end{cases}$

$\sigma_y < 1$ for $\alpha > 0$



(6) fully random vs Structured backgr.
$\lambda=0$ $\lambda=L$

(7) Study (6) by varying K_G^m (at varying σ) for fixed λ_i and fixed fracture density.

	σ	λ	log (K_G^f/K_G^m)
hom	0	N/A	1
	0	N/A	3
	0.375	0	1
	0.375	4	1
	0.375	64	1
	0.375	0	3
	0.375	4	3
	0.375	64	3

σ	λ	log (K_G^f/K_G^m)
0.75	0	1
0.75	4	1
0.75	64	1
0.75	0	3
0.75	4	3
0.75	64	3

14 Single Realizations

Multiple Realizations:

	σ	λ	log (K_G^f/K_G^m)
Hom	0	N/A	3
HET	0.375	4	3
	0.375	4	1

~~4 Multiple~~

EXTENSIONS:

- fracture density > 7%
- longer fracture

PREDICT:

$\lambda=0$ (totally random)
RSRG will match numerical model better
BUT how will combination of matrix & fracture compare / perform ?

HOMEWORK

(A) Set fracture Vol = 0% to remove all fractures in the system, scale α & β between ~~$K_{G,min}^{matrix}$ and $K_{G,max}^{matrix}$~~ (leave as is), Let

$\lambda = \phi$ (random) for $\log(K_G^f/K_G^m) = 1$ & (3) → K_G^m different (.001, .1)

$\sigma_y = 0.375$

structured / unstructured

(B) and $\lambda = 4$

Both (A) & (B) need to be compared with BIGFLOW.

4 ; $\log(\ ) = \{1, 3\}$

(C) Stratification: $\lambda_y \neq \lambda_x$

Anisotropic fracture density → (D)

Anisotropic fracture length → (E)

[illegible]

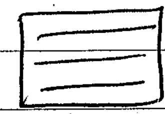
because we don't want the fractures to be fully connecting

x lmean = short, y lmean < long ≈ 0.01 → anisotropic fracture length or fracture density

(D) $f = 7\%$ $\sigma_y = 0$ (Homo) $\log(K_G^f/K_G^m) = 1$ & 3

2

(E) $f = 0\%$ $\{\lambda_x = 64, \lambda_y = 2\}$ →



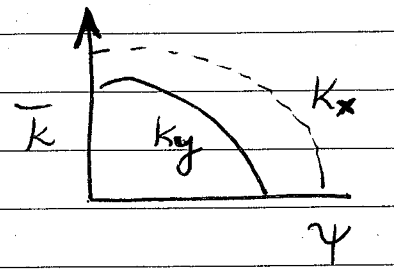
$\log(..) = \{1, 3\}$

anisotropic matrix

$\sigma = 0.75$

2

(D) & (E) have to be done with flow along x & y direction.



By transposing XXLAT just before it is processed !!!!
Also α, β ——

26 & 4 BIGFlow comparisons

Assumptions for all 26 expts:

- Method B
- α scaled between K_s^{m*} & K_s^f

$n = 1.51$

$\alpha_{min} = 0.025$ $\beta_{min} = 0.01$

$\alpha_{max} = 0.075$ $\beta_{max} = 0.05$

$\theta_s = 0.44$ $\theta_r = 0.05$

$hhb = 0$

$$\alpha = \alpha_{max} + \frac{\ln(K_s^f / K_s^m)}{\ln(K_s^f / K_s^{m*})} (\alpha_{min} - \alpha_{max})$$

$K_s^f = 1.0$

$K_s^{m*} = 0.001$

$\therefore K_s^m = K_s^{m*} \curvearrowright \alpha = \alpha_{min}$

& $K_s^m = K_s^F \curvearrowright \alpha = \alpha_{max}$

$$\beta = \beta_{min} + (\beta_{max} - \beta_{min}) K_s^m$$

$\therefore K_s^m = K_s^f \Rightarrow \beta = \beta_{max}$

$K_s^m \rightarrow K_s^{m*} \Rightarrow \beta \rightarrow \beta_{min}$

- fracture centers are exponentially distributed
- fracture length is exponentially distributed and y length is independent of x length (dependent on xlmean, ylmean)
- For different Realizations, cluster center randomly selected
- Probability of a vertical crack = 1.0

11/16 **Long fracture (14%)** HET- METHOD B

$K_{eff} = \frac{\Delta l}{\Delta h} QFA1$	h	QFA1	QFB1	Time (sec)
9.02 064	−10	0.1286E−2	0.1288E−2	.811E4
5.58 E−3	−30	0.349E−3	0.349E−3	.2E5
9.18 E−4	−60	0.573E−4	0.575E−4	.2E5
1.27 E−4	−100	0.791E−5	0.792E−5	.2E5
5.87 E−5	−120	0.367E−5	0.367E−5	.2E5
5.09 E−6 / 4.40 E−6	−200	0.318E−6	0.275E−6	.4E5

DID NOT CONVERGE.

$\Delta l = 64$

$\Delta h = 4$

11/17 Short fractures (14%) HET METHOD B

Keff	h	QFA1	QFB1	Time
5.68E−3	−10	.352E−3	.358E−3	.2E5
2.62E−3	−30	.162E−3	.165E−3	.2E5
7.10E−4	−60	0.443E−4	0.445E−4	.2E5
1.24E−4	−100	0.776E−5	0.776E−5	.2E5
5.34E−6	−200	0.339E−6	0.329E−6	.29E5

11/22

① • Xn ↑ ⟶ 3.7
② • Ksat avg ?
③ • Met A compares better ?
④ • Old Ksat file (Sita's orig file)
won't work because $\alpha < 0$!!!!

① Changing Xn from 1.51 to 3.7
xlmean = 0.001 / xfrac = 0.002
⟶ identical to Xn = 1.51

Effective ~~Ksat avg~~ Sat conductivity ≈ 3.2E-3

$\Delta l = 64$; $\Delta h = 2$

4/23
xfrac = 0.25
xlmean = 0.001
∴ Free Vol = 69%
Het, Mat B

Keff	h	QFA1	QFB1	Time
0.426	-1	0.133E-1	0.133E-1	0.2E5
0.218	-10	0.681E-2	0.681E-2	0.2E5
0.05	-30	0.156E-2	0.156E-2	0.2E5
5.66E-3	-60	0.177E-3	0.177E-3	"
3.52E-4	-100	0.110E-4	0.110E-4	"
1.76E-6	-200	0.549E-7	0.561E-7	"

~~[illegible]~~ ⟶ (row -200)

11/24

Homogeneous Matrix, Long fracture
(sent to YEH)

$\Delta l = 64$
$\Delta h = 2$

fracvar	Keff	h	QFA1	QFB1	Time
0.0005	0.013	-10	0.407E-3	.408E-3	.2E5
.0004	3.65E-3	-30	0.114E-3	0.114E-3	.2E5
.0003	5.57E-4	-60	0.173E-4	0.175E-4	.2E5
	≈ 7.86E-5	-100			
		-200			

Homogeneous Matrix, Short fracture
(sent to YEH)

$\Delta l = 64$
$\Delta h = 2$

	Keff	h	QFA1	QFB1	Time
.00014	5.41E-4	-10	.133E-4	.205E-4	.2E5
	4.19E-4	-30	.105E-4	.157E-4	.2E5
	2.26E-4	-60	.645E-5	0.787E-5	.2E5
	7.23E-5	-100	.241E-5	.211E-5	.2E5
		-200			

11/30 In RELPRMUG4, α is either α_{max} or α_{min} and β is either β_{max} or β_{min}. Not to be used for homogeneous matrix. Use uniform background (generated by TURNING BAND) and regard field as heterogeneous.

12/6 Plot ~~[illegible]~~

(A) 1 { 1, 4, 10 → effect of σ $K_G^F/K_G^m = 1$
2, 7, 13 → effect of σ $K_G^f/K_G^m = 3$

(B) 2 { 3, 4, 5
6, 7, 8

(C) 3 { 9, 10, 11
12, 13, 14

15, 17 → mean / std dev
16, 18 → mean / std dev

CHECK K2 files:

- mean ( )
- std ( ) / log10 (exp(1))

→ std (log (k))

(D) { 19, 20
21, 22 } Effect of X. for no fractures.

(E) { 19, 3
20, 6 } → Vol fracture effect
Vol, fracture

(F) { 21, 4
22, 7 } 4

(g) 23 & 1 : Effect of fracture length anisotropy

24 & 2 "

(h) 25 & 26 Effect of Ratio $\log(K_G^F/K_c^m)$!

(i) 19, 20 / 27, 28 Effect of σ on unfractured medium

1/5/94 Expt ~~#~~ 11, 12 have same fracture Volume in Expt 15A & 16A

Check to see if the difference in effective conductivity is due to differences in network.

Indeed fracture network is different. ∴ Variability in fracture network (although fracture Volume constant) causes slight differences in effective conductivity.

COMPARING WITH BIGFLOW : $\Delta l = 64$, $\Delta h = 2$

EXPT # 11 :

SEMI-ANALYTICAL	KEFF	h	QFA1	QFB1	Time
0.011	0.0166	-1	0.51204E-3	0.52597E-3	.2E5
	0.0125	-10	0.38928E-3	0.39492E-3	.2E5
	0.00653	-30	0.20352E-3	0.20433E-3	.2E5
	0.00248	-60	0.77565E-4	0.77599E-4	.2E5
	0.00083	-100	0.25901E-4	0.25898E-4	.2E5

EXPT # 14

SEMI-ANALYT	KEFF		QFA1	QFB1	Time
.00115	2.08E-3	-1	0.591E-4	0.7061E-4	.4E5

EXPT # 25

$\Delta l = 64$
$\Delta h = 2$

Semi-analytical	KEFF	h	QFA1	QFB1	Time
0.013	0.01082	−1	0.3375 E-3	0.3378E-3	.2E5
0.0099	0.00861	−10	0.2688E-3	0.2690 E-3	.2E5
0.005	0.00517	−30	0.1614E-3	0.1615E-3	"
	0.00237	−60	0.7415E-4	0.7416E-4	"
	0.000821	−100	0.2567E-4	0.2567E-4	"

EXPT #26

$\Delta l = 64$
$\Delta h = 2$

	KEFF	h	QFA1	QFB1	Time
.0013	1.033E-3	−1	0.3226E-4	0.3229E-4	.2E5
.0010	8.26 E-4	−10	0.258 E-4	0.258 E-4	"
.0006	5.02E-4	−30	0.157E-4	0.157E-4	"
.000[illegible]	2.37E-4	−60	0.7398 E-5	0.7401E-5	"
	8.58E-5	−100	0.268E-5	0.268E-5	"

– "Gardner Region"
– Shrt frac (7%, .. 69%) imult= 1 check
Is this homogeneous.

Expt # 14 ? siga 1.0

– Is it the contest in matrix / fracture that causes a discrepancy between Bigflow & semi-analytical. → (Ross)

- Stochasticity → correlation length
- σ → stochasticity

Flowchart of FRACVAR (General-High level)

Pages 1 through 63 of this Scientific Notebook were reviewed for compliance with QAP-001 in response to Corrective Action Request 94-02. Corrections and clarifications were made as appropriate. In some cases, the date of a change will reflect the date of this review rather than the date of the original Scientific Notebook entry.

Randy Folck
SWRI-QA
12/13/94

Project was closed December 1994 because it reached completion.

12/16/96

ADDITIONAL INFORMATION FOR SCIENTIFIC NOTEBOOK No.: 065, 067, 068, and 069

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Date Generated:	1993
Operating System: (including version number)	UNIX
Application Used: (including version number)	NA
Media Type: (CDs, 3 1/2, 5 1/4 disks, etc.)	1 8-mm tape
File Types: (.exe, .bat, .zip, etc.)	Various
Remarks: (computer runs, etc.)	Media contains: data and output files relative to the stochastic project.