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**MODIFICATION AND IMPLEMENTATION OF THE
M.E.T.C. SIMPAC PROGRAM**

May 1980

Work Performed Under Contract No. AC32-79AL10563

Republic Geothermal, Inc.
Santa Fe Springs, California

**U. S. DEPARTMENT OF ENERGY
Geothermal Energy**

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of the
M.E.T.C. SIMPAC PROGRAM

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by: Petroleum Training and Technical Services

May 1980

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SUMMARY

The work reported in this study covers the modifications performed by PTTS in the three dimensional unsteady state model developed by the Morgantown Energy Technology Center by W. K. Sawyer and J. C. Mercer, "A Diffusivity Model for Fluid Flow and Heat Conduction in Porous Media" (Merc/SP-77/2), August 1978, United States Department of Energy, Morgantown Energy Technology Center (M.E.T.C.), Morgantown, West Virginia. The model is used in this contract to stimulate a liquid dominated geothermal reservoir system. A series of cases is cited showing the versatility of the model as a simulation tool.

MODEL DEFINITION

The essential elements of the model are indicated in the following; for a complete derivation the reader is referred to the M.E.T.C. publication.

The SIMPAC model solves the following partial differential equation over a finite difference grid. Appropriate terms are dropped as the dimensionality of the problem dictates.

$$\frac{\partial}{\partial x} \left(k \frac{\partial P}{\partial x} \right) + \frac{\partial}{\partial y} \left(k \frac{\partial P}{\partial y} \right) + \frac{\partial}{\partial z} \left(k \frac{\partial P}{\partial z} \right) + q = \alpha \frac{\partial P}{\partial t} \quad \dots (1)$$

where k , q and α can vary with position and the pressure.

An implicit finite difference formulation of the governing equation is made and the resulting matrix of simultaneous linear equations is solved at every time step by either of the following techniques:

- (1) Point successive over-relaxation (PSOR)
- (2) Line successive over-relaxation (LSOR)
- (3) Direct method using D4 ordering (D4SM)

The analyst has to decide which method is appropriate for the particular problem under study.

The model can be utilized in either of the following modes as shown in Fig. 1.

- (1) Coordinate (x, y, z)
- (2) Radial (r, z)
- (3) Polar (r, θ, z)

The specific orientation is determined at input.

MODEL APPLICATION

The model is generalized to simulate any typical set of homogeneous or heterogeneous problems. However, its greatest efficacy involves its use as a tool to estimate the properties of fractured systems. The SIMPAC can simulate any of the following fracture geometries. See Fig. 2.

- I.(a) Vertical, parallel to x axis
- (b) Vertical, parallel to y axis
- (c) Horizontal, normal to z axis

In addition, the following options are possible:

- II.(a) Finite conductivity
- (b) Infinite conductivity - constant pressure
- (c) Infinite conductivity - constant rate
- (d) Uniform constant rate

The model does not require small block elements to simulate the fracture, but a linear steady state equation is used within the cells penetrated by the fracture for flow normal to the fracture. In simulating fracture behavior the user must utilize considerable care in maintaining compatibility between cell sizes, fracture pressures and time step sizes.

The mechanics of the fracture simulation within the model are shown in Fig. 3.

MODEL OPERATIONS

The model is large, consisting of some 40 subprograms and it must be overlaid to achieve efficient computer storage utilization. The current version implemented by PTTS on the IBM 370/158 has 3 overlays which are respectively 10 k, 40 k, 36 k words.

As published by the METC, the SIMPAC model utilizes a two-pass operation to produce a simulation run.

In the first pass, the following sizes of arrays and maximum dimensions are determined to allocate storage and initialize indices.

In the second pass, the actual simulation run is made on the reservoir data.

PTTS has modified the operation to provide a single pass simulation by combining the two steps.

The Job Control dataset shown in Table 2 is used to initiate a given run.

The datasets and load modules are self-explanatory; if a subsequent simulation study has fewer grid cells, the smaller job control dataset shown in Table 3 can be used thus saving some computer time in execution.

INPUT DATA FORMAT

The input consists basically of five types.

- (1) Grid Information - defines grid sizes, orientation and other relevant information.
- (2) Reservoir Fluid Data - defines fluid properties.
- (3) Reservoir Rock Data - defines petrophysical properties of the reservoir rock.
- (4) Special Operational Data - these data specify changes in the other basic groups, e.g., fractured cells
- (5) Run Time Data - information necessary to operate the model at each time step.

This input data to the model is processed in the order shown below. There are ten elements involved, each corresponding to a specific subprogram.

	1. GRID
	2. PARM
	3. BDRY
	4. FLUID
	5. UINIT
	6. SNODES
	7. MAINLINE
	8. FRAC
	9. RVOL
	10. Timestep cards

A set of examples are shown in the case studies in Appendix I.

STORAGE REQUIREMENTS

The program SIMPAC is segmented and is normally run using the overlay sequence shown in Table 4 . The source program is not large but significant storage requirements may be needed for arrays and other variable storage.

Some typical examples of storage requirements are shown below for some case studies and the approximate relationship between simulation size and storage is shown in Figure 4

<u>GRID SIZE</u>			<u>STORAGE - APPROXIMATE</u>	
I (X)	J (Y)	K (Z)	WORDS	BYTES
8	8	1	1300	10400
8	8	2	3620	28960
12	7	1	1915	15320
12	7	2	5590	44720
21	21	1	29604	236832
21	21	2	108049	864392
21	21	3	234669	1877352
40	40	1	339604	2716832

Model Geometries

Coordinate

Radial or Polar

FIG.1

Parallel to X axis

Y axis

Z axis

FRACTURE ORIENTATION

FIG .2

Fracture Application

FIG.3

STORAGE REQUIREMENTS FOR WORKING ARRAY

11

FIG: 4

TABLE 1
Simulator Units

Parameter	Unit Required
Mass	STB
Length	ft
Time	day
Pressure	psia
Temperature	$^{\circ}\text{F}$
Flow Rate	STB/day
Compressibility	psia^{-1}
Viscosity	cp
Density	lb/ft^3
Transmissibility	STB/(day psi)
Volume Factor	Reservoir bbl/STB
Permeability	Darcy

TABLE 2

CONTROL DATA SET: 1

```
00010 //DIFFUSE JOB NO1NOZIT,'RAFT RIVER TEST',CLASS=D,TIME=(0,59),
00020 // NOTIFY=LOGONID,MSGCLASS=C,MSGLEVEL=(2,0)
00030 /*JOBPARM OUTDEST=RMT3
00040 // EXEC FORTGCG
00050 //FORT.SYSIN DD DSN=DIF.STOR.FORT,DISP=SHR
00060 //GO.FT06F001 DD DSN=DIF.MAIN.FORT,DISP=(OLD,PASS)
00070 // EXEC FORTGLIB,DSN='DIF.LOAD',PROG=DIFF,
00080 // LIB='DIF.LIB',PARM.LKED='XREF,OVLY'
00090 //FORT.SYSIN DD DSN=DIF.MAIN.FORT,DISP=SHR
00100 //LKED.SYSIN DD DSN=DIF.OVLY.DATA,DISP=SHR
00101 //LKED.SYSPRINT DD SYSOUT=C
00110 // EXEC PGM=DIFF
00120 //STEPLIB DD DSN=DIF.LOAD,DISP=SHR
00130 //FT06F001 DD SYSOUT=C
00140 //FT05F001 DD DSN=RAFT.RIVER.DATA,DISP=SHR
00150 //
```

class = D is 384K bytes

TABLE 3

CONTROL DATA SET: 2

00010 //ZE07621 JOB NO1NOZIT,'CR.DIF.RUN.',CLASS=D,TIME=(0,30),
00020 // NOTIFY=LOGONID,MSGCLASS=A,MSGLEVEL=(2,0)
00030 /*JOBPARM OUTDEST=RMT3
00040 // EXEC PGM=DIFF
00050 //STEPLIB DD DSN=ZE0762.DIF.LOAD,DISP=SHR
00055 //FT06F001 DD SYSOUT=A
00070 //FT05F001 DD DSN=ZE0762.SAWYER.DIF1.DATA,DISP=SHR
END OF DATA

TABLE 4
OVERLAY STRUCTURE DATASET

DIF.OVLY.DATA

00010 ENTRY MAIN
00020 INSERT INDEX
00030 OVERLAY PAC1
00040 INSERT GASSIM,ZFACT
00050 OVERLAY PAC2
00060 INSERT TITLE2,FLUID2,RVOL2
00070 OVERLAY PAC2
00080 INSERT TRANS2,RATE2,PRINT2
00090 OVERLAY PAC1
00100 INSERT SCSIM
00110 OVERLAY PAC2
00120 INSERT TITLE1,FLUID1,RVOL1,STOR
00130 OVERLAY PAC2
00140 INSERT TRANS1,RATE1,PRINT1
00150 OVERLAY PAC1
00160 INSERT HCSIM
00170 OVERLAY PAC2
00180 INSERT TITLE3,FLUID3,RVOL3
00190 OVERLAY PAC2
00200 INSERT TRANS3,RATE3,PRINT3
00210 OVERLAY PAC3(REGION)
00220 INSERT HEAD,PSOR,LSOR,D4SM,ORDER,SYMM,SPECN,CONPN
00230 OVERLAY PAC3
00240 INSERT GRID,PARM,BDRY,UNIT,FRAC,SNODES
END OF DATA

APPENDIX I

SAMPLE RUNS

SUMMARY

The model was checked against data published by the original authors to verify its operation. The following examples were used:

1. One Dimensional Heat Conduction problem.
2. Two Dimensional Reservoir with a vertical fracture
 - infinite conductivity
 - constant rate production
3. Two Dimensional Reservoir with a vertical fracture
 - finite conductivity fracture
 - constant rate production

EXAMPLE 1

ONE DIMENSIONAL HEAT CONDUCTION

$$\text{LENGTH} = 1.0$$

$$T(x,0) = 70 \text{ deg. F}$$

$$T(0,t) = 212 \text{ deg. F}$$

$$K = 169 \text{ Btu/hr-deg.F.ft}$$

$$\text{DENSITY} = 50 \text{ lb/ft}^3$$

$$\text{SP.HT} = 1.05 \text{ Btu/lb-deg.F}$$


```

GRID BLOCKS
  1.0      1.0      1.0
  10      1      1
POROSITY & THERMAL CONDUCTIVITY
  0.0      169.0
IRREGULAR BOUNDARIES
  0
MATERIAL PROPERTIES
  50.0      1.05
INITIAL DISTRIBUTION
  70.0
SOURCE NODES
  0
VARIABLE RATE NODES
  0
VARIABLE TEMPERATURE NODES
  0
CONSTANT TEMPERATURE NODES
  1
  1      1      1      212.0
X-DIRECTION BOUNDARY VALUES
  0
Y-DIRECTION BOUNDARY VALUES
  0
INDUCED FRACTURES
  0
PRINT CODES
  5      0      0      0
HISTORY NODES
  0
PUNCH CODES
  0      0      0
SOLUTION PARAMETERS
  1 30 1.70 .001 .0005
TIME STEP PARAMETERS
  200 1.00 1.00 5 100 0.16666
TIME STEP SIZES
  0.1 0.0 0.0 1.0
END OF DATA

```

1-Dimensional Data

TABLE E-2.--PORTIONS OF OUTPUT-SAMPLE PROBLEM THREE

PRESSURE DISTRIBUTION AFTER 60 TIME STEPS	
SIZE OF TIME STEP	= 0.000278 DAYS
TOTAL ELAPSED TIME	= 60.0 SECONDS
INITIAL HEAT CONTENT	= 4420. BTU
SYSTEM CHANGE THIS STEP	= 16. BTU
NET INJECTION THIS STEP	= 16. BTU
INCREMENTAL ERROR THIS STEP	= -0.003 BTU
INJECTION THIS STEP	= 16. BTU
PRODUCTION THIS STEP	= 0. BTU
CUMULATIVE INJECTION	= 1595. BTU
ACTUAL HEAT REMAINING	= 6015. BTU
CALCULATED HEAT REMAINING	= 6015. BTU
MATERIAL BALANCE ERROR	= -0.0000644 BTU

TEMPERATURE DISTRIBUTIONS AT FIVE SECOND INTERVALS

										TIME (secs)
212.	211.	78.	71.	70.	70.	70.	70.	70.	70.	← 5
212.	133.	91.	76.	71.	70.	70.	70.	70.	70.	
212.	145.	102.	81.	73.	71.	70.	70.	70.	70.	
212.	153.	111.	87.	76.	72.	71.	70.	70.	70.	← 20
212.	159.	118.	93.	79.	73.	71.	70.	70.	70.	
212.	164.	124.	98.	83.	75.	72.	71.	70.	70.	
212.	167.	130.	103.	86.	77.	73.	71.	70.	70.	
212.	170.	134.	107.	89.	79.	74.	72.	71.	70.	← 40
212.	172.	138.	111.	93.	82.	75.	72.	71.	70.	
212.	174.	141.	115.	96.	84.	77.	73.	71.	71.	
212.	176.	144.	118.	99.	86.	78.	74.	72.	71.	
212.	178.	146.	121.	101.	88.	80.	75.	73.	72.	← 60

1-D Example Published Results

TEMPERATURE DISTRIBUTION AFTER 20 TIME STEPS
 SIZE OF TIME STEP = 0.000278 HOURS
 TOTAL ELAPSED TIME = 0.00023 DAYS = 0.00556 HOURS = 0.3333 H
 INITIAL HEAT CONTENT 4420. BTU
 SYSTEM CHANGE THIS STEP 27. BTU
 NET INJECTION THIS STEP 27. BTU
 INCREMENTAL ERROR THIS STEP 0.003 BTU
 INJECTION THIS STEP 27. BTU
 PRODUCTION THIS STEP 0. BTU
 CUMULATIVE INJECTION 786. BTU
 ACTUAL HEAT REMAINING 5207. BTU
 CALCULATED HEAT REMAINING 5207. BTU
 MATERIAL BALANCE ERROR 0.0000737 %

NEW RESERVOIR TEMPERATURE DISTRIBUTION FOLLOWS

K = 1

212. 153. 111. 87. 76. 72. 71. 70. 70. 70.

NEW RESERVOIR DELTA-TEMPERATURE DISTRIBUTION FOLLOWS

K = 1

0 1 2 1 1 0 0 0 0 0

1-D Example: 20 sec.

TEMPERATURE DISTRIBUTION AFTER	40	TIME STEPS		
SIZE OF TIME STEP	=	0.000278	HOURS	
TOTAL ELAPSED TIME	=	0.00046	DAYS	= 0.01111 HOURS = 0.6667 MIN
INITIAL HEAT CONTENT	=	4420.	BTU	
SYSTEM CHANGE THIS STEP	=	20.	BTU	
NET INJECTION THIS STEP	=	20.	BTU	
INCREMENTAL ERROR THIS STEP	=	-0.004	BTU	
INJECTION THIS STEP	=	20.	BTU	
PRODUCTION THIS STEP	=	0.	BTU	
CUMULATIVE INJECTION	=	1242.	BTU	
ACTUAL HEAT REMAINING	=	5662.	BTU	
CALCULATED HEAT REMAINING	=	5662.	BTU	
MATERIAL BALANCE ERROR	=	-0.0001266	%	

NEW RESERVOIR TEMPERATURE DISTRIBUTION FOLLOWS

K = 1

212. 170. 134. 107. 89. 79. 74. 72. 71. 70.

1-D Example:40 sec.

TEMPERATURE DISTRIBUTION AFTER	60 TIME STEPS		
SIZE OF TIME STEP	= 0.000278 HOURS		
TOTAL ELAPSED TIME	= 0.000669 DAYS	= 0.01667 HOURS	= 1.0000 MI
INITIAL HEAT CONTENT	= 4420. BTU		
SYSTEM CHANGE THIS STEP	= 16. BTU		
NET INJECTION THIS STEP	= 16. BTU		
INCREMENTAL ERROR THIS STEP	= -0.005 BTU		
INJECTION THIS STEP	= 16. BTU		
PRODUCTION THIS STEP	= 0. BTU		
CUMULATIVE INJECTION	= 159. BTU		
ACTUAL HEAT REMAINING	= 6015. BTU		
CALCULATED HEAT REMAINING	= 6010. BTU		
MATERIAL BALANCE ERROR	= -0.0002626 %		

NEW RESERVOIR TEMPERATURE DISTRIBUTION FOLLOWS

K = 1

212. 178. 146. 121. 101. PP. 80. 75. 73. 72.

NEW RESERVOIR DELTA-TEMPERATURE DISTRIBUTION FOLLOWS

K = 1

0 0 0 1 1 0 0 0 0 0

1-D Example:60sec.

EXAMPLE 2

RESERVOIR SYSTEM DATA

LENGTH = 2000 FT.

WIDTH = 2200 FT.

THICKNESS = 200 FT

FRACTURE = 800 FT.

ORIENTATION = PARALLEL TO X AXIS

INFINITE CONDUCTIVITY AT CONSTANT RATE

RATE = 3000 B/D

EXAMPLE 2

Figure 5

Fracture Application

BLOCK SIZES AND NUMBER OF BLOCKS IN X,Y,Z DIRECTIONS

2000. 2200. 200. 0 0 0
10 11 1

INITIAL POROSITIES, PERMS, AND CODES

0.22000 .025 .025 .001 0 0 0

IRREGULARITIES IN BOUNDARY OR VARIABLE VALUE NODES

0

C	CR	BOB	PBO	VISOB	VISMAX	PMAX
.000001	0.0	1.00	2999.	1.0	1.01	3000
RW	HALF					
.25	.75					

INITIAL PRESSURE AND BLOCKS WITH DIFFERENT PRESSURE

3000.

SOURCE BLOCKS

0

VARIABLE RATE BLOCKS

0

VARIABLE PRESSURE BLOCKS

0

SPECIFIED BLOCK PRESSURES

BOUNDARY PRESSURES X-DIRECTION

BOUNDARY PRESSURES Y-DIRECTION

INDUCED FRACTURES

1

1	4	-3000.				
1	5	1	0.0	0.0	0.0	0.0
2	5	1				
3	5	1				
4	5	1				

-1

PRINT CODES

5 0 1 1 1

HISTORY BLOCKS

0

PUNCH CODES

0 0 0

SOLUTION PARAMETERS

3 2001.200 .001 .00000 .1 0 0

NUMBER OF ITERATIONS AND CHANGES

200 1.0 1.0 6 100 2000.

TIME STEPS

.01

END OF DATA

NUMBER OF NODES IN X-DIRECTION = 10
NUMBER OF NODES IN Y-DIRECTION = 11
NUMBER OF NODES IN Z-DIRECTION = 1

GRID BLOCK SIZES IN X-DIRECTION

1	200.000
2	200.000
3	200.000
4	200.000
5	200.000
6	200.000
7	200.000
8	200.000
9	200.000
10	200.000

GRID BLOCK SIZES IN Y-DIRECTION

1	200.000
2	200.000
3	200.000
4	200.000
5	200.000
6	200.000
7	200.000
8	200.000
9	200.000
10	200.000
11	200.000

GRID BLOCK SIZES IN Z-DIRECTION

1	200.000
---	---------

DIMENSIONS OF RESERVOIR---LENGTH(FT) =2000.0
WIDTH(FT) =2200.0
THICKNESS(FT) = 200.0

POROSITY (PHI) IS INITIALLY SET AT 0.22000 FOR ALL NODES

CONDUCTIVITY (KX) IS INITIALLY SET AT 0.024999999

CONDUCTIVITY (KY) IS INITIALLY SET AT 0.024999999

CONDUCTIVITY (KZ) IS INITIALLY SET AT 0.001000000

OIL COMPRESSIBILITY(PSIA-1)----- = 0.00000100
ROCK COMPRESSIBILITY(PSIA-1)----- = 0.0
VOLUME FACTOR AT BUBBLE POINT----- = 1.000000
BUBBLE POINT PRESSURE(PSIA)----- = 2999.000000
OIL VISCOSITY AT BUBBLE POINT----- = 1.000000
OIL VISCOSITY AT MAXIMUM PRESSURE---- = 1.010000
MAXIMUM PRESSURE----- = 3000.00000

WELLBORE RADIUS(FT)----- = 0.250000
PARAMETER FOR RADIAL FLOW EQUATIONS-- = 0.750000

INITIAL CONDITION IS 3000.0

RESERVOIR CONTAINS THE FOLLOWING INDUCED VERTICAL OR HORIZONTAL FRACTURES

FRACTURE NUMBER	ORIENTATION CODE	LOCATION	WIDTH(FT)	NO. OF NODES PENETRATED	CONDITION CODE	CONDUCTIVITY	POROSITY	VALUE	TOTAL INJ RATE(UNITS/DAY)
= 1	= 1			= 4	= 4				= -3000.00
1	6	1	0.0			0.0	0.0	0.0	
2	6	1	0.0			0.0	0.0	0.0	
3	6	1	0.0			0.0	0.0	0.0	
4	6	1	0.0			0.0	0.0	0.0	

FRACTURE NUMBER = 1 NODES PENETRATED = 4
 ORIENTATION CODE = 1 CONDITION CODE = 4

FRACTURE NODE	INJECTION RATE(STB/DAY)	FRACTURE PRESSURE(PSIA)
1 6 1	-750.00	0.0
2 6 1	-750.00	0.0
3 6 1	-750.00	0.0
4 6 1	-750.00	0.0

CONVERGENCE HAS BEEN REACHED AFTER 7 ITERATIONS OMEGA = 1.200
 FOR TIME STEP 5 STEP SIZE = 0.010000 ELAPSED TIME = 0.050000

PRESSURE DISTRIBUTION AFTER 5 TIME STEPS
 SIZE OF TIME STEP = 0.010000 DAYS
 TOTAL ELAPSED TIME = 0.050000 DAYS = 1.20000 HOURS
 INITIAL FLUID IN PLACE = 34479114.28 STB
 BO AT AVERAGE PRESSURE = 1.0000034 RES BBL/STB
 SYSTEM CHANGE THIS STEP = -30.00 STB
 NET INJECTION THIS STEP = -30.00 STB
 INCREMENTAL ERROR THIS STEP = 0.000 STB
 INJECTION THIS STEP = 0.0 STB
 PRODUCTION THIS STEP = -30.00 STB
 CUMULATIVE INJECTION = -150.00 STB
 ACTUAL FLUID REMAINING = 34478964.28 STB
 CALCULATED FLUID REMAINING = 34478964.28 STB
 MATERIAL BALANCE ERROR = 0.0000000 %

NEW RESERVOIR PRESSURE DISTRIBUTION FOLLOWS

K = 1

3000.3000.3000.3000.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.
 2998.2998.2998.2998.3000.3000.3000.3000.3000.
 2982.2982.2982.2984.2998.3000.3000.3000.3000.
 2998.2998.2998.2998.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.
 3000.3000.3000.3000.3000.3000.3000.3000.3000.

NEW RESERVOIR DELTA-PRESSURE DISTRIBUTION FOLLOWS

K = 1

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
-2	-2	-2	-2	0	0	0	0	0	0
-18	-18	-18	-16	-2	0	0	0	0	0
-2	-2	-2	-2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

EXAMPLE 3

RESERVOIR SYSTEM DATA

LENGTH = 2000 FT.

WIDTH = 2200 FT.

THICKNESS = 200 FT

FRACTURE = 800 FEET

ORIENTATION = PARALLEL TO X AXIS

FRACTURE WIDTH = .167 INCH

FRACTURE PERMEABILITY = 4.0 DARCY

FRACTURE POROSITY = 0.35

FINITE CONDUCTIVITY FRACTURE

RATE = 350 B/D

EXAMPLE 3

Figure 6
Fracture Application

BLOCK SIZES AND NUMBER OF BLOCKS IN X,Y,Z DIRECTIONS

2000. 2200. 200. 0 0 0

10 11 1

INITIAL POROSITIES, PERMS, AND CODES

0.15000 .001 .001 .001 0 0 0

IRREGULARITIES IN BOUNDARY OR VARIABLE VALUE NODES

0

C	CR	BOB	PBO	VISOB	VISMAX	PMAX
.000030	0.0	1.25	1600.	2.0	2.5	3000.
RW	HALF					
.25	.75					

INITIAL PRESSURE AND BLOCKS WITH DIFFERENT PRESSURE

3000.

SOURCE BLOCKS

0

VARIABLE RATE BLOCKS

0

VARIABLE PRESSURE BLOCKS

0

SPECIFIED BLOCK PRESSURES

BOUNDARY PRESSURES X-DIRECTION

BOUNDARY PRESSURES Y-DIRECTION

INDUCED FRACTURES

1

1	3	-350.				
1	6	1	.167	4.0	.35	0.0
2	6	1	.167	4.0	.35	0.0
3	6	1	.167	4.0	.35	0.0
4	5	1	.167	4.0	.35	0.0

-1

PRINT CODES

5 0 0 0 0

HISTORY BLOCKS

4

1	6	1
2	6	1
3	5	1
4	5	1

PUNCH CODES

0 0 0

SOLUTION PARAMETERS

3 2001.200 .001 .00000 .1 0 0

NUMBER OF ITERATIONS AND CHANGES

200 1.0 1.0 6 100 2000.

TIME STEPS

1.

2.

3.

5.

10.

10.

20.

END OF DATA

***** THREE DIMENSIONAL SINGLE PHASE RESERVOIR SIMULATOR FOR A SLIGHTLY COMPRESSIBLE FLUID *****
 RESERVOIR MAY BE IRREGULARLY BOUNDED, HETEROGENEOUS, AND ANISOTROPIC

*****RESERVOIR AND FLUID PROPERTIES FOLLOW*****

NUMBER OF NODES IN X-DIRECTION = 10
 NUMBER OF NODES IN Y-DIRECTION = 11
 NUMBER OF NODES IN Z-DIRECTION = 1

GRID BLOCK SIZES IN X-DIRECTION

1	200.000
2	200.000
3	200.000
4	200.000
5	200.000
6	200.000
7	200.000
8	200.000
9	200.000
10	200.000

GRID BLOCK SIZES IN Y-DIRECTION

1	200.000
2	200.000
3	200.000
4	200.000
5	200.000
6	200.000
7	200.000
8	200.000
9	200.000
10	200.000
11	200.000

GRID BLOCK SIZES IN Z-DIRECTION

1	200.000
---	---------

DIMENSIONS OF RESERVOIR---LENGTH(FT) = 2000.0
 WIDTH(FT) = 2200.0
 THICKNESS(FT) = 200.0

POROSITY (PHI) IS INITIALLY SET AT 0.15000 FOR ALL NODES

CONDUCTIVITY (KY) IS INITIALLY SET AT 0.001000

CONDUCTIVITY (KZ) IS INITIALLY SET AT 0.001000

1.17
OIL COMPRESSIBILITY(PSIA-1)----- = 0.00003000
ROCK COMPRESSIBILITY(PSIA-1)----- = 0.0
VOLUME FACTOR AT BUBBLE POINT----- = 1.250000
BUBBLE POINT PRESSURE(PSIA)----- = 1600.000000
OIL VISCOSITY AT BUBBLE POINT----- = 2.000000
OIL VISCOSITY AT MAXIMUM PRESSURE---- = 2.500000
MAXIMUM PRESSURE----- = 3000.00000

WELLSBORE RADIUS(FT)----- = 0.250000
PARAMETER FOR RADIAL FLOW EQUATIONS-- = 0.750000

INITIAL CONDITION IS 3000.0

RESERVOIR CONTAINS THE FOLLOWING INDUCED VERTICAL OR HORIZONTAL FRACTURES

FRACTURE NUMBER	ORIENTATION CODE	LOCATION	WIDTH(FT)	CONDUCTIVITY	NO. OF NOCES PENETRATED	CONDITION CODE	PEROSITY	VALUE	TOTAL INJ RATE(UNITS/DAY)
1	6	1	0.01392	4.00	4	3	0.350	0.0	-350.00
2	6	1	0.01392	4.00	4	3	0.350	0.0	
3	6	1	0.01392	4.00	4	3	0.350	0.0	
4	6	1	0.01392	4.00	4	3	0.350	0.0	

PRESSURE DISTRIBUTION AFTER	5 TIME STEPS	
SIZE OF TIME STEP	= 10.000000	DAYS
TOTAL ELAPSED TIME	= 21.000000	DAYS = 304.0000
INITIAL FLUID IN PLACE	= 19513537.93	STB
PG AT AVERAGE PRESSURE	= 1.1990374	REPS DPL/STB
SYSTEM CHANGE THIS STEP	= -3496.60	STB
NET INJECTION THIS STEP	= -3500.05	STB
INCREMENTAL ERROR THIS STEP	= 3.447	STB
INJECTION THIS STEP	= 0.0	STB
PRODUCTION THIS STEP	= -3500.04	STB
CUMULATIVE INJECTION	= -7350.07	STB
ACTUAL FLUID REMAINING	= 19606187.86	STB
CALCULATED FLUID REMAINING	= 19606193.45	STB
MATERIAL BALANCE ERROR	= 0.0000285	%

NEW RESERVOIR PRESSURE DISTRIBUTION FOLLOWS

K = 1

3000.3000.3000.3000.3000.3000.3000.3000.3000.3000.
3000.3000.3000.3000.3000.3000.3000.3000.3000.3000.
2999.2999.2999.3000.3000.3000.3000.3000.3000.3000.
2995.2995.2995.2996.2999.3000.3000.3000.3000.3000.
2961.2961.2962.2967.2993.2999.3000.3000.3000.3000.
2749.2749.2752.2771.2967.2996.3000.3000.3000.3000.
2961.2961.2962.2967.2993.2999.3000.3000.3000.3000.
2995.2995.2995.2996.2999.3000.3000.3000.3000.3000.
2999.2999.2999.3000.3000.3000.3000.3000.3000.3000.
3000.3000.3000.3000.3000.3000.3000.3000.3000.3000.
3000.3000.3000.3000.3000.3000.3000.3000.3000.3000.

NEW RESERVOIR DELTA-PRESSURE DISTRIBUTION FOLLOWS

K = 1

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
-1	-1	-1	0	0	0	0	0	0	0
-4	-4	-4	-3	-1	0	0	0	0	0
-25	-25	-25	-21	-5	-1	0	0	0	0
-101	-101	-99	-89	-20	-3	0	0	0	0
-25	-25	-25	-21	-5	-1	0	0	0	0
-4	-4	-4	-3	-1	0	0	0	0	0
-1	-1	-1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

PRESSURE DISTRIBUTION AFTER 55 TIME STEPS
 SIZE OF TIME STEP = 20.000000 DAYS
 TOTAL ELAPSED TIME = 1011.000000 DAYS = 24264.000000
 INITIAL FLUID IN PLACE = 19613537.93 STB
 BO AT AVERAGE PRESSURE = 1.2206831 RES BBL/STB
 SYSTEM CHANGE THIS STEP = -6998.67 STB
 NET INJECTION THIS STEP = -7000.00 STB
 INCREMENTAL ERROR THIS STEP = 1.325 STB
 INJECTION THIS STEP = 0.0 STB
 PRODUCTION THIS STEP = -7000.00 STB
 CUMULATIVE INJECTION = -353851.07 STB
 ACTUAL FLUID REMAINING = 19259686.86 STB
 CALCULATED FLUID REMAINING = 19259795.40 STB
 MATERIAL BALANCE ERROR = 0.0005636 %

NEW RESERVOIR PRESSURE DISTRIBUTION FOLLOWS

K = 1

2340.2363.2408.2471.2548.2628.2702.2762.2804.2825.
 2266.2290.2340.2413.2503.2596.2680.2748.2794.2818.
 2118.2145.2203.2293.2412.2534.2640.2723.2778.2805.
 1898.1927.1991.2105.2279.2450.2590.2693.2759.2791.
 1614.1637.1694.1825.2113.2362.2543.2667.2743.2780.
 1281.1286.1303.1375.1961.2308.2520.2656.2737.2775.
 1614.1637.1694.1825.2113.2362.2543.2667.2743.2780.
 1898.1927.1991.2105.2279.2450.2590.2693.2759.2791.
 2118.2145.2203.2293.2412.2534.2640.2723.2778.2805.
 2266.2290.2340.2413.2503.2596.2680.2748.2794.2818.
 2340.2363.2408.2471.2548.2628.2702.2762.2804.2825.

NEW RESERVOIR DELTA-PRESSURE DISTRIBUTION FOLLOWS

K = 1

-16 -16 -15 -14 -13 -12 -11 -9 -9 -8
 -16 -16 -15 -14 -13 -12 -11 -10 -9 -8
 -16 -15 -15 -14 -13 -12 -11 -10 -9 -8
 -15 -15 -15 -14 -13 -12 -11 -10 -9 -9
 -14 -14 -14 -14 -13 -12 -11 -10 -9 -9
 -13 -13 -13 -13 -13 -12 -11 -10 -9 -9
 -14 -14 -14 -14 -13 -12 -11 -10 -9 -9
 -15 -15 -15 -14 -13 -12 -11 -10 -9 -9
 -16 -15 -15 -14 -13 -12 -11 -10 -9 -8
 -16 -16 -15 -14 -13 -12 -11 -10 -9 -8
 -16 -16 -15 -14 -13 -12 -11 -9 -9 -8

INPUT FORMAT

USER'S MANUAL

APPENDIX - II

Input Data for GRID

1. Title card
 2. Reservoir dimensions-----1 FORMAT (3F10.0, 3I5)

LX Cols. 1-10---Distance in x-direction
LY 11-20---Distance in y-direction
LZ 21-30---Distance in z-direction
KLX 31-35---x-direction code (non-zero for radial or
 polar coordinates)
KLY 36-40---y-direction code (non-zero for radial or
 polar coordinates)
KLZ 41-45---z-direction code
 3. Number of grid blocks-----52 FORMAT (4I5)

II Cols. 1-5 ---Number of x-direction grid points
JJ 6-10---Number of y-direction grid points
 (JJ=1 for radial coordinates)
KK 11-15---Number of z-direction grid points
KRAD 16-20---Specify "1" if radial coordinates are to be used
 Specify "2" if polar coordinates are to be used
 4. X-direction grid blocks-----3 FORMAT (I5, F10.0)

I Cols. 1-5 ---Number of grid block

DX(I) 6-15---Grid block size (rectangular coordinates) or
 inner radius of block (polar coordinates)⁴

II cards are read when KLX is not zero.
 5. Y-direction grid blocks-----3 FORMAT (I5, F10.0)

J Cols. 1-5 ---Number of grid block
DY(J) 6-15---Grid block size (feet for cartesian coordinates;
 degrees for radial or polar coordinates)⁵

JJ cards are read when KLY is not zero.
 6. Z-direction grid blocks-----3 FORMAT (I5, F10.0)

K Cols. 1-5 ---Number of grid block
DZ(K) 6-15---Grid block size

KK cards are read when KLZ is not zero.
- If KLX is zero a uniform block size in the x-direction of LX/II is used.
If KLY is zero a uniform block size in the y-direction of LY/JJ is used.
If KLZ is zero a uniform block size in the z-direction of LZ/KK is used.

Input Data for PARM

1. Title card
2. Porosity⁶ & permeability-----4 FORMAT (4F10.0, 8I5)

PHIC	Cols. 1-10---	Initial porosity to be assigned to all nodes
KXC	11-20---	Initial permeability (KX) to be assigned to all nodes
KYC	21-30---	Initial permeability (KY) to be assigned to all nodes
KZC	31-40---	Initial permeability (KZ) to be assigned to all nodes
NUMP	41-45---	Number of nodes to alter initial porosity
NUMKX	46-50---	Number of nodes to alter initial permeability (KX)
NUMKY	51-55---	Number of nodes to alter initial permeability (KY)
NUMKZ	56-60---	Number of nodes to alter initial permeability (KZ)
KPH	61-65---	Porosity code
KKX	66-70---	Permeability (KX) code
KKY	71-75---	Permeability (KY) code
KKZ	76-80---	Permeability (KZ) code

3. Special porisities-----71 FORMAT (3I5, F10.0)

I	Cols. 1-5 ---	Grid block to have porosity other than PHIC
J	6-10---	
K	11-15---	
PHI(I,J,K)	16-25---	The new porosity value

NUMP cards are read.

4. Porosity distribution
(read only if KPH $\neq$ 0 and NUMP = 0)---44 FORMAT (10F8.5)

PHI	Cols. 1-8 ---	Porosity distribution for Jth
	9-16---	row. II values must be read -
	.	continue on additional cards
	.	if necessary. The row order
	.	must be JJ, JJ-1, JJ-2---1.
	73-80---	

$\left[\begin{smallmatrix} II \\ 10 \end{smallmatrix} \right]$ X JJ cards are read for each layer.

[a] means the least positive integer greater than a.

5. Special permeabilities (KX)-----71 FORMAT (3I5, F10.0)

I	Cols. 1-5 ---	Grid block to have permeability
J	6-10---	(KX) other than KXC
K	11-15---	
KX(I,J,K)	16-25---	The new permeability (KX)

NUMKX cards are read.

6. Permeability (KX) distribution
(read only if KXX $\neq$ 0 and NUMKX = 0-----44 FORMAT (10F8.5))

KX Cols. 1-8 ---KX distribution for Jth row.
 9-16---II values must be read - continue
 . ---on additional cards if necessary. The
 . ---row order must be JJ, JJ-1, JJ-2,---,
 . ---2, 1.
 73-80---

$\left[\frac{II}{10} \right]$ X JJ cards are read for each layer.

7. Special permeabilities (KY)-----44 FORMAT (3I5, F10.0)

I Cols. 1-5 ---Grid blocks to have permeability
 J 6-10---(KY) other than KYC
 K 11-15---
 KY(I,J,K) 16-25---The new permeability (KY)

NUMKY cards are read.

8. Permeability (KY) distribution
(read only if KKY $\neq$ 0 and NUMKY = 0-----44 FORMAT (10F8.5))

KY Cols. 1-8 ---KY distribution for Jth row.
 9-16---II values must be read - continue
 . ---on additional cards if necessary.
 . ---The row order must be JJ, JJ-1, JJ-2,---
 . ---2, 1.
 73-80---

$\left[\frac{II}{10} \right]$ X JJ cards are read for each layer.

9. Special permeabilities (KZ)---71 FORMAT (3I5, F10.0)

I	Cols.	1-5 ---Grid blocks to have permeability
J		6-10---(KZ)other than KYC
K		11-15---
KZ(I,J,K)		16-25---The new permeability (KZ)

NUMKZ cards are read.

10. Permeability (KZ) distribution
(read only if KKZ $\neq$ 0 and NUMKZ = 0)-----44 FORMAT (10F8.5)

KZ	Cols.	1-8 ---KZ distribution for Jth row.
		9-16---II values must be read -
		. ---continue on additional cards
		. ---if necessary. The row order
		. ---must be JJ, JJ-1, JJ-2, ---, 2, 1.
		73-80---

$\left[\frac{II}{10} \right]$ X JJ cards are read for each layer.

When reading initial value, porosity, or permeability distribution the layer order must be 1, 2, ---, KK.

For heat conduction simulations PHI is the fraction of the solid.

Input Data for BDRY

1. Title card
2. Number of blocks to have zero flux at all faces-----2 FORMAT (I5)

IBCODE Cols. 1-5 ---Number of grid blocks to have all transmissibilities zero (used only for rectangular coordinates).

- ### 3. Zero transmissibility nodes-----2 FORMAT (4I5)

I	Cols.	1-5 ---	Grid blocks to have all zero
J		6-10---	transmissibilities
K		11-15---	
IBK(I,J,K)		16-20---	Specify "1" for impermeable nodes
IBCODE cards are read.			

Input Data for FLUID1

1. Title card

2. Fluid and rock properties-----101 FORMAT (8F10.0)

C	Cols.	1-10---Oil compressibility
CR		11-20---Rock compressibility
BOB		21-30---Volume factor at bubble point
PBO		31-40---Bubble point pressure
VISOB		41-50---Oil viscosity at bubble point
VISMAX		51-60---Oil viscosity at maximum pressure
PMAX		61-70---Maximum pressure

3. Title card

4. Parameters-----101 FORMAT (8F10.0)

RW	Cols.	1-10---Hole radius
HALF		11-20---Parameter for radial flow equations

Input Data for FLUID2

1. Title card

2. Reservoir parameters-----19 FORMAT (5F10.0)

TR	Cols.	1-10---Reservoir temperature
TSC		11-20---Standard temperature
PSC		21-30---Standard pressure
RW		31-40---Wellbore radius
HALF		41-50---Parameter for radial flow equations

3. Title card

4. Gas properties-----19 FORMAT (7F10.0)

XCO2	Cols.	1-10---Mole fraction of CO ₂
XH2S		11-20---Mole fraction of H ₂ S
XN2		21-30---Mole fraction of N ₂
GR		31-40---Specific gravity
V1		41-50---Viscosity at 1 atm. and reservoir temperature
PPC		51-60---Critical pressure
TPC		61-70---Critical temperature

5. Number of gas components-----30 FORMAT (I5)

NCOMP	Cols.	1-5
-------	-------	-----

6. Mole fractions-----21 FORMAT (I5, F10.0)

K	Cols.	1-5 ---Component code number
X(K)		6-15---Mole fraction of component

NCOMP cards are read.

Input Data for FLUID3

1. Title card
2. Material constants-----101 FORMAT (3F10.0)

RHO	Cols.	1-10---Density of material
C		11-20---Specific heat
RW		21-30---Hole radius

Input Data for UINIT

1. Title card
2. Initial distribution constants-----63 FORMAT (F10.0, 3I5)

PI	Cols.	1-10---Initial value to be assigned to
KPI		11-15---all nodes if KPI is zero
NPRES		16-20---Number of nodes to be assigned initial value other than PI
FCODE		21-25---Code for determining format of initial distribution

FCODE has meaning only if KPI is not zero.

3. Special initial value (when KPI $\neq$ 0)-----71 FORMAT (3I5, F10.0)

I	Cols.	1-5 ---Grid block to have
J		6-10---initial value other
K		11-15---than PI
PINIT		16-25---

NPRES cards are read.

4. Initial parameters-----59 FORMAT (F20.12, F30.12, F20.12)
(if KPI = 0)

ETO	Cols.	1-20---Prior simulation time
CUMO		21-50---Prior cumulative injection
MBEO		51-70---Prior material balance error

5. Initial distribution-----58 FORMAT (4F19.12)
(if KPI = 0 and FCODE = 0)

P Cols. 1-19
 20-38
 39-57
 58-76

$\left[\frac{II}{4} \right]$ X JJ cards are read per layer.

6. Initial distribution (if KPI $\neq$ 0) and FCODE $\neq$ 0)-----61 FORMAT (16F5.0)

P Cols. 1-5 ---Initial distribution for Jth row.
 6-10---II values must be read - continue
 . ---on additional cards if necessary.
 . ---The row order must be JJ, JJ-1,
 JJ-2,---,2, 1.

$\left[\frac{II}{16} \right]$ X JJ cards are read per layer.

For multiple layers the layer order must be 1, 2,---, KK.

Input Data for SNODES

1. Title card
2. Cylindrical source nodes-----2 FORMAT (I5)

NS Cols. 1-5 ---Number of source nodes.

3. Source node locations---711 FORMAT (4I5, 2F10.0)

E1	Cols.	1-5 ---Grid block containing a source
E2		6-10---(well or heat source at either
E3		11-15---constant rate or specified pressure or temperature at radius RW)
OWK		16-20---Orientation code (see table 4)
PW		21-30---Pressure or temperature at RW.
QW		31-40---Rate (set PW = -1.0 if constant rate is desired)

NS cards are read.

4. Title card

5. Number of variable rate nodes-----2 FORMAT (I5)

NVQN Cols. 1-5

6. Variable rate nodes-----72 FORMAT (3I5, 3F10.0, I5)

QN1 Cols. 1-5 ---Grid block to be assigned a
 QN2 6-10---fixed rate over a time interval
 QN3 11-15---
 QV 16-25---The "on" rate for this block
 PI 26-35---"Productivity Index" (see note below)
 PWF(TWF) 36-45---Wellbore pressure or temperature
 IP 46-50---(see note below)

7. Switching times for variable rate nodes-----721 FORMAT (4F10.0)

D1 Cols. 1-10--- Day
 H1 11-20---"on" Hour
 M1 21-30---time Minute
 SEC1 31-40--- Second

D2 1-10--- Day
 H2 11-20---"off" Hour
 M2 21-30---time Minute
 SEC2 31-40--- Second

If $PI=0.0$, the rate QV is assigned to the corresponding node whenever "on" time < simulation time at end of step $\leq$ "off" time. If $PI > 0$, QV or PWF is calculated according to:

$$QV = PI \cdot 1/(\mu B) \cdot (PWF - P_{avg}) \text{ for oil, water, or gas flow}$$

$$\text{or } QV = PI \cdot (TWF - T) \text{ for heat conduction}$$

If $IP=0$, QV is calculated using PWF and PI; if $IP \neq 0$, PWF is calculated using QV and PI.

8. Title card

9. Number of variable value nodes-----2 FORMAT (I5)

NVPN Cols. 1-5

10. Variable value nodes-----72 FORMAT (3I5, F10.0)

PN1 Cols. 1-5 ---Grid block to be assigned a fixed
 PN2 6-10---value over a time interval
 PN3 11-15---
 PV 16-25---The "on" value for this block

11. Switching times for variable value nodes-----721 FORMAT (4F10.0)

D1 Cols. 1-10--- Day
 H1 11-20---"on" Hour
 M1 21-30---time Minute
 SEC1 31-40--- Second

D2	1-10---	Day
H2	11-20---"off"	Hour
M2	21-30---time	Minute
SEC2	31-40---	Second

The value PV is assigned to the corresponding node wherever "on" time < simulation time at end of step < "off" time. Note that 3 cards are required for each node; hence 3 X NVPN cards are read.

12. Title card

13. Number of constant value nodes-----2 FORMAT (I5)

NP Cols. 1-5

14. Constant value nodes-----72 FORMAT (3I5, F10.0)

S1	Cols. 1-5 ---Grid block to
S2	6-10---have fixed value
S3	11-15---
P	16-25---The fixed value

NP cards are read.

15. Title card

16. Number of boundary values (x-direction)-----2 FORMAT (I5)

KPBX Cols. 1-5 ---Number of boundary grid blocks to have fixed value along x-direction edge

17. X-direction boundary values-----72 FORMAT (3I5, F10.0)

BX1	Cols. 1-5 ---Grid block to have fixed
BX2	6-10---boundary value (along x-axis
BX3	11-15---or along ray)
PBX	16-25---The value (see Table 5)
HFCX	26-35---Film coefficient

KPBX cards are read.

18. Title card

19. Number of boundary values (y-direction)-----2 FORMAT (I5)

KPBY Cols. 1-5 ---Number of boundary grid blocks to have fixed value along y-direction edge

20. Y-direction boundary values-----72 FORMAT (3I5, F10.0)

BY1	Cols. 1-5 ---Grid block to have
BY2	6-10---fixed boundary value (along
BY3	11-15---y-axis or at outer radius)
PBY	16-25---The value (see Table 5)
HFCY	26-35---Film coefficient

KPBY cards are read.

Input Data for SCSIM
GASSIM
HCSIM

1. Title card
2. Number of induced fractures-----2 FORMAT (I5)

NIF Cols. 1-5

Input Data for FRAC

1. Fracture conditions-----91 FORMAT (2I5, F10.0)

OK	Cols. 1-5 ---Orientation code (see table 6)
KFCC	6-10---Condition code (see table 6)
QQ	11-20---Total flow rate for KFCC = 3 or 4

2. Fracture parameters-----7 FORMAT (3I5, 4F10.0)

F1	Cols. 1-5 ---x-direction node penetrated
F2	6-10---y-direction node penetrated
F3	11-15---z-direction node penetrated
WF	16-25---Fracture width (inches)
KF	26-35---Fracture permeability
PHIF	36-45---Fracture porosity
PF	46-55---Fracture pressure (or temperature)

Code -1 in columns 4-5 to indicate no more blocks penetrated.
Repeat 1 and 2 for each induced fracture.

Fracture orientation and condition codes

Orientation Code (OK)	Description
1	Vertical fracture - parallel to x-axis
2	Vertical fracture - parallel to y-axis
3	Horizontal fracture - normal to z-axis
Condition Code (KFCC)	
1	Finite conductivity- must specify WF and KP, may optionally specify PHIF to alter block porosity
2	Infinite conductivity, constant pressure - must specify PF
3	Infinite conductivity, constant rate - must specify QQ, PF is calculated
4	Uniform constant rate - must specify QQ

For KFCC = 2 or 3 it is assumed that the fracture passes through the center of the blocks penetrated. A linear steady-state equation (1, 2) is used for each block penetrated. The block value extrapolated to the center of the current time-step is used for the pressure at a distance $L = a/4$, where a is the block size normal to the plane of the fracture.

For KFCC = 2, 3, or 4 WF, KP, and PHIF may also be specified to alter the porosity and permeability of the blocks penetrated.

Input Data for RVOL1
RVOL2
RVOL3

1. Title card

2. Print codes-----18 FORMAT (20I5)

KT1	Cols.	1-5 ---Every KT1th step new distribution will be printed
LT1		6-10---Every LT1th step new distribution will be punched if KPU2 is not zero
KPR		11-15---Transmissibilities will be printed first and last step if KPR is not zero
KSN		16-20---Every KSNth step special node data and variable rate node data will be printed.
KBV		21-25---Every KT1th step volume factor, z-factor, and compressibility at each node will be printed if KBV is not zero (RVOL2 only)

3. Title card

4. Number of history nodes-----52 FORMAT (I5)

NSPN	Cols.	1-5 ---Number of nodes to print important data every time-step
------	-------	--

5. History nodes-----52 FORMAT (3I5)

ISP	Cols.	1-5 ---Grid blocks designated
JSP		6-10---as history nodes
KSP		11-15---

NSPN cards are read.

6. Title card

7. Punch codes-----2 FORMAT (3I5)

KPU	Cols.	1-5 ---Final distribution will be punched if KPU is not zero.
KPU1		6-10---Data at history nodes will be punched every KSNth step if KPU1 is not zero.
KPU2		11-15---Every LT1th step new distribution will be punched if KPU2 is not zero.

8. Title card

9. Solution parameters-----13 FORMAT (I1, I4, F5.3, 3F10.0, 4I5)

KSOL	Cols. 1	---Indicates solution algorithm If KSOL = 1 PSOR technique will be used If KSOL = 3 LSOR technique will be used If KSOL = 4 D4SM technique will be used
MITER	2-5	---Maximum number of iterations (LSOR only)
OMEGA	6-10	---Starting value of relaxation parameter
TOL	11-20	---Maximum acceptable change (at any node)
TOL1	21-30	---Parameter for determining when to change OMEGA
KODE	41-45	---Optional output (PSOR) if KODE is nonzero
KODE1	46-50	---If KODE1 = 1 residual matrix is printed each iteration of each time-step (PSOR only)

10. Title card

11. Time-step card-----9092 FORMAT (I5, 2F10.0, 2I5, F10.0)

NN	Cols. 1-5	---Maximum number of time-steps
FACT1	6-15	---Factor for increasing time-step size
FACT2	16-25	---Factor for decreasing time-step size
ITER1	26-30	---Minimum number of iterations/step without increasing step size
ITER2	31-35	---Maximum number of iterations/step without decreasing size
TMAX	Cols. 36-45	-----Maximum simulation time

Input Data for SCSIM
GASSIM
HCSIM

1. Title card

2. Time-step size cards-----4 FORMAT (4F10.0)

Day	Cols. 1-10	---Step size in days,
Hour	11-20	---hours, minutes, and
Minute	21-30	---seconds
Second	31-40	

As many cards as desired may be read. If N cards are read all time-steps after step N will be the same size as step N unless altered by FACT1 or FACT2. No alteration is performed on the first N time-steps.

PROGRAM SOURCE

LISTING

APPENDIX - III

SUMMARY

This section contains the following elements:

1. Run Planning Document - this allows the analyst to obtain the approximate storage requirements for a given simulation run.
2. INITIALIZER: - program to initialize the storage program.
3. STOR: - program used to calculate storage values and to write them into the corresponding arrays.

Run Planning DocumentApproximate Storage

Item	Name	Actual Value	Input Value
1. Number of grid blocks - x y z	IM JM KM	= = =	= = =
2. Constant source nodes	NSM	=	=
3. Constant value nodes	NPM	=	=
4. Number of fractures	NFM	=	=
5. Blocks penetrated per fracture	NFCM	=	=
6. Special nodes, etc. - Largest #	NSPM	=	=
7. X-dir boundary values	KPBXM	=	=
8. Y-dir. boundary values	KPBYM	=	=

$IMM = IM + 1 =$
 $JMM = JM + 1 =$
 $KMM = KM + 1 =$
 $IJKM = IM * JM * KM =$

$IMMA = IMM * JM * KM =$
 $JMMA = IM * JMM * KM =$
 $KMMA = IM * JM * KMM =$

$NR8 = NSM * 8$
 $+ NFM * 8$
 $+ NSPM * 48$
 $+ IJKM * 56$
 $+ (IMMA + JMMA + KMMA) * 8$
 $+ IM * 48$
 $+ IMM * 16$

$IR8D4 = 24 (IM * JM * KM / 2)$
 $+ 4 (IM * JM * KM / 2)^2$
 $=$

TOTAL = $NR8 + IR8D4 = () + () =$

DATA IM, JM, KM, NSM, NPM, NFM, NFCM, NSPM, KPBXM, KPBYM/_____,

MCODE = ____

**PROGRAM TO INITIALIZE
STORAGE**

```
1
00060 DATA IM,JM,KM,NSM,NPM,NFM,NFCM,NSPM,WPBXM,WPBYM/
00070 / 10, 11, 1, 1, 1, 1, 5, 26, 1, 1/
00080 DATA KSTOR,KSTOP/1,0/
00090 MCODE=1
00090 IF(KSTOR.NE.0)CALL STOR(IM,JM,KM,NSM,NPM,NFM,NFCM,NSPM,
00100 / WPBXM,WPBYM,MCODE)
00110 STOP
00120 END
```

INITIALIZER

PROGRAM TO CALCULATE STORAGE
STOR

```

00130      SUBROUTINE STOR (IM,JM,KM,NSM,NPM,NFM,NFCM,NSPM,KPBXM,KPBYM
00131      & ,MCODE)
00140 C***** PROGRAM FOR CALCULATING MINIMUM DIMENSIONS OF WORKING ARRAYS FOR
00150 C***** SIMPAC
00160      IMM=IM+1
00170      JMM=JM+1
00180      KMM=KM+1
00190      IMMA=IMM*JM*KM
00200      JMMA=IM*JMM*KM
00210      KMMA=IM*JM*KMM
00220      IJKM=IM*JM*KM
00230      IOD=IM*JM/2+1
00240      NEP=IM*JM*KM/2+1
00250      NME=NEP*(NEP+1)/2
00260      I2D4=4*(KM+IOD)
00270      I4D4=24*NEP
00280      IR3D4=24*NEP+8*NME
00290      NI2=NSM*8+(NPM+NFM+NFM*NFCM+KPBXM+KPBYM)*6+NSPM*22+IJKM*2
00300      NI2=NI2+I2D4
00310      NI4=I4D4
00320      NR4=(NSM+NFM*NFCM)*16+NFM*4+NSPM*12+(KPBXM+KPBYM)*3+IJKM*
00330      220+(IM+JM+KM)*4
00340      NR3=NSM*16+NFM*8+NSPM*48+IJKM*56+(IMMA+JMMA+KMMA)*3+IM*48+IMM*16
00350      NR3=NR3+IR3D4
00360      NI2=.5*NI2      +1
00370      NI4=.25*NI4     +1
00380      NR4=.25*NR4     +1
00390      NR3=.125*NR3    +1
00400      PRINT 4,NI2,NI4,NR4,NR3
00410      4 FORMAT(
00420      &'      INTEGER*2 WK1 (' ,I5,' )
00430      &'      INTEGER*4 WK4 (' ,I5,' )
00440      &'      REAL*4      WK2 (' ,I5,' )
00450      &'      REAL*3      WK3 (' ,I5,' )
00460      PRINT 102,IM,JM,KM,NSM,NPM,NFM,NFCM,NSPM,KPBXM,KPBYM
00495 102 FORMAT(
00510      &'      DATA IM,JM,KM,NSM,NPM,NFM,NFCM,NSPM,KPBXM,KPBYM/
00520      &'      / ,I5,' , ,I5,' , ,I5,' , ,I5,' , ,I5,' , ,I5,' ,
00530      &'      / ,I5,' , ,I5,' , ,I5,' , ,I5,' /
00531      PRINT 105,NI2,NI4,NR4,NR3,MCODE
00532 105 FORMAT(
00533      &'      DO 10 K=1,' ,I5,' ,1X,' 10      WK1(K) = 1' ,/,1X,
00534      &'      DO 15 K=1,' ,I5,' ,1X,' 15      WK4(K) = 0' ,/,1X,
00535      &'      DO 20 K=1,' ,I5,' ,1X,' 20      WK2(K) = 0.0' ,/,1X,
00536      &'      DO 25 K=1,' ,I5,' ,1X,' 25      WK3(K) = 0.0' ,/,1X,
00540      &'      MCODE=' ,I1,'
00550      &'      IMM=IM+1
00560      &'      JMM=JM+1
00570      &'      KMM=KM+1
00580      &'      CALL INDEX(WK1,WK2,WK3,WK4,IM,JM,KM,IMM,JMM,KMM,NSM,
00590      &'      /      NPM,NFM,NFCM,NSPM,KPBXM,KPBYM,MCODE)
00600      &'      STOP
00610      &'      END
00620      )

```


PROGRAM TO CALCULATE STORAGE (CONT'D)

```

00630 C
00640 IWI2=0.5*I2D4-1
00650 IWI4=0.25*I4D4-1
00660 IWR8=0.125*I8D4-1
00670 C
00680 C THE FOLLOWING ARRAYS MUST BE DIMENSIONED FOR SIMPAC
00690 C
00700 C DIMENSION      ARRAY NAMES      SIZE(BYTES/DIMENSION)
00710 C
00720 C      NSM          E1,E2,E3,OWK      4 * 2 = 8
00730 C      NSM          PW,KXS,KYS,KZS    4 * 4 = 16
00740 C      NSM          QW,PW1          2 * 3 = 16
00750 C
00760 C      NPM          S1,S2,S3          3 * 2 = 6
00770 C
00780 C      NFM          OK,NOF,KFCC        3 * 2 = 6
00790 C      NFM          LF                1 * 4 = 4
00800 C      NFM          QQ              1 * 8 = 8
00810 C
00820 C      NSPM         ISP,JSP,KSP,IP,    11 * 2 = 22
00830 C      NSPM         PFLAG,QN1,QN2,
00840 C      NSPM         QN3,PN1,PN2,PN3
00850 C      NSPM         PV,PI,PWF          3 * 4 = 12
00860 C      NSPM         TP1,TP2,QV,TQ1,
00870 C      NSPM         TQ2,QSP           6 * 3 = 43
00880 C
00890 C      KM           SE,MEP            2 * 2 = 4
00900 C
00910 C 5 CONTINUE
00920 C
00930 C      KPBXM         BX1,BX2,BX3        3 * 2 = 6
00940 C      KPBXM         PBX,HFCX          2 * 4 = 8
00950 C
00960 C      KPBYM         BY1,BY2,BY3        3 * 2 = 6
00970 C      KPBYM         PBY,HFCY          2 * 4 = 8
00980 C
00990 C      NFM*NFCM      F1,F2,F3           3 * 2 = 6
01000 C      NFM*NFCM      WF,KF,PHIF,PF    4 * 4 = 16
01010 C
01020 C      IM*JM*KM      IBK                1 * 2 = 2
01030 C      IM*JM*KM      PINIT,
01040 C      IM*JM*KM      KX=A1,KY=A2,
01050 C      IM*JM*KM      KZ=A3,VIS
01060 C
01070 C      IM*JM*KM      Q,P,PM,E           7 * 3 = 56
01080 C      IM*JM*KM      B,QS=GAMMA
01090 C      IM*JM*KM      PHI=VP

```

PROGRAM TO CALCULATE STORAGE (CONT'D)

01100	60	CONTINUE		
01110	C			
01120	C	IOD	IR1, JR1	$2 * 2 = 4$
01130	C			
01140	C	NEP	IR, JR, KR,	$6 * 4 = 24$
01150	C		IC, JC, KC	
01160	C	NEP	BBB, X, CCC	$3 * 3 = 24$
01170	C			
01180	C	NME	AAA	$1 * 3 = 3$
01190	C			
01200	C	IMM*JM*KM	TX	$1 * 3 = 3$
01210	C	IM*JMM*KM	TY	$1 * 3 = 3$
01220	C	IM*JM*KMM	TZ	$1 * 3 = 3$
01230	C			
01240	C	IM	AZ, BZ, CZ, DZ,	$6 * 3 = 48$
01250	C		UZ, UM	
01260	C	IMM	EZ, FZ	$2 * 3 = 16$
01270	C			
01280		RETURN		
01290		END		
END OF DATA				

MAINLINE PROGRAM FOR GEOTHERMAL SIMULATION

SCSIM

```

1
00010 SUBROUTINE SCSIM(E1,E2,E3,S1,S2,S3,F1,F2,F3,OK,OWK,BX1,BX2,BX3,
00020 &SE,MEP,IR1,JR1,
00030 &BY1,BY2,BY3,IBK,KFCC,NOF,ISP,JSP,KSP,PFLAG,QN1,QN2,QN3,PN1,PN2,PN3
00040 &,IP,LF,PW,PV,KXS,KYS,KZS,DX,DY,DZ,PBX,PBY,WF,KF,PHIF,PF,
00050 &PHI,VP,PINIT,KX,KY,KZ,A1,A2,A3,PI,PWF,VIS,HFCX,HFCY,Q,QS,PW1,P,
00060 &PM,BO,E,GAMMA,QQ,
00070 &TX,TY,TZ,QW,QV,TQ1,TQ2,TP1,TP2,QSP,UM,AZ,BZ,CZ,D1,EZ,FZ,UZ,
00080 &BBB,X,CCC,AAA,IR,JR,KR,IC,JC,KC,
00090 &IM,JM,KM,IMM,JMM,KMM,NSM,NPM,NFM,NFCM,NSPM,KPBXM,KPBYM)
00100 INTEGER*2 E1(1),E2(1),E3(1),S1(1),S2(1),S3(1),
00110 &F1(NFM,1),F2(NFM,1),F3(NFM,1),OK(1),OWK(1),HEADIN(40)
00120 &,BX1(1),BX2(1),BX3(1),BY1(1),BY2(1),BY3(1),IBK(IM,JM,1)
00130 &,KP(26),KFCC(1),NOF(1),ISP(1),JSP(1),KSP(1),PFLAG(1)
00140 &,QN1(1),QN2(1),QN3(1),PN1(1),PN2(1),PN3(1),IP(1)
00150 &,SE(1),MEP(1),IR1(1),JR1(1),IXF1(20,20)
00160 C
00170 INTEGER*4 IR(1),JR(1),KR(1),IC(1),JC(1),KC(1)
00180 C
00190 REAL*4 LX,LY,LZ,LF(1),PW(1),KXS(1),PV(1)
00200 &,KYS(1),KZS(1),DX(1),DY(1),DZ(1),PBX(1),PBY(1)
00210 &,WF(NFM,1),KF(NFM,1),PHIF(NFM,1),PF(NFM,1),HFCX(1),HFCY(1)
00220 &,PINIT(IM,JM,1),KX(IM,JM,1),KY(IM,JM,1)
00230 &,KZ(IM,JM,1),A1(IM,JM,1),A2(IM,JM,1),A3(IM,JM,1),VIS(IM,JM,1)
00240 &,PI(1),PWF(1)
00250 C
00260 REAL*8 SUM,STBINT,STBCAL,CUMINJ,Q(IM,JM,1),QS(IM,JM,1),PW1(1)
00270 &,P(IM,JM,1),PM(IM,JM,1),BO(IM,JM,1),E(IM,JM,1),GAMMA(IM,JM,1)
00280 &,TX(IMM,JM,1),TY(IM,JMM,1),TZ(IM,JM,1),TOTINJ,OMEGA,SM,PAVG,
00290 &RESVOL,MDE,MDEO,CUMO,STBACT,QW(1),QQ(1),ETI,ETO,DELT,FT,DAY,HOUR,
00300 &MIN,SEC,TQ1(1),TQ2(1),QV(1),TP1(1),TP2(1),TOL,TOL1,DW,QSP(1)
00310 &,DELTO,NSC,IMBE,SMN,BV,GAMMAC,DIV1,C,CR,PBO,BOB,PP
00320 &,UM(1),AZ(1),BZ(1),CZ(1),D1(1),EZ(1),FZ(1),UZ(1)
00330 &,BBB(1),X(1),CCC(1),AAA(1),PHI(IM,JM,1),VP(IM,JM,1)
00340 C
00350 C
00360 C**** THIS IS A FORTRAN IV PROGRAM FOR SIMULATING THREE DIMENSIONAL
00370 C FLOW OF A SLIGHTLY COMPRESSIBLE LIQUID IN HETEROGENEOUS,
00380 C ANISOTROPIC POROUS MEDIA.
00390 C
00400 C
00410 DATA MDEO,CUMO,ETO/0.0,0.0,0.0/,ETI,CUMINJ,IND/0.0,0.0,0/,
00420 &STBCAL/0.0/
00430 C
00440 C
00450 C
00460 10000 CALL TITLE1
00470 PRINT 20

```

```

00480 C
00490 C*****ESTABLISH RESERVOIR LENGTH,WIDTH,AND THICKNESS AND GRID
00500 C      BLOCK SIZES
00510 C
00520 C      CALL GRID(II,JJ,KK,LX,LY,LZ,DX,DY,DZ,KRAD,STHETA)
00530 C
00540 C*****ESTABLISH POROSITY & PERMEABILITY DISTRIBUTIONS
00550 C
00560 C      CALL PARM(II,JJ,KK,PHI,KX,KY,KZ,IM,JM,KM)
00570 C
00580 C      PRINT 56
00590 C
00600 C*****ESTABLISH IRREGULARITIES IN RESERVOIR BOUNDARY-----
00610 C-----CAUTION:::::IF COMPRESSIBILITY IS ZERO IRREGULAR BOUNDARIES MAY
00620 C      CAUSE A SINGULAR MATRIX
00630 C
00640 C      CALL BDRY(IM,JM,KM,IBK,IBKODE)
00650 C
00660 C*****ESTABLISH FLUID PARAMETERS AND WELLBORE RADIUS
00670 C
00680 C      CALL FLUID1(C,CR,BOB,PBO,VISOB,VISMAX,PMAX,RW,HALF)
00690 C
00700 C*****ESTABLISH INITIAL PRESSURE DISTRIBUTION
00710 C
00720 C      CALL UINIT(II,JJ,KK,PI,PINIT,P,IM,JM,MBOO,CUM0,ETO)
00730 C
00740 C      IF(ETO.GT.0.0) ETI=ETO
00750 C      IF(ETO.GT.0.0) CUMINJ=CUM0
00760 C
00770 C
00780 C*****ESTABLISH SOURCE & CONSTANT PRESSURE NODES
00790 C
00800 C      CALL SNODES(NS,E1,E2,E3,OWK,PW,QW,NP,S1,S2,S3,P,KPBX,BX1,
00810 C      &BX2,BX3,PBX,KPBY,BY1,BY2,BY3,PBY,KX,KY,KZ,KXS,KYS,KZS,IM,JM,
00820 C      &NVQN,QN1,QN2,QN3,TQ1,TQ2,QV,NVPH,PN1,PN2,PN3,TP1,TP2,PV,PINIT,
00830 C      &PI,PWF,IP,HFCX,HFCY)
00840 C
00850 C*****ESTABLISH LOCATIONS OF INDUCED FRACTURES
00860 C
00870 C      READ 60,HEADIN
00880 C      READ 2,NIF
00890 C      IF(NIF.EQ.0)GO TO 1095
00900 C      CALL FRAC(NIF,OK,KFCC,QQ,F1,F2,F3,WF,KF,PHIF,PF,LF,NOF,DX,DY,DZ,
00910 C      &KX,KY,KZ,PHI,II,JJ,KK,IM,JM,NFM)
00911 C      WRITE(6,31) NIF,NIF
00912 C      81 FORMAT(2X,'AFTER CALL TO FRAC : NIF = ',I3,' NIF = ',I3,'/2X,
00913 C      ? 'NOF( ) = ')
00914 C      WRITE(6,22) (NOF(J),J=1,NIF)
00915 C      INTV1 = 1
00916 C      INTV2 = 2
00917 C      INTV3 = 3
00918 C      WRITE(6,23) INTV1
00919 C      DO 35 J=1,NIF
00920 C      <CRS = NOF(J)
00921 C      35 WRITE(6,22) (F1(J,L),L=1,KCRS)

```

```

00922      WRITE(6,23)  INTV2
00923      DO 87 J=1,NIF
00924      KCRS = NOF(J)
00925  37 WRITE(6,22)  (F2(J,L),L=1,KCRS)
00926      WRITE(6,23)  INTV3
00927      DO 88 J=1,NIF
00928      KCRS = NOF(J)
00929  88 WRITE(6,22)  (F3(J,L),L=1,KCRS)
00930      WRITE(6,29)
00931  1095  CONTINUE
00932  C
00940  C*****ESTABLISH RESERVOIR VOLUME & INITIAL FLUID IN PLACE
00950  C
00960      GAMMAC = C/5.615
00970  C
00971      WRITE(6,31)  NF1,NIF
00972  31 FORMAT(2X,'BEFORE CALL TO RVOL1 : NF1 = ',I3,'   NIF = ',I3,/,2X,
00973      ?  'NOF( ) = ')
00974      WRITE(6,22)  (NOF(J),J=1,NIF)
00975      INTV1 = 1
00976      INTV2 = 2
00977      INTV3 = 3
00978      WRITE(6,22)  INTV1
00979      DO 35 J=1,NIF
00980      KCRS = NOF(J)
00981  35 WRITE(6,22)  (F1(J,L),L=1,KCRS)
00982  C      PATCH TO SOLVE PROBLEM OF ARRAY DISTRUCTION.
00983      DO 135 J=1,NIF
00984      DO 135 L=1,KCRS
00985  135 IXF1(J,L) = F1(J,L)
00986      WRITE(6,23)  INTV2
00987      DO 37 J=1,NIF
00988      KCRS = NOF(J)
00989  37 WRITE(6,22)  (F2(J,L),L=1,KCRS)
00990      WRITE(6,23)  INTV3
00991      DO 38 J=1,NIF
00992      KCRS = NOF(J)
00993  38 WRITE(6,22)  (F3(J,L),L=1,KCRS)
00994      WRITE(6,29)
00995      CALL RVOL1(RESVOL,KX,DY,DZ,VIS,KY,KZ,BO,KSOL,MITER,VISOB,
00996      &P,PHI,DX,IBK,SN,STINT,KT1,LT1,II,JJ,KK,IM,JM,BOB,PBO,C,PMAX,
00997      &KPR,LT,KT,I3P,JSP,KSP,MSPN,KPU,KPU1,KPU2,KSN,KS,VISMAY,KRAD,
00998      &TMAY,OMEGA,TOL,TOL1,DW,KODE,KODE1,MN,FACT1,FACT2,ITER1,ITER2)
01001      WRITE(6,21)  NF1,NIF
01002  21 FORMAT(2X,'AFTER CALL TO RVOL1 : NF1 = ',I3,'   NIF = ',I3,/,2X,
01003      ?  'NOF( ) = ')
01004      WRITE(6,22)  (NOF(J),J=1,NIF)
01005  22 FORMAT(1X,10(I5,1X))
01006      INTV1 = 1
01007      INTV2 = 2
01008      INTV3 = 3
01009      WRITE(6,23)  INTV1
01010  23 FORMAT(2X,'F',I1,' ARRAY : ')

```

```

01021      DO 136 J=1,NIF
01022      DO 136 L=1,KCRS
01023 136 F1(J,L) = IXF1(J,L)
01024      DO 25 J=1,NIF
01025      KCRS = NOF(J)
01026      25 WRITE(6,22) (F1(J,L),L=1,KCRS)
01027      WRITE(6,23) INTV2
01028      DO 27 J=1,NIF
01029      KCRS = NOF(J)
01030      27 WRITE(6,22) (F2(J,L),L=1,KCRS)
01031      WRITE(6,23) INTV3
01032      DO 28 J=1,NIF
01033      KCRS = NOF(J)
01034      28 WRITE(6,22) (F3(J,L),L=1,KCRS)
01035      WRITE(6,29)
01036      29 FORMAT(5X,' ... END TRACE ... ',/)
01037      READ 59,HEADIM
01038 C
01039 C
01050 C****THE FOLLOWING LOOP CALCULATES A NEW RESERVOIR PRESSURE
01060 C      DISTRIBUTION FOR EACH TIME STEP
01070 C.
01080      DO 1000 N=1,NN
01090      IF(N.GT.1)DELTO=DELT
01100      IF(N.GT.1)ETI=ETI+DELT
01110      IF(IND.EQ.0)READ (5,4,END=2049) DAY,HOUR,MIN,SEC
01120      IF(IND.EQ.0)DELT = DAY + HOUR/24. + MIN/1440. + SEC/36400.
01130      IF(N.EQ.1)DELTO=DELT
01140      IF(N.EQ.1.OR.IND.EQ.0)GO TO 1050
01150 1049 IF(NITER.LE.ITER1)DELT=DELT*FACT1
01160      IF(NITER.GE.ITER2)DELT=DELT*FACT2
01170 1050 FT=ETI+DELT
01180      IF(ETI+DELT*.5.GE.TMAX)GO TO 1001
01190      IF(N.EQ.1.OR.N.EQ.NN.OR.N.EQ.KT)PRINT 9
01200      IF(C.EQ.0)GO TO 4001
01210      IF(N.EQ.1.OR.N.EQ.NN.OR.N.EQ.KT)CALL HEAD(N,DELT,ETI)
01220 4001 PRINT 9
01230      DIV1=GAMMAC/DELT
01240 C
01250 C****ESTABLISH TRANSMISSIBILITIES THIS STEP
01260 C
01284      CALL TRANS1(II,JJ,KK,IM,JM,IX,TY,TZ,A1,A2,A3,DX,DY,DZ,
01285      &BO,IBK,IBKODE,IMM,JMM,VIS,KRAD,STHETA)
01310      DO 70 J=1,JJ
01311      DO 70 I=1,II
01312      DO 70 K=1,KK
01320      Q(I,J,K)=0.0
01330 70 CONTINUE

```

```

01340 C
01350 C*****CALCULATE INJECTION RATES AT CONSTANT RATE, CONSTANT WELL PRESSURE,
01360 C      AND FRACTURE NODES
01370 C
01380      IF(NS.EQ.0.AND.NIF.EQ.0.AND.KPBX.EQ.0.AND.KPBY.EQ.0)GO TO 2026
01390      CALL RATE1(NS,NIF,KPBX,KPBY,NFM,Q,QW,PW,DX,DY,DZ,E1,
01400      &E2,E3,KXS,KYS,KZS,P,VIS,BO,RW,HALF,KFCC,NOF,OK,OWK,QQ,F1,
01410      &F2,F3,LF,PF,A1,A2,A3,KT,N,NW,BY1,BY2,BY3,BX1,BX2,BX3,PBY,PBX,
01420      &IM,JM,PW1)
01430 2026 CONTINUE
01440 C
01450 C*****ESTABLISH RATES AT VARIABLE RATE NODES FOR THIS STEP
01460 C
01470      IF(NVQN.EQ.0)GO TO 2023
01480      IPP=0
01490      DO 2027 J=1,NVQN
01500      IF(FT.LE.TQ1(J).OR.FT.GT.TQ2(J)) GO TO 2027
01510      IPP=1
01520      IF(PI(J).LE.0.0.OR.IP(J).NE.0)Q(QN1(J),QN2(J),QN3(J))=QV(J)
01530      IF(PI(J).LE.0.0)GO TO 2027
01540      IF(PI(J).GT.0.0.AND.IP(J).EQ.0)Q(QN1(J),QN2(J),QN3(J))=
01550      &PI(J)/(VIS(QN1(J),QN2(J),QN3(J))*BO(QN1(J),QN2(J),QN3(J)))
01560      &*(PWF(J)-P(QN1(J),QN2(J),QN3(J)))
01570      IF(PI(J).GT.0.0.AND.IP(J).NE.0)PWF(J)=QV(J)*VIS(QN1(J),QN2(J),
01580      &QN3(J))*BO(QN1(J),QN2(J),QN3(J))/PI(J)+P(QN1(J),QN2(J),QN3(J))
01590 2027 CONTINUE
01600      IF(IPP.EQ.1) PRINT 591,FT
01610      IF(IPP.EQ.1) PRINT 592,(QN1(J),QN2(J),QN3(J),Q(QN1(J),QN2(J),
01620      &QN3(J)),PI(J),PWF(J),P(QN1(J),QN2(J),QN3(J)),VIS(QN1(J),QN2(J),
01630      &QN3(J)),BO(QN1(J),QN2(J),QN3(J)),IP(J),J=1,NVQN)
01640 2023 CONTINUE
01650 C
01660 C*****CALCULATE MAIN DIAGONAL AND RHS VECTOR
01670 C
01680      DO 80 J=1,JJ
01690      DO 30 I=1,II
01700      DO 30 K=1,KK
01710      SUM=TZ(I,J,K)+TY(I,J,K)+TX(I,J,K)+TX(I+1,J,K)+TY(I,J+1,K)+
01720      &TZ(I,J,K+1)
01730      E(I,J,K)=-SUM-VP(I,J,K)*DIV1/BO(I,J,K)
01740      Q3(I,J,K)=-VP(I,J,K)*DIV1/BO(I,J,K)*P(I,J,K)-Q(I,J,K)
01750 30 CONTINUE
01760 80 IF((N.GT.1.AND.N.LT.NN).OR.KPR.EQ.0)GO TO 352
01770      PRINT 16
01780      PRINT 17,(((I,J,K,TZ(I,J,K),TY(I,J,K),TX(I,J,K),E(I,J,K),TX(I+1,J,
01790      &K),TY(I,J+1,K),TZ(I,J,K+1),Q3(I,J,K),I=1,II),J=1,JJ),K=1,KK)
01800      PRINT 56
01810 352 CONTINUE
01820      IF(KSOL.EQ.1)
01830      &CALL PSOR(II,JJ,KK,S1,S2,S3,NP,QS,E,P,PM,TX,TY,TZ,IX,JM,IXM,JXM,
01840      &OMEGA,TOL,TOL1,DW,KODE,KODE1,NITER,FT,NVQN,PM1,PM2,PM3,TP1,TP2,PV,
01850      &PFLAG,PINIT,DELT,DELTO,ISK,KRAD,STHETA)
01860 C

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01870 C      IF(KSOL.EQ.2)
01880 C      &CALL ADIP(--- TO BE ADDED LATER IF NEEDED---)
01890 C
01900 C      IF(KSOL.EQ.3)
01910 C      &CALL LSOR(II,JJ,KK,IM,JM,IMM,JMM,IX,TY,TZ,E,QS,OMEGA,TOL,TOL1,
01920 C      &NITER,MITER,DELT,DELTO,P,PINIT,UM,AZ,BZ,CZ,D1,EZ,FZ,UZ,
01930 C      &S1,S2,S3,NP,NVPN,TP1,TP2,PN1,PN2,PN3,PV,PFLAG,FT,IBK,KRAD,STHETA)
01940 C
01950 C      IF(KSOL.EQ.4)
01960 C      &CALL D4SM(N,II,JJ,KK,IM,JM,IMM,JMM,IX,TY,TZ,E,QS,P,PINIT,
01970 C      &SE,MEP,IR1,JR1,IR,JR,KR,IC,JC,KC,AAA,BBB,X,CCC,
01980 C      &NVPN,PN1,PN2,PN3,TP1,TP2,PV,PFLAG,FT,IBK)
01990 C      IF(KSOL.EQ.4.AND.NVPN.NE.0)CALL TRANS1(II,JJ,KK,IM,JM,IX,TY,TZ,
02000 C      &A1,A2,A3,DX,DY,DZ,BO,IBK,IBKODE,IMM,JMM,VIS,KRAD,STHETA)
02010 C      PRINT 909,N,DELT,FT
02020 C
02030 C*****CALCULATE INJECTION RATES AT CONSTANT PRESSURE, VARIABLE PRESSURE
02040 C      AND SPECIAL NODES
02050 C
02060 C      IF(NP.EQ.0.AND.NVPN.EQ.0.AND.NSPN.EQ.0)GO TO 2006
02070 C      CALL COMPN(NP,IM,JM,IMM,JMM,N,NN,KT,S1,S2,S3,Q,P,IX,TY,TZ,
02080 C      &FT,NVPN,PN1,PN2,PN3,TP1,TP2,PV,PFLAG,NSPN,ISP,JSP,KSP,QSP)
02090 2005 CONTINUE
02100 C
02110 C*****CALCULATE FLUID REMAINING, VOLUME FACTORS, MBE, AND
02120 C      TOTAL INJECTION(STB) THIS STEP
02130 C
02140 C      PAVG=0.0
02150 C      TOTINJ=0.0
02160 C      SM=0.0
02170 C      ACTINJ=0.0
02180 C      ACTPRD=0.0
02190 C      DO 3006 K=1,KK
02200 C      DO 3006 J=1,JJ
02210 C      DO 3006 I=1,II
02220 C      PP=P(I,J,K)
02230 C      SLOPE=(VISMAX-VISOB)/(PMAX-PBO)
02240 C      VIS(I,J,K)=VISOB+SLOPE*(PP-PBO)
02250 C      VP(I,J,K)=VP(I,J,K)*(1.0+CR*(PP-PINIT(I,J,K)))
02260 C      TOTINJ=TOTINJ+Q(I,J,K)*DELT
02270 C      IF(Q(I,J,K).GT.0.0)ACTINJ=ACTINJ+Q(I,J,K)*DELT
02280 C      IF(Q(I,J,K).LT.0.0)ACTPRD=ACTPRD+Q(I,J,K)*DELT
02290 C      IF(IBK(I,J,K).EQ.0)GO TO 3006
02300 C      PAVG=PAVG+PP*VP(I,J,K)
02310 C      BO(I,J,K)=BOB*DEXP(-C*(PP-PBO))
02320 C      SM=SM + VP(I,J,K)/BO(I,J,K)
02330 3005 CONTINUE
02340 C      PAVG=PAVG/RESVOL
02350 C      BV=BOB*DEXP(-C*(PAVG-PBO))
02360 C      SMN=STBCAL
02370 C      IF(N.EQ.1)SMN=STBINT
02380 C      STBCAL=SM/5.615
02390 C      NSC=STBCAL-SMN
02400 C      IMBE=NSC-TOTINJ
02410 C      CUMINJ=CUMINJ+TOTINJ
02420 C      STBACT=STBINT+CUMINJ-CUMO
02430 C      MBE=(STBCAL/STBACT-1.0)*100.0 + MBE0
02440 C      IF(N.NE.1.AND.N.NE.NN.AND.N.NE.KT)GO TO 999

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02450 C
02460 C*****PRINT NEW DISTRIBUTION & SPECIAL NODE DATA
02470 C
02480 CALL PRINT1(II,JJ,KK,IM,JM,N,DELT,TOTINJ,ACTINJ,ACTPRD,C,Q,
02490 &P,CUMINJ,STBINT,FT,KP,NN,KT,STBCAL,PINIT,BV,MBE,STBACT,
02500 &NSC,IMBE)
02510 999 IF(NSPN.EQ.0)GO TO 998
02520 IF(N.NE.1.AND.N.NE.NN.AND.N.NE.K3)GO TO 998
02530 CALL SPECN(I1,JM,IMM,JMM,KPU1,NSPN,ISP,J3P,
02540 &KSP,P,PINIT,VP,QSP,TX,TY,TZ,FT,DELT,ACTINJ,ACTPRD,TOTINJ,
02550 &CUMINJ,PAVG,MBE)
02560 IF(N.EQ.K3)KS=KS+KSN
02570 998 IF((N.NE.1.AND.N.NE.NN.AND.N.NE.LT).OR.KPU2.EQ.0)GO TO 9935
02580 PRINT 56
02590 WRITE (7,2) II,JJ,KK,FT
02600 DO 995 K=1,KK
02610 J=JJ
02620 997 PUNCH 1129,(P(I,J,K),I=1,II)
02630 J=J-1
02640 IF(J.EQ.0)GO TO 996
02650 GO TO 997
02660 995 CONTINUE
02670 998 CONTINUE
02680 9935 IF(N.EQ.LT)LT=LT+LT1
02690 IF(N.EQ.KT)KT=KT+KT1
02700 1000 CONTINUE
02710 1001 CONTINUE
02720 IF(KPU.EQ.0)GO TO 9999
02730 PRINT 3051,FT,CUMINJ,MBE
02740 PUNCH 3051,FT,CUMINJ,MBE
02750 DO 9000 K=1,KK
02760 J=JJ
02770 3050 PRINT 53,(P(I,J,K),I=1,II)
02780 PUNCH 53,(P(I,J,K),I=1,II)
02790 J=J-1
02800 IF(J.EQ.0)GO TO 9000
02810 GO TO 3050
02820 9000 CONTINUE
02830 3051 FORMAT(F20.12,F30.12,F20.12)
02840 591 FORMAT(T15,'ELAPSED TIME = ',F11.6,5X,'VARIABLE RATE NODES ARE
02850 &'SET AS FOLLOWS',//,8X,'NODE',7X,'RATE',11X,'PI',13X,'PWF',6X,
02860 &' PRESS',3X,' VISC',6X,' FVF IP')
02870 592 FORMAT(5X,3I3,2X,E12.6,2X,E12.6,2X,4F12.3,I5/)
02880 92 FORMAT(F20.0)

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02890 1    FORMAT(3F10.0,3I5)
02900 2    FORMAT(3I5,F15.7)
02910 3    FORMAT(I5,F10.0)
02920 4    FORMAT(4F10.0,4I5)
02930 5    FORMAT(I5,F10.5)
02940 6    FORMAT(F10.7)
02950 7    FORMAT(3I5,4F10.0)
02960 9    FORMAT(/)
02970 12   FORMAT(13X,3I4,2F20.3)
02980 1119  FORMAT(1X,15F5.0)
02990 1129  FORMAT(15F5.0)
03000 16   FORMAT(/////T5,'I    J    K    TZ K-1/2    TY J-1/2    TX I-1/2
03010      &' ,7X,'E' ,8X,'TX I+1/2    TY J+1/2    TZ K+1/2    QS'//)
03020 17   FORMAT(3I5,3F12.4,2X,E12.6,3F12.4,2X,E12.6)
03030 19   FORMAT(4F10.0)
03040 20   FORMAT(T30,'*****RESERVOIR AND FLUID PROPERTIES FOLLOW****'
03050      &'*****'//)
03060 41   FORMAT(20F4.2)
03070 44   FORMAT(16F5.3)
03080 53   FORMAT(I5)
03090 5701  FORMAT(15X,3I5,5X,F7.1)
03100 56   FORMAT(/)
03110 58   FORMAT(4F19.12)
03120 51   FORMAT(15X,I3,3X,F12.7)
03130 53   FORMAT(F10.0,I5)
03140 66   FORMAT(13X,3I4,F20.3)
03150 69   FORMAT(40A2)
03160 71   FORMAT(3I5,F10.0)
03170 72   FORMAT(15F8.4)
03180 79   FORMAT(12X,3I3,F12.5,F14.2,F12.3,F15.2)
03190 91   FORMAT(2I5,F10.0)
03200 909   FORMAT(T15,'FOR TIME STEP',I4,3X,
03210      &'STEP SIZE = ',F11.6,3X,'ELAPSED TIME = ',F11.6//)
03220 9091  FORMAT(1X,15F5.0)
03230 9999  CONTINUE
03240      STOP
03250 2049  IND=1
03260      GO TO 1049
03270 C    DEBUG SUBCHK,INIT,SUBTRACE
03280 C    AT 10000
03290      END
END OF DATA

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