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USER'S GUIDE AND DOCUMENTATION MANUAL FOR "PC-GEL" SIMULATOR

Topical Report

By
Ming-Ming Chang
Hong W. Gao

October 1993

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ABSTRACT

PC-GEL is a three-dimensional, three-phase (oil, water, and gas) permeability modification simulator developed by incorporating an in-situ gelation model into a black oil simulator (BOAST) for personal computer application. The features included in the simulator are: transport of each chemical species of the polymer/crosslinker system in porous media, gelation reaction kinetics of the polymer with crosslinking agents, rheology of the polymer and gel, inaccessible pore volume to macromolecules, adsorption of chemical species on rock surfaces, retention of gel on the rock matrix, and permeability reduction caused by the adsorption of polymer and gel. The in-situ gelation model and simulator were validated against data reported in the literature. The simulator PC-GEL is useful for simulating and optimizing any combination of primary production, waterflooding, polymer flooding, and permeability modification treatments.

A general background of permeability modification using crosslinked polymer gels is given in Section I and the governing equations, mechanisms, and numerical solutions of PC-GEL are given in Section II. Steps for preparing an input data file with reservoir and gel-chemical transport data, and recurrent data are described in Sections III and IV, respectively. Example data inputs are enclosed after explanations of each input line to help the user prepare data files. Major items of the output files are reviewed in Section V. Finally, three sample problems for running PC-GEL are described in Section VI, and input files and part of the output files of these problems are listed in the appendices. For the user's reference a copy of the source code of PC-GEL computer program is attached in Appendix A.

I. INTRODUCTION

Permeability heterogeneity is the main factor that leads to low sweep efficiency in oil recovery from petroleum reservoirs. To improve sweep efficiency, a mobility control method based on using various viscosifying agents, such as dilute solutions of polymers, has been used. This method has been successful in many field tests;[1,2] however, it may leave large areas unswept and may be ineffective in reservoirs which have severe permeability contrast between horizontal strata. To improve the sweep efficiency and increase oil recovery in such reservoirs, some form of permeability modification is necessary. This technique has been used in injection

and production wells. In injection wells, it is used to block high-permeability or watered-out thief zones, thereby diverting most of the injected fluids into previously unswept zones. In production wells, it is intended to reduce water production without adversely affecting oil production. Many laboratory and field studies have addressed this problem. Colloidal suspensions, precipitates, emulsions, acrylic/epoxy resins, and gelled polymers are some of the systems that have been reported to provide significant fluid diversion away from thief zones.[3-19]

Much of the previous permeability modification work has focused on gelled polymers. Gelled polymers are either in-situ polymer gels or crosslinked polymers. In-situ polymer gels can be formed by in-situ polymerization of high concentration of monomer in the presence of a catalyst,[11,12] or by in-situ copolymerization of formaldehyde with phenol or resorcinol.[19,20] In-situ polymer gels can also be formed by using the "CAT-AN" process.[13] This process involves injection of alternating slugs of cationic polyacrylamide and anionic polyacrylamide. Recently, two new methods have been developed to form in-situ polymer gels. One method is to inject a recently developed microbial polymer in strong alkali followed by a slug of strong acid.[21,22] Hydrogel is formed after the pH of the alkaline polymer solution is decreased. The gelation process is reversible. Another method to form in-situ polymer gel is to inject a slug of a mixture of hydroxypropylcellulose (HPC) and a surfactant (sodium dodecyl sulfate) into formation. Gel formation is initiated after the mixture contacts with connate brine.[23]

Crosslinked polymer gels are formed by reacting polymers with crosslinkers. Two types of polymers, polyacrylamides and biopolymers, that are traditionally used in mobility control have been used to react with metallic crosslinking agents to form three-dimensional networks of crosslinked polymers. The crosslinking sites in both types of polymer molecules are the -COO groups. The formation of crosslinked polymer gels is accomplished by ionic bonding of metal ions at carboxyl groups. In the oil industry, the most commonly used metallic crosslinking ions are inorganic Cr(III) ion[6,7,24-26] and Al(III) ion[4,5,15,27,28]. Crosslinked polymers formed by crosslinking polyacrylamides or biopolymers with these metallic crosslinking ions are only applicable to reservoirs with low temperatures and low hardness levels. Using Cr(III) propionate,[29] Cr(III) acetate[16,17,30,31] or Cr(III) malonate[32] as the crosslinking agent, the gels prepared with polyacrylamides can tolerate harsh reservoir conditions and are insensitive to oil field interferences and environments. In addition to metallic crosslinking agents, organic crosslinker has also been used to form thermally stable gels with thermally stable copolymers.[18] The crosslinking condition, gelation time, and gel strength depend on a lot of factors including the type of polymer, type of crosslinker, polymer and crosslinker concentration, pH, temperature, total dissolved salts, and shear. For polyacrylamides, gelation also depends on the degree of hydrolysis.[16,24,31,33-36]

Crosslinked polymer gels can be either formed in situ or prepared on the surface prior to injection. Because of viscoelasticity, crosslinked high-molecular-weight polyacrylamide gels are usually formed in situ. In contrast to crosslinked high-molecular-weight polyacrylamide gels, crosslinked biopolymer gels are pseudoplastic; therefore, they can be prepared on the surface prior to injection. Two types of methods have been developed to form crosslinked polymer gels in situ. The first type is based on a controlled release of an ionic crosslinker. Examples of this type include the chromium redox process[3] and Union Oil Company's high-pH aluminate [$Al(OH)_4^-$]/polymer system.[15] The second type involves alternate injection of a polymer slug and a slug containing a crosslinker to build up layers of crosslinked polymer. An example of this type is the aluminum citrate process.[4,5]

A simulator is very useful to facilitate the design of treatments and to assess potential fields for permeability modification treatments using crosslinked polymers. Such a simulator must be able to describe the transport of the chemical species and the reaction kinetics of the gelation system in stratified reservoirs. It must also be able to account for phenomena such as inaccessible pore volume to macromolecules, adsorption of chemical species on rock surfaces, and retention of crosslinked gels on the rock matrix. Simulation of profile modification using crosslinked polymers have recently appeared in the literature.[37-39] Calculations based on a simplified in-situ gelation model have also been made.[38,40] These simulators were all developed based on chemical flood simulators and are not applicable to reservoirs which contain gas as a component.

In 1990, a three-dimensional, three-phase (oil, water, and gas) permeability modification simulator,[41,42] was developed by incorporating the above-mentioned features into a three-dimensional, three-phase black oil simulator (BOAST).[43] This permeability modification simulator is capable of modeling a three-dimensional reservoir of heterogeneous distributions of porosity, permeability, saturations, and depths to the formation top. This multiple layer model allows investigations of cross flow of fluid in porous media at various vertical transmissibility values. Using the simulator the effects of selected parameters on additional oil recovery over that by waterflood and polymer flood can also be investigated.[41,42, 44]

Because of the relatively efficient mathematical formulation of BOAST and the fast advancement of personal computer technology, the developed permeability modification simulator was adapted for use on a personal computer. The PC version of the simulator is called "PC-GEL". It's source code is listed in Appendix A. To allow the PC simulator to perform multiple simulation runs using different input files, a batch file was created. The use of this batch file is explained in section II. Due to similar input parameters for constructing the reservoir model, data preparation steps described in sections III and IV were modified from sections V and VI of BOAST-VHS user's manual.[45]

II. MODEL DESCRIPTION

2.1 Mathematical Modeling of In-Situ Gelation

Chemical Transport Equations

To model the rate of gel formation through crosslinking of polymer, equations describing the transport and reaction kinetics of gelled polymer systems are formulated. Assuming that all of the chemical species of the polymer/crosslinker system are transported by the aqueous phase only, the conservation equation for each chemical species in the aqueous phase can be written as[46]

$$\frac{\partial(\phi\rho S C_i)}{\partial t} + \frac{\partial[f\rho_R(1 - \phi)C_{ir}]}{\partial t} = D\nabla\cdot(\phi\rho S\nabla C_i) - \nabla\cdot(\rho C_i\vec{u}) + \phi\rho S R_i - Q_i\rho C_i/V\,; \qquad i = 1 \text{ to } 5, \qquad (1)$$

where ρ = aqueous phase density, C_i = mass concentration of component i, $\vec{u}$ = Darcy velocity vector, ϕ = porosity, S = aqueous phase saturation, ρ_R = rock density, f = fraction of rock surface contacted by the aqueous phase, C_{ir} = mass concentration of component i adsorbed on rock surface, Q_i = well rate, V = wellblock volume, D = a constant dispersion coefficient, R_i = formation rate of component i in a unit volume of the porous medium, and ∇ = divergence operator.

To account for the inaccessible pore volume (IPV) effect, both ϕ on the left-hand side and in the first term of the right-hand side of Eq. 1 are replaced by an appropriate porosity for the polymer, ϕ_p.

Gelation Reaction Kinetics

In this simulation study, a dichromate/thiourea redox system[47,48] was chosen for kinetics modeling. In the chromium redox process, chromium in the +6 oxidation state is reduced to Cr(III) with a reducing agent, thiourea. The trivalent chromium then reacts with polymer to form a three-dimensional network of gel structure which is highly resistant to flow and not eluted readily.[3]

1. Chemical Reactions:

$$Cr_2O_7^{2-} + 6\ CSN_2H_4 + 8\ H^+ \rightarrow 2\ Cr^{3+} + 3\ [CSN_2H_3]_2 + 7\ H_2O \tag{2}$$

and $$n\ Cr^{3+} + \text{polymer} \rightarrow \text{gel.} \tag{3}$$

2. Experimental Kinetics:[47-49]

$$\frac{d[Cr_2O_7^{2-}]}{dt} = \frac{1}{6}\frac{d[CSN_2H_4]}{dt} = -k_1[Cr_2O_7^{2-}][CSN_2H_4], \tag{4}$$

$$\frac{d[Cr^{3+}]}{dt} = 2k_1[Cr_2O_7^{2-}][CSN_2H_4] - k_2n[Cr^{3+}]^2[polymer]^2, \tag{5}$$

and $$-\frac{d[polymer]}{dt} = \frac{d[gel]}{dt} = k_2[Cr^{3+}]^2[polymer]^2\ . \tag{6}$$

For a hydrolyzed polyacrylamide molecular weight of about 5 x 10^6, n is about 1x10^3 in Eqs. 3 and 5.[37]

Physical Properties of Polymer and Gel

The polymer and gel physical properties and phenomena modeled in the simulator include viscosity, adsorption/retention on the rock matrix, permeability reduction, and inaccessible pore volume (IPV) to macromolecules.

Viscosity

The effect of polymer concentration on solution viscosity was modeled either by a quadratic[50] or by a third-order polynomial.[51,52]

$$\mu_p = \mu_w + ALPHA1 \times C_p + ALPHA2 \times C_p^2 + ALPHA3 \times C_p^3. \tag{7}$$

The shear rate dependence of polymer viscosity was modeled by Meter's equation.[53]

$$\mu = \mu_\infty + \frac{\mu_o - \mu_\infty}{1 + (\frac{\dot{\gamma}}{\dot{\gamma}_{1/2}})^{p-1}}, \tag{8}$$

where μ_o = zero shear rate viscosity, μ_∞ = infinite shear rate viscosity, $\dot{\gamma}$ = shear rate, $\dot{\gamma}_{1/2}$ = shear rate at which the viscosity is half of μ_o, and p = a parameter determined from experiments.

The equivalent shear rate in porous media was calculated from the following equation:[50]

$$\dot{\gamma} = 268\, |\vec{u}|\, /(k k_r / \phi S)^{0.5}, \tag{9}$$

where $\vec{u}$ = Darcy velocity vector for the aqueous phase, k = absolute permeability in md, k_r = aqueous phase relative permeability, and Eq. 10 was used to calculate k.[52,54]

$$k = [(u_x/|\vec{u}|)^2/k_x + (u_y/|\vec{u}|)^2/k_y]^{-1}, \tag{10}$$

where k_x and k_y = absolute permeabilities in the x and y directions, respectively.

Gel viscosity is treated in a manner similar to that by Sorbie et al.[37] An additional cubic term was use to account for the smooth but rapid increase in gel viscosity at the gelation point.[33]

$$\mu_g = \mu_w + BETA1 \text{ x } C_g + BETA2 \text{ x } C_g^2 ; \qquad (C_g < CGC), \tag{11}$$

and $$\mu_g = \mu_w + BETA1 \text{ x } C_g + BETA2 \text{ x } C_g^2 + BETA3 \text{ x } (C_g - CGC)^3; (C_g > CGC). \tag{12}$$

Adsorption/Retention on Rock Matrix

The adsorption isotherms for all five chemical components are assumed to follow the Langmuir equation.

$$C_{ir} = \frac{BB(I) \text{ x } C_i}{1 + AA(I) \text{ x } C_i}, \tag{13}$$

where i = 1 to 5, and $AA(I)$ and $BB(I)$ are adsorption parameters determined from laboratory for component i. Irreversible adsorption is considered for both polyacrylamide polymer and gel.

Permeability Reduction

The permeability reduction caused by adsorbed polymer and gel is defined as:[56]

$$k(C) = k/RRF, \tag{14}$$

where k = absolute permeability in mD and RRF = residual resistance factor. In this study, RRF was modeled as:[37]

$$RRF = 1 + \sum_{i=1}^{5} l_i g_i(\Gamma_i) \tag{15}$$

for $g_i = 0 \qquad (\Gamma_i \leq \Gamma_i')$, (16)

and $g_i = \Gamma_i - \Gamma_i' \qquad (\Gamma_i > \Gamma_i')$, (17)

where the parameter Γ_i = the amount of component i adsorbed, and Γ_i' = a critical onset value for Γ_i; i.e., the chemical does not block pores below a certain value of adsorption. Values of coefficients, l_i, have to be determined from the laboratory studies. The reduction in permeability is assumed to affect both aqueous and oil phases.

Inaccessible Pore Volume

To account for the IPV effect,[56-58] both ϕ's on the left-hand side and in the first term of the right-hand side of Eq. 1 are replaced by an apparent porosity for the polymer, ϕ_p.

2.2 Black Oil Model

The flux term in transport Eq. 1 is solved from three-dimensional, three-phase continuity equations applicable in an environment of black oil reservoirs.[43] The continuity equations are given by:

$$-\vec{\nabla}\cdot \left(\frac{\rho}{B}\vec{u}\right)_m - Q_m = \frac{\partial}{\partial t}\left(\frac{\phi\rho S}{B}\right)_m, \tag{18}$$

where m = oil, water, or gas phase. Sources (injectors) and sinks (producers) at various strengths are assigned through well rates (Q) in the model.

Black oil simulators describe multiphase flow in porous media without considering the change of composition of the hydrocarbon fluid with production time. They assume that the

liquid hydrocarbon phase consists of only two components: oil and dissolved gas. The gas phase consists of only free hydrocarbon gas. It is assumed that the fluid phase behavior can be represented by a PVT table which is a function of pressure only.

The reservoir fluid approximations are found to be acceptable for a large percentage of the world's oil reservoirs. Thus, black oil simulators have a wide range of applicability and are routinely used for solving field production problems. Although black oil simulators are well suited for studies of numerous problems, they do have some limitations in their scope of applications. They cannot be used to study cases where mass transfer between phases is important. For example, black oil simulators cannot be used to study problems associated with gas condensate and volatile oil reservoirs. In these reservoirs, the composition and physical properties of the phases change with pressure and time. Since reservoirs are usually pressurized during gel chemical injection, oil composition does not change much with production time so that the black oil model treatment is acceptable to the in situ gelation simulations.

The well model in PC-GEL permits specification of rate or pressure constraints on well performance. The model also allows the user to add or recomplete wells during the period represented by the simulation. Several other features are included in the model, such as flexible initialization capabilities, a bubble point pressure tracking scheme, an automatic time step control method, a zero transmissibility option, and a material balance check on solution stability.

2.3 Numerical Solution

The fluid and chemical species flow in porous media is solved in two steps during each time step of the numerical simulation. The fluid flow Eq. 18 is first solved for Darcy velocity using the implicit pressure - explicit saturation (IMPES) procedure. A no-flow boundary of the reservoir is implemented by setting pressure gradient at boundary interfaces to zero. This is followed by the solution of transport equations of gel chemicals (Eqs. 1 through 18). To solve Eq. 1, an extended method of lines[37,59] (MOL) is used. Applying MOL to Eq. 1, the partial differential equation is converted to a system of coupled, non-linear ordinary differential equations. The ordinary differential equations are then solved using the widely used fourth-order Runge-Kutta-Gill method.[60] The amount of gelation is then calculated, and the permeability is adjusted for pressure calculations in the next time step. The above solution procedures are repeated for each time step until the total simulation time is reached.

Numerical dispersion associated with the solution of Eq. 1 in its finite difference form causes a smearing of sharp concentration/saturation fronts. Sorbie et al.[37] have found that using the high-order central difference method in spatial derivative approximation gives satisfactory

results. In our model, a central finite difference method of up to 10th order is used to approximate the spatial derivatives.

PC-GEL employs IMPES formulation for solving its system of finite-difference equations. The IMPES method solves for the pressure distribution for a given time step first, then the saturation distribution for the same time step. The IMPES formulation is straightforward, requires less arithmetic per time step, and hence usually is faster than other formulations. The central processing unit (CPU) time for the iterative methods depends on the type of problem to be solved and the selection of the iterative parameter. Further, the IMPES formulation requires less storage than a fully implicit formulation. This permits the simulation of larger problems on a small computer such as a personal computer.

PC-GEL performs material-balance calculations at the end of each time-step, as a check to determine the degree to which the finite-difference solutions obtained from the IMPES procedure actually satisfy the conservation equations. This basically involves comparing the change of each fluid phase over time with the quantities of fluid produced and injected over the same time period. The change in fluid content (STB or MCF) is estimated directly from calculated saturations and pressures. Quantities produced and/or injected are determined from the production and injection rates at all wells.

Time-step material balances are printed on each recurrent production report and should always be checked carefully before accepting any run as a 'final' result. In general, time-step material balance errors should normally be less than 0.1%. An excessive material-balance error is an indication of a large saturation and/or pressure change that causes the results of PC-GEL to be an inaccurate simulation. The problem can usually be overcome by reducing the time-step size. This can be performed by specifying a smaller minimum time step-size and reducing saturation and pressure tolerances.

2.4 Model Validation

To validate the simulator, results from the in situ gelation model before being incorporated into the BOAST simulator were compared with those of Sorbie et al.[37] Both concentration and viscosity profiles[41] are in excellent agreement with those of Sorbie et al. No residual resistance factor profile is available for comparison.

To validate the simulator, comparisons were made with three-layer[61] and two-layer[62] cross-sectional simulations of polymer floods. The injection sequence for the three-layer, cross-sectional simulation was

(1) 180 days waterflood;

(2) 365 days polymer flood (about 0.17 PV); and

(3) waterflood for the remainder of the project.

The effects of time step size (DT) and grid block size in the x-direction (DX) were studied for the first 600 days at fixed DZ=27 ft. Table 2-1 shows the results after 180 days of waterflood. Changing the size of grid block from 6.6 to 33 ft at fixed DT=1 day, the cumulative oil production after 180 days of waterflood only changed by 2.0%; however, cumulative water production at 180th day decreased with a decrease in the grid block size. Decreasing the grid block size also delayed the water breakthrough and resulted in a small cumulative water production. This was caused by numerical dispersion. Numerical dispersion can be suppressed by using a time step size such that[63]

$$DT = DX/u \tag{19}$$

where u is the frontal advance rate. Calculated DT's for DX=16.5 ft and DX= 13.2 ft were 5.24 and 4.19 days, respectively. Simulation results for DT=5 days and DX=16.5 ft and for DT=4 days and DX=13.2 ft are shown in Table 2-1 (run numbers 8 and 9). In these two cases, water broke through at about the same time, and a sharp water front existed. Compared with runs 1 through 6, the oil production rate was much higher, and cumulative water production was much lower. Using DT=5 days and DX=33 ft (run number 10), the oil production rate and cumulative oil production were almost the same as those in run no. 8. Further increasing the grid block size to 66 ft at DT=5 days, both oil production rate and cumulative oil production decreased, and cumulative water production increased. Hence, during the first 180 days of waterflood, DT=5 days and DX= 16.5 or 33 ft were used in sample problems. After the 180th day, variable time steps (minimum=0.1 day, maximum=5 days) and DX=33 ft were used. Compared with the fractional oil recovery obtained from a two-dimensional (2-D), three-phase, nine-component chemical flood simulator,[61] the agreement between calculated fractional oil recovery in both cases is very good.[41]

TABLE 2-1. - Effects of grid block length and time-step size on three-layer, cross-sectional simulation results at 180th day of waterflood.

Run No.	No. of grid blocks	Grid block length ft	Time Step Size d	Oil prod rate ft^3/d	Cumu-lative oil prod. bbl	Cumu-lative water prod. bbl	Water oil ratio	Water break-through d
1	10	132	1	1093.0	50982.1	3017.9	0.54	122
2	20	66	1	1080.8	52093.8	1096.2	0.56	150
3	40	33	1	1045.8	52821.9	1178.1	0.61	165
4	80	16.5	1	1031.7	53242.7	757.3	0.63	171
5	100	13.2	1	1041.1	53577.8	642.0	0.62	172
6	160	8.25	1	1043.3	53534.9	466.0	0.61	175
7	200	6.6	1	1093.5	53657.2	342.8	0.54	176
8	80	16.5	5	1684.3	53975.4	24.6	0.00	400
9	100	13.2	4	1684.3	53974.4	25.6	0.00	500
10	40	33	5	1684.5	53979.6	20.4	0.00	205
11	20	66	5	1076.0	52448.4	608.5	0.57	160

In the two-layer, cross-sectional simulation runs, 40 and 80 grid blocks in the x-direction and variable time step sizes (0.01 to 5 days and 0.01 to 10 days) were used. Results showed that fractional oil recovery did not change with the grid block size and time step size used, whereas the water-oil ratio did change slightly with the grid block size and time step size when there was no dispersion effect. Calculated fractional oil recovery[41] is in good agreement with those of Naiki (UT)[62] and a predictive model (PM).[64]

2.5 Running PC-GEL

To allow the PC-GEL simulator to perform multiple simulation runs using different input files, a batch file was created. The batch file is named "rungel.bat" and it should normally be located in a directory (called the source directory) that is one level higher than the output and data subdirectories. A copy of "run gel.BAT" is listed in Appendix B. The batch file allows for three separate data subdirectories to store the input files for the simulator. It also allows for three separate output subdirectories to store the output files of the simulator. The three input subdirectories, the three output subdirectories, and the source directory can be set by editing the batch file with an editor. This is a simple procedure; the batch file contains the necessary documentation.

The batch file requires extra memory in the DOS environment. To dedicate enough memory (about 1K) the SHELL command in the CONFIG.SYS file should be modified to:

SHELL=\COMMAND.COM /P /E: 512

For detailed instructions on how to use the batch file, go to the subdirectory on the hard disk containing RUNGEL.BAT and type in response to the DOS prompt:

C:\>RUNGEL

Running the Program PC-GEL

To use the batch file, all of the input files that are to be processed should be located in one of the three special input subdirectories. From the source directory (the directory containing RUNGEL.BAT) the command sequence is as follows:

rungel # dataname1 dataname2 path1(optional) path2(optional)

where:

rungel is the name of the batch program (rungel.bat)
is the total number of input files (6 maximum)
dataname1 is the name of the first input file EXCLUDING the extension ".dat"
dataname2 is the name of the second input file excluding the extension ".dat"
dataname3 is the name of the third input file... and so on.

Path1 is the directory containing the input files beginning from the root directory.
If path1 is left unspecified, the batch program will assume a default input subdirectory.

Path2 is the directory to send the output files to.
If path2 is left unspecified, the batch program will assume a default output subdirectory.

If, for example, the input files INPUT5A.DAT and BFIELD2.DAT were located in an input subdirectory named C:\RUNGEL\DATA2 and the output of the simulation was to be sent to an output subdirectory named C:\RUNGEL\OUTPUT3, then the proper command would be:

C:\>rungel>rungel 2 input5A bfield2 rungel\data2 rungel\output3

2.6 Data Input Requirements

PC-GEL is a program that needs an input data file to run. This section describes briefly the input requirements for PC-GEL. A complete description of the input data required to run PC-GEL is given in Sections III and IV.

All input data for the simulator are contained in a single file. These data can be divided into two groups: (a) initialization data and (b) recurrent data. The initialization data include reservoir geometry, rock porosity and permeability, initial pressure and saturation data, relative permeability and capillary pressure tables, fluid PVT data, and in situ gelation parameters. Also included in this section are the necessary run control parameters and solution specifications.

The recurrent data include the location and initial specifications of wells in the model, time step control information for advancing the simulation through time, a schedule of individual well rates and/or pressure performance, changes in well completions and operations over time, and controls on the type and frequency of printout information provided by the simulator.

Throughout the description of input data in Sections IV and V, the term "header" is used to refer to specific input data records. These records are designed to serve as delineators and/or as data identifiers. The header record may be used to identify conveniently specific data items on the subsequent record or records.

All data values are identified by a name that corresponds to the actual variable name in the model. All data except the 'header' records are entered as free-field format. The term "free-field format" as applied to this program means that an item of data need not appear in a particular location on a data input line. The term 'line' refers to an individual line in an input data set as entered on the monitor. Input data must be entered in a sequence, and a value must be specified for each input datum. If more than one value must appear on a line, each value must be separated from neighboring data by at least one space.

III. DATA INITIALIZATION

This section describes in detail the gel-chemical and reservoir data required to initialize the simulation program. The gel-chemical data include dispersion, adsorption, and reaction rate coefficients for five chemical components and parameters for calculating changes in aqueous viscosity and rock permeability caused by gelation reactions. The reservoir data include the reservoir model grid dimensions and geometry, porosity and permeability distributions, relative permeability and capillary pressure data, fluid PVT data, initial pressure and saturation distributions within the reservoir, run control and diagnostic parameters, time step control parameters, and parameters for numerical solution procedures. These data are read only once at

the beginning of the simulation. They must be read in the order in which they appear in the following input data subsections.

The next several subsections describe in detail the input data for the simulator. Each input entry is illustrated by an example.

3.1 Output File Names

Line 1: Name of the regular output file

FORMAT: 8A1

READ: **OUTPUT**

Note: This line is used to define the name of the regular output file for the simulation run. Enter any desired alphanumeric name up to 8 characters. The output file name will be OUTPUT.OUT

Example: *GELTEST.* The regular output file name is GELTEST.OUT.

Line 2: Name of the summary output file

FORMAT: 8A1

READ: **OUTRATE**

Note: This line is used to define the name of the summary output file for the simulation run. Enter any desired alphanumeric name up to 8 characters. The output file name will be OUTRATE.OUT

Example: *GELRATE* The rate output file name is GELRATE.OUT.

Line 3: Name of the chemical concentration, RRF, and viscosity increase output file

FORMAT: 8A1

READ: **OUTGEL**

Note: This line is used to define the name of the chemical concentration output file for the simulation run. Enter any desired alphanumeric name up to 8 characters. The output file name will be OUTGEL.OUT

Example: *GEL* The chemical concentration output file name is GEL.OUT.

3.2 Grid Dimensions and Geometry

Line 1: Title or name of the run

FORMAT: 40A2

READ: Header

Note: This line is used to enter the title of the simulation program. Enter any desired alphanumeric run title information up to 80 characters.

Example: *IN SITU GELATION SIMULATION RUN*

Line 2: This line is used to enter the number of grid blocks in each direction.

READ: **II, JJ, KK**

II = number of grid blocks in the X-direction

JJ = number of grid blocks in the Y-direction

KK = number of grid blocks in the Z-direction

Example: *9 9 1*

This specifies that there are nine grid blocks in the X and Y directions, and one in the Z direction.

Line 3: Use this line to identify the next set of data

READ: Header (40A2)

Example: *NGEL*

Line 4: Enter switch code or flag.

READ: **NGEL**

NGEL= 1, "Gel Transport" option will be invoked.

0, "Gel Transport" option will not be invoked and PC-GEL will work as a regular black oil simulator.

Example: *1*

This specifies that "Gel Chemical Transport" option will be invoked.

Line 5: Use this line to identify the next set of data.

READ: Header (40A2)

Example: *GRID BLOCK LENGTHS*

Line 6: This line is used to enter codes for inputting grid block dimensions.

READ: **KDX, KDY, KDZ**

KDX = Code for specifying X-direction grid dimensions (see Table 3-1)

KDY = Code for specifying Y-direction grid dimensions (see Table 3-1)

KDZ = Code for specifying Z-direction grid dimensions (see Table 3-1)

Example: *-1 -1 -1* Specifies a single length for each dimension of the grids.

Line 7: This line is used to enter the X-direction grid dimensions in ft.

READ: **DX**

Example: *147*

This specifies that the X-direction grid block length is 147 ft.

Note: See table 3-1 for the number of values. When KDX = 0 or 1, the order of input must be as follows:

J = 1, I = 1, 2, ... II

J = 2, I = 1, 2, ... II

.....

J = JJ, I = 1, 2, ... II

TABLE 3-1. - Options for grid-block geometry

Code	Value	Grid dimension specifications
KDX	-1	X-direction grid dimensions are the same for all grid blocks; input only one DX value
KDX	0	X-direction grid dimensions are read for each grid-block in the first row (J = 1) of layer one (K = 1) input II values of DX. These same x-direction dimensions are assigned to all other rows and all other layers in the model grid.
KDX	1	X-direction dimensions are read for every grid block in layer one (K = 1). input II x JJ values of DX. These same X-direction dimensions are assigned to all other layers in the model grid.
KDY	-1	Y-direction grid dimensions are the same for all grid blocks; input only one DY value.
KDY	0	Y-direction grid dimensions are read for each grid block in the first column (I = 1) of layer one (K = 1). Input JJ values of DY. These same Y-direction dimensions are assigned to all other columns and all other layers in the model grid.
KDY	1	Y-direction dimensions are read for every grid block in layer one (K = 1); input II x JJ values of DY. These same Y-direction dimensions are assigned to all other layers in the model grid.
KDZ	-1	Z-direction grid dimensions are the same for all grid blocks; input only one DZ value.
KDZ	0	A constant value of thickness is read for each layer in the grid; input KK values of DZ.
KDZ	1	Z-direction grid dimensions are read for every grid block; input II x JJ x KK values of DZ.

Line 8: This line is used to enter the Y-direction grid dimensions in ft.

READ: **DY**

This specifies that the Y-direction grid block length is 147 ft.

Note: See table 3-1 for the number of values. When KDY = 0 or 1, the order of input must be the same as that indicated in line 7.

Line 9: This line is used to enter the Z-direction grid dimensions in ft.

READ: **DZ**

Example: *20*

This specifies that the Z-direction grid block length is 20 ft.

Note: See table 3-1 for the number of values. When KDZ = 1, the order of input must be as indicated in line 7 above with the layer order K = 1, 2, ...KK.

3.3 Modifications to Grid Dimensions:

Line 1: Use this line to identify the next set of data.

READ: Header (40A2)

Example: *GRID BLOCK DIMENSION MODIFICATIONS*

Line 2: This line is used to enter the number of grid blocks where grid dimensions are to be changed; plus print code.

READ: **NUMDX, NUMDY, NUMDZ, IDCODE**

NUMDX = Number of grid blocks where X-direction grid dimensions (DX) is to be changed.

NUMDY = Number of grid blocks where Y-direction grid dimensions (DY) is to be changed.

NUMDZ = Number of grid blocks where Z-direction grid dimensions (DZ) is to be changed.

IDCODE = Print code for grid dimension alterations.
If IDCODE = 0, do not print the modified grid dimensions.
If IDCODE = 1, print the modified grid dimensions.

Example: *0 0 0 0*

This specifies that there is no change in grid dimensions; and that the dimensions are not to be printed (even if they were modified).

Line 3: Use NUMDX set of lines to enter the coordinates of the blocks in the X-direction whose dimensions are to be modified; omit this line if NUMDX = 0.

READ: **I, J, K, DX**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

DX = New X-direction grid dimension (DX) for block (I, J, K)

Note: NUMDX lines must be read.

Line 4: Use NUMDY set of lines to enter the coordinates of the blocks in the Y-direction whose dimensions are to be modified; omit this line if NUMDY = 0.

READ: **I, J, K, DY**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

DY = New Y-direction grid dimension (DY) for block (I, J, K)

Note: NUMDY lines must be read.

Line 5: Use NUMDZ set of lines to enter the coordinates of the blocks in the Z-direction whose dimensions are to be modified; omit this line if NUMDZ = 0.

READ: **I, J, K, DZ**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

DZ = New Z-direction grid dimension (DZ) for block (I, J, K)

Note: NUMDZ lines must be read.

3.4 Elevations to Top of Grid-Blocks in Layer I

Remember that with the coordinate system used here, Z-direction values increase going down. Thus, elevations must be read as positive depths below the user selected reference datum. Negative values will be interpreted as heights above the datum.

Line 1: Use this line to identify the next set of data.

READ: Header (40A2)

Example: *CAP ROCK AT BASE DEPTHS*

Line 2: This line is used to enter the code for inputting grid-block elevations.

READ: **KEL**

KEL = Input code

REMARKS: (1) If KEL = 0, a single constant value is read for the elevation at the top of all grid blocks in Layer 1. (i.e., horizontal plane).

(2) If KEL = 1, a separate elevation value must be read for each grid block in Layer 1. II x JJ values must be read.

Example: *0*

This specifies that a single elevation value is to be read.

Line 3: This line is used to enter the depth values.

READ: **ELEV**

ELEV: Elevation to top of grid blocks in feet

Example: *8325.0*

This specifies that the top of the formation is 8325 feet below the datum.

REMARKS: (1) When KEL = 0, read only one value

(2) When KEL = 1, read II x JJ values. These values must be read in the same order as indicated in line 7.

(3) Elevations to the top of the grid-blocks in layers below Layer 1 will be calculated by adding the layer thickness to the preceding layer elevation; i.e., TOP (I, J, K + 1) = TOP (I, J, K) + DZ (I, J, K)

3.5 Porosity and Permeability Distributions

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *POROSITY AND PERMEABILITY INPUTS*

Line 2: This line is used to enter the code for controlling porosity and permeability data input.

READ: **KPH, KKX, KKY, KKZ**

KPH = Code for controlling porosity input data (See table 3-2)

KKX = Code for controlling X-direction permeability (See table 3-2)

KKY = Code for controlling Y-direction permeability (See table 3-2)

KKZ = Code for controlling Z-direction permeability (See table 3-2)

Example: *-1 -1 -1 -1*

This specifies that porosity and permeabilities are uniform over the grid. Only one porosity value and one value of permeability for each X, Y and Z direction is to be read.

Line 3: This line is used to enter porosity values as a fraction.

READ: **PHI**

Example: *0.25* Specifies 25% porosity.

Note: (a) Porosity is read as a fraction (not as a percentage)

(b) See table 3-2 for the number of values. When KPH = + 1, the order of input must be as indicated below with layer order

for K = 1,2, . . . KK:

J = 1, I = 1,2, ... II

J = 2, I = 1,2, ... II

.....

J = JJ, I = 1,2,. . . . II

TABLE 3-2. - Options for grid-block properties

Code	Value	Porosity and permeability specifications
KPH	-1	Porosity is uniform over the grid; input only one PHI value.
KPH	0	Porosity varies by layer; input KK values of PHI
KPH	+1	Porosity varies over the entire grid; input II x JJ x KK values of PHI
KKX	-1	X-direction permeability is uniform over the grid; input only one KX value
KKX	0	X-direction permeability varies by layer; input KK values of KX
KKX	+1	X-direction permeability varies over the entire grid; input II x JJ x KK values of KX
KKY	-1	Y-direction permeability is uniform over the grid; input only one KY value
KKY	0	Y-direction permeability varies by layer; input KK values of KY
KKY	+1	Y-direction permeability varies over the entire grid; input II x JJ x KK values of KY
KKZ	-1	Z-direction permeability is uniform over the grid; input only one KZ value
KKZ	0	Z-direction permeability varies by layer; input KK values of KZ
KKZ	+1	Z-direction permeability varies over the entire grid; input II x JJ x KK values of KZ

Line 4: This line is used to enter X-direction permeability values in md.

READ: **KX**

KX = X-direction permeability values

Example: *200.0*

This specifies that the X-direction permeability is 200 md.

Note: (a) Permeabilities read in millidarcies (md); KX is a real variable.

(b) See table 3-2 for the number of values. When KKX = + 1, the order of input must be as indicated for Line 3 above with layer order K = 1,2, ... KK

Line 5: This line is used to enter Y-direction permeability values in md.

READ: **KY**

KY = Y-direction permeability values (in millidarcies)

KY is a real variable

Example: *200.0*

This specifies that the Y-direction permeability is 200 md.

Note: See table 3-2 for the number of values. When KKY = + 1, the order of input must be as indicated for line 3 above with layer order K = 1, 2, ... KK

Line 6: This line is used to enter Z-direction permeability values in md.

READ: **KZ**

KZ = Z-direction permeability values (in millidarcies);

KZ is a real variable

Example: *20.0*

This specifies that the Z-direction permeability is 20 md.

Note: See table 3-2 for the number of values. When KKZ = + 1, the order of input must be as indicated for line 3 above with layer order K = 1, 2, ... KK

3.6 Modifications to Porosity and Permeability Distributions

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *POROSITY AND PERMEABILITY MODIFICATION*

Line 2: This line is used to enter the number of grid blocks where porosity and/or permeability values are to be changed, as well as the print code.

READ: **NUMP, NUMKX, NUMKY, NUMKZ, IPCODE**

NUMP = Number of grid-blocks where porosity (PHI) values are to be changed

NUMKX = Number of grid-blocks where X-direction permeability values (KX) are to be changed

NUMKY = Number of grid-blocks where Y-direction permeability values (KY) are to be changed

NUMKZ = Number of grid-blocks where Z-direction permeability values (KZ) are to be changed

IPCODE = Print code for porosity and permeability alterations

If IPCODE= 0, do not print modified porosity and permeability alterations

If IPCODE = 1, print modified porosity and permeability distribution

Example: *2 0 0 0 1*

This specifies that the porosity values are to be modified in two grid blocks; no permeability changes and print the modified values.

Line 3: Use NUMP sets of lines to enter the coordinates of the blocks where porosity is to be modified; omit this line if NUMP =0.

READ: **I, J, K, PHI**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

PHI = New value of porosity in fraction for block (I, J, K)

Example: *1 1 1 0.125*

9 1 1 0.125

This specifies that the porosity of the grids (1,1,1) and (9,1,1) are to be changed to 0.125.

Note: (1) Porosity must be entered as a fraction

(2) NUMP lines must be read

Line 4: Use NUMKX sets of lines to enter the coordinates of the blocks in the X-direction where permeability (KX) is to be modified.

READ: **I, J, K, KX**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

KX = New value of X-direction permeability (KX) for block (I, J, K) in millidarcies

Note: (1) NUMKX lines must be read

(2) KX is a real variable

Example: No line in our example problem.

Line 5: Use NUMKY sets of lines to enter the coordinates of the blocks in the Y-direction where permeability (KY) is to be modified.

READ: **I, J, K, KY**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

KY = New value of Y-direction permeability (KY) for block (I, J, K) in millidarcies

Example: No line in our example problem.

Note: (1) NUMKY lines must be read

(2) KY is a real variable

Line 6: Use NUMKZ sets of lines to enter the coordinates of the blocks in the Z-direction where permeability (KZ) is to be modified.

READ: **I, J, K, KZ**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

KZ = New value of Z-direction permeability (KZ) for block (I, J, K) in millidarcies

Example: No line in our example problem.

Note: (1) NUMKZ lines must be read

(2) KZ is a real variable

3.7 Transmissibility Modifications

Note: It is extremely important to keep in mind the directional convention used in specifying transmissibility modifications. For example, in grid block (I, J, K),

TX (I, J, K) is the X-direction transmissibility which refers to flow across the boundary between blocks (I-1,J,K) and (I,J,K)

TY (I, J, K) is the Y-direction transmissibility which refers to flow across the boundary between blocks (I,J-1,K) and (I,J,K)

TZ (I, J, K) is the Z-direction transmissibility which refers to flow across the boundary between blocks (I,J,K-1) and (I,J,K)

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *TRANSMISSIBILITY MODIFICATIONS*

Line 2: This line is used to enter the number of grid blocks where transmissibilities are to be changed, and print code.

READ: **NUMTX, NUMTY, NUMTZ, ITCODE**

NUMTX = Number of grid blocks where X-direction transmissibility (TX) is to be changed

NUMTY = Number of grid blocks where Y-direction transmissibility (TY) is to be changed

NUMTZ = Number of grid blocks where Z-direction transmissibility (TZ) is to be changed

ITCODE = Print code for transmissibility modification

If ITCODE = 0, do not print the modified transmissibility distributions

If ITCODE = 1, print the modified transmissibility distributions

Example: *0 0 0 0*

This specifies that no transmissibility modifications are to be made or printed.

Line 3: Use NUMTX sets of lines to enter the coordinates of the blocks in the X-direction where transmissibility (TX) is to be modified. Omit this line if NUMTX = 0.

READ: **I, J, K, TX**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

TX = New value of X-direction transmissibility (TX) in md-ft for block (I, J, K)

Note: NUMTX lines must be read

Line 4: Use NUMTY sets of lines to enter the coordinates of the blocks in the Y-direction where transmissibility (TY) is to be modified. Omit this line if NUMTY = 0

READ: **I, J, K, TY**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

TY = New value of Y-direction transmissibility (TY) for block (I, J, K)

Note: NUMTY lines must be read

Line 5: Use NUMTZ sets of lines to enter the coordinates of the blocks in the Z-direction where transmissibility (TZ) is to be modified. Omit this line if NUMTZ = 0.

READ: **I, J, K, TZ**

I = X-coordinate of block to be modified

J = Y-coordinate of block to be modified

K = Z-coordinate of block to be modified

TZ = New value of Z-direction transmissibility (TZ) for block (I, J, K)

Note: NUMTZ lines must be read

3.8 Relative Permeability and Capillary Pressure Tables

Line 1: Use this line to input table headings.

READ: Header (40A2)

Example: *SAT KRO KRW KRG PCOW PCGO*

Line 2: Read relative permeability and capillary pressure tables.

READ: **SAT1 KRO1 KRW1 KRG1 PCOW1 PCGO1**

SAT2 KRO2 KRW2 KRG2 PCOW2 PCGO2

.....

SATn KROn KRWn KRGn PCOWn PCGOn

Note:
(1) SATn must be 1.1 or greater
(2) Read each saturation as a fraction in ascending order
(3) Read as many lines as there are table entries (Maximum number of table entries allowed is assigned in the 'DIMENSION' block in PC-GEL)
(4) KRO, KRW etc. are real variables

Example:

0.0	*0.0*	*0.0*	*0.0*	*0.*	*0.*	Begin the relative permeability/capillary pressure data with lowest saturation.
0.10	*0.0*	*0.0*	*0.0*	*0.*	*0.*	
0.20	*0.0015*	*0.0*	*0.075*	*0.*	*0.*	
0.30	*0.0023*	*0.0122*	*0.190*	*0.*	*0.*	
0.40	*0.0370*	*0.0244*	*0.410*	*0.*	*0.*	
0.50	*0.0571*	*0.0336*	*0.72*	*0.*	*0.*	
0.60	*0.134*	*0.0672*	*0.87*	*0.*	*0.*	
0.70	*0.207*	*0.1344*	*0.94*	*0.*	*0.*	
0.80	*0.604*	*0.2688*	*0.966*	*0.*	*0.*	
0.90	*1.00*	*0.4704*	*0.993*	*0.*	*0.*	
1.10	*1.0*	*0.5*	*1.0*	*0.*	*0.*	Saturation greater than or equal to 1.10 specifies the end of the relative permeability/capillary pressure data.

SAT = Phase saturation
KRO = Oil phase relative permeability, fraction
KRW = Water phase relative permeability, fraction
KRG = Gas phase relative permeability, fraction
PCOW = Oil-water capillary pressure, psi
PCGO = Gas-oil capillary pressure, psi

REMARKS: SAT refers to the saturation of each particular phase.

In a data line following SAT = 0.3; KRO would refer to the oil relative permeability in the presence of 30% <u>oil</u> saturation, KRW would refer to the water relative

permeability in the presence of 30% water saturation; KRG would refer to the gas relative permeability in the presence of 30% gas saturation; PCOW would refer to the oil-water capillary pressure in the presence of 30% water saturation, and PCGO would refer to the gas-oil capillary pressure in the presence of 30% gas saturation.

3.9 Oil-Water-Gas PVT Tables

Line 1: Use this line to input table headings for next line.

READ: Header (40A2)

Example: *PBO VSLOPE BSLOPE RSLOPE PMAX IREPRS*

Line 2: Use this line to enter the values of bubble-point pressure, under-saturated oil properties, and maximum PVT table pressure.

READ: **PBO, VSLOPE, BSLOPE, RSLOPE, PMAX, IREPRS**

PBO = Initial reservoir oil bubble-point pressure, psia

VSLOPE = Slope of the oil viscosity versus pressure curve for pressure above PBO (i.e., for under-saturated oil). This value is in cp/psi

BSLOPE = Slope of oil formation volume factor versus pressure curve for pressure above PBO (i.e., for under-saturated oil). This value is in RB/STB/psi.

RSLOPE = Slope of the solution gas-oil ratio versus pressure curve for pressure above PBO (i.e., for under-saturated oil). This value is in SCF/STB/psi

PMAX = Maximum pressure entry for all PVT tables, psia

IREPRS = Code for repressurization algorithm;
IREPRES = 0 means no repressurization will be performed,
IREPRES = 1 means repressurization will be performed.

Example: *4014.7 0.0 -0.000001 0. 9014.7 1*

Notes:
(1) VSLOPE, BSLOPE and RSLOPE are used only for under-saturated oil
(2) BSLOPE should be a negative number and is related to under-saturated oil compressibility, C_O by C_O = BSLOPE/BO
(3) Normally, RSLOPE will be zero
(4) If IREPRS = 0, a new bubble-point pressure will be calculated for each grid block containing free gas at the end of each time step.
(5) PMAX (9014.7 in this example data file) is used as a termination flag for other PVT input variables.

Line 3: Use this line to input oil-PVT table headings.

READ: Header (40A2)

Example: *PRES VISCO BO RSO*

Line 4: Read oil PVT data.

READ: **P1 MUO1 BO1 RSO1**

P2 MUO2 BO2 RSO2

.....

PMAX MUOn BOn RSOn

P = Pressure, psia

MUO = Oil viscosity, cP

BO = Oil formation volume factor, RB/STB

RSO = Solution gas-oil ratio, SCF/STB

Example: *14.7 2.0 1.5 1.0*

4014.7 2.0 1.5 1.0

9014.7 2.0 1.5 1.0 PMAX (9014.7) specifies end of oil PVT data

Note: (1) The last pressure entry must be PMAX as specified in line 2.

(2) Oil properties must be entered as saturated data over the entire pressure range. Laboratory saturated oil data will generally have to be extrapolated above the measured bubble-point pressure to cover the maximum pressure range anticipated during the simulation run. The saturated oil data are required because of the bubble-point tracking scheme used by PC-GEL.

(3) The saturated oil data above the initial bubble point pressure will only be used if the local reservoir pressure rises above the initial bubble point pressure and free gas is introduced. An example of this would be pressure maintenance by gas injection into the oil zone.

Line 5: Use this line to input water PVT table headings.

READ: Header (40A2)

Example: *PRES VISW BW RSW*

Line 6: Read water PVT data.

READ: **P1 MUW1 BW1 RSW1**

P2 MUW2 BW2 RSW2

.....

PMAX MUWn BWn RSWn

P = Pressure, psia

MUW = Water viscosity, cp

BW = Water formation volume factor, RB/STB

RSW = Solution gas-water ratio, SCF/STB

Example: *14.7 1.0 1.0 0.0*

4014.7 1.0 1.0 0.0

9014.7 1.0 1.0 0.0 (PMAX (9014.7) specifies end of water PVT data.)

Notes: (1) The last pressure entry must be PMAX as specified in line 2.

(2) The assumption is often made in black oil simulations that the solubility of gas in reservoir brine can be neglected. This model incorporates this water PVT table to handle such situations as gas production from geo-pressured aquifers, or any other case where gas solubility in water is considered to be of significance to the solution of the problem.

Line 7: Use this line to input gas PVT table headings and rock compressibility.

READ: Header (40A2)

Example: *PRES VISG BG CR*

Line 8: Read gas PVT data and rock compressibility.

READ: **P1 MUG1 BG1 CR1**

P2 MUG2 BG2 CR2

.....

PMAX MUGn BGn CRn

P = Pressure, psia

MUG = Gas viscosity, cp

BG = Gas formation volume factor, RCF/SCF

CR = Rock compressibility, psi^{-1}

Example: *14.7 0.0080 0.935800 0.000003*

514.7 0.0112 0.035228 0.000003

1014.7 0.0140 0.017951 0.000003

2014.7 0.0189 0.009063 0.000003

3014.7 0.0228 0.006064 0.000003

5014.7 0.0309 0.003644 0.000003

9014.7 0.0470 0.002167 0.000003 (PMAX (9014.7) specifies end of gas PVT data.)

Note: (1) The last pressure entry must be PMAX as specified in line 2.

(2) Total number of table entries should be 25 or less.

Line 9: Use this line to identify next set of input data.

READ: Header (40A2)

Example: *RHOSCO RHOSCW RHOSCG*

Line 10: Read stock tank fluid densities.

READ: **RHOSCO, RHOSCW, RHOSCG**

RHOSCO = Stock tank oil density, lb/cu ft

RHOSCW = Stock tank water density, lb/cu ft

RHOSCG = Gas density at standard conditions, lb/cu ft

Example: *46.24 62.24 0.0647*

Note: Stock tank conditions are 14.7 psia and 60° F

3.10 Chemical Data for Gel System

Transport data of the gel chemical system are entered in this section Only if NGEL = 1 is entered in section 3.2. If NGEL = 0, no gel chemical transport calculation will be conducted and, therefore, go to section 3.11. The physical meaning of parameters required in the transport equation is explained in Section II.

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *CHEMICAL DATA FOR GELATION*

Line 2: Read nth-order central difference method for solving the continuity equation.

READ: **MORDER**

Example: *5*

Line 3: Read dispersion coefficients in x-, y-, and z-directions.

READ: **DDX DDY DDZ**

DDX = Dispersion coefficient in the x-direction, ft^2/day

DDY = Dispersion coefficient in the y-direction, ft^2/day

DDZ = Dispersion coefficient in the z-direction, ft^2/day

Example: *0.001875 0.001875 0.001875*

Line 4: Read reaction rate constants.

READ: **K1 K2 NRX**

K1 = Reaction rate constant in ppm^{-1} day^{-1} in Eq. 4.

K2 = Reaction rate constant in ppm^{-3} day^{-1} in Eqs. 5 and 6.

NRX = Value of n in Eqs. 3 and 5.

Example: *1.111E-4 1.111E-4 1000*

Line 5: Read adsorption data in Eq. 13 for five chemicals, respectively.

READ: **(AA(I), I=1,5)**

Example: *0 0 0 0 0*

Line 6: Read adsorption data in Eq. 13 for five chemicals, respectively.

READ: **(BB(I), I=1,5)**

Example: *0 0 0 0.0427 0.0855*

Line 7: Read RRF parameters in Eq. 15 for five chemicals, respectively.

READ: **(CL(I), I=1,5)**

Example: *0 0 0 0 1*

Line 8: Read RRF parameters in Eq. 15 for five chemicals, respectively.

READ: **(GAMA(I), I=1,5)**

Example: *0 0 0 0 0*

Line 9: Read viscosity parameters in Eq. 7 for polymer solution.

READ: **ALPHA1 ALPHA2 ALPHA3**

Example: *3.98E-3 2.29E-6 1.695E-9*

Line 10: Read viscosity parameters in Eqs. 8 and 9 for gel solution.

READ: **BETA1 BETA2 BETA3 CGC**

Example: *4.825E-3 1.608E-6 3.6E-7 1000*

Line 11: Read parameters for calculating parameters in Meter's equation (Eq. 10).

READ: **GAMMA0 GAMMA1 GAMMA2 GAMMA3 SHEARA SHEARB**

$p = GAMMA0 + GAMMA1 \times C_p + GAMMA2 \times C_p^2 + GAMMA3 \times C_p^3$

$\dot{\gamma}_{1/2} = SHERA \times C_p^{SHERB}$

Example: *1.471 1.960E-4 -2.882E-8 0.00 3.923E8 -2.116*

Line 12: Read inaccessible pore volume (IPV) parameters for macromolecules of chemical component 1 through 5, respectively, in each layer.

READ: **(FIPV(I), I=1,5)**

Example: *1.0 1.0 1.0 0.9 0.8* (IPV of five components for layer 1)

1.0 1.0 1.0 0.9 0.8 (IPV of five components for layer 2)

Note: There must be the same number of lines of IPV parameters as there are layers in the reservoir description.

Line 13: Read maximum concentrations allowed for chemical component 1 through 5, respectively, in transport calculations.

READ: **C1MAX C2MAX C3MAX C4MAX C5MAX**

Example: *1000. 1400. 1000. 3000. 3000.*

3.11 Pressure and Saturation Initialization

PC-GEL contains two options for pressure and saturation initialization. Initial pressure and saturation distributions can be calculated based on equilibrium conditions using the elevations and pressure of the gas-oil and water-oil contacts (option 1). Alternatively, the initial pressure distribution can be read on a block-by-block basis, as in the case of a non-equilibrium situation (option 2). Saturations can either be read as constant values for the entire grid (option 1) or the entire S_O and S_W distributions are read on a block-by-block basis, and the program calculates the S_g distribution for each block as $SG = 1.0 - S_O - S_W$ (option 2).

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *INITIAL PRESSURE & SATURATION BASED ON EQUILIBRIUM CONDITIONS.*

Line 2: Use this line to enter the codes for pressure and saturation initialization.

READ: **KPI, KSI**

KPI = Code for controlling pressure initialization (see table 3-3)

KSI = Code for controlling saturation initialization (see table 3-3)

Example: *0 0*

Line 3: Use this line to enter the equilibrium pressure initialization data.

Skip this line if KPI = 1 or 2.

If KIP = 0 then

READ: **PWOC, PGOC, WOC, GOC**

PWOC = Pressure at the water-oil contact, psia

PGOC = Pressure at the gas-oil contact, psia

WOC = Depth to the water/oil contact, in feet below datum

GOC = Depth to the gas/oil contact, in feet below datum

TABLE 3-3. - Options for initializing pressure and saturation

Code	Value	Pressure and saturation specifications
KPI	0	Use equilibrium pressure initialization. Input pressures at the oil/water contact and gas/oil contact and elevations to each contact.
KPI	1	Use non-equilibrium pressure initialization. Read pressures for each grid block on a block-by-block basis. NOTE: II x JJ x KK values must be read.
KPI	2	Use non-equilibrium pressure initialization. Read pressures for each layer.
KSI	0	Initial oil, water and gas saturations are constant over the entire model grid. NOTE: Read three values - SOI, SWI and SGI.
KSI	1	Read oil and water saturations for each grid block on a block-by-block basis. The gas saturations for each grid block will be calculated by the program. NOTE: II x JJ x KK values must be read for oil saturation; II x JJ x KK values must be read for water saturation.
KSI	2	Read oil and water saturation for each layer.

Example: *4806.6 0.0 8425.0 8300.0*

Note: (a) Input this record only if KPI = 0

(b) PWOC and PGOC are used together with depth to calculate the initial oil phase pressure at each grid-block mid point.

Line 4: Use this line to enter the non-equilibrium pressure initialization data.

Skip this line if KPI = 0.

(a) If KPI = 1, then

READ: **P**

P = Pressure for the entire grid, psia

Note: (1) A value of 'P' must be read for each grid block in the model grid. Read a total of II x JJ x KK values. The order of input must be as indicated below with layer order K = 1,2, ..., KK.

J = 1 I = 1,2, ... II

J = 2 I = 1,2, ... II

.....

J = JJ I = 1,2, ... II

(2) Input this record only if KPI = 1

(b) If KPI = 2, then

READ: **P**

P = Initial pressure to be assigned to a layer in the model, psia

Example: *4800. 4810. 4820.*

Note: (1) A value of 'P' must be read for each layer in the model grid. Read a total of KK values in one row following the order of K = 1,2, ..., KK

(2) Input this record only if KPI = 2

Line 5: Use this line to initialize the saturation data for a constant saturation case. If KSI=0, then see (a) below. If KSI = 1, then see (b) below. If KSI = 2, then see (c) below.

(a) If KSI = 0, then

READ: **SOI, SWI, SGI**

SOI = Initial oil saturation to be assigned to all grid blocks in the model

SWI = Initial water saturation to be assigned to all grid blocks in the model

SGI = Initial gas saturation to be assigned to all grid blocks in the model

Example: *0.8 0.2 0.0*

Note: Input all saturation values as a fraction.

(b) In a non-equilibrium case when KSI = 1, then

READ: **SO, SW**

SO = Initial oil saturation array

SW = Initial water saturation array

Note: (1) A value of SO must be read for each grid block in the model grid. Read a total of II x JJ x KK values. The order of input must be as indicated below with layer order K = 1,2, . . . KK.

J = 1 I = 1,2, ..., II

J = 2 I = 1,2, ... II

.....

J = JJ I = 1,2, ... II

(2) A value of S_W must be read for each grid block in the model grid. Read a total of II x JJ x KK values. The order of input must be as indicated above (see note 1) with layer order K = 1,2, ..., KK

(3) Input this record only if KSI = 1

(c) If KSI = 2, then

READ: **SO**

READ: **SW**

SO = Initial oil saturation to be assigned to a layer in the model

SW = Initial water saturation to be assigned a layer in the model

Example: *0.8 0.5 0.9*

0.2 0.5 0.1

Note: (1) Input all saturation values as a fraction.

(2) A value of SO must be read for each layer. Read a total of KK values in one row following the order of K = 1, 2, ..., KK.

(3) A value of SW must be read for each layer. Read a total of KK values in one row following the order of K = 1, 2, ..., KK.

3.12 Debug and Diagnostics Codes

Several codes for controlling diagnostics output for use in program debugging are provided. These codes should normally be set to zero. These codes will not provide information for debugging data input. Activating any of the codes will generate an extremely large volume of output!

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *KSN1 KSM1 KCO1 KTR KCOF*

Line 2: Use this line to input diagnostics codes.

READ: **KSN1, KSM1, KCO1, KTR, KCOF**

KSN1 = LSOR parameter debug output control (see table 3-4)

KSM1 = Solution matrix debug output control (see table 3-4)

KCO1 = Compressibility and formation volume factors debug output control (see table 3-4)

KTR = Transmissibility debug output control (see table 3-4)

KCOF = Density and saturation debug output control (see table 3-4)

Example: *0 0 0 0 0*

In the above example, all diagnostics codes are set equal to 0. This means no diagnostic output is to be printed.

TABLE 3-4. - Options for controlling diagnostics output

Code	Value	Diagnostics specifications
KSN1	0	No LSOR diagnostics output will be printed.
KSNn	n	The number of LSOR iterations required to convergence is printed at each nth time-step.
KSM1	0	No solution matrix will be printed.
KSMn	n	The solution matrix will be printed the first time-step and every n^{th} step thereafter.
KCO1	0	No compressibilities and formation volume factors will be printed.
KCOn	n	Oil, water and gas compressibilities and formation volume factors will be printed the first time and every n^{th} step thereafter.
KTR	0	No transmissibilities will be printed.
	1	Transmissibilities will be printed at the beginning of each simulation run and whenever transmissibilities are modified.
KCOF	0	No saturations, gravity terms and source terms are printed.
	1	Saturations, gravity terms etc. are printed in the main program each time step. Also component mobilities, grid block flow coefficients, formation volume factors and gravity terms are printed at each time step.

3.13 Run Control Parameters

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *NMAX FACT1 FACT2 TMAX WORMAX GORMAX PAMIN PAMAX*

Line 2: Use this line to enter run time control parameters.

READ: **NMAX, FACT1, FACT2, TMAX, WORMAX, GORMAX, PAMIN, PAMAX**

NMAX = Maximum number of time steps allowed before run is terminated

FACT1 = Factor for increasing time step size under automatic time step control;

FACT2 = Factor for decreasing time step size under automatic time step control;

TMAX = Maximum simulation run time, days (run will be terminated when time exceeds TMAX)

WORMAX = Limiting maximum field water-oil ratio, in STB/STB; simulation will be terminated if total producing WOR exceeds WORMAX

GORMAX = Limiting maximum field gas-oil ratio, in SCF/STB; simulation will be terminated if total producing GOR exceeds GORMAX

PAMIN = Limiting minimum field average pressure, psia; simulation will be terminated if average reservoir pressure falls below PAMIN

PAMAX = Limiting maximum field average pressure, psia; simulation will be terminated if average reservoir pressure exceeds PAMAX

Example: *500 1.2 0.5 365.0 20.0 500000.0 14.7 10000*

The above example specifies automatic time step control and the simulation is to be terminated if:

(a) simulation time steps exceed 500 or

(b) simulation run time exceeds 1 year (365 days) or

(c) total producing water-oil ratio exceeds 20 STB/STB or

(d) total producing gas-oil ratio exceeds 500,000 SCF/STB or

(e) average reservoir pressure falls below 14.7 psia or

(f) average reservoir pressure exceeds 10,000 psia.

Note: (1) Time-step size cannot be less than DTMIN nor greater than DTMAX as specified in the recurrent data section

(2) For fixed time-step size, specify FACT1 = 1.0 and FACT2 = 1.0 and/or specify DTMIN = DTMAX = DT in the recurrent data section

(3) For automatic time-step control, set FACT1 > 1.0 and FACT2 < 1.0; suggested values are FACT1 = 1.25 and FACT2 = 0.5

(4) Automatic time-step control means the following:

(a) If at the beginning of a time-step, the maximum grid-block pressure and saturation changes from the previous step are less than DPMAX and DSMAX, respectively (DPMAX and DSMAX are defined in Section 3.14), the size of the current time-step will be increased by FACT1

(b) If at the beginning of a time-step, the maximum grid-block pressure or saturation change from the previous step is greater than DPMAX or DSMAX, respectively, the size of the current time-step will be decreased by FACT2

(c) If at the end of one iteration (after new pressures and saturations are calculated), the maximum pressure change exceeds DPMAX or the maximum saturation

change exceeds DSMAX, and FACT2 < 1.0, the size of the current time-step will be decreased by FACT2 and the iteration will be repeated.

3.14 Solution Method Control Parameters

Line 1: Use this line to identify next set of data.

READ: Header (40A2)

Example: *KSOL MITR OMEGA TOL TOL1 DSMAX DPMAX*

Line 2: Use this line to specify various parameters for controlling LSOR solution method.

READ: **KSOL, MITR, OMEGA, TOL, TOL1, DSMAX, DPMAX**

KSOL = Solution method code (See p. 24 of reference 38)

MITR = Maximum number of LSOR iterations for convergence; a typical value is 100

OMEGA = Initial LSOR acceleration parameter. The initial value for OMEGA must be in the range 1.0 < OMEGA < 2.0. A typical initial value for OMEGA is 1.20. The model will attempt to optimize OMEGA as the solution proceeds if TOL is greater than zero

TOL = Maximum acceptable pressure change for LSOR convergence; a typical value is 0.1 psi

TOL1 = Parameter for determining when to change (i.e. optimize) OMEGA; a typical value is 0.0005. If TOL1 = 0.0 the initial value of OMEGA will be used for the entire simulation

DSMAX = Maximum saturation change (fraction) permitted over a time-step. The time-step size will be reduced by FACT2 if FACT2 < 1.0 and the saturation change of any phase in any grid-block exceeds DSMAX and the current step-size is greater than DTMIN. If the resulting step-size is less than DTMIN, the time-step will be repeated with the step-size DTMIN. A typical value of DSMAX is 0.05

DPMAX = Maximum pressure change (psi) permitted over a time-step. The time-step size will be reduced by FACT2 if FACT2 < 1.0 and the pressure change in any grid-block exceeds DPMAX and the current step-size is greater than DTMIN. If the resulting step-size is less than DTMIN, the time-step will be repeated with step-size DTMIN. A typical value of DPMAX is 50 psi.

Example: *100 1.70 0.1 0.0 0.05 50.0*

IV. RECURRENT DATA

4.1 Introduction

During the course of a simulation run, it is generally desirable to be able to (1) add or delete injection/production wells, (2) control injection/production rates or bottomhole pressures at all existing wells, and (3) specify the types and frequency of output information. These types of controls and output specifications are accomplished in this model via "recurrent data" records. That is, as the simulation proceeds, well specification and print control information is input at preselected times.

Recurrent data record pairs are input which control printed output and time-step size for a specified time period. The first parameter (IWLCNG) on the first recurrent data record specifies whether or not to read well information. If IWLCNG = 0, well information is not read. If IWLCNG = 1, well information is read immediately following the recurrent data record pair. In any case, the simulator advances through time-steps until the specified elapsed time (ICHANG times DT) has occurred. During this period, all print codes and the latest well information applies. At the end of this period, a new set of recurrent data records are read again. This reading process of recurrent data records is repeated until the cumulative simulation time TMAX specified in section 3.13 is reached or exceeded. A general flow diagram outlining the data input structure for recurrent data is shown in Fig. 1.

Line 1: Use this line to signify the start of the recurrent data.
READ: Header (40A2)
Example: *RECURRENT DATA RECORDS*
Note: This line is read only once.

Line 2: Use this line to signify the time increment (in day) for printing simulation results in the rate summary report.
READ: **DTPRINT**
Example: *5.*
This example specifies that key simulation results will be printed every 5 days in the rate summay report.
Note: This line is read only once.

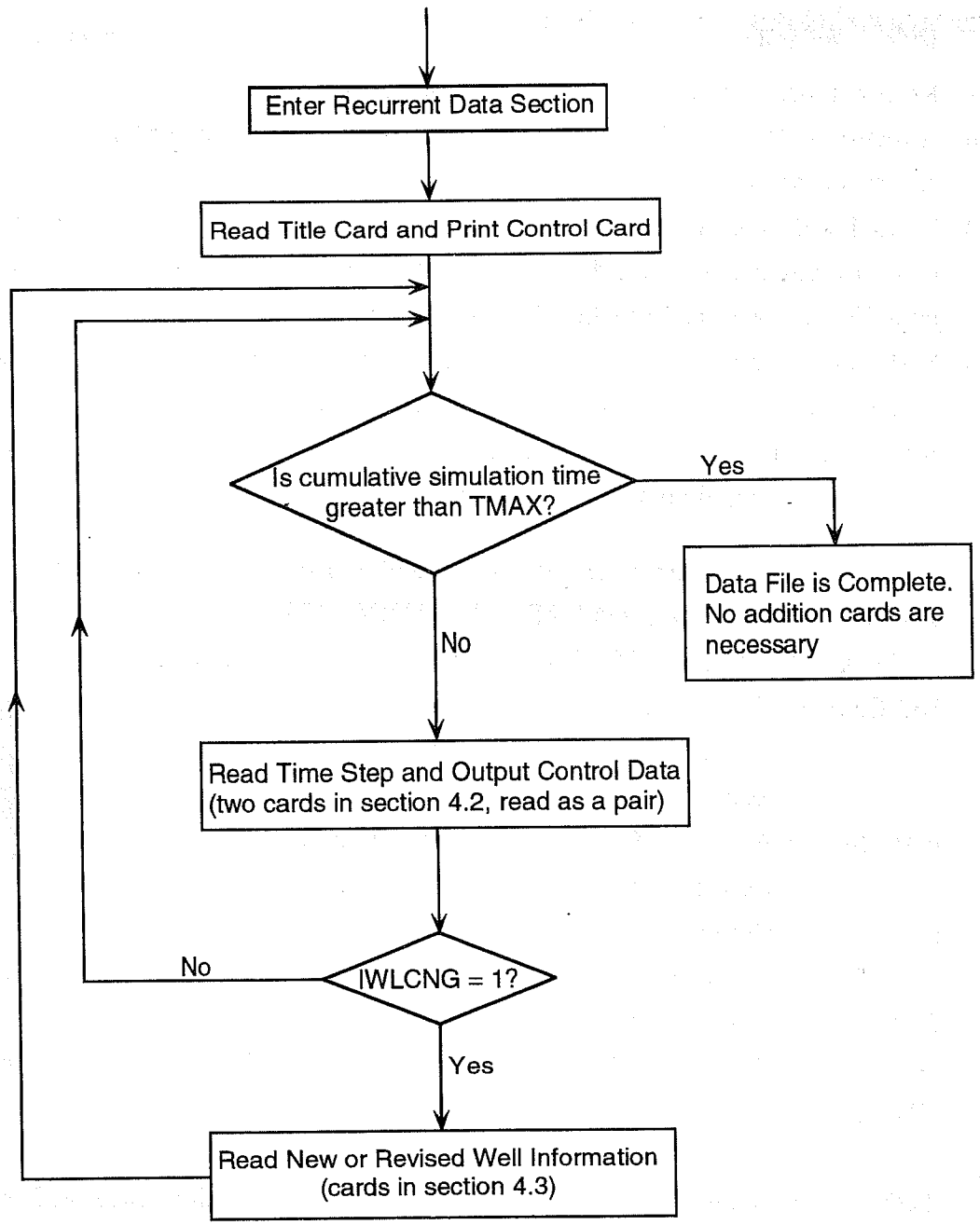

FIGURE 1. - Flow chart of data input structure for recurrent data.

4.2 Time-Step and Output Control Codes

Note: (a) Recurrent data record pairs are read at preselected times

(b) A recurrent data record 'pair' consists of one integer control record and one time-step size specification record

(c) Lines 1 and 2 below constitute a recurrent data record pair. These records may be read any number of times during a simulation run until the cumulative simulation time TMAX specified in section 3.13 is reached or exceeded

(d) Well information records (section 4.3) must be read immediately following each pair of recurrent data records if and only if IWLCNG = 1

(e) If well information is read, all specified rates and pressures will be used this time-step and all subsequent time-steps until new well information is read

Line 1: This line is used to input time-step, output, and transport calculation control codes.

READ: **IWLCNG, ICHANG, IWLREP, ISUMRY, IPMAP, ISOMAP, ISWMAP, ISGMAP, IPBMAP, ICHMAP, CHEMAP, NGEL** (in one line)

IWLCNG = Code to tell the program whether or not the well information lines should be read this time-step. If IWLCNG = 0, well information is not read this step. If IWLCNG = 1, well information is read this step

ICHANG = A number for calculating the time period "ITIME" (see note 2 below) for which this recurrent data record pair will apply

IWLREP = Output code for printing well report, (1 = print, 0 = no print)

ISUMRY = Output code for printing summary report, (1 = print, 0 = no print)

IPMAP = Output code for printing pressure distribution, (1 = print, 0 = no print)

ISOMAP = Output code for printing oil saturation distribution, (1=print, 0=no print)

ISWMAP = Output code for printing water saturation distribution, (1 = print, 0 = no print)

ISGMAP = Output code for printing gas saturation distribution (1=print, 0=no print)

IPBMAP = Output code for printing bubble-point pressures (1 = print, 0 = no print)

ICHMAP = Output code for printing gel chemical distribution in the <u>regular output file</u>, (1 = print, 0 = no print)

CHEMAP = Time increment (in days) for printing detail distributions of chemicals, RRF, and viscosity increase in the <u>chemical concentration and RRF report</u>. Maps will be printed every CHEMAP days. If CHEMAP > ETI, no maps will be printed.

NGEL = Flag code for invoking in situ gelation calculation
If NGEL = 0, no transport calculation, e.g. during waterflood

If NGEL = 1, invoke transport calculation

Example: *1 1 1 1 0 0 0 0 0 0 30. 1*

The above example specifies that:

(a) Well information is read at this step;

(b) 1 is to be used as the number for calculating the time period for which this recurrent data will apply;

(c) well report and summary reports are to be printed at this step;

(d) no pressure, saturation, or gel chemical concentration maps are to be printed in the regular output file at this step;

(e) in situ gelation calculations will be conducted; and

(f) chemical distribution, RRF, and viscosity increase will be printed in a seperate file every 30 days.

Note: (1) If IWLCNG = 1, well information lines must be read.

(2) If 'ETI' is the time at the beginning of the current step, then this recurrent data record pair will apply from ETI until FTMAX = ETI + ITIME where ITIME = ICHANG times DT. DT is the initial time-step size for this period as read in line 2 below.

(3) The actual number of time-steps for which ICHANG is used will likely be different from ICHANG if automatic time-step control is 'on.' Whenever the calculated simulation time exceeds 'FTMAX,' the current step-size is reduced to give an elapsed time of exactly FTMAX. Whenever FTMAX is reached, another recurrent data record pair is read.

(4) If the output code value = 0, the information will not be printed.
If the output code value = 1, the information will be printed for each time-step during this period from ETI days to ETI + ITIME days.

(5) NGEL should be set to 0 before injection of gel chemicals to save model computation time. Once the chemical injection is initiated, NGEL should be always set to 1 in subquent time steps.

Line 2: This line is used to input time-step control information.

READ: **DT, DTMIN, DTMAX, HOUR, MIN, SEC**

DT	=	Initial time-step size (days) for this period
DTMIN	=	Minimum time-step size (days) for this period
DTMAX	=	Maximum time-step size (days) for this period
HOUR	=	Initial time-step size (hours) for this period
MIN	=	Initial time-step size (minutes) for this period
SEC	=	Initial time-step size (seconds) for this period

Example: *3.0 3.0 3.0 0. 0. 0.*

Note: (a) Initial time-step size = DT + HOUR/24 + MIN/1440 + SEC/86400.
In the above example, Initial time-step size = 3.0 + 0./24 + 0./1440 + 0./86400 = DTMIN = DTMAX = 3.0, so the automatic time step control is overridden.

(b) The time period referred to is the time for which this recurrent data pair will be used. This period is from the current simulation time (ETI) to an elapsed time of ETI + ITIME, where ITIME = ICHANG times DT.

(c) Common (suggested) values for DTMIN and DTMAX are 0.1 and 10.0 days, respectively.

(d) Automatic time-step control can be overridden by specifying DTMIN = DTMAX = DT.

REMARK: Lines 1 and 2 above constitute a "recurrent data record pair". If IWLCNG = 1, well data as described in the next section must be read. IF IWLCNG = 0, well data is not read. Recurrent data records should be input until the cumulative time as given by the summation of ICHANG times DT for each pair exceeds the maximum desired simulation time (TMAX). The simulation will terminate if EOF (end of file) is encountered due to no more recurrent data.

4.3 Well Information Records

Line 1: Use this line to describe well activities. (Omit this line if IWLCNG = 0)

READ: Header (40A2)

Example: *NUMBER OF WELLS*

Line 2: Total number of vertical wells for which well information is to be read (Omit this line if IWLCNG = 0)

READ: **NVQN**

NVQN = Number of vertical wells

Example: *2* specifies 2 vertical wells

Note: (1) Must repeat lines 3, 4, 5, 6 a total of NVQN times

(2) Wells may be added or recompleted at any time during the simulation. However, once a well has been specified, it must be included each time when well information is read unless the well is currently shut-in.

Line 3: Vertical well ID (Omit this line if IWLCNG = 0)

READ: **WELLID = Five character well name**

Example: *3.0 3.0 3.0 0. 0. 0.*

Note: (a) Initial time-step size = DT + HOUR/24 + MIN/1440 + SEC/86400.
In the above example, Initial time-step size = 3.0 + 0./24 + 0./1440 + 0./86400 = DTMIN = DTMAX = 3.0, so the automatic time step control is overridden.

(b) The time period referred to is the time for which this recurrent data pair will be used. This period is from the current simulation time (ETI) to an elapsed time of ETI + ITIME, where ITIME = ICHANG times DT.

(c) Common (suggested) values for DTMIN and DTMAX are 0.1 and 10.0 days, respectively.

(d) Automatic time-step control can be overridden by specifying DTMIN = DTMAX = DT.

REMARK: Lines 1 and 2 above constitute a "recurrent data record pair". If IWLCNG = 1, well data as described in the next section must be read. IF IWLCNG = 0, well data is not read. Recurrent data records should be input until the cumulative time as given by the summation of ICHANG times DT for each pair exceeds the maximum desired simulation time (TMAX). The simulation will terminate if EOF (end of file) is encountered due to no more recurrent data.

4.3 Well Information Records

Line 1: Use this line to describe well activities. (Omit this line if IWLCNG = 0)

READ: Header (40A2)

Example: *NUMBER OF WELLS*

Line 2: Total number of vertical wells for which well information is to be read (Omit this line if IWLCNG = 0)

READ: **NVQN**

NVQN = Number of vertical wells

Example: *2* specifies 2 vertical wells

Note: (1) Must repeat lines 3, 4, 5, 6 a total of NVQN times

(2) Wells may be added or recompleted at any time during the simulation. However, once a well has been specified, it must be included each time when well information is read unless the well is currently shut-in.

Line 3: Vertical well ID (Omit this line if IWLCNG = 0)

READ: **WELLID = Five character well name**

Example: *PROD1; this indicates the vertical well name is PROD1*

Line 4: Vertical Well Information (Omit this line if IWLCNG = 0)

READ: **I, J, PERFI, NLAYER, KIP, QO, QW, QG, QT**

I = X-coordinate of grid-block containing this well

J = Y-coordinate of grid-block containing this well

PERFI = Layer number of the uppermost layer completed.

NLAYER = Total number of consecutive completion layers, starting with and including PERFI.

KIP = Code for specifying both well type and whether the well's production (injection) performance is determined by specifying rates or specifying flowing bottomhole pressure and also whether an explicit or implicit pressure calculation is to be made. For most cases, the implicit pressure calculation is recommended. See Table 4-1 for the code details. For more information on KIP see the notes of this section.

QO = Oil rate, STB/D (nonzero only if KIP = 1 and QT = 0.0)

QW = Water rate, STB/D (nonzero only if KIP = 2)

QG = Gas rate, MCF/D (nonzero only if KIP = 3)

QT = Total fluid rate (nonzero only if KIP = 1 and QO = 0.0)

Example: *10 1 1 1 1 600. 0. 0. 0.*

The above example specifies that the well PROD1 is located in the grid block (10,1,1); completed in one layer and produces oil at the rate of 600 STB/D.

Note: (1) Table 4-1 summarizes all well control options

(2) Negative rates indicate fluid injection; positive values indicate fluid production.

(3) NLAYER must include all layers from PERFI to the lower most layer completed. For example, in a 5-layer model, if a well is completed in layers 2, 3, & 5, set PERFI = 2 and NLAYER = 4. Note that in this, layer 4 must be included in NLAYER even though layer 4 is not perforated. Layer 4 may be shut in by specifying a large SKIN value (e.g. 9999) for layer 4 in line 4 below.

(4) The total fluid rate given by QT is the oil plus water plus gas production for the well or the total reservoir voidage at stock tank conditions.

(5) Only one of the four values (QO, QW, QG, or QT) may be nonzero. If KIP < 0, all four values should be zero.

(6) For most applications, implicit pressure calculations are recommended.

(7) If KIP = 2, -2 or -12, only water will be produced or injected; if KIP = 3, -3, or -13, only gas will be produced or injected; solution gas is not considered; therefore, these

options are only recommended for water or gas injection wells. If KIP = 1, -1, or -11, oil, water, and gas will be produced in proportion to fluid mobilities and pressure constraints.

(8) If KIP > 0, the specified rate will be allocated to layers based on total layer mobilities; e.g. if QW is specified and there are two layers QW1 = QW * TM1/(TM1 + TM2) and QW2 = QW * TM2/(TM1 + TM2), where TM1 = total mobility for layer 1 and TM2 = total mobility for layer 2.

TABLE 4-1. - Options for controlling well performance

Code	Value	Rate or pressure specifications
KIP	1	Production (oil) well; specify rate, QO or QT
KIP	2	Water well; specify injection rate, QW
KIP	3	Gas well; specify injection rate, QG
KIP	-1	Oil well; oil, water & gas production rates will be calculated based on fluid mobilities and PID and PWF for each layer. Well will be shut-in if block pressure <PWF. Explicit pressure calculations are used.
KIP	-2	Water well; Water injection rate will be calculated based on total mobility of oil, water, and gas and PID and PWF for each layer. Well will be shut-in if block pressure >PWF. Explicit pressure calculations are used.
KIP	-3	Gas well; Gas injection rate will be calculated based on total mobility of oil, water, and gas and PID and PWF for each layer. Well will be shut-in if block pressure >PWF. Explicit pressure calculations are used.
KIP	-11	Oil well; Oil, water, and gas rates will be calculated based on fluid mobilities and PID and PWF for each layer. Implicit pressure calculations are used.
KIP	-12	Water well; Water injection rate will be calculated based on water mobility and PID and PWF for each layer. Implicit pressure calculations are used.
KIP	-13	Gas well; Gas injection rate will be calculated based on gas mobility and PID and PWF for each layer. Implicit pressure calculations are used.

Line 5: Use this line to enter wellbore radius, skin, and flowing bottomhole pressure in each layer for vertical well. Wellbore radius and skin values are used to calculate layer productivity index PID. (Omit this line if IWLCNG = 0)

READ: **RW, SKIN, PWF**

RW = Wellbore radius, ft

SKIN = Wellbore skin (no unit)

PWF = Layer flowing bottomhole pressure, psia

Example: *0.25 0.0 2500.0*

Note: (1) Exactly NLAYER lines must be read (even if the well is rate controlled). Each of these lines specify a wellbore radius (RW), skin (SKIN), and flowing bottomhole pressure (FBHP) for one completion layer; thus, NLAYER of these lines must be read. The first line read applies to the uppermost completion layer (PERFI); additional lines apply to succeeding layers. If rates are specified for this well (KIP = +1, +2, or +3), PWF will not be used and should be read as zero; however, RW and SKIN will be used to calculate a FBHP for the well. This FBHP will be printed out on the well report, but it will not be used in any way to control the well performance.

(2) The layer productivity index PID is calculated from Peaceman's formula in the model.

(3) Formation damage or stimulation at any point in time can be handled on a layer-by-layer basis by changing the layer SKIN.

Example: *1 1 1 1 2 0 -900.0 0.0 0.0*

0.25 0.0 7500.0

The above example specifies that well number 2 is an injection well (INJ1), is located in the grid block (1,1,1), completed in one layer; the well is a water injection well (KIP=2) and the injection rate is 900 STB/D. The layer wellbore radius for this well is 0.25 ft, skin factor is 0.0, and the flowing bottomhole pressure 7500 psia will not be used in calculations.

Line 6: Use this line to enter injection concentration of gel chemicals. (Omit this line if IWLCNG = 0, or NGEL=0, or for production well)

READ: **CQI(1), CQI(2), CQI(3), CQI(4), CQI(5)**

CQI(1) = injection concentration of dicromate, ppm

CQI(2) = injection concentration of thiourea, ppm

CQI(3) = injection concentration of cromium (+3) cation, ppm

CQI(4) = injection concentration of polymer (polyacryl amide), ppm

CQI(5) = injection concentration of gel, ppm

Example: *1000. 1400. 0. 3000. 0.*

The above example specifies that the well injects 1000 ppm of dichromate, 1400 ppm of thiourea, and 3000 ppm of polymer into the reservoir.

V. MODEL OUTPUT

PC-GEL generates in simulation three output files: regular output report, rate summary report, and chemical concentration, residual resistance factor (RRF), and viscosity increase report. This section provides a brief description of these three output reports.

5.1 Rate Summary Report

The rate summary report provides a quick overview of simulation results of the production history in a table format. The information listed includes average reservoir pressure and production and injection data of oil, water, and gas, respectively, with simulation times. The variation of oil rates, water-oil ratio, and gas-oil ratio provide useful information about the performance and production status of the reservoir. If an automatic time step control is employed, the number of time steps used is a good indicator of computation time required and how fast the change of saturations or pressures in the reservoir model.

5.2 Regular Output Report

The regular output file of PC-GEL provides a complete report of simulation results. This regular output report consists of two parts: (1) reservoir, fluid, and well data initialized by the user, and (2) recurrent production report at times specified by the user.

5.2.1 Model Start Up

At model start up the program always writes the initialization data to the output file. The program also writes the initial well locations and well control information to this file. In addition to providing a complete report, this gives the user an excellent opportunity to quickly check for input data errors. The information printed prior to the first summary report consists of the following items, in the order given:

(1) Grid-block sizes;
(2) Node midpoint elevations;
(3) Porosity distribution;
(4) Permeability distribution;
(5) Relative permeability and capillary pressure table;
(6) Oil-water-gas PVT table;
(7) Slopes calculated from PVT data for use in determining fluid compressibilities;
(8) in situ gelation system parameters;
(9) Solution method parameters and time-step control data;
(10) Initial well locations and well control information;

(11) Initial fluids in place by layer; and

(12) Initial pressure and saturation distributions.

Other output can be obtained at the user's command. For example, whenever a modification option is activated, the user may print out the altered array. It is worthwhile to do this as a check on the input modifications.

5.2.2 Recurrent Production Report:

Using the output codes, the user can print out the following information during the course of a simulation run:

1. Well report;
2. Summary report;
3. Pressure and saturation distribution arrays; and
4. Chemical concentration distributions.

Well Report:

A well report may be specified at any time during the simulation run. Each time a well report is specified, production and injection rates and cumulatives for each layer of each well are tabulated and summarized. For oil producers, oil, water, and gas production is printed on the well report.

Summary Report:

The summary report provides useful information which can also be obtained at any desired time. The summary report contains a concise summary of field injection and production performance information including (a) average reservoir pressure, (b) total reservoir oil, water, and gas production rates and cumulative production, (c) total reservoir water, and gas injection rates and cumulative injection, (d) total reservoir current and cumulative water-oil, and gas-oil ratios, (e) time-step and material balances for oil, water, and gas, (f) and maximum pressure, and saturation changes for the current time-step, and where these changes are occurring in the reservoir model.

The summary report serves two major purposes by permitting the user to (1) quickly review total reservoir performance and (2) determine if the model is functioning properly. As a general rule, maximum saturation changes nearly always should be less than 5%, and time-step material balance errors should normally be less than 0.1%.

Material balances or saturation changes that are excessive do not necessarily mean that the model cannot handle the problem at hand. However, it does mean that adjustments are needed to some of the input parameters. Normally, the first adjustment is reduction of time-step size. If this modification does not completely solve the problem, reduce injection and/or

production rates to determine if well controls are excessive based on existing flow capacity and reservoir pressure. By making full use of automatic time-step control and being careful not to over-pressure or overproduce the reservoir, most reservoir production-injection problems with or without in situ gelation treatment can be properly simulated using PC-GEL.

Pressure and Saturation Distributions:

The user may output pressure, saturation, and bubble-point pressure arrays at any time-step desired. Distributions of pressure and saturations provide useful information about fluid flow in the reservoir and strategy for optimizing production and injection. For large two-dimensional or three-dimensional problems, an enormous output file can result if all these arrays are frequently printed. Therefore, these distributions should only be printed when needed. Normally, the bubble-point pressure array need not ever be printed out. This array provides mainly diagnostic information.

The pressure and saturation arrays should always be checked carefully at discrete times during the simulation to assure that overall pressure and saturation trends are as they should be. Reducing the time step size of simulation usually will eliminate or reduce the numerical dispersion which results in distorted distributions of pressure and saturations. Also, if a material balance problem exists, these maps may help to isolate the problem.

Gel Chemicals Distributions:

Concentration distributions of five gel chemicals in the porous media are printed in the regular output file. To save space, chemical concentration values will be printed for only 11 grids at an even space increment for each row of the reservoir model. These distribution maps provides users informations about the transport and reaction of five chemicals: dichromate, thiourea, chromium ion, polymer, and gel.

5.3 Chemical Concentration, RRF, and Viscosity Increase Report

Distributions of gel chemicals concentration, RRF, and viscosity increase in each grid block are printed. These detail maps serves for three purposes: (1) information about RRF and viscosity increase in the aqueous phase; (2) a check of the numerical performance for PC-GEL simulation; and (3) a source file for generating plots of simulation results.

The in situ gelation is closely associated with the gel chemicals concentration in porous media. The permeability reduction (or residual resistance factor) reflects the amount of gelation in the porous media. The decrease of permeability is calculated according to Eqs. 15 through 17 in section II and parameters defined by the user in the input file.

VI. EXAMPLE PROBLEMS

6.1 Introduction

To illustrate the capability of the model for simulating a wide range of problems, three examples are given in this section. Example 1 is for a waterflood, example 2 is for a polymer flood and example 3 is for a near-wellbore polymer gel treatment. All the input data files were created based on a quarter of a five-spot, two-layer reservoir model having dimensions of 1,000 ft x 1,000 ft x 30 ft with one injection well and one production well located at two opposite corners. The thickness of each layer was 15 ft. The reservoir model was represented by 10 grid blocks in both x and y directions and two grid blocks in the z direction. Horizontal permeabilities in both x and y directions were 100 mD in the top layer and 1,000 mD in the bottom layer. The vertical/horizontal permeability contrast was 0.001. Complete input and output files for each of the three sample problems are presented in the appendices and are included in the data diskette. Users can consider these input data as a guide for building their own input data files.

6.2 Problem Description

Sample Problem 1:

This example illustrates production simulation of 5-year waterflooding. Injection rate was 535 bbl/day. Water was injected into both layers. Simulation run was conducted for 5 years. The input data file name for this case is BWF5YR.DAT. Two output files, BWF5YR.OUT and RWF5YR.OUT were created. Because the injected water did not contain any chemical species, the subroutine that calculates the concentration profiles of the chemical species was bypassed. Therefore, the output file, GWF5YR.OUT, that did not contain any information was not transferred and stored in the output file directory. All the input and part of output files are presented in Appendix C.

Sample Problem 2:

This example is for a 500 days of polymer flooding initiated after 1 year of waterflooding. Injection rates for both water and polymer solution were 535 bbls/day. Both polymer and water were injected into both layers. Simulation run was conducted for 5 years. The input data file name for this case is B1YRPF.DAT. Three output files, B1YRPF.OUT,

R1YRPF.OUT and G1YRPF.OUT, were created. All the input and part of output files are presented in Appendix D.

Sample Problem 3:

This example is for a 5 days of polymer gel treatment initiated after 1 year of waterflooding. Waterflooding resumes after the gel treatment. Injection rates for both water and polymer gel system were 535 bbls/day. The injected gel chemicals contained 1,000 ppm dichromate (component 1), 1,400 ppm thiourea (component 2), and 3,000 ppm polymer (component 4). In the data file, components 3 and 5 are for chromium ion and gelled polymer, respectively. Water was injected into both layers and gel system was injected into the bottom layer only. Simulation run was conducted for 5 years. The input data file name for this case is B1YRG5D.DAT. Three output files, B1YRG5D.OUT, R1YRG5D.OUT and G1YRG5D.OUT, were created. All the input and part of output files are presented in Appendix E.

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NOMENCLATURE

C - chemical concentration, m/m, ppm

D - dispersion coefficient, L^2/t, ft^2/D

f - fraction of rock surface contacted by aqueous phase

k - permeability, L^2, mD

k1 - reaction rate constant, 1/t, $ppm^{-1}D^{-1}$

k2 - reaction rate constant, 1/t, $ppm^{-3}D^{-1}$

n - mass stoichiometric ratio

Q - well rate, L^3/t, B/D

R - reaction rate, 1/t, ppm/D

S - water saturation

$\vec{u}$ - darcy velocity vector, L/t, ft/D

V - volume of grid block, L^3, ft^3

ρ - density, m/L^3, lbm/ft^3

ϕ - porosity

$\dot{\gamma}$ - shear rate, 1/t, 1/sec

Γ - amount of adsorption, m/m, ppm

∇- divergence of operator

Subscript

i - chemical species

r - rock phase or relative permeability

p - polymer

x - x direction

y - y direction

APPENDIX A. COMPUTER SOURCE CODE OF PC-GEL

```
C   NIPER'S 3-DIMENSIONAL, 3-PHASE PERMEABILITY MODIFICATION SIMULATOR
C    --- GEL OPTION (SOLVES CHEMICAL CONCENTRATION)
C
C ***** 'PARAGEL.FOR' IS INCLUDED FOR RE-DIMENSION .....
C       COMPILE THIS WHEN 'PARAGEL.FOR' IS IN THE SAME ACCOUNT
        INCLUDE 'PARAGEL.FOR'
        REAL KX,KY,KZ,KROT,KRWT,KRGT,MUOT,MUWT,MUGT,MCFG,MCFG1,MCFGT,
      & MCFGI,MBEO,MBEW,MBEG,MIN,K1,K2
        CHARACTER*2 TITLE(80),FNAME,MNAME,TAG
        CHARACTER*5 WELLID
         CHARACTER*4 LNAME
        COMMON /IDEN/ WELLID(NW)
        COMMON /IO/ NI,NO
        COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
      & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
        COMMON /COEF/ AW(NX,NY,NZ),AE(NX,NY,NZ),AN(NX,NY,NZ),
      & AS(NX,NY,NZ),AB(NX,NY,NZ),AT(NX,NY,NZ),E(NX,NY,NZ),B(NX,NY,NZ)
         COMMON /SARRAY/ PN(NX,NY,NZ),
      & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
      & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
      & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
      & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
        COMMON /PERM/ KX(NX,NY,NZ),KY(NX,NY,NZ),KZ(NX,NY,NZ)
        COMMON /TRAN/ TX(NX+1,NY,NZ),TY(NX,NY+1,NZ),TZ(NX,NY,NZ+1)
        COMMON /ELEV/ EL(NX,NY,NZ)
        COMMON /PRTP/ P(NX,NY,NZ)
        COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
      & SWINI(NX,NY,NZ)
        COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
      & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
      & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
      & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
        COMMON /SRATE/ PID(NW,NL),PWF(NW,NL),PWFC(NW,NL),KIP(NW),
      & GMO(NW,NL),GMW(NW,NL),GMG(NW,NL),LAYER(NW),QVO(NW),
      & QVW(NW),QVG(NW),QVT(NW),CUMO(NW,NL),CUMW(NW,NL),CUMG(NW,NL)
        COMMON /VOLFAC/ BO(NX,NY,NZ),BW(NX,NY,NZ),BG(NX,NY,NZ)
        COMMON /RATE/ QO(NX,NY,NZ),QW(NX,NY,NZ),QG(NX,NY,NZ)
        COMMON /RATEQ/ QO0(NX,NY,NZ),QW0(NX,NY,NZ),QG0(NX,NY,NZ),ITFLAG
        COMMON /TERM1/ GOWT(NX,NY,NZ),GWWT(NX,NY,NZ),GGWT(NX,NY,NZ),
      & OW(NX+1,NY,NZ),OE(NX+1,NY,NZ),WW(NX+1,NY,NZ),WE(NX+1,NY,NZ),
      & OS(NX,NY+1,NZ),ON(NX,NY+1,NZ),WS(NX,NY+1,NZ),WN(NX,NY+1,NZ),
      & OT(NX,NY,NZ+1),OB(NX,NY,NZ+1),WT(NX,NY,NZ+1),WB(NX,NY,NZ+1)\
        COMMON /TERM2/ QOWG(NX,NY,NZ)
        COMMON /COMPRS/ CT(NX,NY,NZ)
        COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
        COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
        COMMON /IQN/ IQN1(NW),IQN2(NW),IQN3(NW)
        COMMON /IQH/ IQH1(NW,NL),IQH2(NW,NL),IQH3(NW,NL),COND(NW)
        COMMON /CODE/ KSM1,KSN1,KCO1,NN,FACT1,FACT2,TMAX,KSOL,MITER,
      & OMEGA,TOL,TOL1,KSN,KSM,KCO,KTR,KCOFF,DSMAX,DPMAX,WORMAX,
      & GORMAX,PAMIN,PAMAX
        COMMON /ADD1/ IM,JM,KM,ETI,FT,FTMAX
        COMMON /ADD2/ COP,CWP,CGP,CWI,CGI,CPOI,PVWI,POIR,CPOU
        COMMON /PSCNTL/ KPI,KSI
        COMMON /MBE/ MBEO,MBEW,MBEG
        COMMON /NUMBER/ II,JJ,KK
        COMMON /VOL/ SCFO,SCFW,SCFG,SCFG1,STBO,STBW,MCFG,MCFG1,MCFGT,
      & MCFGI,STBOI,STBWI,RESVOL
        COMMON /BAL/ OP,WP,GP,WI,GI,PAVG0,PAVG,OPR,WPR,GPR,WIR,GIR,CWOR,
      & WOR,CGOR,GOR
        COMMON /PRTCNT/ IWLCNG,ICHANG,IWLREP,ISUMRY,
      & IPMAP,ISOMAP,ISWMAP,ISGMAP,IPBMAP,ICHMAP,CHEMAP
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      COMMON /IO2/ NO2
      COMMON /CHRCTR/ FNAME,MNAME(NUM),LNAME,TAG
      COMMON /TTEST/ NUMPRD,SONTVL
      COMMON /SWTCH/ NGRSW,NTRSW,NRESTART,NGEL
      COMMON  /R1XYZ/  R11X,R21X,R31X,R41X,R11Y,R21Y,R31Y,R41Y,
     & R11Z,R21Z,R31Z,R41Z
      COMMON /T1XYZ/ T1X,T2X,T3X,T4X,T1Y,T2Y,T3Y,T4Y,T1Z,T2Z,T3Z,T4Z
      COMMON /DXYZ/ DX0,DXP,DXM,XW,DY0,DYP,DYM,YW,DZ0,DZP,DZM,ZW
      COMMON /RXYZ/ RX,RY,RZ,AX,AY,AZ,I,J,K
      COMMON /COUNT/ N1READ,N2READ
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /FLORAT/ UWN(NX,NY,NZ),UEN(NX,NY,NZ),USN(NX,NY,NZ),
     & UNN(NX,NY,NZ),UTN(NX,NY,NZ),UBN(NX,NY,NZ)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
      COMMON /SHEAR/GAMMA0,GAMMA1,GAMMA2,GAMMA3,SHEARA,SHEARB
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /DT/ DELT,DELT0
      COMMON /TIMESTEP/ N
      COMMON /MAXC/ C1MAX,C2MAX,C3MAX,C4MAX,C5MAX
      DIMENSION OOIP(NZ),OWIP(NZ),ODGIP(NZ),OFGIP(NZ)

      CHARACTER*12 OUTPUT, OUTRATE, OUTGEL
      NI=5
      NO=6
      OPEN(UNIT=NI,FILE='INPUT.DAT',STATUS='OLD')
      OPEN(UNIT=13,FILE='OTNAM.TXT',STATUS='NEW')
      N1READ=0
      N2READ=0
      VERSION=1.1
      READ(NI,3009)OUTPUT
      N1READ=N1READ+1
      READ(NI,3009)OUTRATE
      N1READ=N1READ+1
      READ(NI,3009)OUTGEL
      N1READ=N1READ+1
      WRITE(13,2008)'  Output Files: '
      WRITE(13,2009) OUTPUT
      WRITE(13,2009) OUTRATE
      WRITE(13,2009) OUTGEL
2008  FORMAT(A16)
2009  FORMAT(A28)
3009  FORMAT(A12)
      OPEN(UNIT=NO,FILE=OUTPUT,STATUS='NEW')
      OPEN(UNIT=14,FILE=OUTRATE,STATUS='NEW')
      OPEN(UNIT=10,FILE=OUTGEL,STATUS='NEW')
      WRITE(NO,3005)
      WRITE(NO,3007) VERSION
      WRITE(NO,3006)
 3007 FORMAT(T30,'*',T50,'            NIPER:   ',T98,'*',/T30,'*',
     & T48,'BLACK OIL PRIMARY AND SECONDARY RECOVERY MODEL',T98,'*',
     & /T30,'*',
     & T48,'   FOR PERMEABILITY MODIFICATION TREATMENT  ',T98,'*',
     & /T30,'*',T59,'(VERSION  ',F3.1,')',T98,'*')
 3005 FORMAT(//T30,69('*'),/T30,'*',T98,'*'/T30,'*',T98,'*')
 3006 FORMAT(T30,'*',T98,'*'/T30,'*',T98,'*'/T30,69('*'),///)
C
C**** ESTABLISH RESERVOIR AND BLOCK DIMENSIONS
C
      CALL GRID1
```

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C
C**** ESTABLISH POROSITY AND PERMEABILITY AT EACH ZONE
C
      CALL PARM1
C
C**** CALCULATE INTERBLOCK TRANSMISSIBILITIES
C
      RFT=0.
      CALL TRAN1
C
C**** EMPIRICAL DATA
C
      CALL TABLE
C
C**** READ GELATION DATA IF THIS OPTION IS INVOKED
C
      IF(NGEL.EQ.1)CALL GELDATA
C
C**** ESTABLISH INITIAL CONDITIONS
C
      CALL UINIT1
C
C**** SOLUTION METHOD, DEBUG PRINT, AND TIME-STEP CONTROL PARAMETERS.
C
      CALL CODES
      READ(NI,69)(TITLE(IH),IH=1,40)
      READ(NI,*) SUREP
      PRIN=SUREP
69    FORMAT(40A2)
      D5615 = 1./5.615
      D288  = 1./288.
      D114  = 1./144.
      NMAX = NN+1
      DO 1000 N=1,NMAX
C
C*** NLOOP DEFINED TO AVOID INDEX MODIFICATION WARNINGS IN
C  CALLS TO MATBAL, SOLMAT, LSOR.
      NLOOP=N
C
C**** RECURRENT DATA.
C
      IF(FT.LT.FTMAX) GO TO 46
      READ(NI,*) IWLCNG,ICHANG,IWLREP,ISUMRY,
     & IPMAP,ISOMAP,ISWMAP,ISGMAP,IPBMAP,ICHMAP,CHEMAP,NGEL
      READ(NI,*) DAY,DTMIN,DTMAX,HOUR,MIN,SEC
      IF(IWLCNG.EQ.0) GO TO 45
      CALL NODES(NVQN)
 45   DELT=DAY+HOUR/24.+MIN/1440.+SEC/86400.
      FTMAX=ETI+ICHANG*DELT
 46   IF(N.EQ.1)DELT0=DELT
      IF(N.EQ.1)GO TO 1050
      IF(DSMC.LT.DSMAX.AND.DPMC.LT.DPMAX)DELT=DELT*FACT1
      IF(DSMC.GT.DSMAX.OR.DPMC.GT.DPMAX)DELT=DELT*FACT2
      IF(DELT.LT.DTMIN)DELT=DTMIN
      IF(DELT.GT.DTMAX)DELT=DTMAX
      IF(ETI+DELT.GT.FTMAX)DELT=FTMAX-ETI
1050  FT=ETI+DELT
      IF(ETI+DELT*0.5.GE.TMAX) GO TO 1010
C****ITFLAG COUNTS THE NUMBER OF TIME STEP REPITITIONS.
      ITFLAG=0
C****REENTRY POINT FOR REPEATED TIME STEP.
1060  CONTINUE
      DIV1 = 1./DELT
      IF(N.GT.1.OR.ITFLAG.GT.0) GO TO 105
```

```
      RESVOL=0.0
      SCFO=0.0
      SCFG=0.0
      SCFG1=0.0
      DO 102 K=1,KK
      OOIP(K)=0.
      OWIP(K)=0.
      ODGIP(K)=0.
      OFGIP(K)=0.
      DO 100 J=1,JJ
      DO 100 I=1,II
      PP=P(I,J,K)
      BPT=PBOT(I,J,K)
      VP(I,J,K)=VP(I,J,K)*DX(I,J,K)*DY(I,J,K)*DZ(I,J,K)
      RESVOL=RESVOL+VP(I,J,K)
C**** NOTE: WE ARE ASSUMING INITIAL PHI IS AT INITIAL RESERVOIR PRESSURE
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PP,RSO)
      CALL INTERP(PWT,RSWT,MPWT,PP,RSW)
      CALL INTPVT(BPT,BSLOPE,POT,BOT,MPOT,PP,BO(I,J,K))
      CALL INTERP(PWT,BWT,MPWT,PP,BW(I,J,K))
      CALL INTERP(PGT,BGT,MPGT,PP,BG(I,J,K))
      FF1=SO(I,J,K)/BO(I,J,K)
      FF2=SW(I,J,K)/BW(I,J,K)
      SCFO=SCFO+VP(I,J,K)*FF1
      SCFW=SCFW+VP(I,J,K)*FF2
      SCFG=SCFG+VP(I,J,K)*SG(I,J,K)/BG(I,J,K)
      SCFG1=SCFG1+VP(I,J,K)*(RSO*FF1+RSW*FF2)
      CALL INTERP(POT,BOPT,MPOT,PP,BODER)
      CALL INTERP(POT,RSOPT,MPOT,PP,RSODER)
      CALL INTERP(PWT,BWPT,MPWT,PP,BWDER)
      CALL INTERP(PWT,RSWPT,MPWT,PP,RSWDER)
      CALL INTERP(PGT,BGPT,MPGT,PP,BGDER)
      IF(PP.GT.PBOT(I,J,K))BODER=BSLOPE
      IF(PP.GT.PBOT(I,J,K))RSODER=RSLOPE
      CO=-(BODER-BG(I,J,K)*RSODER)/BO(I,J,K)
      CW=-(BWDER-BG(I,J,K)*RSWDER)/BW(I,J,K)
      CG=-BGDER/BG(I,J,K)
      CALL INTERP(PGT,CRT,MPGT,PP,CR)
      CT(I,J,K)=CR + CO*SO(I,J,K) +CW*SW(I,J,K) + CG*SG(I,J,K)
      OOIP(K)=OOIP(K)+D5615*.000001*SON(I,J,K)*VP(I,J,K)/BO(I,J,K)
      OWIP(K)=OWIP(K)+D5615*.000001*SWN(I,J,K)*VP(I,J,K)/BW(I,J,K)
      ODGIP(K)=ODGIP(K)+.001*.000001*(RSO*SON(I,J,K)*VP(I,J,K)/BO(I,J,K)
     & +RSW*SWN(I,J,K)*VP(I,J,K)/BW(I,J,K))
      OFGIP(K)=OFGIP(K)+.001*.000001*SGN(I,J,K)*VP(I,J,K)/BG(I,J,K)
      IF(KCO1.EQ.0)GO TO 100
      WRITE(NO,21)I,J,K,VP(I,J,K),CT(I,J,K),BO(I,J,K),SO(I,J,K),
     &BW(I,J,K),SW(I,J,K),BG(I,J,K),SG(I,J,K)
 21   FORMAT(1X,3I3,8E15.6)
 100  CONTINUE
      WRITE(NO,110)K,OOIP(K),OWIP(K),ODGIP(K),OFGIP(K)
 110  FORMAT(/,1X,'LAYER',I3,' INITIAL FLUID VOLUMES:',
     & /,10X,'OIL IN PLACE (MILLION STB)',T60,F10.4,
     & /,10X,'WATER IN PLACE (MILLION STB)',T60,F10.4,
     & /,10X,'SOLUTION GAS IN PLACE (BILLION SCF)',T60,F10.4,
     & /,10X,'FREE GAS IN PLACE (BILLION SCF)',T60,F10.4/)
 102  CONTINUE
      TOOIP=0.
      TOWIP=0.
      TODGIP=0.
      TOFGIP=0.
      DO 103 K=1,KK
      TOOIP=TOOIP+OOIP(K)
      TOWIP=TOWIP+OWIP(K)
      TODGIP=TODGIP+ODGIP(K)
```

```
103   TOFGIP=TOFGIP+OFGIP(K)
      WRITE(NO,115) TOOIP,TOWIP,TODGIP,TOFGIP
115   FORMAT(/,1X,'TOTAL INITIAL FLUID VOLUMES IN RESERVOIR:',
     & /,10X,'OIL IN PLACE (MILLION STB)',T60,F10.4,
     & /,10X,'WATER IN PLACE (MILLION STB)',T60,F10.4,
     & /,10X,'SOLUTION GAS IN PLACE (BILLION SCF)',T60,F10.4,
     & /,10X,'FREE GAS IN PLACE (BILLION SCF)',T60,F10.4/)
      STBO=SCFO*D5615
      STBW=SCFW*D5615
      MCFG=SCFG*0.001
      MCFG1=SCFG1*0.001
      STBOI=STBO
      STBWI=STBW
      MCFGI=MCFG+MCFG1
      IF(MCFGI.LE.1.D-7.AND.MCFGT.LE.1.D-7)MBEG=0.0
105   IF(N.EQ.1.AND.ITFLAG.LE.0) CALL PRTPS(N,DELT0)
      IF(N.EQ.NMAX) GO TO 1010
C
C**** ESTABLISH RATES & CALCULATE BHFP(IF PID IS NONZERO)
C
      IF(NVQN.NE.0)CALL QRATE(1,NVQN)
C
C**** CALCULATE SEVEN DIAGONAL MATRIX FOR PRESSURE SOLUTION

      IF(RFT.GT.1.)CALL TRAN1
1160  CALL SOLMAT(DIV1,D288,D144,N)

C**** MODIFY MATRIX ELEMENTS FOR WELLS UNDER IMPLICIT CONTROL.
C
      IF(NVQN.NE.0) CALL PRATEI(1,NVQN)
C
C**** CALCULATE NEW PRESSURE DISTRIBUTION
C
1170  CALL LSOR(DELT,DELT0,N)
C
C**** CALCULATE IMPLICIT RATES.
C
      IF(NVQN.NE.0) CALL PRATEO(1,NVQN)
2051  CONTINUE
C
C**** CALCULATE NEW FLUID SATURATIONS
C
      SCFO=0.0
      SCFW=0.0
      SCFG=0.0
      SCFG1=0.0
      RESVOL=0.0
      DO 400 K=1,KK
      DO 400 J=1,JJ
      DO 400 I=1,II
      PPN=PN(I,J,K)
      PP=P(I,J,K)
      BPT=PBOT(I,J,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PP,RSO)
      CALL INTERP(PWT,RSWT,MPWT,PP,RSW)
      CALL INTERP(PGT,CRT,MPGT,PPN,CR)
      BPT=PBOT(I,J,K)
      CALL INTPVT(BPT,BSLOPE,POT,BOT,MPOT,PP,BBO)
      CALL INTERP(PWT,BWT,MPWT,PP,BBW)
      CALL INTERP(PGT,BGT,MPGT,PP,BBG)
      VPP=VP(I,J,K) * (1.0+CR*(P(I,J,K)-PPN))
      RESVOL=RESVOL+VPP
C
      DP1=0.0
```

```
      DP2=0.0
      DP3=0.0
      DP4=0.0
      DP5=0.0
      DP6=0.0
      IF((I-1).GT.0)  DP1=P(I-1,J,K)-PP
      IF((I+1).LE.II) DP2=P(I+1,J,K)-PP
      IF((J-1).GT.0)  DP3=P(I,J-1,K)-PP
      IF((J+1).LE.JJ) DP4=P(I,J+1,K)-PP
      IF((K-1).GT.0)  DP5=P(I,J,K-1)-PP
      IF((K+1).LE.KK) DP6=P(I,J,K+1)-PP
C
      DAODP=OW(I,J,K)*DP1+OE(I,J,K)*DP2+OS(I,J,K)*DP3
     &    +ON(I,J,K)*DP4+OT(I,J,K)*DP5+OB(I,J,K)*DP6
      DAWDP=WW(I,J,K)*DP1+WE(I,J,K)*DP2+WS(I,J,K)*DP3
     &    +WN(I,J,K)*DP4+WT(I,J,K)*DP5+WB(I,J,K)*DP6
      SW(I,J,K)=((DAWDP+GWWT(I,J,K)-QW(I,J,K))*DELT +VP(I,J,K)*
     &SWN(I,J,K)/BW(I,J,K)) * BBW/VPP
      SSSW=SW(I,J,K)
      CALL INTERP(SAT,KRWT,MSAT,SSSW,RKRWS)
      IF(RKRWS.LE.0.0)SW(I,J,K)=SWN(I,J,K)
      SSNO=SON(I,J,K)
      CALL INTERP(SAT,KROT,MSAT,SSNO,RKRON)
      SO(I,J,K)=((DAODP+GOWT(I,J,K)-QO(I,J,K))*DELT +VP(I,J,K)*
     &SON(I,J,K)/BO(I,J,K)) * BBO/VPP
      IF(RKRON.LE.0.0) SO(I,J,K)=SON(I,J,K)
      SG(I,J,K)=1.0-SO(I,J,K)-SW(I,J,K)
      IF(RSO.LE.0.0.AND.RSW.LE.0.0) GO TO 403
      IF(SG(I,J,K).GT.0.0) GO TO 405
403    SG(I,J,K)=0.0
      SSSO=SO(I,J,K)
      CALL INTERP(SAT,KROT,MSAT,SSSO,RKROS)
      IF(RKROS.LE.0.0)THEN
      SW(I,J,K)=1.0-SO(I,J,K)
      ELSE
      SO(I,J,K)=1.0-SW(I,J,K)
      ENDIF
975     FORMAT(F8.2,2I4,2F9.6,F9.1,F9.6)
405   CONTINUE
C
      RW=(RHOSCW + RSW*RHOSCG)/BBW
      SSW=SW(I,J,K)
      CALL INTERP(SAT,PCOWT,MSAT,SSW,PCOW)
      IF(I.EQ.1) GO TO 152
      PP1=P(I-1,J,K)
      SSW1=SW(I-1,J,K)
      CALL INTERP(PWT,RSWT,MPWT,PP1,RSW1)
      CALL INTERP(PWT,BWT,MPWT,PP1,BBW1)
      CALL INTERP(SAT,PCOWT,MSAT,SSW1,PCOW1)
      RW1=(RHOSCW + RSW1*RHOSCG)/BBW1
      GW1=(RW1+RW)*D288*(EL(I-1,J,K)-EL(I,J,K))-
     & PCOW+PCOW1
152   IF(I.EQ.II) GO TO 154
      PP2=P(I+1,J,K)
      SSW2=SW(I+1,J,K)
      CALL INTERP(PWT,RSWT,MPWT,PP2,RSW2)
      CALL INTERP(PWT,BWT,MPWT,PP2,BBW2)
      CALL INTERP(SAT,PCOWT,MSAT,SSW2,PCOW2)
      RW2=(RHOSCW + RSW2*RHOSCG)/BBW2
      GW2=(RW2+RW)*D288*(EL(I+1,J,K)-EL(I,J,K))-
     & PCOW+PCOW2
C
154   IF(J.EQ.1) GO TO 156
      PP3=P(I,J-1,K)
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      SSW3=SW(I,J-1,K)
      CALL INTERP(PWT,RSWT,MPWT,PP3,RSW3)
      CALL INTERP(PWT,BWT,MPWT,PP3,BBW3)
      CALL INTERP(SAT,PCOWT,MSAT,SSW3,PCOW3)
      RW3=(RHOSCW + RSW3*RHOSCG)/BBW3
      GW3=(RW3+RW)*D288*(EL(I,J-1,K)-EL(I,J,K))-
     & PCOW+PCOW3
156   IF(J.EQ.JJ) GO TO 158
      PP4=P(I,J+1,K)
      SSW4=SW(I,J+1,K)
      CALL INTERP(PWT,RSWT,MPWT,PP4,RSW4)
      CALL INTERP(PWT,BWT,MPWT,PP4,BBW4)
      CALL INTERP(SAT,PCOWT,MSAT,SSW4,PCOW4)
      RW4=(RHOSCW + RSW4*RHOSCG)/BBW4
      GW4=(RW4+RW)*D288*(EL(I,J+1,K)-EL(I,J,K))-
     & PCOW+PCOW4
C
158   IF(K.EQ.1) GO TO 162
      PP5=P(I,J,K-1)
      SSW5=SW(I,J,K-1)
      CALL INTERP(PWT,RSWT,MPWT,PP5,RSW5)
      CALL INTERP(PWT,BWT,MPWT,PP5,BBW5)
      CALL INTERP(SAT,PCOWT,MSAT,SSW5,PCOW5)
      RW5=(RHOSCW +RSW5*RHOSCG)/BBW5
      GW5=(RW5+RW)*D288*(EL(I,J,K-1)-EL(I,J,K))-
     & PCOW+PCOW5
162   IF(K.EQ.KK) GO TO 164
      PP6=P(I,J,K+1)
      SSW6=SW(I,J,K+1)
      CALL INTERP(PWT,RSWT,MPWT,PP6,RSW6)
      CALL INTERP(PWT,BWT,MPWT,PP6,BBW6)
      CALL INTERP(SAT,PCOWT,MSAT,SSW6,PCOW6)
      RW6=(RHOSCW +RSW6*RHOSCG)/BBW6
      GW6=(RW6+RW)*D288*(EL(I,J,K+1)-EL(I,J,K))-
     & PCOW+PCOW6
C
164   UX(I,J,K)=0.
      IF((I-1).GT.0) UX(I,J,K)=UX(I,J,K)+
     & WW(I,J,K)*(DP1-GW1)/DY(I-1,J,K)/DZ(I-1,J,K)/2
      IF((I+1).LE.II) UX(I,J,K)= UX(I,J,K)-
     & WE(I,J,K)*(DP2-GW2)/DY(I+1,J,K)/DZ(I+1,J,K)/2
      IF(I.EQ.1.OR.I.EQ.II) UX(I,J,K)=UX(I,J,K)*2
      UY(I,J,K)=0.
      IF((J-1).GT.0) UY(I,J,K)=UY(I,J,K)+
     & WS(I,J,K)*(DP3-GW3)/DX(I,J-1,K)/DZ(I,J-1,K)/2
      IF((J+1).LE.JJ) UY(I,J,K)=UY(I,J,K)-
     & WN(I,J,K)*(DP4-GW4)/DX(I,J+1,K)/DZ(I,J+1,K)/2
      IF(J.EQ.1.OR.J.EQ.JJ) UY(I,J,K)=UY(I,J,K)*2
      UZ(I,J,K)=0.
      IF((K-1).GT.0) UZ(I,J,K)=UZ(I,J,K)+
     & WT(I,J,K)*(DP5-GW5)/DY(I,J,K-1)/DX(I,J,K-1)/2
      IF((K+1).LE.KK)UZ(I,J,K)=UZ(I,J,K)-
     & WB(I,J,K)*(DP6-GW6)/DY(I,J,K+1)/DX(I,J,K+1)/2
      IF(K.EQ.1.OR.K.EQ.KK) UZ(I,J,K)=UZ(I,J,K)*2
C
      IF((I-1).GT.0) UWN(I,J,K)=
     &  WW(I,J,K)*(DP1-GW1)/DY(I-1,J,K)/DZ(I-1,J,K)
      IF(I.EQ.1) UWN(I,J,K)=0.0
      IF((I+1).LE.II) UEN(I,J,K)=
     & -WE(I,J,K)*(DP2-GW2)/DY(I+1,J,K)/DZ(I+1,J,K)
      IF(I.EQ.II) UEN(I,J,K)=0.0
      IF((J-1).GT.0) USN(I,J,K)=
     &  WS(I,J,K)*(DP3-GW3)/DX(I,J-1,K)/DZ(I,J-1,K)
      IF(J.EQ.1) USN(I,J,K)=0.0
```

```
      IF((J+1).LE.JJ) UNN(I,J,K)=
     & -WN(I,J,K)*(DP4-GW4)/DX(I,J+1,K)/DZ(I,J+1,K)
      IF(J.EQ.JJ) UNN(I,J,K)=0.0
      IF((K-1).GT.0) UTN(I,J,K)=
     &  WT(I,J,K)*(DP5-GW5)/DX(I,J,K-1)/DY(I,J,K-1)
      IF(K.EQ.1) UTN(I,J,K)=0.0
      IF((K+1).LE.KK) UBN(I,J,K)=
     & -WB(I,J,K)*(DP6-GW6)/DX(I,J,K+1)/DY(I,J,K+1)
      IF(K.EQ.KK) UBN(I,J,K)=0.0
C
      IF(KCOFF.EQ.0) GO TO 397
      RHO1=VPP*SO(I,J,K)/BBO
      RHO2=VP(I,J,K)*SON(I,J,K)/BO(I,J,K)
      DIFFO=RHO1-RHO2
      RHW1=VPP*SW(I,J,K)/BBW
      RHW2=VP(I,J,K)*SWN(I,J,K)/BW(I,J,K)
      DIFFW=RHW1-RHW2
      RHG1=VPP*SG(I,J,K)/BBG
      RHG2=VP(I,J,K)*SGN(I,J,K)/BG(I,J,K)
      DIFFG=RHG1-RHG2
      WRITE(NO,33)
      WRITE(NO,21)I,J,K,P(I,J,K),SO(I,J,K),SON(I,J,K),SW(I,J,K),
     &SWN(I,J,K),SG(I,J,K),SGN(I,J,K),VPP
      WRITE(NO,21)I,J,K,GOWT(I,J,K),QO(I,J,K),GWWT(I,J,K),
     &QW(I,J,K)
      WRITE(NO,21)I,J,K,DAODP,DAWDP,DELT
      WRITE(NO,21)I,J,K,RHO1,RHO2,DIFFO
      WRITE(NO,21)I,J,K,RHW1,RHW2,DIFFW
      WRITE(NO,21)I,J,K,RHG1,RHG2,DIFFG,GGWT(I,J,K),QG(I,J,K)
C
 397  VP(I,J,K)=VPP
      BO(I,J,K)=BBO
      BW(I,J,K)=BBW
      BG(I,J,K)=BBG
      FF1=SO(I,J,K)/BO(I,J,K)
      FF2=SW(I,J,K)/BW(I,J,K)
      SCFO=SCFO+VP(I,J,K)*FF1
      SCFW=SCFW+VP(I,J,K)*FF2
      SCFG=SCFG+VP(I,J,K)*SG(I,J,K)/BG(I,J,K)
      SCFG1=SCFG1+VP(I,J,K)*(RSO*FF1+RSW*FF2)
      CALL INTERP(POT,BOPT,MPOT,PP,BODER)
      CALL INTERP(POT,RSOPT,MPOT,PP,RSODER)
      CALL INTERP(PWT,BWPT,MPWT,PP,BWDER)
      CALL INTERP(PWT,RSWPT,MPWT,PP,RSWDER)
      CALL INTERP(PGT,BGPT,MPGT,PP,BGDER)
      IF(PP.GT.PBOT(I,J,K))BODER=BSLOPE
      IF(PP.GT:PBOT(I,J,K))RSODER=RSLOPE
      CO=-(BODER-BG(I,J,K)*RSODER)/BO(I,J,K)
      CW=-(BWDER-BG(I,J,K)*RSWDER)/BW(I,J,K)
      CG=-BGDER/BG(I,J,K)
      CALL INTERP(PGT,CRT,MPGT,PP,CR)
      CT(I,J,K)=CR + CO*SO(I,J,K) +CW*SW(I,J,K) + CG*SG(I,J,K)
      IF(N.EQ.KCO)WRITE(NO,21)I,J,K,CR,CO,RSO,CW,RSW,CG
C
 400  CONTINUE
C
C     AUTO. TIME STEP CONTROL CALC. OF PRESSURE AND SAT. MAXIMA.
      PPM=0.
      SOM=0.
      SWM=0.
      SGM=0.
      DO 240 K=1,KK
      DO 240 J=1,JJ
      DO 240 I=1,II
```

```
      DPO=P(I,J,K)-PN(I,J,K)
      DSO=SO(I,J,K)-SON(I,J,K)
      DSW=SW(I,J,K)-SWN(I,J,K)
      DSG=SG(I,J,K)-SGN(I,J,K)
      IF(ABS(DPO).GT.ABS(PPM)) PPM=DPO
      IF(ABS(DSO).GT.ABS(SOM)) SOM=DSO
      IF(ABS(DSW).GT.ABS(SWM)) SWM=DSW
      IF(ABS(DSG).GT.ABS(SGM)) SGM=DSG
 240  CONTINUE
      DPMC=ABS(PPM)
      DSMC=ABS(SOM)
      IF(DSMC.LT.ABS(SGM))DSMC=ABS(SGM)
      IF(DSMC.LT.ABS(SWM))DSMC=ABS(SWM)
C****REPEAT TIME STEP?
      IF(DSMC.LT.DSMAX.AND.DPMC.LT.DPMAX) GO TO 402
      IF(DELT.LE.DTMIN.OR.FACT2.GE.1.0) GO TO 402
      ITFLAG=ITFLAG+1
      DELT=DELT*FACT2
      IF(DELT.LT.DTMIN) DELT=DTMIN
      FT=ETI+DELT
      IF(FT.GT.FTMAX) DELT=FTMAX-ETI
C****RESET VARIABLES.
      DO 250 I=1,II
      DO 250 J=1,JJ
      DO 250 K=1,KK
      P(I,J,K)=PN(I,J,K)
      SO(I,J,K)=SON(I,J,K)
      SW(I,J,K)=SWN(I,J,K)
      SG(I,J,K)=SGN(I,J,K)
 250  CONTINUE
C
 33   FORMAT(//)
C
      GO TO 1060
 402  CONTINUE
C
C****UNDERSATURATED GRID BLOCK SATURATION CALCULATION.
C
      DO 410 I=1,II
      DO 410 J=1,JJ
      DO 410 K=1,KK
      IF(P(I,J,K).GT.PN(I,J,K)) GO TO 410
      IF(P(I,J,K).LT.PBOT(I,J,K)) GO TO 410
      IP=I+1
      IM=I-1
      JP=J+1
      JM=J-1
      KP=K+1
      KM=K-1
      IF(IP.GT.II) GO TO 412
      IF(SGN(IP,J,K).GT.0.0001) GO TO 410
 412  IF(IM.LT.1) GO TO 414
      IF(SGN(IM,J,K).GT.0.0001) GO TO 410
 414  IF(JP.GT.JJ) GO TO 416
      IF(SGN(I,JP,K).GT.0.0001) GO TO 410
 416  IF(JM.LT.1) GO TO 418
      IF(SGN(I,JM,K).GT.0.0001) GO TO 410
 418  IF(KP.GT.KK) GO TO 420
      IF(SGN(I,J,KP).GT.0.0001) GO TO 410
 420  IF(KM.LT.1) GO TO 422
      IF(SGN(I,J,KM).GT.0.0001) GO TO 410
 422  SG(I,J,K)=0.0
 410  CONTINUE
C
```

```
C**** CALCULATE CHEMICAL CONCENTRATION FOR GELATION OPTION
C
      IF(NGEL.EQ.1)CALL GEL
C
C**** REPRESSURIZATION ALGORITHM.
      IF(IREPRS.EQ.1) GO TO 51
      DO 50 I=1,II
      DO 50 J=1,JJ
      DO 50 K=1,KK
      IF(SG(I,J,K).LE.0.0001) GO TO 50
      PP=P(I,J,K)
      IF(P(I,J,K).GT.PBOT(I,J,K)) PP=PBOT(I,J,K)
      CALL INTERP(POT,BOT,MPOT,PP,BBO)
      CALL INTERP(POT,RSOT,MPOT,PP,RSO)
      CALL INTERP(PGT,BGT,MPGT,PP,BBG)
      IF(SO(I,J,K).EQ.0.0) GO TO 50
      RSONEW=RSO + SG(I,J,K)*BBO/(SO(I,J,K)*BBG)
      CALL INTERP(RSOT,POT,MPOT,RSONEW,PBONEW)
      PBOT(I,J,K)=PBONEW
 50   CONTINUE
 51   CONTINUE
C**** UPDATE OLD FLUID VOLUMES FOR MATERIAL BALANCE.
      STBOI=STBO
      STBWI=STBW
      MCFGI=MCFGT
C**** UPDATE  NEW FLUID VOLUMES.
      STBO=SCFO*D5615
      STBW=SCFW*D5615
      MCFG=SCFG*0.001
      MCFG1=SCFG1*0.001
      MCFGT=MCFG+MCFG1
C
C***** DEBUG PRINT OF PRESENT AND FUTURE P,SO,SW,SG VALUES.
      IF(KCOFF.EQ.0)GO TO 291
      DO 290 K=1,KK
      DO 290 J=1,JJ
      DO 290 I=1,II
      WRITE(NO,21)I,J,K,PN(I,J,K),SON(I,J,K),SWN(I,J,K),SGN(I,J,K)
      WRITE(NO,21)I,J,K,P(I,J,K),SO(I,J,K),SW(I,J,K),SG(I,J,K)
290   CONTINUE
291   CONTINUE
C
C**** WELL REPORT (ALL RATE & PRESSURE DATA APPLICABLE THIS STEP)
C
      IJ=0
      TOR=0.
      TGR=0.
      TWR=0.
      TOC=0.
      TGC=0.
      TWC=0.
      N2=NVQN
      DO 2050 J=1,N2
      GOR=0.
      WOR=0.
      IJ=IJ+1
      IF (J.LE.NVQN)THEN
      IQ1=IQN1(J)
      IQ2=IQN2(J)
      IQ3=IQN3(J)
      LAY=IQ3+(LAYER(J)-1)
      ELSE
      IQ3=1
      LAY=LAYER(J)
```

```
      ENDIF
      DO 2050 KKK=IQ3,LAY
      K=KKK
      IF (J.GT.NVQN)THEN
      IQ1=IQH1(J,KKK)
      IQ2=IQH2(J,KKK)
      K=IQH3(J,KKK)
      ENDIF
      QO0(IQ1,IQ2,K)=QO(IQ1,IQ2,K)
      QW0(IQ1,IQ2,K)=QW(IQ1,IQ2,K)
      QG0(IQ1,IQ2,K)=QG(IQ1,IQ2,K)
      QOO=QO(IQ1,IQ2,K)*D5615
      QWW=QW(IQ1,IQ2,K)*D5615
      QGG=QG(IQ1,IQ2,K)*.001
      CUMO(J,KKK)=CUMO(J,KKK)+QOO*DELT*.001
      CUMW(J,KKK)=CUMW(J,KKK)+QWW*DELT*.001
      CUMG(J,KKK)=CUMG(J,KKK)+QGG*DELT*.001
      IF(IWLREP.EQ.0) GO TO 2050
 891  IF(IJ.EQ.1.AND.KKK.EQ.IQ3)WRITE(NO,591)FT
      IF(IJ.EQ.1.AND.KKK.EQ.IQ3)WRITE(NO,5911)
 5911 FORMAT(/,T56,'------ RATE ------',22X,'--- CUMULATIVE ---',
     & /,13X,'WELL LOCATION',4X,'CALC   SPEC   SPEC',4X,
     & 'OIL   GAS   WATER   GOR   WOR',5X,
     & 'OIL   GAS   WATER',/,
     & 14X,'ID',3X,'I  J  K   BHFP   BHFP   PI',
     & 3X,'STB/D   MCF/D   STB/D',20X,'MSTB   MMCF   MSTB',/)
      IF(QOO.EQ.0.)GO TO 998
      GOR=QGG*1000./QOO
      WOR=QWW/QOO
 998  WRITE(NO,592)WELLID(J),IQ1,IQ2,K,PWFC(J,KKK),PWF(J,KKK),
     & PID(J,KKK),QOO,QGG,QWW,GOR,WOR,CUMO(J,KKK),CUMG(J,KKK),
     & CUMW(J,KKK)
 592  FORMAT(11X,A5,1X,3I3,2F8.0,F7.3,3F9.0,F7.0,F7.3,3F8.0)
      TOR=TOR+QOO
      TGR=TGR+QGG
      TWR=TWR+QWW
      TOC=TOC+CUMO(J,KKK)
      TGC=TGC+CUMG(J,KKK)
      TWC=TWC+CUMW(J,KKK)
 2050 CONTINUE
      IF(IWLREP.EQ.0)GO TO 2052
 791  WRITE(NO,5912)TOR,TGR,TWR,TOC,TGC,TWC
 5912 FORMAT(12X,102('-'),/,
     &12X,'TOTALS',31X,3F9.0,14X,3F8.0,/)
 2052 CONTINUE
C
C*****CALCULATE MATERIAL BALANCE ERRORS & AVERAGE RESERVOIR PRESSURE
C
      DELT0=DELT
      ETI=ETI+DELT
      CALL MATBAL(DELT0,D5615)
C
      IF(WOR.GT.WORMAX.AND.WORMAX.NE.0.0) GO TO 1002
      IF(GOR.GT.GORMAX) GO TO 1003
      IF(PAVG.LT.PAMIN) GO TO 1004
      IF(PAVG.GT.PAMAX) GO TO 1005
C
C***** SUMMARY REPORT.
      IF(ETI.LT.PRIN) GO TO 988
      FOR=COP/TOOIP/1E+6
      WRITE(14,987) N,ETI,PAVG,OPR,COP,GPR,CGP,FOR,WPR,CWP,WOR,
     & PVWI,CPOI,WIR,CWI
      PRIN=ETI+SUREP
 987  FORMAT(1X,I5,F8.2,2F8.1,F10.1,F8.1,F8.1,F10.5,F8.1,F10.1,
```

```
     & F8.2,F9.4,F10.1,F7.1,F10.1)
988   CONTINUE
      IF(ISUMRY.EQ.0) GO TO 2057
      NLP=N+1
691   CALL PRTPS(NLP,DELT0)
2057  IF(N.NE.KCO.OR.KCO1.EQ.0)GO TO 500
      DO 300 K=1,KK
      DO 300 J=1,JJ
      DO 300 I=1,II
      WRITE(NO,21)I,J,K,VP(I,J,K),CT(I,J,K),BO(I,J,K),SO(I,J,K),
     &BW(I,J,K),SW(I,J,K),BG(I,J,K),SG(I,J,K)
300   CONTINUE
C
500   CONTINUE
      IF(N.EQ.KSN)KSN=KSN+KSN1
      IF(N.EQ.KSM)KSM=KSM+KSM1
      IF(N.EQ.KCO)KCO=KCO+KCO1
C**** UPDATE ARRAYS.
      DO 1150 K=1,KK
      DO 1150 J=1,JJ
      DO 1150 I=1,II
      QO(I,J,K)=0.0
      QW(I,J,K)=0.0
      QG(I,J,K)=0.0
      PN(I,J,K)=P(I,J,K)
      SON(I,J,K)=SO(I,J,K)
      SWN(I,J,K)=SW(I,J,K)
      SGN(I,J,K)=SG(I,J,K)
C
      IF((I-1).GT.0) UW(I,J,K)=UWN(I,J,K)
      IF(I.EQ.1) UW(I,J,K)=0.0
      IF((I+1).LE.II) UE(I,J,K)=UEN(I,J,K)
      IF(I.EQ.II) UE(I,J,K)=0.0
      IF((J-1).GT.0) US(I,J,K)=USN(I,J,K)
      IF(J.EQ.1) US(I,J,K)=0.0
      IF((J+1).LE.JJ) UN(I,J,K)=UNN(I,J,K)
      IF(J.EQ.JJ) UN(I,J,K)=0.0
      IF((K-1).GT.0) UT(I,J,K)=UTN(I,J,K)
      IF(K.EQ.1) UT(I,J,K)=0.0
      IF((K+1).LE.KK) UB(I,J,K)=UBN(I,J,K)
      IF(K.EQ.KK) UB(I,J,K)=0.0
1150  CONTINUE
C
591   FORMAT(///T5,10('*'),' WELL REPORT FOR ALL ACTIVE WELLS ',
     &4X,'ELAPSED TIME =',F11.6,' DAYS FROM BEGINNING OF SIMULATION ',
     &10('*'),//)
C
      IF(WOR.GT.WORMAX.AND.WORMAX.NE.0.0) GO TO 1002
      IF(GOR.GT.GORMAX) GO TO 1003
      IF(PAVG.LT.PAMIN) GO TO 1004
      IF(PAVG.GT.PAMAX) GO TO 1005
1000  CONTINUE
C
1002  WRITE(NO,2002)
      GO TO 1010
1003  WRITE(NO,2003)
      GO TO 1010
1004  WRITE(NO,2004)
      GO TO 1010
1005  WRITE(NO,2005)
1010  CLOSE(UNIT=NI)
      CLOSE(UNIT=NO)
      STOP
C
```

```
2002  FORMAT(/T15,'MAXIMUM WOR HAS BEEN EXCEEDED --- SIMULATION',
     &' IS BEING TERMINATED'//)
2003  FORMAT(/T15,'MAXIMUM GOR HAS BEEN EXCEEDED --- SIMULATION',
     &' IS BEING TERMINATED'//)
2004  FORMAT(/T15,'MINIMUM AVERAGE RESERVOIR PRESSURE WAS NOT',
     &' ACHIEVED --- SIMULATION IS BEING TERMINATED'//)
2005  FORMAT(/T15,'MAXIMUM AVERAGE RESERVOIR PRESSURE
     &HAS BEEN EXCEEDED --- SIMULATION IS BEING TERMINATED'//)
C
      END
C
      BLOCK DATA
      INCLUDE 'PARAGEL.FOR'
      COMMON /IO/ NI,NO
      COMMON /TRAN/ TX(NX+1,NY,NZ),TY(NX,NY+1,NZ),TZ(NX,NY,NZ+1)
      COMMON /SRATE/ PID(NW,NL),PWF(NW,NL),PWFC(NW,NL),KIP(NW),
     & GMO(NW,NL),GMW(NW,NL),GMG(NW,NL),LAYER(NW),QVO(NW),
     & QVW(NW),QVG(NW),QVT(NW),CUMO(NW,NL),CUMW(NW,NL),CUMG(NW,NL)
      COMMON /COEF/ AW(NX,NY,NZ),AE(NX,NY,NZ),AN(NX,NY,NZ),
     & AS(NX,NY,NZ),AB(NX,NY,NZ),AT(NX,NY,NZ),E(NX,NY,NZ),B(NX,NY,NZ)
      COMMON /TERM1/ GOWT(NX,NY,NZ),GWWT(NX,NY,NZ),GGWT(NX,NY,NZ),
     & OW(NX+1,NY,NZ),OE(NX+1,NY,NZ),WW(NX+1,NY,NZ),WE(NX+1,NY,NZ),
     & OS(NX,NY+1,NZ),ON(NX,NY+1,NZ),WS(NX,NY+1,NZ),WN(NX,NY+1,NZ),
     & OT(NX,NY,NZ+1),OB(NX,NY,NZ+1),WT(NX,NY,NZ+1),WB(NX,NY,NZ+1)
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)

      COMMON /ADD1/ IM,JM,KM,ETI,FT,FTMAX
      COMMON /ADD2/ COP,CWP,CGP,CWI,CGI,CPOI,PVWI,POIR,CPOU
      DATA NI,NO/5,6/
      DATA TX,TY,TZ/NXPYZ*0.0,NXYPZ*0.0,NXYZP*0.0/
      DATA CUMO,CUMW,CUMG/NWZ*0.0,NWZ*0.0,NWZ*0.0/
      DATA AW,AS,AT/MAX*0.0,MAX*0.0,MAX*0.0/
      DATA AE,AN,AB/MAX*0.0,MAX*0.0,MAX*0.0/
      DATA OW,OE,WW,WE/NXPYZ*0.0,NXPYZ*0.0,NXPYZ*0.0,NXPYZ*0.0/
      DATA OS,ON,WS,WN/NXYPZ*0.0,NXYPZ*0.0,NXYPZ*0.0,NXYPZ*0.0/
      DATA OT,OB,WT,WB/NXYZP*0.0,NXYZP*0.0,NXYZP*0.0,NXYZP*0.0/
      DATA IM,JM,KM,ETI,FT,FTMAX/NX,NY,NZ,0.0,0.0,0.0/
      DATA COP,CWP,CGP,CWI,CPOI,CGI/0.0,0.0,0.0,0.0,0.0,0.0/
      DATA CPOU/0.0/
      DATA DTMUW,RF/MAX*0.0,MAX*1.0/
      END
C

      BLOCK DATA FILNAM
C
C=============================================BLOCK DATA FILNAM
C
C     CHARACTER VARIABLE INITIALIZATION FOR GRAPHICS.
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      CHARACTER*2 FNAME,MNAME,TAG
      CHARACTER*4 LNAME
      COMMON /CHRCTR/ FNAME,MNAME(NUM),LNAME,TAG
      COMMON /TTEST/ NUMPRD,SONTVL
      COMMON /IO2/ NO2
      DATA NO2/7/
      DATA NUMPRD/1/
      DATA FNAME,LNAME/'SO','.DAT'/
      DATA MNAME/'01','02','03','04','05','06','07','08','09',
```

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     &  '10','11','12','13','14','15','16','17','18','19','20',
     &  '21','22','23','24','25','26','27','28','29','30','31',
     &  '32','33','34','35','36','37','38','39','40'/
      END
C
C
C
      SUBROUTINE INTPVT(BPT,RM,X,Y,N,XO,YO)
C
C=================================================================INTPVT
C
C     PERFORM LINEAR INTERPOLATION WITH FLOATING BUBBLE POINT CALCULATION
C     OF UNDERSATURATED OIL PVT PROPERTIES.
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      DIMENSION X(NTE),Y(NTE)
      IF(XO.GT.BPT)GO TO 100
      IF(XO.GE.X(N))YO=Y(N)
      IF(XO.GE.X(N))RETURN
      DO 10 I=2,N
      IF(XO.GE.X(I))GO TO 10
      YO=Y(I-1)+(XO-X(I-1))*(Y(I)-Y(I-1))/(X(I)-X(I-1))
      RETURN
 10   CONTINUE
 100  CONTINUE
      DO 200 I=2,N
      IF(BPT.GE.X(I))GO TO 200
      YOBP=Y(I-1)+(BPT-X(I-1))*(Y(I)-Y(I-1))/(X(I)-X(I-1))
      YO=YOBP+RM*(XO-BPT)
      RETURN
 200  CONTINUE
      END
C
C
C
      SUBROUTINE INTERP(X,Y,N,XO,YO)
C
C=================================================================INTERP
C
C     PERFORM LINEAR INTERPOLATION.
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      DIMENSION X(NTE),Y(NTE)
      IF(XO.GE.X(N)) YO=Y(N)
      IF(XO.GE.X(N)) RETURN
      DO 10 I=2,N
      IF(XO.GE.X(I)) GO TO 10
      YO=Y(I-1) +(XO-X(I-1))*(Y(I)-Y(I-1))/(X(I)-X(I-1))
      RETURN
 10   CONTINUE
      END
C
      SUBROUTINE GRID1
C
C=================================================================GRID1
C
C     READ GRID BLOCK SIZES AND COMPUTE NODE ELEVATIONS
C
C=================================================================
C
```

```
      INCLUDE 'PARAGEL.FOR'
      CHARACTER*2 TITLE(80)
      COMMON /IO/ NI,NO
      COMMON /NUMBER/ II,JJ,KK
      COMMON /ELEV/ EL(NX,NY,NZ)
      COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
      COMMON /SWTCH/ NGRSW,NTRSW,NRESTART,NGEL
      COMMON /COUNT/ N1READ,N2READ
      DIMENSION SUM(NX,NY),VAREL(NX,NY),RDXL(NX),RDYL(NY),RDZL(NZ)
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      WRITE(NO,70) (TITLE(IH),IH=1,40)
      WRITE(14,69) (TITLE(IH),IH=1,40)
      WRITE(14,2999)
      WRITE(14,3001)
      WRITE(14,3002)
      READ(NI,*) II,JJ,KK
      N1READ=N1READ+1
 2999 FORMAT(//,'  SUMMARY REPORT',/)
 3001 FORMAT('  N   ETI   PAVG  OPR    COP   GPR
     & CGP   FOR   WPR   CWP   WOR   PVWI
     & CPOI   WIR   CWI')
 3002 FORMAT('      (DAY)  (PSI)  (STB/D)   (BBL)  (MCF/D)
     & (MCF)       (STB/D)  (BBL)   (B/B)
     & (LB)   (B/D)  (BBL)',/)
 3004 FORMAT('      (DAY)',17X,10I10,/)
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      READ(NI,*) NGEL
      N1READ=N1READ+1
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
C
C*****READ INPUT CODES FOR DX,DY,DZ
C
      READ(NI,*)KDX,KDY,KDZ
      N1READ=N1READ+1
C
C*****ESTABLISH GRID BLOCK LENGTH (DX) DISTRIBUTION
C
      IF(KDX.GE.0)GO TO 180
      READ(NI,*)DXC
      N1READ=N1READ+1
      DO 175 K=1,KK
      DO 175 J=1,JJ
      DO 175 I=1,II
175   DX(I,J,K)=DXC
      WRITE(NO,56)
      WRITE(NO,29)DXC
      GO TO 195
 180  IF(KDX.GT.0)GO TO 185
      READ(NI,*)(RDXL(I),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
      DO 187 K=1,KK
      DO 187 J=1,JJ
      DO 187 I=1,II
 187  DX(I,J,K)=RDXL(I)
      DO 182 I=1,II
 182  WRITE(NO,511)I,RDXL(I)
      GO TO 195
185   WRITE(NO,43)
      K=1
      WRITE(NO,38)K
```

```
      DO 190 J=1,JJ
      READ(NI,*)  (DX(I,J,K),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
 190  WRITE(NO,72)(DX(I,J,K),I=1,II)
      DO 194 K=2,KK
      WRITE(NO,38) K
      DO 194 J=1,JJ
      DO 193 I=1,II
 193  DX(I,J,K)=DX(I,J,1)
 194  WRITE(NO,72) (DX(I,J,K),I=1,II)
195   CONTINUE
      WRITE(NO,56)
C
C*****ESTABLISH GRID BLOCK LENGTH (DY) DISTRIBUTION
C
      IF(KDY.GE.0)GO TO 200
      READ(NI,*)DYC
      N1READ=N1READ+1
      DO 202 K=1,KK
      DO 202 J=1,JJ
      DO 202 I=1,II
202   DY(I,J,K)=DYC
      WRITE(NO,56)
      WRITE(NO,33)DYC
      GO TO 220
 200  IF(KDY.GT.0)GO TO 207
      READ(NI,*)(RDYL(J),J=1,JJ)
      N1READ=N1READ+1+INT(JJ/10)
      IF(MOD(JJ,10).EQ.0)N1READ=N1READ-1
      DO 205 K=1,KK
      DO 205 J=1,JJ
      DO 205 I=1,II
 205  DY(I,J,K)=RDYL(J)
      DO 210 J=1,JJ
 210  WRITE(NO,512)J,RDYL(J)
      GO TO 220
207   WRITE(NO,47)
      K=1
      WRITE(NO,38)K
      DO 215 I=1,II
      READ(NI,*)(DY(I,J,K),J=1,JJ)
      N1READ=N1READ+1+INT(JJ/10)
      IF(MOD(JJ,10).EQ.0)N1READ=N1READ-1
 215  WRITE(NO,72)(DY(I,J,K),J=1,JJ)
      DO 214 K=2,KK
      WRITE(NO,38) K
      DO 214 J=1,JJ
      DO 213 I=1,II
 213  DY(I,J,K)=DY(I,J,1)
 214  WRITE(NO,72) (DY(I,J,K),I=1,II)
220   CONTINUE
      WRITE(NO,56)
C
C*****ESTABLISH GRID BLOCK LENGTH (DZ) DISTRIBUTION
C
      IF(KDZ.GE.0)GO TO 225
      READ(NI,*)DZC
      N1READ=N1READ+1
      DO 230 K=1,KK
      DO 230 J=1,JJ
      DO 230 I=1,II
 230  DZ(I,J,K)=DZC
      WRITE(NO,56)
```

```
      WRITE(NO,36)DZC
      GO TO 245
 225  IF(KDZ.GT.0)GO TO 232
      READ(NI,*)(RDZL(K),K=1,KK)
      N1READ=N1READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N1READ=N1READ-1
      DO 235 K=1,KK
      DO 235 J=1,JJ
      DO 235 I=1,II
 235  DZ(I,J,K)=RDZL(K)
      DO 237 K=1,KK
 237  WRITE(NO,513)K,RDZL(K)
      GO TO 245
232   WRITE(NO,48)
      DO 240 K=1,KK
      WRITE(NO,38)K
      DO 242 J=1,JJ
      READ(NI,*)(DZ(I,J,K),I=1,II)
      N1READ=N1READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N1READ=N1READ-1
 242  WRITE(NO,72)(DZ(I,J,K),I=1,II)
240   CONTINUE
245   CONTINUE
      WRITE(NO,56)
C
C********GRID BLOCK LENGTH MODIFICATIONS
C
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      READ(NI,*) NUMDX,NUMDY,NUMDZ,IDCODE
      N1READ=N1READ+1
      IF(NUMDX.EQ.0) GO TO 8530
      WRITE(NO,31)
      DO 275 L=1,NUMDX
      READ(NI,*)I,J,K,DX(I,J,K)
      N1READ=N1READ+1
 275  WRITE(NO,32)I,J,K,DX(I,J,K)
      IF(IDCODE.NE.1)GO TO 8530
      WRITE(NO,43)
      DO 853 K=1,KK
      WRITE(NO,38)K
      DO 854 J=1,JJ
 854  WRITE(NO,72)(DX(I,J,K),I=1,II)
853   CONTINUE
8530  CONTINUE
      IF(NUMDY.EQ.0) GO TO 8550
      WRITE(NO,34)
      DO 276 L=1,NUMDY
      READ(NI,*)I,J,K,DY(I,J,K)
      N1READ=N1READ+1
 276  WRITE(NO,32)I,J,K,DY(I,J,K)
      IF(IDCODE.NE.1) GO TO 8550
      WRITE(NO,47)
      DO 855 K=1,KK
      WRITE(NO,38)K
      DO 856 J=1,JJ
 856  WRITE(NO,72)(DY(I,J,K),I=1,II)
855   CONTINUE
8550  CONTINUE
      IF(NUMDZ.EQ.0) GO TO 8570
      WRITE(NO,37)
      DO 277 L=1,NUMDZ
      READ(NI,*)I,J,K,DZ(I,J,K)
      N1READ=N1READ+1
```

```
 277  WRITE(NO,32)I,J,K,DZ(I,J,K)
      IF(IDCODE.NE.1) GO TO 8570
      WRITE(NO,48)
      DO 857 K=1,KK
      WRITE(NO,38)K
      DO 858 J=1,JJ
 858  WRITE(NO,72)(DZ(I,J,K),I=1,II)
857   CONTINUE
8570  CONTINUE
C
C*****ESTABLISH NODE MID-POINT ELEVATION.
C
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      READ(NI,*)KEL
      N1READ=N1READ+1
      IF(KEL.EQ.1)GO TO 920
      READ(NI,*)ELEV
      N1READ=N1READ+1
      DO 910 J=1,JJ
      DO 910 I=1,II
 910  VAREL(I,J)=ELEV
 920  IF(KEL.NE.1)GO TO 930
      DO 922 J=1,JJ
      READ(NI,*)(VAREL(I,J),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
 922  CONTINUE
 930  CONTINUE
      DO 923 I=1,II
      DO 923 J=1,JJ
 923  SUM(I,J)=0.
      DO 926 K=1,KK
      DO 926 J=1,JJ
      DO 926 I=1,II
      DEL=SUM(I,J)+DZ(I,J,K)*0.5
      EL(I,J,K)=VAREL(I,J)+DEL
 926  SUM(I,J)=DZ(I,J,K)+SUM(I,J)
      WRITE(NO,390)
      DO 600 K=1,KK
      WRITE(NO,38)K
      DO 600 J=1,JJ
      WRITE(NO,72)(EL(I,J,K),I=1,II)
600   CONTINUE
69    FORMAT(40A2)
56    FORMAT(//)
70    FORMAT(T24,82('*'),/,T24,('*'),T105,('*'),/,
     & T24,('*'),40A2,T105,('*'),/,T24,('*'),T105,
     & ('*'),/,T24,82('*'),//)
72    FORMAT(1X,20F6.0)
29    FORMAT(T15,'GRID BLOCK LENGTH (DX) IS INITIALLY',
     &' SET AT',F10.4,' FOR ALL NODES'//)
31    FORMAT(//T15,'********GRID BLOCK LENGTH (DX) NODE MODIFICATIONS',
     &'**********',//T15,'   I   J   K        NEW DX VALUE')
32    FORMAT(15X,3I5,5X,F14.4)
33    FORMAT(T15,'GRID BLOCK WIDTH  (DY) IS INITIALLY',
     &' SET AT',F10.4,' FOR ALL NODES'//)
34    FORMAT(//T15,'********GRID BLOCK WIDTH  (DY) NODE MODIFICATIONS',
     &'**********',//T15,'   I   J   K        NEW DY VALUE')
36    FORMAT(T15,'GRID BLOCK DEPTH  (DZ) IS INITIALLY',
     &' SET AT',F10.4,' FOR ALL NODES'//)
37    FORMAT(//T15,'********GRID BLOCK DEPTH  (DZ) NODE MODIFICATIONS',
     &'**********',//T15,'   I   J   K        NEW DZ VALUE')
38    FORMAT(/1X,'K =',I2/)
```

```
390   FORMAT(//T15,'********** NODE MIDPOINT ELEVATIONS **********'/)
43    FORMAT(//T15,'********GRID BLOCK LENGTH (DX) DISTRIBUTION********'
     &/)
47    FORMAT(//T15,'********GRID BLOCK WIDTH  (DY) DISTRIBUTION********'
     &/)
48    FORMAT(//T15,'********GRID BLOCK DEPTH  (DZ) DISTRIBUTION********'
     &/)
 511  FORMAT(T15,'GRID SIZE (DX) IN COLUMN',I5,' IS INITIALLY SET AT'
     &,F8.2,' FOR ALL NODES',/)
 512  FORMAT(T15,'GRID SIZE (DY) IN ROW   ',I5,' IS INITIALLY SET AT'
     &,F8.2,' FOR ALL NODES',/)
 513  FORMAT(T15,'GRID SIZE (DZ) IN LAYER ',I5,' IS INITIALLY SET AT'
     &,F8.2,' FOR ALL NODES',/)
      RETURN
      END
      SUBROUTINE PARM1
C
C=================================================================PARM1
C
C     READ POROSITY AND PERMEABILITY ARRAYS.
C
C     When KKX = -1, a single Kx is read for all grid blocks
C        KKX =  0, a constant Kx is read for each of KK layers
C        KKX =  1, a seperate Kx is read for each II x JJ x KK grid block
C        KKX =  2, a constant Kx is read for each II x KK grid block
C     The same rule is applied to KKY and KKZ
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL KX,KY,KZ,KXC,KYC,KZC
      CHARACTER*2 TITLE(80)
      COMMON /IO/ NI,NO
      COMMON /NUMBER/ II,JJ,KK
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
      COMMON /PERM/ KX(NX,NY,NZ),KY(NX,NY,NZ),KZ(NX,NY,NZ)
      COMMON /COUNT/ N1READ,N2READ
      DIMENSION RPHL(NZ),RKXL(NZ),RKYL(NZ),RKZL(NZ)
      DIMENSION XKX(NX),YKX(NX),ZKX(NX)
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
C
C*****READ INPUT CODES FOR PHI,KX,KY,KZ
C
      READ(NI,*)KPH,KKX,KKY,KKZ
      N1READ=N1READ+1
C
C*****ESTABLISH POROSITY (PHI) DISTRIBUTION
C
      PV=0.0
      IF(KPH.GE.0)GO TO 135
      READ(NI,*)PHIC
      N1READ=N1READ+1
      DO 140 K=1,KK
      DO 140 J=1,JJ
      DO 140 I=1,II
140   VP(I,J,K)=PHIC
      WRITE(NO,56)
      WRITE(NO,26)PHIC
      GO TO 165
 135  IF(KPH.GT.0)GO TO 145
      READ(NI,*)(RPHL(K),K=1,KK)
      N1READ=N1READ+1+INT(KK/10)
```

```
      IF(MOD(KK,10).EQ.0)N1READ=N1READ-1
      DO 550 K=1,KK
      DO 550 J=1,JJ
      DO 550 I=1,II
 550  VP(I,J,K)=RPHL(K)
      DO 560 K=1,KK
 560  WRITE(NO,510)K,RPHL(K)
      GO TO 165
145   WRITE(NO,39)
      DO 160 K=1,KK
      WRITE(NO,38)K
      DO 155 J=1,JJ
      READ(NI,*)(VP(I,J,K),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
 155  WRITE(NO,73)(VP(I,J,K),I=1,II)
160   CONTINUE
165   DO 170 K=1,KK
      DO 170 J=1,JJ
      DO 170 I=1,II
      PV=PV+VP(I,J,K)*DX(I,J,K)*DY(I,J,K)*DZ(I,J,K)
170   POR(I,J,K)=VP(I,J,K)
      WRITE(NO,56)
C
C*****ESTABLISH PERMEABILITY (KX) DISTRIBUTION
C
      IF(KKX.GE.0)GO TO 180
C *** A single constant Kx is read for all grid blocks
      READ(NI,*)KXC
      N1READ=N1READ+1
      DO 175 K=1,KK
      DO 175 J=1,JJ
      DO 175 I=1,II
175   KX(I,J,K)=KXC
      WRITE(NO,56)
      WRITE(NO,29)KXC
      GO TO 195
C *** a constant value Kx is read for each of the KK layers
 180  IF(KKX.GT.0)GO TO 185
      READ(NI,*)(RKXL(K),K=1,KK)
      N1READ=N1READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N1READ=N1READ-1
      DO 187 K=1,KK
      DO 187 J=1,JJ
      DO 187 I=1,II
 187  KX(I,J,K)=RKXL(K)
      DO 182 K=1,KK
 182  WRITE(NO,511)K,RKXL(K)
      GO TO 195
C *** a sperate Kx value is read for each (II x JJ x KK) grid block
185   IF(KKX.GT.1)GO TO 193
      WRITE(NO,43)
      DO 192 K=1,KK
      WRITE(NO,38)K
      DO 190 J=1,JJ
      READ(NI,*)(KX(I,J,K),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
 190  WRITE(NO,72)(KX(I,J,K),I=1,II)
192   CONTINUE
      GO TO 195
C *** a Kx value is read for each (II) column and each (KK) layer : (II x KK)
193   WRITE(NO,43)
      DO 194 K=1,KK
```

```
      WRITE(NO,38)K
      READ(NI,*)(XKX(I),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
      DO 196 J=1,JJ
      DO 197 I=1,II
 197  KX(I,J,K)=XKX(I)
 196  WRITE(NO,72)(KX(I,J,K),I=1,II)
194   CONTINUE
195   CONTINUE
      WRITE(NO,56)
C
C*****ESTABLISH PERMEABILITY (KY) DISTRIBUTION
C
      IF(KKY.GE.0)GO TO 200
      READ(NI,*)KYC
      N1READ=N1READ+1
      DO 202 K=1,KK
      DO 202 J=1,JJ
      DO 202 I=1,II
202   KY(I,J,K)=KYC
      WRITE(NO,56)
      WRITE(NO,33)KYC
      GO TO 220
 200  IF(KKY.GT.0)GO TO 207
      READ(NI,*)(RKYL(K),K=1,KK)
      N1READ=N1READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N1READ=N1READ-1
      DO 205 K=1,KK
      DO 205 J=1,JJ
      DO 205 I=1,II
 205  KY(I,J,K)=RKYL(K)
      DO 210 K=1,KK
 210  WRITE(NO,512)K,RKYL(K)
      GO TO 220
 207  IF(KKY.GT.1)GO TO 216
      WRITE(NO,47)
      DO 212 K=1,KK
      WRITE(NO,38)K
      DO 215 J=1,JJ
      READ(NI,*)(KY(I,J,K),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
 215  WRITE(NO,72)(KY(I,J,K),I=1,II)
212   CONTINUE
      GO TO 220
C *** a Ky value is read for each (II) column and each (KK) layer : (II x KK)
216   WRITE(NO,47)
      DO 217 K=1,KK
      WRITE(NO,38)K
      READ(NI,*)(YKX(I),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
      DO 218 J=1,JJ
      DO 219 I=1,II
 219  KY(I,J,K)=YKX(I)
 218  WRITE(NO,72)(KY(I,J,K),I=1,II)
217   CONTINUE
220   CONTINUE
      WRITE(NO,56)
C
C*****ESTABLISH PERMEABILITY (KZ) DISTRIBUTION
C
      IF(KKZ.GE.0)GO TO 225
```

```
      READ(NI,*)KZC
      N1READ=N1READ+1
      DO 230 K=1,KK
      DO 230 J=1,JJ
      DO 230 I=1,II
230   KZ(I,J,K)=KZC
      WRITE(NO,56)
      WRITE(NO,36)KZC
      GO TO 245
 225  IF(KKZ.GT.0)GO TO 232
      READ(NI,*)(RKZL(K),K=1,KK)
      N1READ=N1READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N1READ=N1READ-1
      DO 235 K=1,KK
      DO 235 J=1,JJ
      DO 235 I=1,II
 235  KZ(I,J,K)=RKZL(K)
      DO 237 K=1,KK
 237  WRITE(NO,513)K,RKZL(K)
      GO TO 245
 232  IF(KKZ.GT.1)GO TO 243
      WRITE(NO,48)
      DO 240 K=1,KK
      WRITE(NO,38)K
      DO 242 J=1,JJ
      READ(NI,*)(KZ(I,J,K),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
 242  WRITE(NO,72)(KZ(I,J,K),I=1,II)
240   CONTINUE
      GO TO 245
C *** a Kz value is read for each (II) column and each (KK) layer : (II x KK)
243   WRITE(NO,48)
      DO 244 K=1,KK
      WRITE(NO,38)K
      READ(NI,*)(ZKX(I),I=1,II)
      N1READ=N1READ+1+INT(II/10)
      IF(MOD(II,10).EQ.0)N1READ=N1READ-1
      DO 246 J=1,JJ
      DO 247 I=1,II
 247  KZ(I,J,K)=ZKX(I)
 246  WRITE(NO,72)(KZ(I,J,K),I=1,II)
244   CONTINUE
245   CONTINUE
      WRITE(NO,56)
C
C**********POROSITY AND PERMEABILITY MODIFICATIONS
C
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      READ(NI,*) NUMP,NUMKX,NUMKY,NUMKZ,IPCODE
      N1READ=N1READ+1
      IF(NUMP.EQ.0) GO TO 8510
      WRITE(NO,27)
      DO 274 L=1,NUMP
      READ(NI,*)I,J,K,VP(I,J,K)
      N1READ=N1READ+1
 274  WRITE(NO,32)I,J,K,VP(I,J,K)
      IF(IPCODE.NE.1) GO TO 8510
      WRITE(NO,39)
      DO 851 K=1,KK
      WRITE(NO,38)K
      DO 852 J=1,JJ
 852  WRITE(NO,73)(VP(I,J,K),I=1,II)
```

```
 851  CONTINUE
8510  CONTINUE
      IF(NUMKX.EQ.0) GO TO 8530
      WRITE(NO,31)
      DO 275 L=1,NUMKX
      READ(NI,*)I,J,K,KX(I,J,K)
      N1READ=N1READ+1
 275  WRITE(NO,32)I,J,K,KX(I,J,K)
      IF(IPCODE.NE.1)GO TO 8530
      WRITE(NO,43)
      DO 853 K=1,KK
      WRITE(NO,38)K
      DO 854 J=1,JJ
 854  WRITE(NO,72)(KX(I,J,K),I=1,II)
853   CONTINUE
8530  CONTINUE
      IF(NUMKY.EQ.0) GO TO 8550
      WRITE(NO,34)
      DO 276 L=1,NUMKY
      READ(NI,*)I,J,K,KY(I,J,K)
      N1READ=N1READ+1
 276  WRITE(NO,32)I,J,K,KY(I,J,K)
      IF(IPCODE.NE.1) GO TO 8550
      WRITE(NO,47)
      DO 855 K=1,KK
      WRITE(NO,38)K
      DO 856 J=1,JJ
 856  WRITE(NO,72)(KY(I,J,K),I=1,II)
855   CONTINUE
8550  CONTINUE
      IF(NUMKZ.EQ.0) GO TO 8570
      WRITE(NO,37)
      DO 277 L=1,NUMKZ
      READ(NI,*)I,J,K,KZ(I,J,K)
      N1READ=N1READ+1
 277  WRITE(NO,32)I,J,K,KZ(I,J,K)
      IF(IPCODE.NE.1) GO TO 8570
      WRITE(NO,48)
      DO 857 K=1,KK
      WRITE(NO,38)K
      DO 858 J=1,JJ
 858  WRITE(NO,72)(KZ(I,J,K),I=1,II)
857   CONTINUE
8570  CONTINUE
C
69    FORMAT(40A2)
56    FORMAT(//)
72    FORMAT(1X,20F6.2)
73    FORMAT(1X,20F6.4)
26    FORMAT(T15,'POROSITY (PHI) IS INITIALLY SET AT',F8.4,' FOR ALL',
     &' NODES'//)
27    FORMAT(//T15,'**********POROSITY NODE MODIFICATIONS**********',
     &//T15,'   I   J   K       NEW PHI VALUE')
29    FORMAT(T15,'PERMEABILITY (KX) IS INITIALLY',
     &' SET AT',F10.4,' FOR ALL NODES'//)
31    FORMAT(//T15,'**********PERMEABILITY (KX) NODE MODIFICATIONS',
     &'**********',//T15,'   I   J   K       NEW KX VALUE')
32    FORMAT(15X,3I5,5X,F14.4)
33    FORMAT(T15,'PERMEABILITY (KY) IS INITIALLY',
     &' SET AT',F10.4,' FOR ALL NODES'//)
34    FORMAT(//T15,'**********PERMEABILITY (KY) NODE MODIFICATIONS',
     &'**********',//T15,'   I   J   K       NEW KY VALUE')
36    FORMAT(T15,'PERMEABILITY (KZ) IS INITIALLY',
     &' SET AT',F10.4,' FOR ALL NODES'//)
```

```
37      FORMAT(//T15,'**********PERMEABILITY (KZ) NODE MODIFICATIONS',
       &'**********',//T15,'   I   J   K        NEW KZ VALUE')
38      FORMAT(/1X,'K =',I2/)
39      FORMAT(//T15,'**********POROSITY DISTRIBUTION FOLLOWS**********'/)
390     FORMAT(//T15,'********** NODE MIDPOINT ELEVATIONS **********'/)
43      FORMAT(//T15,'**********PERMEABILITY (KX) DISTRIBUTION**********'
       &/)
445     FORMAT(13F10.2)
47      FORMAT(//T15,'**********PERMEABILITY (KY) DISTRIBUTION**********'
       &/)
48      FORMAT(//T15,'**********PERMEABILITY (KZ) DISTRIBUTION**********'
       &/)
510     FORMAT(//T15,'POROSITY IN LAYER',I5,' IS INITIALLY SET AT',F8.5,
       &' FOR ALL NODES',/)
511     FORMAT(T15,'PERMEABILITY (KX) IN LAYER',I5,' IS INITIALLY SET AT'
       &,F8.2,' FOR ALL NODES',/)
512     FORMAT(T15,'PERMEABILITY (KY) IN LAYER',I5,' IS INITIALLY SET AT'
       &,F8.2,' FOR ALL NODES',/)
513     FORMAT(T15,'PERMEABILITY (KZ) IN LAYER',I5,' IS INITIALLY SET AT'
       &,F8.2,' FOR ALL NODES',/)
        RETURN
        END
        SUBROUTINE TRAN1
C
C=================================================================TRAN1
C
C       COMPUTE GEOMETRIC PART OF TRANSMISSIBILITIES.
C
C=================================================================
C
        INCLUDE 'PARAGEL.FOR'
        CHARACTER*2 TITLE(80)
         COMMON /IO/ NI,NO
        COMMON /NUMBER/ II,JJ,KK
        COMMON /SARRAY/ PN(NX,NY,NZ),
       & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
       & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
       & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
       & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
        COMMON /PERM/ KX(NX,NY,NZ),KY(NX,NY,NZ),KZ(NX,NY,NZ)
        COMMON /TRAN/ TX(NX+1,NY,NZ),TY(NX,NY+1,NZ),TZ(NX,NY,NZ+1)
        COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
        COMMON /CODE/ KSM1,KSN1,KCO1,NN,FACT1,FACT2,TMAX,KSOL,MITER,
       & OMEGA,TOL,TOL1,KSN,KSM,KCO,KTR,KCOFF,DSMAX,DPMAX,WORMAX,
       & GORMAX,PAMIN,PAMAX
        COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
       & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
        COMMON /SWTCH/ NGRSW,NTRSW,NRESTART,NGEL
        COMMON /COUNT/ N1READ,N2READ
        COMMON /TIMESTEP/ NTS
C
        REAL KX,KY,KZ
        DO 30 K=1,KK
        DO 30 J=1,JJ
        DO 30 I=1,II
        FACX=1.0
        FACY=1.0
        FACZ=1.0
        IF(I.GT.1.AND.I.LT.II)
       & FACX=4.*DX(I,J,K)/(2.*DX(I,J,K)+DX(I+1,J,K)+DX(I-1,J,K))
        IF(J.GT.1.AND.J.LT.JJ)
       & FACY=4.*DY(I,J,K)/(2.*DY(I,J,K)+DY(I,J+1,K)+DY(I,J-1,K))
        IF(K.GT.1.AND.K.LT.KK)
       & FACZ=4.*DZ(I,J,K)/(2.*DZ(I,J,K)+DZ(I,J,K+1)+DZ(I,J,K-1))
```

```
C
      A1(I,J,K)=FACX*KX(I,J,K)*DY(I,J,K)*DZ(I,J,K)
      A2(I,J,K)=FACY*KY(I,J,K)*DX(I,J,K)*DZ(I,J,K)
      A3(I,J,K)=FACZ*KZ(I,J,K)*DX(I,J,K)*DY(I,J,K)
C-----------------------------------------------------------------------
C **** Reduce Permeability Caused by Adsorption (RF is Resistance Factor)
      IF(RF(I,J,K).GT.1.)THEN
      A1(I,J,K)=A1(I,J,K)/RF(I,J,K)
      A2(I,J,K)=A2(I,J,K)/RF(I,J,K)
      A3(I,J,K)=A3(I,J,K)/RF(I,J,K)
      ENDIF
C-----------------------------------------------------------------------
 30   CONTINUE
      IF(II.EQ.1)GO TO 501
      DO 50 K=1,KK
      DO 50 J=1,JJ
      DO 50 I=2,II
      TX(I,J,K)=.012656*A1(I-1,J,K)*A1(I,J,K)/(DX(I-1,J,K)*A1(I,J,K)
     &+DX(I,J,K)*A1(I-1,J,K))
 50   CONTINUE
 501  CONTINUE
      IF(JJ.EQ.1)GO TO 551
      DO 55 K=1,KK
      DO 55 J=2,JJ
      DO 55 I=1,II
      TY(I,J,K)=.012656*A2(I,J-1,K)*A2(I,J,K)/(DY(I,J-1,K)*A2(I,J,K)
     &+DY(I,J,K)*A2(I,J-1,K))
 55   CONTINUE
 551  CONTINUE
      IF(KK.EQ.1)GO TO 600
      DO 60 K=2,KK
      DO 60 J=1,JJ
      DO 60 I=1,II
      TZ(I,J,K)=.012656*A3(I,J,K-1)*A3(I,J,K)/(DZ(I,J,K-1)*A3(I,J,K)
     &+DZ(I,J,K)*A3(I,J,K-1))
 60   CONTINUE
600   CONTINUE
C
      IF(NTS.GT.1.)RETURN
C
C****** TRANSMISSIBILITY MODIFICATIONS
C
      READ(NI,69) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      READ(NI,*) NUMTX,NUMTY,NUMTZ,ITCODE
      N1READ=N1READ+1
      IF(NUMTX.EQ.0) GO TO 100
      WRITE(NO,31)
      DO 275 L=1,NUMTX
      READ(NI,*)I,J,K,TX(I,J,K)
      N1READ=N1READ+1
 275  WRITE(NO,32)I,J,K,TX(I,J,K)
 100  IF(ITCODE.NE.1)GO TO 8530
      WRITE(NO,44)
      DO 853 K=1,KK
      WRITE(NO,38)K
      DO 854 J=1,JJ
 854  WRITE(NO,72)(TX(I,J,K),I=1,II)
 853  CONTINUE
8530  CONTINUE
      IF(NUMTY.EQ.0) GO TO 110
      WRITE(NO,34)
      DO 276 L=1,NUMTY
      READ(NI,*)I,J,K,TY(I,J,K)
```

```
      N1READ=N1READ+1
 276  WRITE(NO,32)I,J,K,TY(I,J,K)
 110  IF(ITCODE.NE.1) GO TO 8550
      WRITE(NO,47)
      DO 855 K=1,KK
      WRITE(NO,38)K
      DO 856 J=1,JJ
 856  WRITE(NO,72)(TY(I,J,K),I=1,II)
 855  CONTINUE
8550  CONTINUE
      IF(NUMTZ.EQ.0) GO TO 120
      WRITE(NO,37)
      DO 277 L=1,NUMTZ
      READ(NI,*)I,J,K,TZ(I,J,K)
      N1READ=N1READ+1
 277  WRITE(NO,32)I,J,K,TZ(I,J,K)
 120  IF(ITCODE.NE.1) GO TO 8570
      WRITE(NO,48)
      DO 857 K=1,KK
      WRITE(NO,38)K
      DO 858 J=1,JJ
 858  WRITE(NO,72)(TZ(I,J,K),I=1,II)
 857  CONTINUE
8570  CONTINUE
C
      IF(KTR.EQ.0)RETURN
C
      WRITE(NO,43)
      DO 42 K=1,KK
      DO 42 J=1,JJ
      DO 42 I=1,II
      WRITE(NO,41)I,J,K,A1(I,J,K),A2(I,J,K),A3(I,J,K),
     &TX(I,J,K),TY(I,J,K),TZ(I,J,K)
42    CONTINUE
      RETURN
C
 69   FORMAT(40A2)
 31   FORMAT(//T15,'**********TRANSMISSIBILITY (TX) NODE MODIFICATIONS',
     & '**********',//T15,'   I   J   K        NEW TX VALUE')
 32   FORMAT(15X,3I5,5X,F14.4)
 34   FORMAT(//T15,'**********TRANSMISSIBILITY (TY) NODE MODIFICATIONS',
     & '**********',//T15,'   I   J   K        NEW TY VALUE')
 37   FORMAT(//T15,'**********TRANSMISSIBILITY (TZ) NODE MODIFICATIONS',
     & '**********',//T15,'   I   J   K        NEW TZ VALUE')
 38   FORMAT(/1X,'K =',I2/)
 41   FORMAT(1X,3I5,6F15.3)
 43   FORMAT(//1X,'   I   J   K       A1          A2     ',
     & '    A3          TX          TY          TZ'/)
 44   FORMAT(//T15,'**********TRANSMISSIBILITY (TX) DISTRIBUTION'
     & ,'**********'/)
 47   FORMAT(//T15,'**********TRANSMISSIBILITY (TY) DISTRIBUTION'
     & ,'**********'/)
 48   FORMAT(//T15,'**********TRANSMISSIBILITY (TZ) DISTRIBUTION'
     & ,'**********'/)
 72   FORMAT(1X,20F6.1)
C
      END
      SUBROUTINE TABLE
C
C=================================================================TABLE
C
C     READ PVT AND RELATIVE PERMEABLITY DATA.
C
C=================================================================
```

```
C
      INCLUDE 'PARAGEL.FOR'
      CHARACTER*2 TITLE(80)
      REAL KROT,KRWT,KRGT,MUOT,MUWT,MUGT,KX,KY,KZ
      COMMON /IO/ NI,NO
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
      COMMON /COUNT/ N1READ,N2READ
C
      WRITE(NO,111)
C
C**** RELATIVE PERMEABILITY & CAPILLARY PRESSURE TABLE
C
      READ(NI,1) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      WRITE(NO,11) (TITLE(IH),IH=1,40)
      DO 5 I=1, NTE
      READ(NI,*) SAT(I),KROT(I),KRWT(I),KRGT(I),PCOWT(I),PCGOT(I)
      N1READ=N1READ+1
      WRITE(NO,21)SAT(I),KROT(I),KRWT(I),KRGT(I),PCOWT(I),PCGOT(I)
      IF(SAT(I).GE.1.0999) GO TO 10
5     CONTINUE
C
C**** BUBBLE POINT & MAXIMUM PRESSURES
C
10    MSAT=I
      READ(NI,1) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      WRITE(NO,11)(TITLE(IH),IH=1,40)
      READ(NI,*) PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS
      N1READ=N1READ+1
      WRITE(NO,31)PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS
C
C**** OIL PVT TABLE
C
      READ(NI,1) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      WRITE(NO,11) (TITLE(IH),IH=1,40)
      DO 15 I=1, NTE
      READ(NI,*) POT(I),MUOT(I),BOT(I),RSOT(I)
      N1READ=N1READ+1
      WRITE(NO,23)POT(I),MUOT(I),BOT(I),RSOT(I)
      RSOT(I)=0.17809*RSOT(I)
      IF(POT(I).GE.PMAXT)GO TO 20
15    CONTINUE
C
C**** WATER PVT TABLE
C
20    MPOT=I
      READ(NI,1) (TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      WRITE(NO,11) (TITLE(IH),IH=1,40)
      DO 25 I=1,NTE
      READ(NI,*) PWT(I),MUWT(I),BWT(I),RSWT(I)
      N1READ=N1READ+1
      WRITE(NO,23) PWT(I),MUWT(I),BWT(I),RSWT(I)
      RSWT(I)=0.17809*RSWT(I)
      IF(PWT(I).GE.PMAXT)GO TO 30
25    CONTINUE
C
```

```
C**** GAS PVT & ROCK DATA TABLE
C
30      MPWT=I
        READ(NI,1) (TITLE(IH),IH=1,40)
        N1READ=N1READ+1
        WRITE(NO,11) (TITLE(IH),IH=1,40)
        DO 35 I=1,999
        READ(NI,*) PGT(I),MUGT(I),BGT(I),CRT(I)
        N1READ=N1READ+1
        WRITE(NO,24) PGT(I),MUGT(I),BGT(I),CRT(I)
        IF(PGT(I).GE.PMAXT) GO TO 40
35      CONTINUE
C
40      MPGT=I
        CONTINUE
C
C**** OIL, WATER, & GAS DENSITIES AT STOCK TANK CONDITIONS
C
        READ(NI,1) (TITLE(IH),IH=1,40)
        N1READ=N1READ+1
        WRITE(NO,11) (TITLE(IH),IH=1,40)
        READ(NI,*)RHOSCO,RHOSCW,RHOSCG,RHOROCK
        N1READ=N1READ+1
        WRITE(NO,4)RHOSCO,RHOSCW,RHOSCG,RHOROCK
C
C**** CALCULATE SLOPES DBO/DP, DRSO/DP, DBW/DP, DRSW/DP, DBG/DP
C
        WRITE(NO,222)
        WRITE(NO,223)
        DO 100 I=2,MPOT
        DIV=1.0/(POT(I)-POT(I-1))
        BOPT(I)=(BOT(I)-BOT(I-1))*DIV
        RSOPT(I)=(RSOT(I)-RSOT(I-1))*DIV
100     WRITE(NO,224)POT(I),BOT(I),BOPT(I),RSOT (I),RSOPT(I)
        WRITE(NO,333)
        DO 200 I=2,MPWT
        DIV=1.0/(PWT(I)-PWT(I-1))
        BWPT(I)=(BWT(I)-BWT(I-1))*DIV
        RSWPT(I)=(RSWT(I)-RSWT(I-1))*DIV
200     WRITE(NO,224)PWT(I),BWT(I),BWPT(I),RSWT(I),RSWPT(I)
C
        WRITE(NO,444)
        DO 300 I=2,MPGT
        BGPT(I)=(BGT(I)-BGT(I-1))/(PGT(I)-PGT(I-1))
300     WRITE(NO,445)PGT(I),BGT(I),BGPT(I)
C
C**** NOTE: SLOPE AT POINT "I" IS BASED ON POINTS "I" AND "I-1"
C
1       FORMAT(40A2)
4       FORMAT(2X,8F10.4)
11      FORMAT(//,1X,40A2/)
21      FORMAT(1X,4F10.4,2F10.2)
23      FORMAT(3X,F10.1,1X,F8.4,2X,F8.4,2X,F8.2)
24      FORMAT(3X,F10.1,1X,F8.4,E10.3,E10.3)
31      FORMAT(F10.2,E10.3,1X,E10.3,2F10.2,I5)
111     FORMAT(//T15,'***** EMPIRICAL DATA TABLE *****'//)
222     FORMAT(//T15,'***** SLOPES FOR COMPRESSIBILITY CALCULATIONS',
       &' ****')
223     FORMAT(//T16,'P',T25,'BO',T33,'DBO/DP',T47,'RSO',
       &T55,'DRSO/DP'/)
224     FORMAT(  T13,F7.1,F8.4,3X,E11.4,F8.1,2X,E11.4)
333     FORMAT(//T16,'P',T25,'BW',T33,'DBW/DP',T47,'RSW',
       &T55,'DRSW/DP'/)
444     FORMAT(//15X,'P',12X,'BG',12X,'DBGDP')
```

```
445     FORMAT(10X,F9.1,1X,2E15.4)
C
        RETURN
        END
        SUBROUTINE UINIT1
C
C=================================================================UINIT1
C
C       READ INITIAL PRESSURE AND SATURATION ARRAY.
C
C=================================================================
C
        INCLUDE 'PARAGEL.FOR'
        REAL MBEO,MBEW,MBEG,KX,KY,KZ,KROT,KRWT,KRGT,MUOT,MUWT,MUGT
        CHARACTER*2 TITLE(80)
        COMMON /IO/ NI,NO
        COMMON /NUMBER/ II,JJ,KK
        COMMON /MBE/ MBEO,MBEW,MBEG
        COMMON /PSCNTL/ KPI,KSI
        COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
      & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
        COMMON /SARRAY/ PN(NX,NY,NZ),
      & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
      & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
      & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
      & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
        COMMON /ELEV/ EL(NX,NY,NZ)
        COMMON /PRTP/ P(NX,NY,NZ)
        COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
      & SWINI(NX,NY,NZ)
        COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
      & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
      & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
      & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
        COMMON /COUNT/ N1READ,N2READ
        DIMENSION PPK(NZ),SOK(NZ),SWK(NZ)
C
        MBEO=0.0
        MBEW=0.0
        MBEG=0.0
C
C***  INITIALIZE BUBBLE POINT PRESSURE ARRAY
C
        DO 8 I=1,II
        DO 8 J=1,JJ
        DO 8 K=1,KK
 8      PBOT(I,J,K) = PBO
C
        READ(5,69) (TITLE(IH),IH=1,40)
        N2READ=N2READ+1
        READ(NI,*) KPI,KSI
        N2READ=N2READ+1
        IF(KPI.NE.0) GO TO 5601
        READ(5,*) PI,PGOC,WOC,GOC
        N2READ=N2READ+1
        DO 200 K=1,KK
        DO 200 J=1,JJ
        DO 200 I=1,II
        IF(EL(I,J,K).LT.GOC) GO TO 175
        IF(EL(I,J,K).GT.WOC)GO TO 150
        BPT=PBOT(I,J,K)
        CALL INTPVT(BPT,BSLOPE,POT,BOT,MPOT,PI,BBO)
        CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PI,RSO)
        RHOO=(RHOSCO+RSO*RHOSCG)/BBO
```

```
      PN(I,J,K)=PI+RHOO*(EL(I,J,K)-WOC)/144.
      GO TO 200
 150  CALL INTERP(PWT,BWT,MPWT,PI,BBW)
      CALL INTERP(PWT,RSWT,MPWT,PI,RSW)
      RHOW=(RHOSCW+RSW*RHOSCG)/BBW
      PN(I,J,K)=PI+RHOW*(EL(I,J,K)-WOC)/144.
      GO TO 200
 175  CALL INTERP(PGT,BGT,MPGT,PGOC,BBG)
      RHOG=RHOSCG/BBG
      PN(I,J,K)=PGOC+RHOG*(EL(I,J,K)-GOC)/144.
 200  CONTINUE
      GO TO 3015
 5601 IF(KPI.NE.1) GO TO 5610
      DO 3010 K=1,KK
      DO 3005 J=1,JJ
 3005 READ(5,*)(PN(I,J,K),I=1,II)
      N2READ=N2READ+1+INT(II/10)
3010  CONTINUE
      GO TO 3015
C*** PRESSURE AT EACH LAYER TO BE READ ....
5610  READ(NI,*)(PPK(K),K=1,KK)
      N2READ=N2READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N2READ=N2READ-1
      DO 3080 K=1,KK
      DO 3080 J=1,JJ
      DO 3080 I=1,II
3080  PN(I,J,K)=PPK(K)
C
3015  CONTINUE
C**** INITIALIZE N+1 PRESSURE ARRAY.
      DO 3012 I=1,II
      DO 3012 J=1,JJ
      DO 3012 K=1,KK
 3012 P(I,J,K)=PN(I,J,K)
      IF(KSI.NE.0)GO TO 5600
      READ(5,*) SOI,SWI,SGI
      N2READ=N2READ+1
      DO 30 K=1,KK
      DO 30 J=1,JJ
      DO 30 I=1,II
      SON(I,J,K)=SOI
      SWN(I,J,K)=SWI
      SWINI(I,J,K)=SWI
      SGI=1.0-SOI-SWI
      SGN(I,J,K)=SGI
      SO(I,J,K)=SOI
      SW(I,J,K)=SWI
      SG(I,J,K)=SGI
      IF(SG(I,J,K).LT.0.0)  SG(I,J,K)=0.0
  30  CONTINUE
      RETURN
 5600 IF(KSI.NE.1) GO TO 5620
      DO 3011 K=1,KK
      DO 3006 J=1,JJ
      READ(5,*)(SO(I,J,K),I=1,II)
 3006 N2READ=N2READ+1+INT(II/10)
 3011 CONTINUE
      DO 3020 K=1,KK
      DO 3007 J=1,JJ
      READ(5,*)(SW(I,J,K),I=1,II)
      SWINI(I,J,K)=SW(I,J,K)
 3007 N2READ=N2READ+1+INT(II/10)
 3020 CONTINUE
      DO 3030 K=1,KK
```

```
      DO 3030 J=1,JJ
      DO 3030 I=1,II
      SG(I,J,K)=1.0-SO(I,J,K)-SW(I,J,K)
      IF(SG(I,J,K).LT.0.0) SG(I,J,K)=0.0
      SON(I,J,K)=SO(I,J,K)
      SWN(I,J,K)=SW(I,J,K)
      SGN(I,J,K)=SG(I,J,K)
 3030 CONTINUE
69    FORMAT(40A2)
      RETURN
C*** OIL/WATER SATURATIONS AT EACH LAYER TO BE READ ....
5620  READ(NI,*)(SOK(K),K=1,KK)
      N2READ=N2READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N2READ=N2READ-1
      READ(NI,*)(SWK(K),K=1,KK)
      N2READ=N2READ+1+INT(KK/10)
      IF(MOD(KK,10).EQ.0)N2READ=N2READ-1
      DO 3090 K=1,KK
      DO 3090 J=1,JJ
      DO 3090 I=1,II
      SO(I,J,K)=SOK(K)
      SW(I,J,K)=SWK(K)
      SWINI(I,J,K)=SWK(K)
      SG(I,J,K)=1.-SOK(K)-SWK(K)
      SON(I,J,K)=SOK(K)
      SWN(I,J,K)=SWK(K)
      SGN(I,J,K)=1.-SOK(K)-SWK(K)
3090  CONTINUE
      RETURN
      END
C
      SUBROUTINE CODES
C
C=================================================================CODES
C
C     READ SOLUTION METHOD, SOLUTION PARAMETERS, AND DIAGNOSTIC CONTROLS
C
C=================================================================
C
      CHARACTER*2 TITLE(80)
      COMMON /IO/ NI,NO
      COMMON /CODE/ KSM1,KSN1,KCO1,NN,
     &FACT1,FACT2,TMAX,KSOL,MITER,OMEGA,TOL,TOL1,
     & KSN,KSM,KCO,KTR,KCOFF,DSMAX,DPMAX,
     &WORMAX,GORMAX,PAMIN,PAMAX
      READ(NI,69) (TITLE(IH),IH=1,40)
      READ(NI,*) KSN1,KSM1,KCO1,KTR,KCOFF
C     EVERY KSM1 TH STEP SOLUTION MATRIX WILL BE WRITTEN
C     EVERY KSN1 TH STEP LSOR DATA WILL BE WRITTEN
C     EVERY KCO1 TH STEP COMPRESSIBILITIES & VOLUME FACTORS WILL BE WRITTEN
C     IF KTR IS NONZERO TRANSMISSIBILITIES WILL BE WRITTEN
      READ(NI,69) (TITLE(IH),I=1,40)
      READ(NI,*)NN,FACT1,FACT2,TMAX,WORMAX,GORMAX,PAMIN,PAMAX
      WRITE(NO,59) NN,FACT1,FACT2,TMAX,WORMAX,GORMAX,PAMIN,PAMAX
C     NN--MAXIMUM NUMBER OF TIME-STEPS
C     FACT1--FACTOR FOR INCREASING TIME-STEP SIZE
C     FACT2--FACTOR FOR DECREASING TIME-STEP SIZE
C     TMAX--MAXIMUM SIMULATION TIME
      READ(NI,69) (TITLE(IH),I=1,40)
      READ(NI,*)KSOL,MITER,OMEGA,TOL,TOL1,DSMAX,DPMAX
      IF(KSOL.EQ.1) WRITE(NO,73)
      IF(KSOL.EQ.2) WRITE(NO,75) MITER,OMEGA,TOL,TOL1
      IF(KSOL.EQ.3) WRITE(NO,77)
      WRITE(NO,79) DSMAX,DPMAX
```

```
      KSN=KSN1
      KSM=KSM1
      KCO=KCO1
      RETURN
C
 73   FORMAT(//T15,'SOLUTION METHOD IS BAND')
 75   FORMAT(//T15,'SOLUTION METHOD IS LSOR:',
     &/T20,'MAXIMUM NUMBER OF ITERATIONS     (MITR) = ',5X,I5,
     &/T20,'INITIAL ACCELERATION PARAMETER   (OMEGA) = ',F10.4,
     &/T20,'MAXIMUM PRESSURE RESIDUAL        (TOL) = ',F10.4,
     &/T20,'PARAMETER FOR CHANGING OMEGA     (TOL1) = ',F10.4)
 77   FORMAT(//T15,'SOLUTION METHOD IS D4.')
 79   FORMAT(/T15,'AUTOMATIC TIME STEP CRITERIA:',
     &/T20,'MAXIMUM ALLOWED SATURATION CHANGE (DSMAX) = ',F10.4,
     &/T20,'MAXIMUM ALLOWED PRESSURE CHANGE   (DPMAX) = ',F10.4/)
59    FORMAT(//T15,'MAXIMUM NUMBER OF TIME-STEPS =',I10/
     &T15,'FACTOR FOR INCREASING DELT =',F10.6,3X,
     &'WHEN DSMAX AND DPMAX NOT EXCEEDED.'/,
     &T15,'FACTOR FOR DECREASING DELT =',F10.6,3X,
     &'WHEN DSMAX OR DPMAX IS EXCEEDED.'/,
     &T15,'MAXIMUM SIMULATION TIME =',F11.6/,
     &T15,'MAXIMUM RESERVOIR WOR/TIME-STEP =',F8.0,' STB/STB'/
     &T15,'MAXIMUM RESERVOIR GOR/TIME-STEP =',F8.0,' SCF/STB'/
     &T15,'MINIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP =',F8.0/
     &T15,'MAXIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP =',F8.0//)
69    FORMAT(40A2)
311   FORMAT (I5,F10.0,I5)
      END
C
C
C
      SUBROUTINE NODES(NVQN)
C
C=================================================================NODES
C
C     READ TIME STEP AND VERTICAL WELL INFORMATION.
C
C    NVQN = # OF VERTICAL WELLS
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL KX,KY,KZ,RATIOK,RAT1,K1,K2
      CHARACTER*2 TITLE(80)
      CHARACTER*5 WELLID
      COMMON /IDEN/ WELLID(NW)
      COMMON /IO/ NI,NO
      COMMON /NUMBER/ II,JJ,KK
      COMMON /SWTCH/ NGRSW,NTRSW,NRESTART,NGEL
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
      COMMON /PERM/ KX(NX,NY,NZ),KY(NX,NY,NZ),KZ(NX,NY,NZ)
      COMMON /SRATE/ PID(NW,NL),PWF(NW,NL),PWFC(NW,NL),KIP(NW),
     & GMO(NW,NL),GMW(NW,NL),GMG(NW,NL),LAYER(NW),QVO(NW),
     & QVW(NW),QVG(NW),QVT(NW),CUMO(NW,NL),CUMW(NW,NL),CUMG(NW,NL)
      COMMON /IQN/ IQN1(NW),IQN2(NW),IQN3(NW)
      COMMON /IQH/ IQH1(NW,NL),IQH2(NW,NL),IQH3(NW,NL),COND(NW)
      COMMON /R1XYZ/ R11X,R21X,R31X,R41X,R11Y,R21Y,R31Y,R41Y,
     & R11Z,R21Z,R31Z,R41Z
      COMMON /T1XYZ/ T1X,T2X,T3X,T4X,T1Y,T2Y,T3Y,T4Y,T1Z,T2Z,T3Z,T4Z
      COMMON /DXYZ/ DX0,DXP,DXM,XW,DY0,DYP,DYM,YW,DZ0,DZP,DZM,ZW
      COMMON /RXYZ/ RX,RY,RZ,AX,AY,AZ,I,J,K
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
```

```
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
C
C**** ESTABLISH RATE-SPECIFIED & PRESSURE-SPECIFIED WELLS
C
      READ(5,69) (TITLE(IH),IH=1,40)
      READ(5,*)NVQN
      IF(NVQN.EQ.0)GO TO 2011
      WRITE(NO,67)
      WRITE(NO,68)
      DO 2000 J=1,NVQN
C**  INPUT RATE SIGNS BY CONVENTION:
C**  INJECTORS ARE NEGATIVE; PRODUCERS ARE POSITIVE.
      READ(NI,1) WELLID(J)
      READ(5,*) IQN1(J),IQN2(J),IQN3(J),LAYER(J),KIP(J),
     & QVO(J),QVW(J),QVG(J),QVT(J)
      IQ3=IQN3(J)
      LAY=IQ3+(LAYER(J)-1)
      SUMPID=0.
      DO 1900 K=IQ3,LAY
      READ(5,*) RWV,SV,PWF(J,K)
      I1=IQN1(J)
      I2=IQN2(J)
      RATIOK=SQRT(KY(I1,I2,K)/KX(I1,I2,K))
      RAT1=RATIOK**0.5
      RADIUSO=0.28*(RATIOK*DX(I1,I2,K)**2+1/RATIOK*DY(I1,I2,K)
     &  **2)**0.5/(RAT1+1/RAT1)
      PID(J,K)=0.00708*SQRT(KX(I1,I2,K)*KY(I1,I2,K))*DZ(I1,I2,K)
     & /(ALOG(RADIUSO/RWV)+SV)
      WRITE(NO,70)IQN1(J),IQN2(J),K,QVO(J),QVW(J),QVG(J),
     & QVT(J),PWF(J,K),PID(J,K)
      MAPWI(IQN1(J),IQN2(J),K)=J
      SUMPID=SUMPID+PID(J,K)
 1900 CONTINUE
      IF(NGEL.NE.1.OR.QVW(J).GE.0.) GO TO 2000
      READ(NI,*)(CQI(J,KC),KC=1,5)
 2000 CONTINUE
C
      WRITE(NO,33)
      DO 2999 J=1,NVQN
      IQ3=IQN3(J)
      LAY=IQ3+(LAYER(J)-1)
      DO 2999 K=IQ3,LAY
      IF(KIP(J).EQ.1) WRITE(NO,2995) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.2) WRITE(NO,2996) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.3) WRITE(NO,2997) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.-1) WRITE(NO,3005) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.-2) WRITE(NO,3006) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.-3) WRITE(NO,3007) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.-11) WRITE(NO,3015) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.-12) WRITE(NO,3016) IQN1(J),IQN2(J),K
      IF(KIP(J).EQ.-13) WRITE(NO,3017) IQN1(J),IQN2(J),K
 2999 CONTINUE
C
 2011 CONTINUE
 1    FORMAT(A5)
 69   FORMAT(40A2)
 722  FORMAT(3F10.4)
 721  FORMAT(4F10.0)
 67   FORMAT(//T15,'RESERVOIR CONTAINS THE FOLLOWING RATE NODES
```

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     & (FOR VERTICAL WELLS)'/)
68     FORMAT(T2,'  NODE  ',3X,' OIL(STBD)',
     &3X,'WATER(STBD)',3X,'GAS(MCFD)',3X,'TOTAL(RBD)',3X,'BHFP(PSIA)'
     &,3X,'PID')
70     FORMAT(1X,3I3,3X,F11.2,4F13.2,F10.6)
71     FORMAT(9X,3I4,F10.2,3F5.1,10X,F10.2,3F5.1,F12.3)
33     FORMAT(/)
 2995  FORMAT(T15,'BLOCK ',3I3,
     & ' CONTAINS A RATE SPECIFIED PRODUCING WELL')
 2996  FORMAT(T15,'BLOCK ',3I3,
     & ' CONTAINS A RATE SPECIFIED WATER INJECTION WELL')
 2997  FORMAT(T15,'BLOCK ',3I3,
     & ' CONTAINS A RATE SPECIFIED GAS INJECTION WELL')
 3005  FORMAT(T15,'BLOCK ',3I3,' CONTAINS AN ',
     & 'EXPLICIT PRESSURE SPECIFIED PRODUCING WELL')
 3006  FORMAT(T15,'BLOCK ',3I3, ' CONTAINS AN ',
     & 'EXPLICIT PRESSURE SPECIFIED WATER INJECTION WELL')
 3007  FORMAT(T15,'BLOCK ',3I3,' CONTAINS AN ',
     & 'EXPLICIT PRESSURE SPECIFIED GAS INJECTION WELL')
 3015  FORMAT(T15,'BLOCK ',3I3,' CONTAINS AN ',
     & 'IMPLICIT PRESSURE SPECIFIED PRODUCING WELL')
 3016  FORMAT(T15,'BLOCK ',3I3,' CONTAINS AN ',
     & 'IMPLICIT PRESSURE SPECIFIED WATER INJECTION WELL')
 3017  FORMAT(T15,'BLOCK ',3I3,' CONTAINS AN ',
     & 'IMPLICIT PRESSURE SPECIFIED GAS INJECTION WELL')
       RETURN
       END
C
       SUBROUTINE QRATE(IWELTYPE,NVQN)
C
C=================================================================QRATE
C
C  COMPUTE WELL RATES WHEN RATE OR EXPLICIT PRESSURE CONSTRAIN
C  ACTIVATED;
C
C     (IWELTYPE = 1 FOR VERTICAL WELL OPTION      )
C
C=================================================================
C
       INCLUDE 'PARAGEL.FOR'
       REAL KROT,KRWT,KRGT,MUWT,MUOT,MUGT,KX,KY,KZ
     & ,MUO,MUW,MUG,KRO,KRW,KRG
       COMMON /ELEV/ EL(NX,NY,NZ)
       COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
       COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
       COMMON /PRTP/ P(NX,NY,NZ)
       COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
     & SWINI(NX,NY,NZ)
       COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
       COMMON /SRATE/ PID(NW,NL),PWF(NW,NL),PWFC(NW,NL),KIP(NW),
     & GMO(NW,NL),GMW(NW,NL),GMG(NW,NL),LAYER(NW),QVO(NW),
     & QVW(NW),QVG(NW),QVT(NW),CUMO(NW,NL),CUMW(NW,NL),CUMG(NW,NL)
       COMMON /RATE/ QO(NX.NY,NZ),QW(NX,NY,NZ),QG(NX,NY,NZ)
       COMMON /RATEQ/ QO0(NX,NY,NZ),QW0(NX,NY,NZ),QG0(NX,NY,NZ),ITFLAG
       COMMON /IQN/ IQN1(NW),IQN2(NW),IQN3(NW)
       COMMON /IQH/ IQH1(NW,NL),IQH2(NW,NL),IQH3(NW,NL),COND(NW)
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      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /SWTCH/ NGRSW,NTRSW,NRESTART,NGEL
      COMMON /PRTCNT/ IWLCNG,ICHANG,IWLREP,ISUMRY,
     & IPMAP,ISOMAP,ISWMAP,ISGMAP,IPBMAP,ICHMAP,CHEMAP
      DIMENSION GRAVITY(NW,NL),GMTB(NW,NL)
C
      IF(IWELTYPE.EQ.1)THEN
      N1=1
      N2=NVQN
      ELSE
      N1=NVQN+1
      N2=NVQN
      ENDIF
C
      DO 105 J=N1,N2
      IF(IWELTYPE.EQ.1)THEN
      IQ1=IQN1(J)
      IQ2=IQN2(J)
      IQ3=IQN3(J)
      LAY=IQ3+(LAYER(J)-1)
      ELSE
      IQ3=1
      LAY=LAYER(J)
      ENDIF

      SUM1=0.
      SUM2=0.
      ITERQ=0
      IF(KIP(J).EQ.1)RHO=RHOSCO
      IF(KIP(J).EQ.2)RHO=RHOSCW
      IF(KIP(J).EQ.3)RHO=RHOSCG
 1172 ITERQ=ITERQ+1

      DO 1170 KKK=IQ3,LAY
      K=KKK
      IF(IWELTYPE.EQ.2)THEN
      IQ1=IQH1(J,KKK)
      IQ2=IQH2(J,KKK)
      K=IQH3(J,KKK)
      ENDIF

      IF(ITERQ.NE.1) GO TO 1210

C ******************** ITEQR = 1 ********************************
      PWFC(J,KKK)=-1.0
      PP=P(IQ1,IQ2,K)
      BPT=PBOT(IQ1,IQ2,K)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,PP,MUO)
      CALL INTERP(PWT,MUWT,MPWT,PP,MUW)
      IF(NGEL.EQ.1)MUW=MUW+DTMUW(IQ1,IQ2,K)
      CALL INTERP(PGT,MUGT,MPGT,PP,MUG)
      SSO=SO(IQ1,IQ2,K)
      SSW=SW(IQ1,IQ2,K)
      SSG=SG(IQ1,IQ2,K)
      CALL INTERP(SAT,KRWT,MSAT,SSW,KRW)
      CALL INTERP(SAT,KROT,MSAT,SSO,KRO)
      CALL INTERP(SAT,KRGT,MSAT,SSG,KRG)
      GMW(J,KKK)=KRW/MUW
      GMO(J,KKK)=KRO/MUO
      GMG(J,KKK)=KRG/MUG
      CALL INTPVT(BPT,BSLOPE,POT,BOT,MPOT,PP,BBO)
```

```
      CALL INTERP(PWT,BWT,MPWT,PP,BBW)
      CALL INTERP(PGT,BGT,MPGT,PP,BBG)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PP,RSO)
      CALL INTERP(PWT,RSWT,MPWT,PP,RSW)

      IF(KIP(J).LT.0) GO TO 1300

C ************************************************** RATE CONSTRAINT
      IF(KKK.EQ.IQ3) EL0=EL(IQ1,IQ2,K)
      PWFC(J,KKK)=0.0
      IF(PID(J,KKK)/RF(IQ1,IQ2,K).LE.0.0001) GO TO 1205
      FAC=PID(J,KKK)/RF(IQ1,IQ2,K)
      IF(KIP(J).EQ.1.AND.QVT(J).EQ.0.)THEN
      GMTB(J,KKK)=GMO(J,KKK)/BBO
      ELSE
      GMTB(J,KKK)=GMO(J,KKK)/BBO+GMW(J,KKK)/BBW+GMG(J,KKK)/BBG
      ENDIF
      GRAVITY(J,KKK)=RHO*(EL(IQ1,IQ2,K)-EL0)/144.
      SUM1=SUM1+GMTB(J,KKK)*FAC
      SUM2=SUM2+GMTB(J,KKK)*FAC*(PP-GRAVITY(J,KKK))
 1205 GO TO 1170

C ******************** ITEQR = 2 **********************************
 1210 CONTINUE
      IF(KIP(J).EQ.2) PWFC(J,IQ3)=(SUM2-QVW(J))/SUM1
      IF(KIP(J).EQ.3) PWFC(J,IQ3)=(SUM2-QVG(J)*1000./5.615)/SUM1
      IF(KIP(J).EQ.1.AND.QVT(J).NE.0.) PWFC(J,IQ3)=(SUM2-QVT(J))/SUM1
      IF(KIP(J).EQ.1.AND.QVT(J).EQ.0.) PWFC(J,IQ3)=(SUM2-QVO(J))/SUM1
      PWFC(J,KKK)=PWFC(J,IQ3)+GRAVITY(J,KKK)
      FACTOR=5.615*PID(J,KKK)*(P(IQ1,IQ2,K)-PWFC(J,KKK))/RF(IQ1,IQ2,K)

      PPN=PN(IQ1,IQ2,K)
      BPT=PBOT(IQ1,IQ2,K)
      CALL INTPVT(BPT,BSLOPE,POT,BOT,MPOT,PPN,BBO)
      CALL INTERP(PWT,BWT,MPWT,PPN,BBW)
      CALL INTERP(PGT,BGT,MPGT,PPN,BBG)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PPN,RSO)
      CALL INTERP(PWT,RSWT,MPWT,PPN,RSW)
      IF(KIP(J).EQ.2)THEN
      QW(IQ1,IQ2,K)=GMTB(J,KKK)*FACTOR/BBW
      IF(ITFLAG.GT.0.AND.IWLCNG.EQ.0)
     & QW(IQ1,IQ2,K)=(QW(IQ1,IQ2,K)+QW0(IQ1,IQ2,K))/2
      ENDIF
      IF(KIP(J).EQ.3)THEN
      QG(IQ1,IQ2,K)=GMTB(J,KKK)*FACTOR/BBG
      IF(ITFLAG.GT.0.AND.IWLCNG.EQ.0)
     & QG(IQ1,IQ2,K)=(QG(IQ1,IQ2,K)+QG0(IQ1,IQ2,K))/2
      ENDIF
      IF(KIP(J).EQ.1) THEN
      QO(IQ1,IQ2,K)=GMO(J,KKK)/BBO*FACTOR
      QW(IQ1,IQ2,K)=GMW(J,KKK)/BBW*FACTOR
      QG(IQ1,IQ2,K)=GMG(J,KKK)/BBG*FACTOR
     & +RSO*QO(IQ1,IQ2,K)+RSW*QW(IQ1,IQ2,K)
      IF(ITFLAG.GT.0.AND.IWLCNG.EQ.0)THEN
      QO(IQ1,IQ2,K)=(QO(IQ1,IQ2,K)+QO0(IQ1,IQ2,K))/2
      QW(IQ1,IQ2,K)=(QW(IQ1,IQ2,K)+QW0(IQ1,IQ2,K))/2
      QG(IQ1,IQ2,K)=(QG(IQ1,IQ2,K)+QG0(IQ1,IQ2,K))/2
      ENDIF
      ENDIF
      GO TO 1170

C ******************************************** EXPLICIT PRESSURE CONSTRAINT
 1300 CONTINUE
C**** OIL PRODUCER
```

```
      IF(KIP(J).NE.-1) GO TO 1310
      QO(IQ1,IQ2,K)=PID(J,KKK)*5.615*GMO(J,KKK)/RF(IQ1,IQ2,K)
     & *(PPN-PWF(J,KKK))/BBO
      IF(PPN.LE.PWF(J,KKK)) QO(IQ1,IQ2,K)=0.0
      QW(IQ1,IQ2,K)=QO(IQ1,IQ2,K)*GMW(J,KKK)*BBO
     & /(BBW*GMO(J,KKK))
      QG(IQ1,IQ2,K)=QO(IQ1,IQ2,K)*(GMG(J,KKK)*BBO
     & /(BBG*GMO(J,KKK))+RSO)+RSW*QW(IQ1,IQ2,K)
      GO TO 1340
C**** WATER INJECTOR
 1310 IF(KIP(J).NE.-2) GO TO 1320
      QW(IQ1,IQ2,K)=PID(J,KKK)/RF(IQ1,IQ2,K)*5.615*(GMO(J,KKK)
     & +GMW(J,KKK)+GMG(J,KKK))*(PPN-PWF(J,KKK))/BBW
      IF(PPN.GE.PWF(J,KKK)) QW(IQ1,IQ2,K)=0.0
      GO TO 1340
C**** GAS INJECTOR
 1320 IF(KIP(J).NE.-3) GO TO 1340
      QG(IQ1,IQ2,K)=PID(J,KKK)/RF(IQ1,IQ2,K)*5.615*(GMO(J,KKK)
     & +GMW(J,KKK)+GMG(J,KKK))*(PPN-PWF(J,KKK))/BBG
      IF(PPN.GE.PWF(J,KKK)) QG(IQ1,IQ2,K)=0.0
 1340 CONTINUE

 1170 CONTINUE
      IF(ITERQ.EQ.1.AND.KIP(J).GT.0) GO TO 1172
  105 CONTINUE
      RETURN
      END


      SUBROUTINE SOLMAT(DIV1,D288,D144,N)
C
C=================================================================SOLMAT
C
C  COMPUTE PRESSURE EQUATION COEFFICENTS.
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL KROT,KRWT,KRGT,MUOT,MUWT,MUGT,KX,KY,KZ
      REAL MUO4,MUW4,MUG4,MUO5,MUW5,MUG5,MUO6,MUW6,MUG6
     &,KRO1,KRW1,KRG1,KRO2,KRW2,KRG2,KRO3,KRW3,KRG3
     &,MUO1,MUW1,MUG1,MUO2,MUW2,MUG2,MUO3,MUW3,MUG3
     &,KRO4,KRW4,KRG4,KRO5,KRW5,KRG5,KRO6,KRW6,KRG6
     &,MO1,MW1,MG1,MO2,MW2,MG2,MO3,MW3,MG3
     &,MO4,MW4,MG4,MO5,MW5,MG5,MO6,MW6,MG6
     &,MUO,MUW,MUG
C
      COMMON /IO/ NI,NO
      COMMON /NUMBER/ II,JJ,KK
      COMMON /CODE/ KSM1,KSN1,KCO1,NN,FACT1,FACT2,TMAX,KSOL,MITER,
     & OMEGA,TOL,TOL1,KSN,KSM,KCO,KTR,KCOFF,DSMAX,DPMAX,WORMAX,
     & GORMAX,PAMIN,PAMAX
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /COEF/ AW(NX,NY,NZ),AE(NX,NY,NZ),AN(NX,NY,NZ),
     & AS(NX,NY,NZ),AB(NX,NY,NZ),AT(NX,NY,NZ),E(NX,NY,NZ),B(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
      COMMON /ELEV/ EL(NX,NY,NZ)
      COMMON /TRAN/ TX(NX+1,NY,NZ),TY(NX,NY+1,NZ),TZ(NX,NY,NZ+1)
      COMMON /PRTP/ P(NX,NY,NZ)
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      COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
     & SWINI(NX,NY,NZ)
      COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
      COMMON /VOLFAC/ BO(NX,NY,NZ),BW(NX,NY,NZ),BG(NX,NY,NZ)
      COMMON /RATE/ QO(NX,NY,NZ),QW(NX,NY,NZ),QG(NX,NY,NZ)
      COMMON /TERM1/ GOWT(NX,NY,NZ),GWWT(NX,NY,NZ),GGWT(NX,NY,NZ),
     & OW(NX+1,NY,NZ),OE(NX+1,NY,NZ),WW(NX+1,NY,NZ),WE(NX+1,NY,NZ),
     & OS(NX,NY+1,NZ),ON(NX,NY+1,NZ),WS(NX,NY+1,NZ),WN(NX,NY+1,NZ),
     & OT(NX,NY,NZ+1),OB(NX,NY,NZ+1),WT(NX,NY,NZ+1),WB(NX,NY,NZ+1)
      COMMON /TERM2/ QOWG(NX,NY,NZ)
      COMMON /COMPRS/ CT(NX,NY,NZ)
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /SWTCH/ NGRSW,NTRSW,NRESTART,NGEL
      DATA RSO1,RSO2,RSO3,RSO4,RSO5,RSO6/6*0.0/
      DATA RSW1,RSW2,RSW3,RSW4,RSW5,RSW6/6*0.0/
C
      DO 200 K=1,KK
      DO 200 J=1,JJ
      DO 200 I=1,II
C
      PP=P(I,J,K)
      BPT=PBOT(I,J,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PP,RSO)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,PP,MUO)
      CALL INTERP(PWT,RSWT,MPWT,PP,RSW)
      CALL INTERP(PWT,MUWT,MPWT,PP,MUW)
      IF(NGEL.EQ.1)MUW=MUW+DTMUW(I,J,K)
      CALL INTERP(PGT,MUGT,MPGT,PP,MUG)
      SSO=SO(I,J,K)
      SSW=SW(I,J,K)
      SSG=SG(I,J,K)
      CALL INTERP(SAT,PCOWT,MSAT,SSW,PCOW)
      CALL INTERP(SAT,PCGOT,MSAT,SSG,PCGO)
C
      RO=(RHOSCO + RSO*RHOSCG)/BO(I,J,K)
      RW=(RHOSCW + RSW*RHOSCG)/BW(I,J,K)
      RG=RHOSCG/BG(I,J,K)
C
      IF(I.EQ.1)GO TO 115
      P1=P(I-1,J,K)
      BPT=PBOT(I-1,J,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,P1,RSO1)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,P1,MUO1)
      CALL INTERP(PWT,RSWT,MPWT,P1,RSW1)
      CALL INTERP(PWT,MUWT,MPWT,P1,MUW1)
      IF(NGEL.EQ.1)MUW1=MUW1+DTMUW(I-1,J,K)
      CALL INTERP(PGT,MUGT,MPGT,P1,MUG1)
      SO1S=SO(I-1,J,K)
      SW1S=SW(I-1,J,K)
      SG1S=SG(I-1,J,K)
      CALL INTERP(SAT,PCOWT,MSAT,SW1S,PCOW1)
      CALL INTERP(SAT,PCGOT,MSAT,SG1S,PCGO1)
C
C
      RO1=(RHOSCO + RSO1*RHOSCG)/BO(I-1,J,K)
      RW1=(RHOSCW + RSW1*RHOSCG)/BW(I-1,J,K)
      RG1=RHOSCG/BG(I-1,J,K)
C
      FACT=-D288*(EL(I-1,J,K)-EL(I,J,K))
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      GOW1=(RO1+RO)*FACT
      GWW1=(RW1+RW)*FACT + PCOW-PCOW1
      GGW1=(RG1+RG)*FACT + PCGO1-PCGO
C
      P11=P1-PP
      HO1=P11+GOW1
      HW1=P11+GWW1
      HG1=P11+GGW1
C
      IF(HO1.GE.0.)CALL INTERP(SAT,KROT,MSAT,SO1S,KRO1)
      IF(HO1.LT.0.)CALL INTERP(SAT,KROT,MSAT,SSO,KRO1)
      IF(HW1.GE.0.)CALL INTERP(SAT,KRWT,MSAT,SW1S,KRW1)
      IF(HW1.LT.0.)CALL INTERP(SAT,KRWT,MSAT,SSW,KRW1)
      IF(HG1.GE.0.)CALL INTERP(SAT,KRGT,MSAT,SG1S,KRG1)
      IF(HG1.LT.0.)CALL INTERP(SAT,KRGT,MSAT,SSG,KRG1)
      MO1=4.0*KRO1/((BO(I-1,J,K)+BO(I,J,K)) * (MUO1+MUO))
      MW1=4.0*KRW1/((BW(I-1,J,K)+BW(I,J,K)) * (MUW1+MUW))
      MG1=4.0*KRG1/((BG(I-1,J,K)+BG(I,J,K)) * (MUG1+MUG))
C
115   AOW=TX(I,J,K)*MO1
      AWW=TX(I,J,K)*MW1
      AGW=TX(I,J,K)*MG1
C
      IF(I.EQ.II)GO TO 125
      P2=P(I+1,J,K)
      BPT=PBOT(I+1,J,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,P2,RSO2)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,P2,MUO2)
      CALL INTERP(PWT,RSWT,MPWT,P2,RSW2)
      CALL INTERP(PWT,MUWT,MPWT,P2,MUW2)
      IF(NGEL.EQ.1)MUW2=MUW2+DTMUW(I+1,J,K)
      CALL INTERP(PGT,MUGT,MPGT,P2,MUG2)
      SO2=SO(I+1,J,K)
      SW2=SW(I+1,J,K)
      SG2=SG(I+1,J,K)
      CALL INTERP(SAT,PCOWT,MSAT,SW2,PCOW2)
      CALL INTERP(SAT,PCGOT,MSAT,SG2,PCGO2)
C
      RO2=(RHOSCO + RSO2*RHOSCG)/BO(I+1,J,K)
      RW2=(RHOSCW + RSW2*RHOSCG)/BW(I+1,J,K)
      RG2=RHOSCG/BG(I+1,J,K)
C
      FACT=-D288*(EL(I+1,J,K)-EL(I,J,K))
      GOW2=(RO2+RO)*FACT
      GWW2=(RW2+RW)*FACT + PCOW-PCOW2
      GGW2=(RG2+RG)*FACT + PCGO2-PCGO
C
      P22=P2-PP
      HO2=P22+GOW2
      HW2=P22+GWW2
      HG2=P22+GGW2
      IF(HO2.GE.0.)CALL INTERP(SAT,KROT,MSAT,SO2,KRO2)
      IF(HO2.LT.0.)CALL INTERP(SAT,KROT,MSAT,SSO,KRO2)
      IF(HW2.GE.0.)CALL INTERP(SAT,KRWT,MSAT,SW2,KRW2)
      IF(HW2.LT.0.)CALL INTERP(SAT,KRWT,MSAT,SSW,KRW2)
      IF(HG2.GE.0.)CALL INTERP(SAT,KRGT,MSAT,SG2,KRG2)
      IF(HG2.LT.0.)CALL INTERP(SAT,KRGT,MSAT,SSG,KRG2)
      MO2=4.0*KRO2/((BO(I+1,J,K)+BO(I,J,K)) * (MUO2+MUO))
      MW2=4.0*KRW2/((BW(I+1,J,K)+BW(I,J,K)) * (MUW2+MUW))
      MG2=4.0*KRG2/((BG(I+1,J,K)+BG(I,J,K)) * (MUG2+MUG))
C
125   AOE=TX(I+1,J,K)*MO2
      AWE=TX(I+1,J,K)*MW2
      AGE=TX(I+1,J,K)*MG2
```

```
C
C
      IF(J.EQ.1)GO TO 135
      P3=P(I,J-1,K)
      BPT=PBOT(I,J-1,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,P3,RSO3)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,P3,MUO3)
      CALL INTERP(PWT,RSWT,MPWT,P3,RSW3)
      CALL INTERP(PWT,MUWT,MPWT,P3,MUW3)
      IF(NGEL.EQ.1)MUW3=MUW3+DTMUW(I,J-1,K)
      CALL INTERP(PGT,MUGT,MPGT,P3,MUG3)
      SO3=SO(I,J-1,K)
      SW3=SW(I,J-1,K)
      SG3=SG(I,J-1,K)
      CALL INTERP(SAT,PCOWT,MSAT,SW3,PCOW3)
      CALL INTERP(SAT,PCGOT,MSAT,SG3,PCGO3)
C
      RO3=(RHOSCO + RSO3*RHOSCG)/BO(I,J-1,K)
      RW3=(RHOSCW + RSW3*RHOSCG)/BW(I,J-1,K)
      RG3=RHOSCG/BG(I,J-1,K)
C
      FACT=-D288*(EL(I,J-1,K)-EL(I,J,K))
      GOW3=(RO3+RO)*FACT
      GWW3=(RW3+RW)*FACT + PCOW-PCOW3
      GGW3=(RG3+RG)*FACT + PCGO3-PCGO
C
      P33=P3-PP
      HO3=P33+GOW3
      HW3=P33+GWW3
      HG3=P33+GGW3
      IF(HO3.GE.0.)CALL INTERP(SAT,KROT,MSAT,SO3,KRO3)
      IF(HO3.LT.0.)CALL INTERP(SAT,KROT,MSAT,SSO,KRO3)
      IF(HW3.GE.0.)CALL INTERP(SAT,KRWT,MSAT,SW3,KRW3)
      IF(HW3.LT.0.)CALL INTERP(SAT,KRWT,MSAT,SSW,KRW3)
      IF(HG3.GE.0.)CALL INTERP(SAT,KRGT,MSAT,SG3,KRG3)
      IF(HG3.LT.0.)CALL INTERP(SAT,KRGT,MSAT,SSG,KRG3)
      MO3=4.0*KRO3/((BO(I,J-1,K)+BO(I,J,K)) * (MUO3+MUO))
      MW3=4.0*KRW3/((BW(I,J-1,K)+BW(I,J,K)) * (MUW3+MUW))
      MG3=4.0*KRG3/((BG(I,J-1,K)+BG(I,J,K)) * (MUG3+MUG))
C
135   AOS=TY(I,J,K)*MO3
      AWS=TY(I,J,K)*MW3
      AGS=TY(I,J,K)*MG3
C
      IF(J.EQ.JJ)GO TO 140
      P4=P(I,J+1,K)
      BPT=PBOT(I,J+1,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,P4,RSO4)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,P4,MUO4)
      CALL INTERP(PWT,RSWT,MPWT,P4,RSW4)
      CALL INTERP(PWT,MUWT,MPWT,P4,MUW4)
      IF(NGEL.EQ.1)MUW4=MUW4+DTMUW(I,J+1,K)
      CALL INTERP(PGT,MUGT,MPGT,P4,MUG4)
      SO4=SO(I,J+1,K)
      SW4=SW(I,J+1,K)
      SG4=SG(I,J+1,K)
      CALL INTERP(SAT,PCOWT,MSAT,SW4,PCOW4)
      CALL INTERP(SAT,PCGOT,MSAT,SG4,PCGO4)
C
      RO4=(RHOSCO + RSO4*RHOSCG)/BO(I,J+1,K)
      RW4=(RHOSCW + RSW4*RHOSCG)/BW(I,J+1,K)
      RG4=RHOSCG/BG(I,J+1,K)
C
      FACT=-D288*(EL(I,J+1,K)-EL(I,J,K))
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```
      GOW4=(RO4+RO)*FACT
      GWW4=(RW4+RW)*FACT + PCOW-PCOW4
      GGW4=(RG4+RG)*FACT + PCGO4-PCGO
C
      P44=P4-PP
      HO4=P44+GOW4
      HW4=P44+GWW4
      HG4=P44+GGW4
      IF(HO4.GE.0.)CALL INTERP(SAT,KROT,MSAT,SO4,KRO4)
      IF(HO4.LT.0.)CALL INTERP(SAT,KROT,MSAT,SSO,KRO4)
      IF(HW4.GE.0.)CALL INTERP(SAT,KRWT,MSAT,SW4,KRW4)
      IF(HW4.LT.0.)CALL INTERP(SAT,KRWT,MSAT,SSW,KRW4)
      IF(HG4.GE.0.)CALL INTERP(SAT,KRGT,MSAT,SG4,KRG4)
      IF(HG4.LT.0.)CALL INTERP(SAT,KRGT,MSAT,SSG,KRG4)
      MO4=4.0*KRO4/((BO(I,J+1,K)+BO(I,J,K)) * (MUO4+MUO))
      MW4=4.0*KRW4/((BW(I,J+1,K)+BW(I,J,K)) * (MUW4+MUW))
      MG4=4.0*KRG4/((BG(I,J+1,K)+BG(I,J,K)) * (MUG4+MUG))
C
140   AON=TY(I,J+1,K)*MO4
      AWN=TY(I,J+1,K)*MW4
      AGN=TY(I,J+1,K)*MG4
C
C
      IF(K.EQ.1)GO TO 145
      P5=P(I,J,K-1)
      BPT=PBOT(I,J,K-1)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,P5,RSO5)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,P5,MUO5)
      CALL INTERP(PWT,RSWT,MPWT,P5,RSW5)
      CALL INTERP(PWT,MUWT,MPWT,P5,MUW5)
      IF(NGEL.EQ.1)MUW5=MUW5+DTMUW(I,J,K-1)
      CALL INTERP(PGT,MUGT,MPGT,P5,MUG5)
      SO5=SO(I,J,K-1)
      SW5=SW(l,J,K-1)
      SG5=SG(I,J,K-1)
      CALL INTERP(SAT,PCOWT,MSAT,SW5,PCOW5)
      CALL INTERP(SAT,PCGOT,MSAT,SG5,PCGO5)
      RO5=(RHOSCO + RSO5*RHOSCG)/BO(I,J,K-1)
      RW5=(RHOSCW + RSW5*RHOSCG)/BW(I,J,K-1)
      RG5=RHOSCG/BG(I,J,K-1)
C
      FACT=-D288*(EL(I,J,K-1)-EL(I,J,K))
      GOW5=(RO5+RO)*FACT
      GWW5=(RW5+RW)*FACT + PCOW-PCOW5
      GGW5=(RG5+RG)*FACT + PCGO5-PCGO
      P55=P5-PP
      HO5=P55+GOW5
      HW5=P55+GWW5
      HG5=P55+GGW5
      IF(HO5.GE.0.)CALL INTERP(SAT,KROT,MSAT,SO5,KRO5)
      IF(HO5.LT.0.)CALL INTERP(SAT,KROT,MSAT,SSO,KRO5)
      IF(HW5.GE.0.)CALL INTERP(SAT,KRWT,MSAT,SW5,KRW5)
      IF(HW5.LT.0.)CALL INTERP(SAT,KRWT,MSAT,SSW,KRW5)
      IF(HG5.GE.0.)CALL INTERP(SAT,KRGT,MSAT,SG5,KRG5)
      IF(HG5.LT.0.)CALL INTERP(SAT,KRGT,MSAT,SSG,KRG5)
      MO5=4.0*KRO5/((BO(I,J,K-1)+BO(I,J,K)) * (MUO5+MUO))
      MW5=4.0*KRW5/((BW(I,J,K-1)+BW(I,J,K)) * (MUW5+MUW))
      MG5=4.0*KRG5/((BG(I,J,K-1)+BG(I,J,K)) * (MUG5+MUG))
C
C
145   AOT=TZ(I,J,K)*MO5
      AWT=TZ(I,J,K)*MW5
      AGT=TZ(I,J,K)*MG5
C
```

```
      IF(K.EQ.KK)GO TO 150
      P6=P(I,J,K+1)
      BPT=PBOT(I,J,K+1)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,P6,RSO6)
      CALL INTPVT(BPT,VSLOPE,POT,MUOT,MPOT,P6,MUO6)
      CALL INTERP(PWT,RSWT,MPWT,P6,RSW6)
      CALL INTERP(PWT,MUWT,MPWT,P6,MUW6)
      IF(NGEL.EQ.1)MUW6=MUW6+DTMUW(I,J,K+1)
      CALL INTERP(PGT,MUGT,MPGT,P6,MUG6)
      SO6=SO(I,J,K+1)
      SW6=SW(I,J,K+1)
      SG6=SG(I,J,K+1)
C
      CALL INTERP(SAT,PCOWT,MSAT,SW6,PCOW6)
      CALL INTERP(SAT,PCGOT,MSAT,SG6,PCGO6)
      RO6=(RHOSCO + RSO6*RHOSCG)/BO(I,J,K+1)
      RW6=(RHOSCW + RSW6*RHOSCG)/BW(I,J,K+1)
      RG6=RHOSCG/BG(I,J,K+1)
C
      FACT=-D288*(EL(I,J,K+1)-EL(I,J,K))
      GOW6=(RO6+RO)*FACT
      GWW6=(RW6+RW)*FACT + PCOW-PCOW6
      GGW6=(RG6+RG)*FACT + PCGO6-PCGO
C
      P66=P6-PP
      HO6=P66+GOW6
      HW6=P66+GWW6
      HG6=P66+GGW6
      IF(HO6.GE.0.)CALL INTERP(SAT,KROT,MSAT,SO6,KRO6)
      IF(HO6.LT.0.)CALL INTERP(SAT,KROT,MSAT,SSO,KRO6)
      IF(HW6.GE.0.)CALL INTERP(SAT,KRWT,MSAT,SW6,KRW6)
      IF(HW6.LT.0.)CALL INTERP(SAT,KRWT,MSAT,SSW,KRW6)
      IF(HG6.GE.0.)CALL INTERP(SAT,KRGT,MSAT,SG6,KRG6)
      IF(HG6.LT.0.)CALL INTERP(SAT,KRGT,MSAT,SSG,KRG6)
      MO6=4.0*KRO6/((BO(I,J,K+1)+BO(I,J,K)) * (MUO6+MUO))
      MW6=4.0*KRW6/((BW(I,J,K+1)+BW(I,J,K)) * (MUW6+MUW))
      MG6=4.0*KRG6/((BG(I,J,K+1)+BG(I,J,K)) * (MUG6+MUG))
C
150   AOB=TZ(I,J,K+1)*MO6
      AWB=TZ(I,J,K+1)*MW6
      AGB=TZ(I,J,K+1)*MG6
C
      RSO1A=0.5*(RSO1+RSO)
      RSO2A=0.5*(RSO2+RSO)
      RSO3A=0.5*(RSO3+RSO)
      RSO4A=0.5*(RSO4+RSO)
      RSO5A=0.5*(RSO5+RSO)
      RSO6A=0.5*(RSO6+RSO)
      RSW1A=0.5*(RSW1+RSW)
      RSW2A=0.5*(RSW2+RSW)
      RSW3A=0.5*(RSW3+RSW)
      RSW4A=0.5*(RSW4+RSW)
      RSW5A=0.5*(RSW5+RSW)
      RSW6A=0.5*(RSW6+RSW)
      AO1=AOW*GOW1
      AO2=AOE*GOW2
      AO3=AOS*GOW3
      AO4=AON*GOW4
      AO5=AOT*GOW5
      AO6=AOB*GOW6
      AW1=AWW*GWW1
      AW2=AWE*GWW2
      AW3=AWS*GWW3
      AW4=AWN*GWW4
```

```
      AW5=AWT*GWW5
      AW6=AWB*GWW6
C
      GOWT(I,J,K)= AO1 + AO2 + AO3 + AO4 + AO5 + AO6
      GWWT(I,J,K)= AW1 + AW2 + AW3 + AW4 + AW5 + AW6
      GGWT(I,J,K)=AGW*GGW1+AGE*GGW2+AGS*GGW3+AGN*GGW4+AGT*GGW5+AGB*GGW6
     &+RSO1A*AO1+RSO2A*AO2+RSO3A*AO3+RSO4A*AO4+RSO5A*AO5+RSO6A*AO6
     &+RSW1A*AW1+RSW2A*AW2+RSW3A*AW3+RSW4A*AW4+RSW5A*AW5+RSW6A*AW6
C
      QOWG(I,J,K)=(BO(I,J,K)-BG(I,J,K)*RSO)*(-GOWT(I,J,K)+QO(I,J,K)) +
     &        (BW(I,J,K)-BG(I,J,K)*RSW)*(-GWWT(I,J,K)+QW(I,J,K)) +
     &         BG(I,J,K)*(-GGWT(I,J,K)+QG(I,J,K))
C
      AW(I,J,K)=(BO(I,J,K) + 0.5*BG(I,J,K)*(RSO1-RSO)) * AOW +
     &       (BW(I,J,K) + 0.5*BG(I,J,K)*(RSW1-RSW)) * AWW +
     &       BG(I,J,K)*AGW
      AE(I,J,K)=(BO(I,J,K) + 0.5*BG(I,J,K)*(RSO2-RSO)) * AOE +
     &       (BW(I,J,K) + 0.5*BG(I,J,K)*(RSW2-RSW)) * AWE +
     &       BG(I,J,K)*AGE
      AS(I,J,K)=(BO(I,J,K) + 0.5*BG(I,J,K)*(RSO3-RSO)) * AOS +
     &       (BW(I,J,K) + 0.5*BG(I,J,K)*(RSW3-RSW)) * AWS +
     &       BG(I,J,K)*AGS
      AN(I,J,K)=(BO(I,J,K) + 0.5*BG(I,J,K)*(RSO4-RSO)) * AON +
     &       (BW(I,J,K) + 0.5*BG(I,J,K)*(RSW4-RSW)) * AWN +
     &       BG(I,J,K)*AGN
      AT(I,J,K)=(BO(I,J,K) + 0.5*BG(I,J,K)*(RSO5-RSO)) * AOT +
     &       (BW(I,J,K) + 0.5*BG(I,J,K)*(RSW5-RSW)) * AWT +
     &       BG(I,J,K)*AGT
      AB(I,J,K)=(BO(I,J,K) + 0.5*BG(I,J,K)*(RSO6-RSO)) * AOB +
     &       (BW(I,J,K) + 0.5*BG(I,J,K)*(RSW6-RSW)) * AWB +
     &       BG(I,J,K)*AGB
      OW(I,J,K)=AOW
      OE(I,J,K)=AOE
      OS(I,J,K)=AOS
      ON(I,J,K)=AON
      OT(I,J,K)=AOT
      OB(I,J,K)=AOB
      WW(I,J,K)=AWW
      WE(I,J,K)=AWE
      WS(I,J,K)=AWS
      WN(I,J,K)=AWN
      WT(I,J,K)=AWT
      WB(I,J,K)=AWB
      IF(KCOFF.EQ.0)GO TO 200
      WRITE(NO,33)
      WRITE(NO,2)I,J,K,MO1,MO2,MO3,MO4,MO5,MO6
      WRITE(NO,2)I,J,K,MW1,MW2,MW3,MW4,MW5,MW6
      WRITE(NO,2)I,J,K,MG1,MG2,MG3,MG4,MG5,MG6
      WRITE(NO,2)I,J,K,AOW,AOE,AOS,AON,AOT,AOB,BO(I,J,K),RSO
      WRITE(NO,2)I,J,K,AWW,AWE,AWS,AWN,AWT,AWB,BW(I,J,K),RSW
      WRITE(NO,2)I,J,K,AGW,AGE,AGS,AGN,AGT,AGB,BG(I,J,K)
      WRITE(NO,2)I,J,K,GOWT(I,J,K),QO(I,J,K),GWWT(I,J,K),QW(I,J,K),
     &         GGWT(I,J,K),QG(I,J,K),QOWG(I,J,K)
200   CONTINUE
C
C**** CALCULATE MAIN DIAGONAL AND RHS VECTOR
C
      DO 300 K=1,KK
      DO 300 J=1,JJ
      DO 300 I=1,II
C
      SUM(I,J,K)=AW(I,J,K)+AE(I,J,K)+AS(I,J,K)+AN(I,J,K)+
     &  AT(I,J,K)+AB(I,J,K)
      GAM(I,J,K)=VP(I,J,K)*CT(I,J,K)*DIV1
```

```
      E(I,J,K)=-SUM(I,J,K) - GAM(I,J,K)
      B(I,J,K)= QOWG(I,J,K) - GAM(I,J,K)*P(I,J,K)
300   CONTINUE
      IF(KSM1.EQ.0)RETURN
      IF(N.NE.1.AND.N.NE.NN.AND.N.NE.KSM)RETURN
      WRITE(NO,4)
      DO 404 K=1,KK
      DO 404 J=1,JJ
      DO 404 I=1,II
      WRITE(NO,2)I,J,K,AT(I,J,K),AS(I,J,K),AW(I,J,K),E(I,J,K),
     & AE(I,J,K)   ,AN(I,J,K),AB(I,J,K),B(I,J,K)
404   CONTINUE
4     FORMAT(//T3,'NODE     AT(I,J,K)    AS(I,J,K)    AW(I,J,K)',
     &'    E(I,J,K)    AE(I,J,K)    AN(I,J,K)    AB(I,J,K)',
     &'    B(I,J,K)'/)
2     FORMAT(1X,3I3,8E15.6)
33    FORMAT(//)
C
      RETURN
      END

      SUBROUTINE PRATEI(IWELTYPE,NVQN)
C
C=================================================================QRATE
C
C  COMPUTE WELL RATES WHEN RATE OR EXPLICIT PRESSURE CONSTRAIN
C  ACTIVATED;
C     PRATEI: REVISES PRESSURE EQUATION COEFFICENTS WHEN IMPLICIT
C          PRESSURE CONSTRAIN ACTIVATED;
C     PRATEO: COMPUTE RATES WHEN IMPLICIT PRESSURE CONSTRAIN
C          ACTIVATE.
C
C    (IWELTYPE = 1 FOR VERTICAL WELL)
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL KROT,KRWT,KRGT,MUWT,MUOT,MUGT
     & ,MUO,MUW,MUG,KRO,KRW,KRG
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /COEF/ AW(NX,NY,NZ),AE(NX,NY,NZ),AN(NX,NY,NZ),
     & AS(NX,NY,NZ),AB(NX,NY,NZ),AT(NX,NY,NZ),E(NX,NY,NZ),B(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
      COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
      COMMON /SRATE/ PID(NW,NL),PWF(NW,NL),PWFC(NW,NL),KIP(NW),
     & GMO(NW,NL),GMW(NW,NL),GMG(NW,NL),LAYER(NW),QVO(NW),
     & QVW(NW),QVG(NW),QVT(NW),CUMO(NW,NL),CUMW(NW,NL),CUMG(NW,NL)
      COMMON /IQN/ IQN1(NW),IQN2(NW),IQN3(NW)
      COMMON /IQH/ IQH1(NW,NL),IQH2(NW,NL),IQH3(NW,NL),COND(NW)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)


      IF(IWELTYPE.EQ.1)THEN
      N1=1
      N2=NVQN
      ELSE
```

```
      N1=NVQN+1
      N2=NVQN
      ENDIF
C
      DO 205 J=N1,N2
      IF(KIP(J).GE.-10) GO TO 205
      IF(IWELTYPE.EQ.1)THEN
      IQ1=IQN1(J)
      IQ2=IQN2(J)
      IQ3=IQN3(J)
      LAY=IQ3+(LAYER(J)-1)
      ELSE
      IQ3=1
      LAY=LAYER(J)
      ENDIF
      DO 203 KKK=IQ3,LAY
      K=KKK
      IF(IWELTYPE.EQ.2)THEN
      IQ1=IQH1(J,KKK)
      IQ2=IQH2(J,KKK)
      K=IQH3(J,KKK)
      ENDIF
      P56=PID(J,KKK)*5.615/RF(IQ1,IQ2,K)
      PPN=PN(IQ1,IQ2,K)
      BPT=PBOT(IQ1,IQ2,K)
      CALL INTPVT(BPT,BSLOPE,POT,BOT,MPOT,PPN,BBO)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PPN,RSO)
      CALL INTERP(PWT,BWT,MPWT,PPN,BBW)
      CALL INTERP(PGT,BGT,MPGT,PPN,BBG)
      CALL INTERP(PWT,RSWT,MPWT,PPN,RSW)
      CPIO=GMO(J,KKK)*P56*(BBO-BBG*RSO)/BBO
      CPIW=GMW(J,KKK)*P56*(BBW-BBG*RSW)/BBW
      CPIG=GMG(J,KKK)*P56
      CPI=CPIO+CPIW+CPIG
      B(IQ1,IQ2,K)=B(IQ1,IQ2,K)-CPI*PWF(J,KKK)
      E(IQ1,IQ2,K)=E(IQ1,IQ2,K)-CPI
 203  CONTINUE
 205  CONTINUE
      RETURN
      END
C
      SUBROUTINE PRATEO(IWELTYPE,NVQN)
C
C=================================================================QRATE
C
C  COMPUTE WELL RATES WHEN RATE OR EXPLICIT PRESSURE CONSTRAIN
C  ACTIVATED;
C     PRATEI: REVISES PRESSURE EQUATION COEFFICENTS WHEN IMPLICIT
C          PRESSURE CONSTRAIN ACTIVATED;
C     PRATEO: COMPUTE RATES WHEN IMPLICIT PRESSURE CONSTRAIN
C          ACTIVATE.
C
C     (IWELTYPE = 1 FOR VERTICAL WELL)
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL KROT,KRWT,KRGT,MUWT,MUOT,MUGT
     & ,MUO,MUW,MUG,KRO,KRW,KRG
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /COEF/ AW(NX,NY,NZ),AE(NX,NY,NZ),AN(NX,NY,NZ),
     & AS(NX,NY,NZ),AB(NX,NY,NZ),AT(NX,NY,NZ),E(NX,NY,NZ),B(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
```

```
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
      COMMON /PRTP/ P(NX,NY,NZ)
      COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
      COMMON /SRATE/ PID(NW,NL),PWF(NW,NL),PWFC(NW,NL),KIP(NW),
     & GMO(NW,NL),GMW(NW,NL),GMG(NW,NL),LAYER(NW),QVO(NW),
     & QVW(NW),QVG(NW),QVT(NW),CUMO(NW,NL),CUMW(NW,NL),CUMG(NW,NL)
      COMMON /VOLFAC/ BO(NX,NY,NZ),BW(NX,NY,NZ),BG(NX,NY,NZ)
      COMMON /RATE/ QO(NX,NY,NZ),QW(NX,NY,NZ),QG(NX,NY,NZ)
      COMMON /IQN/ IQN1(NW),IQN2(NW),IQN3(NW)
      COMMON /IQH/ IQH1(NW,NL),IQH2(NW,NL),IQH3(NW,NL),COND(NW)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)

C
      IF(IWELTYPE.EQ.1)THEN
      N1=1
      N2=NVQN
      ELSE
      N1=NVQN+1
      N2=NVQN
      ENDIF
C
      DO 2059 J=N1,N2
      IF(KIP(J).GE.-10) GO TO 2059
      IF(IWELTYPE.EQ.1)THEN
      IQ1=IQN1(J)
      IQ2=IQN2(J)
      IQ3=IQN3(J)
      LAY=IQ3+(LAYER(J)-1)
      ELSE
      IQ3=1
      LAY=LAYER(J)
      ENDIF
      DO 2057 KKK=IQ3,LAY
      K=KKK
      IF(IWELTYPE.EQ.2)THEN
      IQ1=IQH1(J,KKK)
      IQ2=IQH2(J,KKK)
      K=IQH3(J,KKK)
      ENDIF
      PP=P(IQ1,IQ2,K)
      PPN=PN(IQ1,IQ2,K)
      BPT=PBOT(IQ1,IQ2,K)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PPN,RSON)
      CALL INTPVT(BPT,RSLOPE,POT,RSOT,MPOT,PP,RSO)
      CALL INTERP(PWT,RSWT,MPWT,PPN,RSWN)
      CALL INTERP(PWT,RSWT,MPWT,PP,RSW)
      RSOAV=0.5*(RSO+RSON)
      RSWAV=0.5*(RSW+RSWN)
      FACTOR=PID(J,KKK)*5.615*(PP-PWF(J,KKK))/RF(IQ1,IQ2,K)
      IF(KIP(J).EQ.-13) GO TO 2053
      QW(IQ1,IQ2,K)=GMW(J,KKK)/BW(IQ1,IQ2,K)*FACTOR
      IF(KIP(J).EQ.-12)QW(IQ1,IQ2,K)=
     & (GMO(J,KKK)+GMW(J,KKK)+GMG(J,KKK))/BW(IQ1,IQ2,K)*FACTOR
      IF(KIP(J).EQ.-12) GO TO 2057
      QO(IQ1,IQ2,K)=GMO(J,KKK)/BO(IQ1,IQ2,K)*FACTOR
      IF(FACTOR.LE.0.)QO(IQ1,IQ2,K)=0.
      QG(IQ1,IQ2,K)=GMG(J,KKK)/BG(IQ1,IQ2,K)*FACTOR
     & +RSOAV*QO(IQ1,IQ2,K)+RSWAV*QW(IQ1,IQ2,K)
```

```
      GO TO 2057
 2053 QG(IQ1,IQ2,K)=(GMO(J,KKK)+GMW(J,KKK)+GMG(J,KKK))
     & /BG(IQ1,IQ2,K)*FACTOR
 2057 CONTINUE
 2059 CONTINUE
      RETURN
      END
C
      SUBROUTINE MATBAL(DELT0,D5615)
C
C=================================================================MATBAL
C
C  COMPUTE SIMPLE MATERIAL BALANCE.
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL MBEO,MBEW,MBEG,KX,KY,KZ,MCFG,MCFG1,MCFGT,MCFGI,K1,K2
      COMMON /NUMBER/ II,JJ,KK
      COMMON /VOL/ SCFO,SCFW,SCFG,SCFG1,STBO,STBW,MCFG,MCFG1,MCFGT,
     & MCFGI,STBOI,STBWI,RESVOL
      COMMON /ADD2/ COP,CWP,CGP,CWI,CGI,CPOI,PVWI,POIR,CPOU
      COMMON /MBE/ MBEO,MBEW,MBEG
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
      COMMON /PRTP/ P(NX,NY,NZ)
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /RATE/ QO(NX,NY,NZ),QW(NX,NY,NZ),QG(NX,NY,NZ)
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /BAL/ OP,WP,GP,WI,GI,PAVG0,PAVG,OPR,WPR,GPR,WIR,GIR,CWOR,
     & WOR,CGOR,GOR
C
      FACT=D5615*DELT0
      PAVG0=0.0
      PAVG=0.0
      OP=0.0
      WP=0.0
      GP=0.0
      WI=0.0
      POI=0.0
      POU=0.0
      GI=0.0
      DO 100 K=1,KK
      DO 100 J=1,JJ
      DO 100 I=1,II
      PAVG0=PAVG0+PN(I,J,K)*VP(I,J,K)
      PAVG=PAVG+P(I,J,K)*VP(I,J,K)
      OP=OP+QO(I,J,K)*FACT
      IF(QW(I,J,K).GT.0.0)WP=WP+QW(I,J,K)*FACT
      IF(QW(I,J,K).GT.0.0)POU=POU+QW(I,J,K)*
     & C(I,J,((4-1)*KK+K))*DELT0*RHOSCW
      IF(QW(I,J,K).LT.0.0)WI=WI-QW(I,J,K)*FACT
      IF(QW(I,J,K).LT.0.0)POI=POI-QW(I,J,K)*
     & CQI(MAPWI(I,J,K),4)*DELT0*RHOSCW
      IF(QG(I,J,K).GT.0.0)GP=GP+QG(I,J,K)*DELT0
      IF(QG(I,J,K).LT.0.0)GI=GI+QG(I,J,K)*DELT0
```

```
100   CONTINUE
      COP=COP+OP
      CWP=CWP+WP
      CGP=CGP+GP*.001
      CWI=CWI+WI
      CPOI=CPOI+POI*0.000001
      CPOU=CPOU+POU*0.000001
      PVWI=CWI*5.615/PV
      CGI=CGI+GI*.001
C****CONVERT SCF TO MCF.
      GP=GP*.001
      GI=GI*.001
      DIV=1.0/DELT0
      OPR=OP*DIV
      WPR=WP*DIV
      GPR=GP*DIV
      WIR=WI*DIV
      POIR=POI*DIV*0.000001
      GIR=GI*DIV
      PAVG=PAVG/RESVOL
      PAVG0=PAVG0/RESVOL
C
      DENOM1=STBOI - OP
      IF(DENOM1.LT.1.E-7) GO TO 200
      MBEO=(STBO/(STBOI-OP) - 1.0)*100.0
 200  CONTINUE
      DENOM2=STBWI-WP-WI
      IF(DENOM2.LT.1.E-7) GO TO 201
      MBEW=(STBW/(STBWI-WP-WI) - 1.0)*100.0
 201  CONTINUE
      DENOM3=MCFGI-GP-GI
      IF(DENOM3.LT.1.E-7) GO TO 203
      MBEG=(MCFGT/(MCFGI-GP-GI) - 1.0)*100.0
 203  CONTINUE
C
      IF(OP.EQ.0.0)GOR=0.0
      IF(OP.EQ.0.0)WOR=0.0
      IF(OP.EQ.0.0)GO TO 333
      GOR=GP/OP
      WOR=WP/OP
 333  IF(COP.EQ.0.0)CGOR=0.0
      IF(COP.EQ.0.0)CWOR=0.0
      IF(COP.EQ.0.0)GO TO 666
      CGOR=CGP/COP*1000.0
      CWOR=CWP/COP
 666  CONTINUE
C
      GP=GP*0.001
      GI=GI*0.001
      RETURN
      END
      SUBROUTINE PRTPS(N,DELT0)
C
C=================================================================PRTPS
C
C  WRITE SUMMARY REPORT.
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      REAL MBEO,MBEW,MBEG,MCFG,MCFG1,MCFGT,MCFGI,K1,K2
      COMMON /IO/ NI,NO
      COMMON /ADD1/ IM,JM,KM,ETI,FT,FTMAX
      COMMON /ADD2/ COP,CWP,CGP,CWI,CGI,CPOI,PVWI,POIR,CPOU
```

```
      COMMON /PSCNTL/ KPI,KSI
      COMMON /MBE/ MBEO,MBEW,MBEG
      COMMON /NUMBER/ II,JJ,KK
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
      COMMON /VOL/ SCFO,SCFW,SCFG,SCFG1,STBO,STBW,MCFG,MCFG1,MCFGT,
     & MCFGI,STBOI,STBWI,RESVOL
      COMMON /BAL/ OP,WP,GP,WI,GI,PAVG0,PAVG,OPR,WPR,GPR,WIR,GIR,CWOR,
     & WOR,CGOR,GOR
      COMMON /PRTCNT/ IWLCNG,ICHANG,IWLREP,ISUMRY,
     & IPMAP,ISOMAP,ISWMAP,ISGMAP,IPBMAP,ICHMAP,CHEMAP
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
      COMMON /PRTP/ P(NX,NY,NZ)
      COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
     & SWINI(NX,NY,NZ)
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      PPM=0.
      SOM=0.
      SWM=0.
      SGM=0.
      IF(N.EQ.1) GO TO 300
      DO 240 K=1,KK
      DO 240 J=1,JJ
      DO 240 I=1,II
      DPO=P(I,J,K)-PN(I,J,K)
      DSO=SO(I,J,K)-SON(I,J,K)
      DSW=SW(I,J,K)-SWN(I,J,K)
      DSG=SG(I,J,K)-SGN(I,J,K)
      IF(ABS(DPO).LE.ABS(PPM))GO TO 210
      PPM=DPO
      IPM=I
      JPM=J
      KPM=K
210   IF(ABS(DSO).LE.ABS(SOM))GO TO 220
      SOM=DSO
      IOM=I
      JOM=J
      KOM=K
220   IF(ABS(DSW).LE.ABS(SWM))GO TO 230
      SWM=DSW
      IWM=I
      JWM=J
      KWM=K
230   IF(ABS(DSG).LE.ABS(SGM))GO TO 240
      SGM=DSG
      IGM=I
      JGM=J
      KGM=K
240   CONTINUE
      WRITE(NO,5)
      WRITE(NO,105)
      WRITE(NO,6)
      NLM=N-1
      GORM=1000.*GOR
      WRITE(NO,110)ETI,NLM,DELT0,PAVG,PAVG0,IPM,JPM,KPM,PPM,
```

```
     & IOM,JOM,KOM,SOM,IGM,JGM,KGM,SGM,IWM,JWM,KWM,SWM,
     & MBEO,MBEG,MBEW,OPR,COP,GPR,CGP,WPR,CWP
      WRITE(NO,111) GIR,CGI,WIR,CWI,WOR,CWOR,GORM,CGOR
 110  FORMAT(/,1X,'ELAPSED TIME (DAYS)       =',F9.2,3X,
     & 'TIME STEP NUMBER          =',I5,7X,
     & 'TIME STEP SIZE (DAYS)      =',F9.2,//,1X,
     & 'CURRENT AVG RES PRESSURE   =',F9.1,3X,
     & 'PREVIOUS AVG RES PRESSURE  =',F9.1,3X,
     & 'PRESSURE DPMAX(',I3,',',I3,',',I3,')  =',F9.1,/,1X,
     & 'OIL DSMAX(',I3,',',I3,',',I3,')       =',E10.4,3X,
     & 'GAS DSMAX(',I3,',',I3,',',I3,')       =',E10.4,3X,
     & 'WATER DSMAX(',I3,',',I3,',',I3,')     =',E10.4,/,1X,
     & 'OIL MATERIAL BALANCE (%)   =',E10.4,3X,
     & 'GAS MATERIAL BALANCE (%)   =',E10.4,3X,
     & 'WATER MATERIAL BALANCE (%) =',E10.4,//,1X,
     & 'OIL PRODUCTION RATE (STB/D) =',F9.1,3X,
     & 'CUM. OIL PRODUCTION (STB)   =',E10.4,/,1X,
     & 'GAS PRODUCTION RATE (MSCF/D)=',F9.1,3X,
     & 'CUM. GAS PRODUCTION (MSCF)  =',E10.4,/,1X,
     & 'WATER PRODUCTION RATE(STB/D)=',F9.1,3X,
     & 'CUM. WATER PRODUCTION (STB) =',E10.4)
 111  FORMAT(/1X,'GAS INJECTION RATE (MSCF/D) =',F9.1,3X,
     & 'CUM. GAS INJECTION (MSCF)   =',E10.4,/,1X,
     & 'WATER INJECTION RATE (STB/D)=',F9.1,3X,
     & 'CUM. WATER INJECTION (STB)  =',E11.4,//,1X,
     & 'PRODUCING WOR (STB/STB)     =',F9.3,3X,
     & 'CUM. WOR (STB/STB)          =',F9.3,/,1X,
     & 'PRODUCING GOR (SCF/STB)     =',F9.0,3X,
     & 'CUM. GOR (SCF/STB)          =',F9.0,//)
 300  IF(N.EQ.1.AND.KPI.EQ.0) WRITE(NO,304)
 304  FORMAT(//T15,7('*'),' INITIAL ARRAYS ',7('*')//)
      IF(IPMAP.EQ.0.AND.N.NE.1)GO TO 315
      WRITE(NO,61)
      DO 310 K=1,KK
      WRITE(NO,51)K
      DO 310 J=1,JJ
      WRITE(NO,41)(P(I,J,K),I=1,II,II/10)
 310  CONTINUE
C
 315  IF(ISOMAP.EQ.0.AND.N.NE.1)GO TO 422
      WRITE(NO,71)
      DO 420 K=1,KK
      WRITE(NO,51)K
      DO 420 J=1,JJ
      WRITE(NO,101)(SO(I,J,K),I=1,II,II/10)
420   CONTINUE
C
 422  IF(ISWMAP.EQ.0.AND.N.NE.1)GO TO 432
      WRITE(NO,81)
      DO 430 K=1,KK
      WRITE(NO,51)K
      DO 430 J=1,JJ
      WRITE(NO,101)(SW(I,J,K),I=1,II,II/10)
430   CONTINUE
C
 432  IF(ISGMAP.EQ.0.AND.N.NE.1)GO TO 4400
      WRITE(NO,91)
      DO 440 K=1,KK
      WRITE(NO,51)K
      DO 440 J=1,JJ
      WRITE(NO,101)(SG(I,J,K),I=1,II,II/10)
 440  CONTINUE
4400  CONTINUE
      IF(IPBMAP.EQ.0)GO TO 4500
```

```
      WRITE(NO,102)
 102  FORMAT(//T15,'***** BUBBLE POINT PRESSURE DISTRIBUTION *****'/)
      DO 450 K=1,KK
      WRITE(NO,51)K
      DO 450 J=1,JJ
      WRITE(NO,41)(PBOT(I,J,K),I=1,II,II/10)
 450  CONTINUE
4500  CONTINUE
      IF(ICHMAP.EQ.0)GO TO 4600
      WRITE(NO,103)
 103  FORMAT(//T15,'***** CHEMICAL CONCENTRATION DISTRIBUTION *****'/)
      DO 460 NC=1,5
      IF(NC.EQ.1)WRITE(NO,116)
      IF(NC.EQ.2)WRITE(NO,112)
      IF(NC.EQ.3)WRITE(NO,113)
      IF(NC.EQ.4)WRITE(NO,114)
      IF(NC.EQ.5)WRITE(NO,115)
      DO 460 K=(NC-1)*KK+1,NC*KK
      DO 460 J=1,JJ
      WRITE(NO,42)(C(I,J,K),I=1,II,II/10)
 460  CONTINUE
4600  CONTINUE
      IF(N.NE.1)WRITE(NO,7)
C
5     FORMAT(//T30,69('*'),/T30,'*',T98,'*'/T30,'*',T98,'*')
6     FORMAT(T30,'*',T98,'*'/T30,'*',T98,'*'/T30,69('*'),///)
7     FORMAT(///T5,54('*'),' END OF REPORT ',54('*'),6(/))
105   FORMAT(T30,'*',T45,'SUMMARY REPORT: NIPER MODEL    '
     &,T98,'*')
41    FORMAT(5X,20F6.0)
42    FORMAT(1X,11F11.3)
51    FORMAT(/1X,'K =',I2/)
61    FORMAT(//T15,'***** RESERVOIR PRESSURE DISTRIBUTION *****'/)
71    FORMAT(//T15,'********* OIL SATURATION *********'/)
81    FORMAT(//T15,'******** WATER SATURATION *********'/)
91    FORMAT(//T15,'********* GAS SATURATION *********'/)
101   FORMAT(5X,20F6.3)
116   FORMAT(//T5,'=== CHROMATE(CR2O7) CONCENTRATION (PPM) ==='/)
112   FORMAT(//T5,'=== THIOUREA CONCENTRATION (PPM) ==='/)
113   FORMAT(//T5,'=== CHROMIUM(CR+3) CONCENTRATION (PPM) ==='/)
114   FORMAT(//T5,'=== POLYMER CONCENTRATION (PPM) ==='/)
115   FORMAT(//T5,'=== GEL CONCENTRATION (PPM) ==='/)
      RETURN
      END

      SUBROUTINE LSOR(DELT,DELT0,N)
C
C=================================================================LSOR
C
C  THIS PROGRAM SOLVES A LINEAR SYSTEM OF THREE-DIMENSIONAL FINITE-
C  DIFFERENCE EQUATIONS.
C  ( LINEAR SUCCESSIVE OVERRELAXATION METHOD )
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      COMMON /IO/ NI,NO
      COMMON /NUMBER/ II,JJ,KK
      COMMON /CODE/ KSM1,KSN1,KCO1,NN,FACT1,FACT2,TMAX,KSOL,MITER,
     & OMEGA,TOL,TOL1,KSN,KSM,KCO,KTR,KCOFF,DSMAX,DPMAX,WORMAX,
     & GORMAX,PAMIN,PAMAX
      COMMON /COEF/ AW(NX,NY,NZ),AE(NX,NY,NZ),AN(NX,NY,NZ),
     & AS(NX,NY,NZ),AB(NX,NY,NZ),AT(NX,NY,NZ),E(NX,NY,NZ),B(NX,NY,NZ)
      COMMON /PRTP/ P(NX,NY,NZ)
```

```
      DIMENSION UM(NX),AZL(NX),BZL(NX),CZL(NX),DZL(NX),UZL(NX)
C
      DIV=DELT/DELT0
      NITER=0
      DMAX=1.0
      RHO1=0.0
      THETA=0.0
C
 11   CONTINUE
      TW = 1.0 - OMEGA
      DMAX0=DMAX
      THETA0=THETA
      IF(NITER.GE.MITER)WRITE(NO,30)NITER,TOL,DMAX
      IF(NITER.GE.MITER)RETURN
      NITER = NITER +1
      DMAX=0.0
C
 2    DO 20 K=1,KK
      DO 20 J=1,JJ
      DO 15 I=1,II
      UM(I) = P(I,J,K)
C
27    AZL(I) = AW(I,J,K)
      BZL(I)=E(I,J,K)
      CZL(I)=AE(I,J,K)
      DZL(I)=B(I,J,K)
      IF(JJ.EQ.1) GO TO 14
      JM=J-1
      JP=J+1
      IF(J.EQ.1) JM=1
      IF(J.EQ.JJ) JP=JJ
      DZL(I)=DZL(I) - AS(I,J,K)*P(I,JM,K) - AN(I,J,K)*P(I,JP,K)
 14   IF(KK.EQ.1) GO TO 15
      KM=K-1
      KP=K+1
      IF(K.EQ.1)KM=1
      IF(K.EQ.KK) KP=KK
      DZL(I)=DZL(I) - AT(I,J,K)*P(I,J,KM) - AB(I,J,K)*P(I,J,KP)
15    CONTINUE
C
      CALL LTRI(II,AZL,BZL,CZL,DZL,UZL)
C
      DO 16 I=1,II
      GSLSOR=UZL(I)
      P(I,J,K) = TW*UM(I) + OMEGA*GSLSOR
      ARG=P(I,J,K) - UM(I)
      DM=ABS(ARG)
      IF(DM.GT.DMAX) DMAX = DM
16    CONTINUE
C
20    CONTINUE
 3    IF(TOL1.EQ.0.0)GO TO 25
      THETA=DMAX/DMAX0
      DELTA=THETA-THETA0
      ARG=DELTA
      ARG=ABS(ARG)
      IF(ARG.GT.TOL1)GO TO 25
      OM=OMEGA-1.0
      RHO1=(THETA+OM)*(THETA+OM)/(THETA*OMEGA*OMEGA)
      IF(RHO1.GE.1.0)GO TO 25
      ARG=1.0-RHO1
      OMEGA=2.0/(1.0+SQRT(ARG))
C
25    IF(DMAX.GT.TOL)GO TO 11
```

```
      IF(N.NE.KSN) GO TO 300
      WRITE(NO,40)NITER,OMEGA,DMAX,THETA,RHO1
300   CONTINUE
40    FORMAT(T5,'CONVERGENCE(LSOR)  HAS BEEN REACHED AFTER ',I3,
     &' ITERATIONS',5X,'OMEGA = ',F6.3/
     &T5,'DMAX = ',F10.6,5X,'THETA = ',F10.6,5X,'RHO1 = ',F10.6/)
30    FORMAT(T15,'CONVERGENCE(LSOR)  WAS NOT REACHED IN ',I5,
     &' ITERATIONS'/T15,'TOL = ',F10.7,10X,'DMAX = ',F15.7)
C
      RETURN
      END
      SUBROUTINE LTRI(N,A,BI,C,D,X)
C
C=================================================================LTRI
C
C   THIS PROGRAM SOLVES THE TRIDIAGONAL SYSTEM
C   GENERATED BY THE SYSTEM OF N EQUATIONS
C
C     A(I)*U(I-1) + BI(I)*U(I) + C(I)*U(I+1) = D(I)
C
C=================================================================
C
      INCLUDE 'PARAGEL.FOR'
      DIMENSION A(NX),BI(NX),C(NX),D(NX),
     & X(NX),BETA(NX),GAMMA(NX),W(NX)
      BETA(1)=BI(1)
      GAMMA(1)=D(1)/BI(1)
      NM=N-1
C     COMPUTE FORWARD SOLUTION.
      DO 10 I=1,NM
      W(I)=C(I)/BETA(I)
      IP=I+1
 10   BETA(IP)=BI(IP)-A(IP)*W(I)
      DO 20 I=2,N
      IM=I-1
 20   GAMMA(I)=(D(I)-A(I)*GAMMA(IM))/BETA(I)
C     COMPUTE BACK SOLUTION
      X(N)=GAMMA(N)
      DO 30 J=1,NM
      I=N-J
      IP=I+1
 30   X(I)=GAMMA(I)-W(I)*X(IP)
      RETURN
      END
C     COMPILE THIS WHEN 'PARAGEL.FOR' IS IN THE SAME ACCOUNT
C
C-----------------------------------------------------------------
      SUBROUTINE GELDATA
C
C *** READ CHEMICAL DATA FOR GELATION PROCESS
C-----------------------------------------------------------------
      INCLUDE 'PARAGEL.FOR'
      CHARACTER*2 TITLE(80)
      REAL K1,K2
      COMMON /IO/ NI,NO
      COMMON /NUMBER/ II,JJ,KK
      COMMON /COUNT/ N1READ,N2READ
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
```

```
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /SHEAR/GAMMA0,GAMMA1,GAMMA2,GAMMA3,SHEARA,SHEARB
      COMMON /MAXC/C1MAX,C2MAX,C3MAX,C4MAX,C5MAX
C
C **** READ INFORMATION ******
      READ(NI,1)(TITLE(IH),IH=1,40)
      N1READ=N1READ+1
      WRITE(NO,100)
      READ(NI,*)MORDER
      N1READ=N1READ+1
      READ(NI,*)DDX,DDY,DDZ
      N1READ=N1READ+1
      WRITE(NO,110)DDX,DDY,DDZ
      READ(NI,*)K1,K2,NRX
      N1READ=N1READ+1
      WRITE(NO,120)K1,K2,NRX
      READ(NI,*)(AA(I),I=1,5)
      N1READ=N1READ+1
      WRITE(NO,130)(AA(I),I=1,5)
      READ(NI,*)(BB(I),I=1,5)
      N1READ=N1READ+1
      WRITE(NO,140)(BB(I),I=1,5)
      READ(NI,*)(CL(I),I=1,5)
      N1READ=N1READ+1
      WRITE(NO,150)(CL(I),I=1,5)
      READ(NI,*)(GAMA(I),I=1,5)
      N1READ=N1READ+1
      WRITE(NO,160)(GAMA(I),I=1,5)
      READ(NI,*)ALPHA1,ALPHA2,ALPHA3
      N1READ=N1READ+1
      WRITE(NO,170)ALPHA1,ALPHA2,ALPHA3
      READ(NI,*)BETA1,BETA2,BETA3,CGC
      N1READ=N1READ+1
      READ(NI,*)GAMMA0,GAMMA1,GAMMA2,GAMMA3,SHEARA,SHEARB
      WRITE(NO,175)SHEARA,SHEARB,GAMMA0,GAMMA1,GAMMA2,GAMMA3
      WRITE(NO,180)BETA1,BETA2,BETA3,CGC
      N1READ=N1READ+1
      WRITE(NO,185)
      DO 40 K=1,KK
      READ(NI,*)(FIPV(K,I),I=1,5)
      WRITE(NO,190)K,(FIPV(K,I),I=1,5)
      N1READ=N1READ+1
   40 CONTINUE
      READ(NI,*)C1MAX,C2MAX,C3MAX,C4MAX,C5MAX
      WRITE(NO,195)C1MAX,C2MAX,C3MAX,C4MAX,C5MAX
      N1READ=N1READ+1
      DO 50 K=1,KK*5
      DO 50 J=1,JJ
      DO 50 I=1,II
      C(I,J,K)=0.0
      CADS(I,J,K)=0.0
      DCADS(I,J,K)=0.0
   50 CONTINUE
      DO 60 K=1,KK
      DO 60 J=1,JJ
      DO 60 I=1,II
      UW(I,J,K)=0.0
      UE(I,J,K)=0.0
      US(I,J,K)=0.0
      UN(I,J,K)=0.0
      UT(I,J,K)=0.0
      UB(I,J,K)=0.0
   60 CONTINUE
    1 FORMAT(40A2)
```

```
100   FORMAT(//30X,20('*'),'CHEMICAL SYSTEM PARAMETERS',
     &  20('*')/)
110   FORMAT(/15X,'DISPERSION COEFFICIENT IN X DIRECTION =',
     & E15.5//15X,'DISPERSION COEFFICIENT IN Y DIRECTION =',
     & E15.5//15X,'DISPERSION COEFFICIENT IN Z DIRECTION =',
     & E15.5/)
120   FORMAT(/15X,'REACTION RATE CONSTANTS K1=',E15.5,5X,
     & 'K2=',E15.5,5X,'N =',I10/)
130   FORMAT(/15X,'ADSORPTION PARAMETERS :'//10X,'A (1-5 COMPONENTS) :',
     &5E15.5/)
140   FORMAT(/10X,'B (1-5 COMPONENTS) :',5E15.5/)
150   FORMAT(/15X,'RESIDUAL RESISTANCE FACTOR PARAMETERS :',
     &  //10X,'CL (1-5 COMPONENTS) :',F14.3,4F15.3/)
160   FORMAT(/10X,'GAMMA (1-5 COMPONS) :',F14.3,4F15.3/)
170   FORMAT(/15X,'POLYMER RHEOLOGY PARAMETERS :'//20X,
     & 'ALPHA1 = ',E15.5/20X,'ALPHA2 = ',E15.5/20X,
     & 'ALPHA3 = ',E15.5/)
175   FORMAT(/20X,'SHEARA = ',E15.5/20X,'SHEARB = ',E15.5,
     & //20X,'GAMMA0 = ',E15.5/20X,'GAMMA1 = ',E15.5,
     & /20X,'GAMMA2 = ',E15.5/20X,'GAMMA3 = ',E15.5/)
180   FORMAT(//15X,'GEL RHEOLOGY PARAMETERS :'//20X,
     & 'BETA1 = ',E15.5/20X,'BETA2 = ',E15.5/20X,'BETA3 = ',
     & E15.5/20X,'CRITICAL CONC. = ',F15.3)
185   FORMAT(/15X,'IPV FACTORS (1-5 COMPONENTS) :')
190   FORMAT(/10X,'LAYER K = ',I5,' :',5F10.3)
195   FORMAT(/15X,'MAX CONCS. FOR COMPONENTS ARE: '//5X,
     &  5F20.3/)
      RETURN
      END
C
C-----------------------------------------------------------------
      SUBROUTINE GEL
C
C *** SOLUTION OF CHEMICAL TRANSPORTATION EQUATION *******
C-----------------------------------------------------------------
C
      INCLUDE 'PARAGEL.FOR'
      REAL K1,K2
      DIMENSION AA1(NORDER,NORDER),FK(4)
      COMMON /IO/ NI,NO
      COMMON /CNEXT/ CNEXT(NX,NY,NZC),CC3(NX,NY,NZ)
      COMMON /RATE/ QO(NX,NY,NZ),QW(NX,NY,NZ),QG(NX,NY,NZ)
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /VECTOR/ DX(NX,NY,NZ),DY(NX,NY,NZ),DZ(NX,NY,NZ)
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /NUMBER/ II,JJ,KK
      COMMON /INDX/ I,J,K
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /PRTP/ P(NX,NY,NZ)
      COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
     & SWINI(NX,NY,NZ)
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
```

```
      COMMON /TRAN/ TX(NX+1,NY,NZ),TY(NX,NY+1,NZ),TZ(NX,NY,NZ+1)
      COMMON /ADD1/ IM,JM,KM,ETI,FT,FTMAX
      COMMON /PRTCNT/ IWLCNG,ICHANG,IWLREP,ISUMRY,
     & IPMAP,ISOMAP,ISWMAP,ISGMAP,IPBMAP,ICHMAP,CHEMAP
      COMMON /DT/ DELT,DELT0
      COMMON /TIMESTEP/ NTS
      COMMON /MAXC/C1MAX,C2MAX,C3MAX,C4MAX,C5MAX
C
C **** Calculate coefficients in converting dC/dX & dC2/dX2 into F.D. form :
      S2=1./(2.**.5)
      AA1(1,1)=1.
      DO 10 N=2,MORDER
      AA1(N,1)=2.*N/(N+1)
      DO 10 K=2,N
      AA1(N,K)=(N-K+1)*AA1(N,K-1)/(N+K)
 10   CONTINUE
C
C **** Solve Concentration for 5 components in each grid block
      DO 2000 NC=1,5
      DO 1000 K=1,KK
      KC=K+(NC-1)*KK
      DO 1000 J=1,JJ
      DO 1000 I=1,II
      DX1=DX(I,J,K)
      DY1=DY(I,J,K)
      DZ1=DZ(I,J,K)
C **** Convert "dC/dX", "dC/dY", "dC/dZ" to 10th order
C     Convert "d2C/dX2", "d2C/dY2", "d2C/dZ2" to 10th order
      IORDER=MIN(I,II-I+1)
      IORDER=MIN(IORDER-1,MORDER)
      DCDX1=0.
      DCDX2=0.
      IF(IORDER.EQ.0.AND.I.EQ.1)GO TO 202
      IF(IORDER.EQ.0.AND.I.EQ.II)GO TO 204
      DO 200 L=1,IORDER
      DCDX1=DCDX1-(-1)**L*AA1(IORDER,L)*(C(I+L,J,KC)-C(I-L,J,KC))
     & /(2*L*DX1)
      DCDX2=DCDX2-(-1)**L*AA1(IORDER,L)*(C(I+L,J,KC)-2*C(I,J,KC)
     & +C(I-L,J,KC))/(L*DX1)**2
 200  CONTINUE
      GO TO 210
 202  DCDX1=(-C(I+2,J,KC)+4*C(I+1,J,KC)-3*C(I,J,KC))/(2*DX1)
      DCDX2=(C(I+2,J,KC)-2*C(I+1,J,KC)+C(I,J,KC))/DX1/DX1
      GO TO 210
 204  DCDX1=(3*C(I,J,KC)-4*C(I-1,J,KC)+C(I-2,J,KC))/(2*DX1)
      DCDX2=(C(I,J,KC)-2*C(I-1,J,KC)+C(I-2,J,KC))/DX1/DX1
C
 210  JORDER=MIN(J,JJ-J+1)
      JORDER=MIN(JORDER-1,MORDER)
      DCDY1=0.
      DCDY2=0.
      IF(JORDER.EQ.0)GO TO 222
      DO 220 L=1,JORDER
      DCDY1=DCDY1-(-1)**L*AA1(JORDER,L)*(C(I,J+L,KC)-C(I,J-L,KC))
     & /(2*L*DY1)
      DCDY2=DCDY2-(-1)**L*AA1(JORDER,L)*(C(I,J+L,KC)-2*C(I,J,KC)
     & +C(I,J-L,KC))/(L*DY1)**2
 220  CONTINUE
      GO TO 230
 222  IF(JJ.EQ.1)GO TO 230
      IF(JJ.GT.2)GO TO 226
      IF(J.EQ.1)DCDY1=(C(I,J+1,KC)-C(I,J,KC))/DY1
      IF(J.EQ.JJ)DCDY1=(C(I,J,KC)-C(I,J-1,KC))/DY1
      GO TO 230
```

```
 226    IF(J.EQ.1)THEN
        DCDY1=(-C(I,J+2,KC)+4*C(I,J+1,KC)-3*C(I,J,KC))/(2*DY1)
        DCDY2=(C(I,J+2,KC)-2*C(I,J+1,KC)+C(I,J,KC))/DY1/DY1
        ENDIF
        IF(J.EQ.JJ)THEN
        DCDY1=(3*C(I,J,KC)-4*C(I,J-1,KC)+C(I,J-2,KC))/(2*DY1)
        DCDY2=(C(I,J,KC)-2*C(I,J-1,KC)+C(I,J-2,KC))/DY1/DY1
        ENDIF
C
 230    KORDER=MIN(K,KK-K+1)
        KORDER=MIN(KORDER-1,MORDER)
        DCDZ1=0.
        DCDZ2=0.
        IF(KORDER.EQ.0)GO TO 245
        DO 240 L=1,KORDER
        DCDZ1=DCDZ1-(-1)**L*AA1(KORDER,L)*(C(I,J,KC+L)-C(I,J,KC-L))
       &  /(2*L*DZ1)
        DCDZ2=DCDZ2-(-1)**L*AA1(KORDER,L)*(C(I,J,KC+L)-2*C(I,J,KC)
       &  +C(I,J,KC-L))/(L*DZ1)**2
 240    CONTINUE
        GO TO 250
 245    IF(KK.EQ.1)GO TO 250
        IF(KK.GT.2)GO TO 246
        IF(K.EQ.1)DCDZ1=(C(I,J,KC+1)-C(I,J,KC))/DZ1
        IF(K.EQ.KK)DCDZ1=(C(I,J,KC)-C(I,J,KC-1))/DZ1
        GO TO 250
 246    IF(K.EQ.1)THEN
        DCDZ1=(-C(I,J,KC+2)+4*C(I,J,KC+1)-3*C(I,J,KC))/(2*DZ1)
        DCDZ2=(C(I,J,KC+2)-2*C(I,J,KC+1)+C(I,J,KC))/DZ1/DZ1
        ENDIF
        IF(K.EQ.KK)THEN
        DCDZ1=(3*C(I,J,KC)-4*C(I,J,KC-1)+C(I,J,KC-2))/(2*DZ1)
        DCDZ2=(C(I,J,KC)-2*C(I,J,KC-1)+C(I,J,KC-2))/DZ1/DZ1
        ENDIF
 250    CONTINUE
C
C **** Chemical Transport Equation .........
C    ---- solved using Runge-Kuta-Gill (4th order) method ---------
        FPARTX=0.0
        IF(I.EQ.1) GO TO 320
        IF(I.EQ.II) GO TO 325
        F1X=RHOSCW*SWN(I,J,K)*(POR(I+1,J,K)-POR(I-1,J,K))/(2*DX1)
        F2X=.00000305*POR(I,J,K)*SWN(I,J,K)*(PN(I+1,J,K)-PN
       & (I-1,J,K))/(2*DX1)
        F3X=POR(I,J,K)*RHOSCW*(SWN(I+1,J,K)-SWN(I-1,J,K))/(2*DX1)
        GO TO 330
 320    F1X=RHOSCW*SWN(I,J,K)*(-POR(I+2,J,K)+4*POR(I+1,J,K)-3*
       & POR(I,J,K))/(2*DX1)
        F2X=.00000305*POR(I,J,K)*SWN(I,J,K)*(-PN(I+2,J,K)+4*
       & PN(I+1,J,K)-3*PN(I,J,K))/(2*DX1)
        F3X=POR(I,J,K)*RHOSCW*(-SWN(I+2,J,K)+4*SWN(I+1,J,K)-3*
       & SWN(I,J,K))/(2*DX1)
        GO TO 330
 325    F1X=RHOSCW*SWN(I,J,K)*(3*POR(I,J,K)-4*POR(I-1,J,K)+
       & POR(I-2,J,K))/(2*DX1)
        F2X=.00000305*POR(I,J,K)*SWN(I,J,K)*(3*PN(I,J,K)-4*PN
       & (I-1,J,K)+PN(I-2,J,K))/(2*DX1)
        F3X=POR(I,J,K)*RHOSCW*(3*SWN(I,J,K)-4*SWN(I-1,J,K)+
       & SWN(I-2,J,K))/(2*DX1)
 330    FPARTX=(F1X+F2X+F3X)*FIPV(K,NC)
C
        FPARTY=0.0
        IF(J.EQ.1) GO TO 350
        IF(J.EQ.JJ) GO TO 355
```

```
      F1Y=RHOSCW*SWN(I,J,K)*(POR(I,J+1,K)-POR(I,J-1,K))/(2*DY1)
      F2Y=.00000305*POR(I,J,K)*SWN(I,J,K)*(PN(I,J+1,K)-PN
     & (I,J-1,K))/(2*DY1)
      F3Y=POR(I,J,K)*RHOSCW*(SWN(I,J+1,K)-SWN(I,J-1,K))/(2*DY1)
      GO TO 360
350   F1Y=RHOSCW*SWN(I,J,K)*(-POR(I,J+2,K)+4*POR(I,J+1,K)-3*
     & POR(I,J,K))/(2*DY1)
      F2Y=.00000305*POR(I,J,K)*SWN(I,J,K)*(-PN(I,J+2,K)+4*PN
     & (I,J+1,K)-3*PN(I,J,K))/(2*DY1)
      F3Y=POR(I,J,K)*RHOSCW*(-SWN(I,J+2,K)+4*SWN(I,J+1,K)-3*
     & SWN(I,J,K))/(2*DY1)
      GO TO 360
355   F1Y=RHOSCW*SWN(I,J,K)*(3*POR(I,J,K)-4*POR(I,J-1,K)+
     & POR(I,J-2,K))/(2*DY1)
      F2Y=.00000305*POR(I,J,K)*SWN(I,J,K)*(3*PN(I,J,K)-4*PN
     & (I,J-1,K)+PN(I,J-2,K))/(2*DY1)
      F3Y=POR(I,J,K)*RHOSCW*(3*SWN(I,J,K)-4*SWN(I,J-1,K)+
     & SWN(I,J-2,K))/(2*DY1)
360   FPARTY=(F1Y+F2Y+F3Y)*FIPV(K,NC)
C
      FPARTZ=0.0
      IF(KK.GT.1.AND.K.EQ.1) GO TO 370
      IF(KK.GT.1.AND.K.EQ.KK) GO TO 375
      F1Z=RHOSCW*SWN(I,J,K)*(POR(I,J,K+1)-POR(I,J,K-1))/(2*DZ1)
      F2Z=.00000305*POR(I,J,K)*SWN(I,J,K)*(PN(I,J,K+1)-PN
     & (I,J,K-1))/(2*DZ1)
      F3Z=POR(I,J,K)*RHOSCW*(SWN(I,J,K+1)-SWN(I,J,K-1))/(2*DZ1)
      GO TO 380
370   F1Z=RHOSCW*SWN(I,J,K)*(POR(I,J,K+1)-POR(I,J,K))/DZ1
      F2Z=.00000305*POR(I,J,K)*SWN(I,J,K)*(PN(I,J,K+1)-PN
     & (I,J,K))/DZ1
      F3Z=POR(I,J,K)*RHOSCW*(SWN(I,J,K+1)-SWN(I,J,K))/DZ1
      GO TO 380
375   F1Z=RHOSCW*SWN(I,J,K)*(POR(I,J,K)-POR(I,J,K-1))/DZ1
      F2Z=.00000305*POR(I,J,K)*SWN(I,J,K)*(PN(I,J,K)-PN
     & (I,J,K-1))/DZ1
      F3Z=POR(I,J,K)*RHOSCW*(SWN(I,J,K)-SWN(I,J,K-1))/DZ1
380   FPARTZ=(F1Z+F2Z+F3Z)*FIPV(K,NC)
C
      CONTINUE

      IF(I.EQ.1.AND.UE(I,J,K).GE.0.)GX=UE(I,J,K)*C(I,J,KC)/DX1
      IF(I.EQ.1.AND.UE(I,J,K).LT.0.)GX=UE(I,J,K)*C(I+1,J,KC)/DX1
      IF(I.EQ.II.AND.UW(I,J,K).GE.0.)GX=-UW(I,J,K)*C(I-1,J,KC)/DX1
      IF(I.EQ.II.AND.UW(I,J,K).LT.0.)GX=-UW(I,J,K)*C(I,J,KC)/DX1
      IF(I.NE.1.AND.I.NE.II.AND.UE(I,J,K).GE.0.AND.UW(I,J,K).GE.
     & 0.)GX=(UE(I,J,K)*C(I,J,KC)-UW(I,J,K)*C(I-1,J,KC))/DX1
      IF(I.NE.1.AND.I.NE.II.AND.UE(I,J,K).GE.0.AND.UW(I,J,K).LT.
     & 0.)GX=(UE(I,J,K)*C(I,J,KC)-UW(I,J,K)*C(I,J,KC))/DX1
      IF(I.NE.1.AND.I.NE.II.AND.UE(I,J,K).LT.0.AND.UW(I,J,K).GE.
     & 0.)GX=(UE(I,J,K)*C(I+1,J,KC)-UW(I,J,K)*C(I-1,J,KC))/DX1
      IF(I.NE.1.AND.I.NE.II.AND.UE(I,J,K).LT.0.AND.UW(I,J,K).LT.
     & 0.)GX=(UE(I,J,K)*C(I+1,J,KC)-UW(I,J,K)*C(I,J,KC))/DX1

      IF(J.EQ.1.AND.UN(I,J,K).GE.0.)GY=UN(I,J,K)*C(I,J,KC)/DY1
      IF(J.EQ.1.AND.UN(I,J,K).LT.0.)GY=UN(I,J,K)*C(I,J+1,KC)/DY1
      IF(J.EQ.JJ.AND.US(I,J,K).GE.0.)GY=-US(I,J,K)*C(I,J-1,KC)/DY1
      IF(J.EQ.JJ.AND.US(I,J,K).LT.0.)GY=-US(I,J,K)*C(I,J,KC)/DY1
      IF(J.NE.1.AND.J.NE.JJ.AND.UN(I,J,K).GE.0.AND.US(I,J,K).GE.
     & 0.)GY=(UN(I,J,K)*C(I,J,KC)-US(I,J,K)*C(I,J-1,KC))/DY1
      IF(J.NE.1.AND.J.NE.JJ.AND.UN(I,J,K).GE.0.AND.US(I,J,K).LT.
     & 0.)GY=(UN(I,J,K)*C(I,J,KC)-US(I,J,K)*C(I,J,KC))/DY1
      IF(J.NE.1.AND.J.NE.JJ.AND.UN(I,J,K).LT.0.AND.US(I,J,K).GE.
     & 0.)GY=(UN(I,J,K)*C(I,J+1,KC)-US(I,J,K)*C(I,J-1,KC))/DY1
```

```
      IF(J.NE.1.AND.J.NE.JJ.AND.UN(I,J,K).LT.0.AND.US(I,J,K).LT.
     & 0.)GY=(UN(I,J,K)*C(I,J+1,KC)-US(I,J,K)*C(I,J,KC))/DY1

      IF(K.EQ.1.AND.UB(I,J,K).GE.0.)GZ=UB(I,J,K)*C(I,J,KC)/DZ1
      IF(K.EQ.1.AND.UB(I,J,K).LT.0.)GZ=UB(I,J,K)*C(I,J,KC+1)/DZ1
      IF(K.EQ.KK.AND.UT(I,J,K).GE.0.)GZ=-UT(I,J,K)*C(I,J,KC-1)/DZ1
      IF(K.EQ.KK.AND.UT(I,J,K).LT.0.)GZ=-UT(I,J,K)*C(I,J,KC)/DZ1
      IF(K.NE.1.AND.K.NE.KK.AND.UB(I,J,K).GE.0.AND.UT(I,J,K).GE.
     & 0.)GZ=(UB(I,J,K)*C(I,J,KC)-UT(I,J,K)*C(I,J,KC-1))/DZ1
      IF(K.NE.1.AND.K.NE.KK.AND.UB(I,J,K).GE.0.AND.UT(I,J,K).LT.
     & 0.)GZ=(UB(I,J,K)*C(I,J,KC)-UT(I,J,K)*C(I,J,KC))/DZ1
      IF(K.NE.1.AND.K.NE.KK.AND.UB(I,J,K).LT.0.AND.UT(I,J,K).GE.
     & 0.)GZ=(UB(I,J,K)*C(I,J,KC+1)-UT(I,J,K)*C(I,J,KC-1))/DZ1
      IF(K.NE.1.AND.K.NE.KK.AND.UB(I,J,K).LT.0.AND.UT(I,J,K).LT.
     & 0.)GZ=(UB(I,J,K)*C(I,J,KC+1)-UT(I,J,K)*C(I,J,KC))/DZ1

      GPART=(GX+GY+GZ)*RHOSCW

      DISPER=0.0
      IF(TX(I,J,K).NE.0.0.AND.TX(I+1,J,K).NE.0.0) DISPER=
     & DISPER+DDX*DCDX2
      IF(TY(I,J,K).NE.0.0.AND.TY(I,J+1,K).NE.0.0) DISPER=
     & DISPER+DDY*DCDY2
      IF(TZ(I,J,K).NE.0.0.AND.TZ(I,J,K+1).NE.0.0) DISPER=
     & DISPER+DDZ*DCDZ2
      H1=POR(I,J,K)*FIPV(K,NC)*RHOSCW*SWN(I,J,K)*DISPER
      H2=DDX*FPARTX*DCDX1
      IF(TX(I,J,K).EQ.0.0.OR.TX(I+1,J,K).EQ.0.0) H2=0.0
      H3=DDY*FPARTY*DCDY1
      IF(TY(I,J,K).EQ.0.0.OR.TY(I,J+1,K).EQ.0.0) H3=0.0
      H4=DDZ*FPARTZ*DCDZ1
      IF(TZ(I,J,K).EQ.0.0.OR.TZ(I,J,K+1).EQ.0.0) H4=0.0
      H5=GPART-RHOSCW*POR(I,J,K)*SWN(I,J,K)*RXRATE(NC)
      H7=RHOROCK*(1-POR(I,J,K))*DCADS(I,J,K)
      DPART=POR(I,J,K)*FIPV(K,NC)*RHOSCW*SWN(I,J,K)

      DO 500 IR=1,4
      IF(IR.EQ.1)C0=C(I,J,KC)
      IF(IR.EQ.2)C0=C(I,J,KC)+.5*FK(1)*DELT
      IF(IR.EQ.3)C0=C(I,J,KC)+((S2-.5)*FK(1)+(1.-S2)*FK(2))
     & *DELT
      IF(IR.EQ.4)C0=C(I,J,KC)+((1.+S2)*FK(3)-S2*FK(2))*DELT
      EPART=POR(I,J,K)*FIPV(K,NC)*C0*(RHOSCW*(SW(I,J,K)-SWN(I,J,K))+
     & SWN(I,J,K)*.00000305*(P(I,J,K)-PN(I,J,K)))
      H6=0.
      IF(QW(I,J,K).LT.0.0) H6=QW(I,J,K)*CQI(MAPWI(I,J,K),NC)
     & *RHOSCW/(DX1*DY1*DZ1)
      IF(QW(I,J,K).GT.0.0) H6=QW(I,J,K)*C0*RHOSCW/
     & (DX1*DY1*DZ1)
      FK(IR)=(H1+H2+H3+H4-H5-H6-EPART/DELT-H7)/DPART
      IF(QW(I,J,K).LT.0.0) GO TO 510
      IF(QW(I,J,K).GT.0.0) GO TO 510
500   CONTINUE
      CNEXT(I,J,KC)=C(I,J,KC)+(FK(1)+2*(1.-S2)*FK(2)+2*(1.+S2)
     & *FK(3)+FK(4))*DELT/6.
      GO TO 520
510   CNEXT(I,J,KC)=C(I,J,KC)+FK(1)*DELT
      GO TO 520
C **** Back Calculate Chemical Concentration to be Consumed if CNEXT(I,J,K) < 0
520   IF(NC.EQ.1.AND.CNEXT(I,J,KC).GT.C1MAX) CNEXT(I,J,KC)=C1MAX
      IF(NC.EQ.2.AND.CNEXT(I,J,KC).GT.C2MAX) CNEXT(I,J,KC)=C2MAX
      IF(NC.EQ.3.AND.CNEXT(I,J,KC).GT.C3MAX) CNEXT(I,J,KC)=C3MAX
      IF(NC.EQ.4.AND.CNEXT(I,J,KC).GT.C4MAX) CNEXT(I,J,KC)=C4MAX
      IF(NC.EQ.5.AND.CNEXT(I,J,KC).GT.C5MAX) CNEXT(I,J,KC)=C5MAX
```

```
      IF(CNEXT(I,J,KC).LT.0.)THEN
      CNEXT(I,J,KC)=0.
      ENDIF
C
 1000 CONTINUE
      IF(NTS.NE.1) GO TO 2550
      ETIN=CHEMAP
 2550 IF(ETI.LT.ETIN) GO TO 2000
      IF(NC.EQ.1)WRITE(10,3050)ETI
      WRITE(10,3100)NC
      DO 1500 K=(NC-1)*KK+1, NC*KK
      DO 1500 J=1,JJ
      WRITE(10,3112)(CNEXT(I,J,K),I=1,II,II/10)
 1500 CONTINUE
 2000 CONTINUE
      DO 2500 K=1,KK*5
      DO 2500 J=1,JJ
      DO 2500 I=1,II
      C(I,J,K)=CNEXT(I,J,K)
 2500 CONTINUE
C
      CALL RFACTOR
      CALL DELTMUW
      IF(ETI.LT.ETIN) GO TO 2700
      WRITE(10,3113)
      DO 2600 K=1,KK
      WRITE(10,3070)K
      DO 2600 J=1,JJ
      WRITE(10,3112)(RF(I,J,K),I=1,II)
 2600 CONTINUE
      WRITE(10,3114)
      DO 2650 K=1,KK
      WRITE(10,3070)K
      DO 2650 J=1,JJ
      WRITE(10,3112)(DTMUW(I,J,K),I=1,II)
 2650 CONTINUE
      IF(ETI.EQ.0.0) GO TO 2700
      ETIN=ETI+CHEMAP
 2700 CONTINUE
C
 3050 FORMAT(//T5,F15.3,' DAYS')
 3070 FORMAT(//1X,'K =',I2/)
 3100 FORMAT(/T5,'  COMPONENT =',I3)
 3110 FORMAT(/I5,1X,6F11.7,I5)
 3111 FORMAT(6X,10F11.7)
 3112 FORMAT(1X,11E11.3)
 3113 FORMAT(/T5,' RESIDUAL RESISTANCE FACTOR :')
 3114 FORMAT(/T5,' INCREASE IN WATER VISCOSITY IN CENTIPOISES :')
      RETURN
      END
C
C-----------------------------------------------------------------
      FUNCTION NFACT(N)
C ****** Calculate Factorial of N *******
      K=1
      DO 100 I=1,N
      K=K*I
  100 CONTINUE
      NFACT=K
      RETURN
      END
C
C-----------------------------------------------------------------
      FUNCTION RXRATE(NC)
```

```
C ***** Calculate Reaction Rate for 5 Chemical Components *****
      INCLUDE 'PARAGEL.FOR'
      REAL K1,K2
      COMMON /NUMBER/ II,JJ,KK
      COMMON /INDX/ I,J,K
      COMMON /DT/ DELT,DELT0
      COMMON /CNEXT/ CNEXT(NX,NY,NZC),CC3(NX,NY,NZ)
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      C1=C(I,J,K)
      C2=C(I,J,KK+K)
      C3=C(I,J,KK*2+K)
      C4=C(I,J,KK*3+K)
      C5=C(I,J,KK*4+K)
      IF(NC.EQ.1)RXRATE=-K1*C1*C2
      IF(NC.EQ.2)RXRATE=-6*K1*C1*C2*(60./216.)
C
      IF(NC.EQ.3)THEN
      CC1=1.0E6
      CC2=1.0E6
      IF(CNEXT(I,J,K).EQ.0.)CC1=2*C1/DELT
      IF(CNEXT(I,J,KK+K).EQ.0.)CC2=C2/DELT*(216./180.)
      CC3(I,J,K)=MIN(CC1,CC2)
      IF(CC3(I,J,K).EQ.1.0E6)THEN
      RXRATE=2*K1*C1*C2*(52./216.)-NRX*K2*(C3*C4)**2/100000.
      ELSE
      RXRATE=CC3(I,J,K)*(52./216.)-NRX*K2*(C3*C4)**2/100000.
      ENDIF
      ENDIF
C
      IF(NC.EQ.4)THEN
      IF(CNEXT(I,J,KK*2+K).GT.0.)THEN
      RXRATE=-K2*(C3*C4)**2
      ELSE
      IF(CC3(I,J,K).EQ.1.0E6)THEN
      RXRATE=-100000./NRX*(C3/DELT+2*K1*C1*C2*(52./216.))
      ELSE
      RXRATE=-100000./NRX*(C3/DELT+CC3(I,J,K)*(52./216.))
      ENDIF
      ENDIF
      ENDIF
C
      IF(NC.EQ.5)THEN
      IF(CNEXT(I,J,KK*2+K).GT.0.)THEN
      RXRATE=K2*(C3*C4)**2*(1.+NRX/100000.)
      ELSE
      IF(CC3(I,J,K).EQ.1.0E6)THEN
      RXRATE=100000./NRX*(C3/DELT+2*K1*C1*C2*(52./216.))
      ELSE
      RXRATE=100000./NRX*(C3/DELT+CC3(I,J,K)*(52./216.))
      ENDIF
      ENDIF
      ENDIF
      RETURN
      END
C
C-----------------------------------------------------------------
      FUNCTION RXCONC(NC,RXREAL)
C ***** Back Calculate Chemical Concentration Available for Reaction ****
      INCLUDE 'PARAGEL.FOR'
      REAL K1,K2
      COMMON /NUMBER/ II,JJ,KK
```

```
      COMMON /INDX/ I,J,K
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      C1=C(I,J,K)
      C2=C(I,J,KK+K)
      C3=C(I,J,KK*2+K)
      C4=C(I,J,KK*3+K)
      C5=C(I,J,KK*4+K)
      RXCONC=0.
      IF(NC.EQ.1.AND.C2.GT.0.)RXCONC=-RXREAL/(K1*C2)
      IF(NC.EQ.2.AND.C1.GT.0.)RXCONC=-RXREAL/(6*K1*C1)
      IF(NC.EQ.3.AND.C4.GT.0.AND.(2*K1*C1*C2).GT.RXREAL)
     & RXCONC=(((-RXREAL+2*K1*C1*C2)/(NRX*K2))**.5)/C4
      IF(NC.EQ.4.AND.C3.GT.0.AND.RXREAL.LT.0.)
     & RXCONC=((-RXREAL/K2)**.5)/C3
      IF(NC.EQ.5)RXCONC=0.
      RETURN
      END
C-----------------------------------------------------------------------
      SUBROUTINE RFACTOR
C ***** Calculate Resistance Factor for Permeability Reduction Caused by
C     Adsorption   **************
      INCLUDE 'PARAGEL.FOR'
      DIMENSION ADSOP(5)
      REAL KX,KY,KZ,KROT,KRWT,KRGT,MUOT,MUWT,MUGT,K1,K2,KRW1
      COMMON /NUMBER/ II,JJ,KK
      COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /PERM/ KX(NX,NY,NZ),KY(NX,NY,NZ),KZ(NX,NY,NZ)
      COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
     & SWINI(NX,NY,NZ)
      COMMON /DT/ DELT,DELT0
      RFT=1.
      DO 100 K=1,KK
      DO 100 J=1,JJ
      DO 100 I=1,II
      RF(I,J,K)=1.
      DO 50 NC=1,5
      KC=K+(NC-1)*KK
      ADSOP(NC)=BB(NC)*C(I,J,KC)/(1+AA(NC)*C(I,J,KC))
      IF(ADSOP(NC).LT.CADS(I,J,KC)) ADSOP(NC)=CADS(I,J,KC)
      IF(ADSOP(NC).GT.GAMA(NC))
     &  RF(I,J,K)=RF(I,J,K)+CL(NC)*(ADSOP(NC)-GAMA(NC))
      DCADS(I,J,KC)=(ADSOP(NC)-CADS(I,J,KC))/DELT
      CADS(I,J,KC)=ADSOP(NC)
C
 50   CONTINUE
100   CONTINUE
      RETURN
      END
C
```

```
C ----------------------------------------------------------------------
      SUBROUTINE DELTMUW
C ***** Calculate Water Viscosity Increase at the Presence of Gel/Polymer ****
      INCLUDE 'PARAGEL.FOR'
      REAL KX,KY,KZ,KROT,KRWT,KRGT,MUOT,MUWT,MUGT,K1,K2,KRW1
      COMMON /NUMBER/ II,JJ,KK
      COMMON /GEL/ DDX,DDY,DDZ,K1,K2,NRX,C(NX,NY,NZC),
     & UX(NX,NY,NZ),UY(NX,NY,NZ),UZ(NX,NY,NZ),MAPWI(NX,NY,NZ),
     & CQI(NW,5),MORDER,FIPV(NZ,5),UW(NX,NY,NZ),UE(NX,NY,NZ),
     & US(NX,NY,NZ),UN(NX,NY,NZ),UT(NX,NY,NZ),UB(NX,NY,NZ)
      COMMON /VIS/ ALPHA1,ALPHA2,ALPHA3,BETA1,BETA2,BETA3,CGC,
     & DTMUW(NX,NY,NZ)
      COMMON /SPVT/ SAT(NTE),KROT(NTE),KRWT(NTE),KRGT(NTE),PCOWT(NTE),
     & PCGOT(NTE),POT(NTE),MUOT(NTE),BOT(NTE),BOPT(NTE),RSOT(NTE),RSOPT
     & (NTE),PWT(NTE),MUWT(NTE),BWT(NTE),BWPT(NTE),RSWT(NTE),RSWPT(NTE),
     & PGT(NTE),MUGT(NTE),BGT(NTE),BGPT(NTE),CRT(NTE)
      COMMON /ADSORB/ AA(5),BB(5),CL(5),GAMA(5),RF(NX,NY,NZ),
     & RFT,CADS(NX,NY,NZC),DCADS(NX,NY,NZC)
      COMMON /BUBBLE/ PBO,VSLOPE,BSLOPE,RSLOPE,PMAXT,IREPRS,RHOROCK,
     & RHOSCO,RHOSCG,RHOSCW,MSAT,MPOT,MPWT,MPGT,PBOT(NX,NY,NZ)
      COMMON /PORE/ VP(NX,NY,NZ),POR(NX,NY,NZ),PV
      COMMON /SARRAY/ PN(NX,NY,NZ),
     & SON(NX,NY,NZ),SWN(NX,NY,NZ),SGN(NX,NY,NZ),
     & SO1(NX,NY,NZ),SW1(NX,NY,NZ),SG1(NX,NY,NZ),
     & A1(NX,NY,NZ),A2(NX,NY,NZ),A3(NX,NY,NZ),
     & SUM(NX,NY,NZ),GAM(NX,NY,NZ),QS(NX,NY,NZ)
      COMMON /TIMESTEP/ NTS
      COMMON /PERM/ KX(NX,NY,NZ),KY(NX,NY,NZ),KZ(NX,NY,NZ)
      COMMON /SHEAR/GAMMA0,GAMMA1,GAMMA2,GAMMA3,SHEARA,SHEARB
      COMMON /PRTS/ SO(NX,NY,NZ),SW(NX,NY,NZ),SG(NX,NY,NZ),
     & SWINI(NX,NY,NZ)
C
      DO 100 K=1,KK
      DO 100 J=1,JJ
      DO 100 I=1,II
      IF(C(I,J,K+3*KK).LE.0.0001) GO TO 60
      DTMUP0=ALPHA1*C(I,J,K+3*KK)+ALPHA2*C(I,J,K+3*KK)**2+ALPHA3
     &  *C(I,J,K+3*KK)**3
      ETERP=GAMMA0+GAMMA1*C(I,J,K+3*KK)+GAMMA2*C(I,J,K+3*KK)**2+
     &  GAMMA3*C(I,J,K+3*KK)**3
      SHALF=SHEARA*C(I,J,K+3*KK)**SHEARB
      UWABS=(UX(I,J,K)*UX(I,J,K)+UY(I,J,K)*UY(I,J,K)+UZ(I,J,K)*
     &  UZ(I,J,K))**0.5
      IF(UWABS.EQ.0.) GO TO 40
      BARK1=(UX(I,J,K)/UWABS)**2/KX(I,J,K)/RF(I,J,K)+
     &  (UY(I,J,K)/UWABS)**2/KY(I,J,K)/RF(I,J,K)
      IF(BARK1.LE.1E-10) GO TO 40
      BARK=1./BARK1
      SSW1=SW(I,J,K)
      CALL INTERP(SAT,KRWT,MSAT,SSW1,KRW1)
      IF(KRW1.LE.0.0)GO TO 40
      SHRATE=268.4*UWABS*(POR(I,J,K)*SSW1/BARK/KRW1)
     &  **0.5
      GO TO 50
40    SHRATE=0.0
50    DTMUP=DTMUP0/(1+(SHRATE/SHALF)**(ETERP-1))
      GO TO 70
60    DTMUP=0.
70    IF(C(I,J,K+4*KK).LE.0.) C(I,J,K+4*KK)=0.
      DTMUW(I,J,K)=DTMUP+BETA1*C(I,J,K+4*KK)+BETA2*C(I,J,K+4*KK)**2
      IF(C(I,J,K+4*KK).GT.CGC)DTMUW(I,J,K)=
     & DTMUW(I,J,K)+BETA3*(C(I,J,K+4*KK)-CGC)**3
100   CONTINUE
      RETURN
```

```
      END
```

Source Code Of PARAGEL.FOR

```
C   NIPER'S 3-DIMENSIONAL, 3-PHASE PERMEABILITY MODIFICATION SIMULATOR
C
C    NX = NO. OF GRID BLOCKS IN X-DIRECTION
C    NY = NO. OF GRID BLOCKS IN Y-DIRECTION
C    NZ = NO. OF GRID BLOCKS IN Z-DIRECTION
C    NTE = MAX NO. OF PVT TABLE ENTRIES
C    NW = MAX NO. OF WELLS
C    NUM = MAX NO. OF OUTPUT (E.G. SATN.) MAP FILES
C    NL = MAX NO. OF COMPLETED GRID BLOCKS OF HORIZONTAL/SLANTED WELL
C    NZC = # OF CHEM. COMPONENTS IN WATER IS LIMITED TO 5 HERE
C    NORDER = # OF ORDER OF SPACE APPROXIMATION IN CENTRAL DIFFERENCE
C      EXPANSION IS LIMITED TO 5 HERE

      PARAMETER(NX=10,NY=10,NZ=2,NTE=40,NW=15,NUM=40,NL=50,
     & NXP=NX+1,NYP=NY+1,NZP=NZ+1,NZC=NZ*5,NORDER=5,
     & MAX=NX*NY*NZ,NXPYZ=NXP*NY*NZ,NXYPZ=NX*NYP*NZ,NXYZP=NX*NY*NZP,
     & NWZ=NW*NL)
```

APPENDIX B. BATCH FILE "RUNGEL.BAT" FOR MULTIPLE SIMULATION RUNS

```
@echo off
echo ------------------------------
echo PCGEL Multiple Run Program for
echo NIPER's PC-Based Permeability
echo Modification Simulator
echo August 1993 ------------------
@echo off
rem ------------------------------------------------------------------
rem NOTE: default directory setting is the default directory
rem that contains the pcgel.exe files. This directory
rem must also contain the following rungel.bat support files:
rem
rem text1.txt          All of these files
rem text2.txt          are necessary for the
rem text3.txt          generation of the dataname.log
rem text4.txt          Timestamp file.
rem  text5.txt
rem  change.txt
rem  change1.txt
rem  showprg.bat
rem  expshow.bat
rem  time.stp
rem  edsttm.exe
rem  edentm.exe
rem  edstda.exe
rem  edenda.exe
rem ----------------------------------------
rem default directory setting is the default directory for
rem the pcgel.exe file and the subprograms used by rungel.bat.
rem
rem default1 directory setting is the default directory setting
rem for the output of the PCGEL simulations.
rem
rem default2 directory setting is the directory that the
rem rungel.bat file ---this program--- will return to on
rem a syntax error.
rem
rem ---In order to keep your directory clean--- have a copy of
rem this program, rungel.bat--- in a higher directory by itself. That
rem must be specified in default2. Syntax for default2 is the same
rem as before. Starting with the root directory, give the path.
rem
rem set directory of pcgel.exe files
set default=rungel\runfiles

rem set directory to use as input
set default3=rungel\data1

rem set directory to receive the output of the PCGEL simulator
set default1=rungel\output1

rem set directory for this file--rungel.bat--to return to on syntax error
set default2=rungel

rem set starprg to the name of the pcgel.exe file
set starprg=pcgel.exe
rem  ..................
rem
set forsrce=rungel\forsrce
set runfiles=rungel\runfiles
```

```
set data1=rungel\data1
set data2=rungel\data2
set data3=rungel\data3

set output1=rungel\output1
set output2=rungel\output2
set output3=rungel\output3

rem ----------------------------------------------------------------
rem This program is to send multiple input files to the PCGEL simulator
rem so that the simulator can be given many data sets to process
rem automatically (perhaps overnight) and store the results in a
rem separate directory for later analysis.

rem The command sequence to initiate the PCGEL simulator is
rem
rem rungel # dataname1 dataname2 dataname3....path1 path2
rem
rem The name of the batch file- 'rungel' occupies parameter %0.
rem #, the number of datasets, occupies parameter %1
rem Parameters %2 through %7 may be taken by dataset filenames.
rem Parameters %8 and %9 are taken by the two path specifications.
rem
rem However, if only a few datasets are to be run, then the parameter
rem for the output path specification (path2) will be in a parameter
rem other than %9.
rem ----------------------------------------------------------------

if not "%1"=="transfer" goto notrans
cls
rem
rem

%4:
cd\%default%
cls
type cptmsg.txt
if "%default2%"=="root" cd\
if not "%default2%"=="root" cd\%default2%
pause
cls

echo Creating subdirectories in the target directory
echo ..
echo ..

rem create subdirectories in target drive and directory

%3:
cd\%2
md forsrce
md runfiles
md data1
md data2
md data3
md output1
md output2
md output3

rem reset to current drive
%4:
echo Transferring %starprg%, rungel.bat and support files
echo to directory %3:\%2\runfiles
echo ..
```

```
echo ..
rem reset to default directory
cd\%default%
if exist text1.txt copy text1.txt %3:\%2\runfiles
if exist text2.txt copy text2.txt %3:\%2\runfiles
if exist text3.txt copy text3.txt %3:\%2\runfiles
if exist text4.txt copy text4.txt %3:\%2\runfiles
if exist text5.txt copy text5.txt %3:\%2\runfiles
if exist cptmsg.txt copy cptmsg.txt %3:\%2\runfiles
if exist change.txt copy change.txt %3:\%2\runfiles
if exist change1.txt copy change1.txt %3:\%2\runfiles
if exist edsttm.exe copy edsttm.exe %3:\%2\runfiles
if exist edentm.exe copy edentm.exe %3:\%2\runfiles
if exist edstda.exe copy edstda.exe %3:\%2\runfiles
if exist edenda.exe copy edenda.exe %3:\%2\runfiles
if exist showprg.bat copy showprg.bat %3:\%2\runfiles
if exist expshow.bat copy expshow.bat %3:\%2\runfiles
if exist time.stp copy time.stp %3:\%2\runfiles
copy %starprg% %3:\%2\runfiles
if exist readme.bat copy readme.bat %3:\%2\runfiles
if exist rungel.bat copy rungel.bat %3:\%2
if exist rungel.bat copy rungel.bat %3:\%2\runfiles


if "%forsrce%"=="root" cd\
if not "%forsrce%"=="root" cd\%forsrce%

echo Transferring .for and .obj files
echo in %4:\%forsrce% to %3:\%2\forsrce
if exist *.for copy *.for %3:\%2\forsrce
if exist *.obj copy *.obj %3:\%2\forsrce

if not exist *.for goto nodfc
if "%5"=="dfn" goto nodfc
if not "%5"=="dft" if not "%5"=="dfs" goto dfs
if not "%5"=="dft" goto dfs

:dft
%3:
cd\%2\forsrce
if exist *.for erase *.for
if exist *.obj erase *.obj
if exist *.sld erase *.sld
goto nodfc

if not "%5"=="dfs" goto nodfc
:dfs
%4:
cd\%forsrce%
if exist *.for erase *.for
if exist *.obj erase *.obj
if exist *.sld erase *.sld
:nodfc

if "%output1%"=="root" cd\
if not "%output1%"=="root" cd\%output1%
echo Transferring old output data in %4:\%output1% to
echo %3:\%2\output1
if exist *.* copy *.* %3:\%2\output1

if "%output2%"=="root" cd\
if not "%output2%"=="root" cd\%output2%
echo Transferring old output data in %4:\%output2% to
echo %3:\%2\output2
```

```
if exist *.* copy *.* %3:\%2\output2

if "%output3%"=="root" cd\
if not "%output3%"=="root" cd\%output3%
echo Transferring old output data in %4:\%output3% to
echo %3:\%2\output3
if exist *.* copy *.* %3:\%2\output3

rem reset to data1 directory
%4:
cd\%data1%
echo ..
echo ..
echo Transferring all data files in data directories
echo %data1%, %data2%, %data3%.
if exist *.dat copy *.dat %3:\%2\data1
cd\%data2%
if exist *.dat copy *.dat %3:\%2\data2
cd\%data3%
if exist *.dat copy *.dat %3:\%2\data3
echo ..
echo ..
echo All data files in directories %data1%, %data2%, and %data3%
echo have been transferred.
rem
echo ..
echo ..
echo File %starprg%, rungel.bat and all rungel.bat support files
echo have been transferred to directory %2
echo or to a subdirectory thereof.
echo ..
echo ..
echo If you are planning to relocate the default directory to
echo %3:\%2\runfiles, then remember to change
echo the value of default to %2\runfiles
echo in the file rungel.bat located
echo in directory %2.
echo ..
echo ..
cd\
goto terminate
:notrans

rem ----------------------------------------------------------------
rem  The following module determines if %2 is null. If it is, then
rem either the dataset name has been left off, or the # of datasets
rem has been omitted. So the batchfile responds with an error message
rem and instructions for its use.
rem ----------------------------------------------------------------
rem

if not "%2"==""  goto noerror

:syntax
rem  reset current directory to default2

if "%default2%"=="root" cd\
if not "%default2%"=="root" cd\%default2%
cls
rem ----------------------------------------------------------------
echo The proper syntax to run PCGEL is
echo rungel # dataname1 dataname2...path1 (optional) path2 (optional)
echo ----------------------------------------------------------------
echo where rungel is the name of the boot program
```

```
echo ..
echo # is the total number of datasets (6 max),
echo ..
echo and dataname1, etc. is the name of the data
echo EXCLUDING the extension .dat
echo ..
echo Path1 specifies the directory of the datasets
echo beginning from the root directory. If unspecified,
echo it assumes the default directory %default3%.
echo ..
echo Path2 is the directory to send the output to.
echo Default for Path2 is %default1%.
echo ----------------------------------------------------------------
echo For example, to run data sttst09.dat, type
echo rungel 1 sttst09
echo ----------------------------------------------------------------
echo Or, to run datasets sttst09.dat and sttst01.dat, type
echo rungel 2 sttst09 sttst01
echo ----------------------------------------------------------------
pause
cls
echo ----------------------------------------------------------
echo The syntax for the path1 option is (as an example)
echo rungel 2 sttst09 sttst01 %default3%
echo Path2 has the same form. Specify path beginning from
echo the root directory. Syntax for path2 option is
echo rungel 2 sttst09 sttst01 %default3% %default1%
echo ----------------------------------------------------------
echo If you do not like the current default directory for
echo the datafiles, it may be changed by changing the
echo variable default3 in the file rungel.bat.
echo ----------------------------------------------------------
echo Similarly, if you wish to change the default output
echo directory, change the variable default1 in the file
echo rungel.bat.
echo ----------------------------------------------------------
echo ..
echo ..
echo ..
pause
cls
echo ----------------------------------------------------------------
echo In order to transfer the files %starprg%, rungel.bat and all
echo rungel.bat support files from the default directory to
echo another directory of your choice, issue the alternate syntax
echo rungel transfer path targetdrive sourcedrive dfs/dft/dfn (optional)
echo ..
echo ..
echo dfs - delete fortran in source directory
echo dft - delete fortran in target directory
echo dfn - delete fortran in neither directory
echo ..
echo ..
echo Default is dfs. This is done to accomodate any
echo copyright restrictions on the fortran sourcecode.
echo The syntax for the path is the same as before.
echo ----------------------------------------------------------------
echo ..
echo ..
echo ..
pause
cls
echo ----------------------------------------------------------------
echo The transfer command may also be used to perform the initial
```

```
echo installation from the floppy drive to the hard drive.
echo ..
echo For example, to copy from a default directory on drive b
echo to a new subdirectory (gelsim) on a hard drive,
echo such as the directory c:\dos\f7713\gelsim,
echo go to the directory on drive b containing rungel.bat and type
echo rungel transfer dos\f7713\gelsim c b dfn
echo ..
echo The directories forsrce,runfiles,data1,data2,data3,output1
echo output2, and output3 would be created as subdirectories of
echo  c:\dos\f7713\gelsim
echo ..
echo ..
echo The batch file rungel.bat in subdirectory c:\dos\f7713\gelsim
echo would have to be modified to address the new directory on drive c.
echo ------------------------------------------------------------------
echo ..
echo ..
echo ..
pause
cls
echo ----------------------------------------------------------
echo For the previous example, the batch file
echo rungel.bat would need to be edited as follows:
echo ..
echo (line 72):    set default=dos\f7713\gelsim\runfiles
echo (line 76):    set default3=dos\f7713\gelsim\data1
echo (line 79):    set default1=dos\f7713\gelsim\output1
echo (line 83):    set default2=dos\f7713\gelsim
echo ..
echo (line 112):   set forsrce=dos\f7713\gelsim\forsrce
echo (line 115):   set runfiles=dos\f7713\gelsim\runfiles
echo ..
echo (line 119):   set data1=dos\f7713\gelsim\data1
echo (line 120):   set data2=dos\f7713\gelsim\data2
echo (line 121):   set data3=dos\f7713\gelsim\data3
echo ..
echo (line 124):   set output1=dos\f7713\gelsim\output1
echo (line 125):   set output2=dos\f7713\gelsim\output2
echo (line 126):   set output3=dos\f7713\gelsim\output3
echo ----------------------------------------------------------
echo ..
echo ..
echo ..
pause
cls
echo ----------------------------------------------------------
echo If you relocate the files %starprg%, rungel.bat, all the
echo rungel.bat support files, and/or datafiles to another
echo directory, you will have to change the value of the variable
echo default in the file rungel.bat to point to the new directory.
echo In addition, you should change the other default values and
echo reset the links to the PCGEL support directories. For more
echo information, see documentation in file rungel.bat.
echo ----------------------------------------------------------
echo ..
echo ..
echo ..
pause
echo ..
echo ..
echo ..
rem
rem after displaying error routine, go to end of batchfile.
```

```
rem
goto terminate

:noerror

rem ------------------------------------------------------------------
rem If %2 is not null, then syntax is o.k. (hopefully), so initialize.
rem Turn off echo and clear the screen.
@echo off
cls
rem ------------------------------------------------------------------
rem This module goes to the proper directory to locate datafiles.
rem It determines where the path1 specification is in the command
rem line, and attempts to access the path. If the path has been
rem ommitted from the user's instruction, then the module does
rem nothing.
rem In any case, it assumes the datafiles are located
rem somewhere on the currently active drive.
rem ------------------------------------------------------------------
rem set directory to default data directory initially
rem

cd\%default3%

rem now check to see if user has entered a specific data directory. If so,
rem then check to see if the data directory is valid.
if "%1"=="1" if not "%3"=="" if exist \%3\nul cd\%3
if "%1"=="1" if not "%3"=="" if not exist \%3\nul echo Directory %3 does not exist.
if "%1"=="1" if not "%3"=="" if not exist \%3\nul pause
if "%1"=="1" if not "%3"=="" if not exist \%3\nul goto syntax

if "%1"=="1" if not "%4"=="" if not exist \%4\nul echo Directory %4 does not exist.
if "%1"=="1" if not "%4"=="" if not exist \%4\nul pause
if "%1"=="1" if not "%4"=="" if not exist \%4\nul goto syntax

rem ------------------------------------------------------------------
if "%1"=="2" if not "%4"=="" if exist \%4\nul cd\%4
if "%1"=="2" if not "%4"=="" if not exist \%4\nul echo Directory %4 does not exist.
if "%1"=="2" if not "%4"=="" if not exist \%4\nul pause
if "%1"=="2" if not "%4"=="" if not exist \%4\nul goto syntax

if "%1"=="2" if not "%5"=="" if not exist \%5\nul echo Directory %5 does not exist.
if "%1"=="2" if not "%5"=="" if not exist \%5\nul pause
if "%1"=="2" if not "%5"=="" if not exist \%5\nul goto syntax

rem ------------------------------------------------------------------
if "%1"=="3" if not "%5"=="" if exist \%5\nul cd\%5
if "%1"=="3" if not "%5"=="" if not exist \%5\nul echo Directory %5 does not exist.
if "%1"=="3" if not "%5"=="" if not exist \%5\nul pause
if "%1"=="3" if not "%5"=="" if not exist \%5\nul goto syntax

if "%1"=="3" if not "%6"=="" if not exist \%6\nul echo Directory %6 does not exist.
if "%1"=="3" if not "%6"=="" if not exist \%6\nul pause
if "%1"=="3" if not "%6"=="" if not exist \%6\nul goto syntax

rem ------------------------------------------------------------------
if "%1"=="4" if not "%6"=="" if exist \%6\nul cd\%6
if "%1"=="4" if not "%6"=="" if not exist \%6\nul echo Directory %6 does not exist.
if "%1"=="4" if not "%6"=="" if not exist \%6\nul pause
if "%1"=="4" if not "%6"=="" if not exist \%6\nul goto syntax

if "%1"=="4" if not "%7"=="" if not exist \%7\nul echo Directory %7 does not exist.
if "%1"=="4" if not "%7"=="" if not exist \%7\nul pause
if "%1"=="4" if not "%7"=="" if not exist \%7\nul goto syntax
```

```
rem ----------------------------------------------------------------
if "%1"=="5" if not "%7"=="" if exist \%7\nul cd\%7
if "%1"=="5" if not "%7"=="" if not exist \%7\nul echo Directory %7 does not exist.
if "%1"=="5" if not "%7"=="" if not exist \%7\nul pause
if "%1"=="5" if not "%7"=="" if not exist \%7\nul goto syntax

if "%1"=="5" if not "%8"=="" if not exist \%8\nul echo Directory %8 does not exist.
if "%1"=="5" if not "%8"=="" if not exist \%8\nul pause
if "%1"=="5" if not "%8"=="" if not exist \%8\nul goto syntax

rem ----------------------------------------------------------------
if "%1"=="6" if not "%8"=="" if exist \%8\nul cd\%8
if "%1"=="6" if not "%8"=="" if not exist \%8\nul echo Directory %8 does not exist.
if "%1"=="6" if not "%8"=="" if not exist \%8\nul pause
if "%1"=="6" if not "%8"=="" if not exist \%8\nul goto syntax

if "%1"=="6" if not "%9"=="" if not exist \%9\nul echo Directory %9 does not exist.
if "%1"=="6" if not "%9"=="" if not exist \%9\nul pause
if "%1"=="6" if not "%9"=="" if not exist \%9\nul goto syntax

rem ----------------------------------------------------------------
rem now in data directory
set usedef=0
set usedef1=0

if "%1"=="1" if not "%3"=="" if not exist *.dat echo Data files not in directory %3.
if "%1"=="2" if not "%4"=="" if not exist *.dat echo Data files not in directory %4.
if "%1"=="3" if not "%5"=="" if not exist *.dat echo Data files not in directory %5.
if "%1"=="4" if not "%6"=="" if not exist *.dat echo Data files not in directory %6.
if "%1"=="5" if not "%7"=="" if not exist *.dat echo Data files not in directory %7.
if "%1"=="6" if not "%8"=="" if not exist *.dat echo Data files not in directory %8.

if not exist *.dat echo Will now attempt to access the default
if not exist *.dat echo directory %default3%.
if not exist *.dat echo --
if not exist *.dat echo --
if not exist *.dat echo Press Ctrl+ Break  or  Ctrl+ C
if not exist *.dat echo to terminate batch file or
if not exist *.dat pause
if not exist *.dat echo Accessing default data directory %default3%.
if not exist *.dat set usedef=1
if not exist *.dat cd\%default3%

rem ----------------------------------------------------------------
rem This program is integrated with the PCGEL simulator in the following
rem manner. Each dataset specified by the user is, one at a time, copied
rem to the filename input.dat, the default input file for the PCGEL
rem simulator. The output of the simulator is in the form dataname1.out,
rem dataname2.out, dataname3.out, datanameN.out...
rem
rem After the output files have been created, they are recopied
rem to the proper output directory.
rem
rem
rem ----------------------------------------------------------------
@cls
@echo off
rem ----------------------------------------------------------------
rem
set one=1

set two=2
```

```
set three=3

set four=4

set five=5

set six=6
rem
rem NOTE: this program does use a counter, the environmental
rem variable %count%, to determine which dataset name should
rem currently be used to rename the pcgel.etc files.
rem
rem ----------------------------------------------------------------
rem Based on %1 (# of datasets), insert 0's in stack ----------------
rem ----------------------------------------------------------------
rem

:first
if not "%1"=="1" goto second
set one=0
goto begin

:second
if not "%1"=="2" goto third
set one=0
set two=0
goto begin

:third
if not "%1"=="3" goto fourth
set one=0
set two=0
set three=0
goto begin

:fourth
if not "%1"=="4" goto fifth
set one=0
set two=0
set three=0
set four=0
goto begin

:fifth
if not "%1"=="5" goto sixth
set one=0
set two=0
set three=0
set four=0
set five=0
goto begin

:sixth
if not "%1"=="6" set one=0
if not "%1"=="6" goto begin
set one=0
set two=0
set three=0
set four=0
set five=0
set six=0
goto begin
```

```
rem ------------------------------------------------------------
rem loop command structure ----------------------------------------
rem ------------------------------------------------------------
rem

:begin

cd\%default%

if exist otnam.txt erase otnam.txt
if exist input.dat erase input.dat
if exist rungel.out erase rungel.out
if exist rungel.srf erase rungel.srf
if exist rungel.rep erase rungel.rep
if exist rungel.rst erase rungel.rst
if exist rungel.sum erase rungel.sum
if exist rungel.bak erase rungel.bak

cd\%default3%
if "%1"=="1" if not "%3"=="" if not "%usedef%"=="1" if exist \%3\nul cd\%3
if "%1"=="2" if not "%4"=="" if not "%usedef%"=="1" if exist \%4\nul cd\%4
if "%1"=="3" if not "%5"=="" if not "%usedef%"=="1" if exist \%5\nul cd\%5
if "%1"=="4" if not "%6"=="" if not "%usedef%"=="1" if exist \%6\nul cd\%6
if "%1"=="5" if not "%7"=="" if not "%usedef%"=="1" if exist \%7\nul cd\%7
if "%1"=="6" if not "%8"=="" if not "%usedef%"=="1" if exist \%8\nul cd\%8

:aa
if "%one%"=="1" goto bb
set count=1
goto keepon

:bb
if "%two%"=="2" goto cc
set count=2
goto keepon

:cc
if "%three%"=="3" goto dd
set count=3
goto keepon

:dd
if "%four%"=="4" goto ee
set count=4
goto keepon

:ee
if "%five%"=="5" goto ff
set count=5
goto keepon

:ff
if "%six%"=="6" goto start
set count=6
goto keepon

rem ------------------------------------------------------------
rem end of loop command structure, but NOT the end of the loop -------
rem ------------------------------------------------------------
rem
rem
rem ------------------------------------------------------------
rem keep on doing the loop ----------------------------------------
rem ------------------------------------------------------------
```

```
rem

:keepon
@echo off
cls
rem ----------------------------------------------------------------
rem using a counter, determine which dataset to copy as input.dat ---
rem ----------------------------------------------------------------
rem

if "%count%"=="1" copy %2.dat input.dat
if "%count%"=="1" cls

if "%count%"=="2" copy %3.dat input.dat
if "%count%"=="2" cls

if "%count%"=="3" copy %4.dat input.dat
if "%count%"=="3" cls

if "%count%"=="4" copy %5.dat input.dat
if "%count%"=="4" cls

if "%count%"=="5" copy %6.dat input.dat
if "%count%"=="5" cls

if "%count%"=="6" copy %7.dat input.dat
if "%count%"=="6" cls

copy input.dat \%default%
cls
erase input.dat
cls
echo ------------------------------
echo PCGEL Multiple Run Program for
echo NIPER's PC-Based Permeability
echo Modification Simulator
echo August 1993 ------------------
echo ..
echo ..
if "%count%"=="1" echo Inserting file %2.dat for input.
if "%count%"=="2" echo Inserting file %3.dat for input.
if "%count%"=="3" echo Inserting file %4.dat for input.
if "%count%"=="4" echo Inserting file %5.dat for input.
if "%count%"=="5" echo Inserting file %6.dat for input.
if "%count%"=="6" echo Inserting file %7.dat for input.
echo ..
echo ..
echo ..
echo There are %1 total input files to process.
echo ..
echo ..
echo ..
if "%count%"=="1" echo This file, %2.dat, is the first input file.
if "%count%"=="2" echo This file, %3.dat, is the second input file.
if "%count%"=="3" echo This file, %4.dat, is the third input file.
if "%count%"=="4" echo This file, %5.dat, is the fourth input file.
if "%count%"=="5" echo This file, %6.dat, is the fifth input file.
if "%count%"=="6" echo This file, %7.dat, is the sixth input file.
echo ..
echo ..
echo ..
echo The PCGEL Permeability Modification Simulator is executing...
echo ..
echo ..
```

```
echo ..
echo Please leave this computer on, a program is running.

rem now goto runfiles directory
cd\%default%
rem
rem ----------------------------------------------------------------
rem put starttime in file time.txt
rem put startdate in file dte.txt
rem put contents of time.stp in as dummy input for time
rem put contents of time.stp in as dummy input for date
rem ----------------------------------------------------------------
rem

time < time.stp> time.txt
date < time.stp> dte.txt


rem ----------------------install pcgel----------------------------
%starprg%


rem ----------------------------------------------------------------
rem put endtime in file time1.txt
rem put enddate in file dte1.txt
rem ----------------------------------------------------------------

time < time.stp> time1.txt
date < time.stp> dte1.txt

echo ------------------------------------
echo The PCGEL simulator has terminated.
echo ------------------------------------

rem
rem ----------------------------------------------------------------
rem using a counter, determine what to rename the pcgel.etc files ---
rem the files are renamed while still in the runfiles directory   ---
rem ----------------------------------------------------------------
rem



rem
rem ----------------------------------------------------------------
rem send dataname to output file generated by showprg.bat and
rem send starprg to output file generated by showprg1.bat for
rem later use in the timestamp.
rem ----------------------------------------------------------------

if "%count%"=="1" call showprg %2
if "%count%"=="2" call showprg %3
if "%count%"=="3" call showprg %4
if "%count%"=="4" call showprg %5
if "%count%"=="5" call showprg %6
if "%count%"=="6" call showprg %7

call expshow %starprg%


rem
rem ----------------------------------------------------------------
rem modify time.txt and time1.txt and dte.txt and dte1.txt to one line
rem and combine them into one file
```

```
rem named msg.txt and erase original time files
rem ----------------------------------------------------------------
cls
@echo off
rem makstp.bat
cls
erase msg.txt

ren time.txt msg.txt
edsttm
erase msg.txt
ren nmsg.txt time.txt

cls
ren time1.txt msg.txt
edentm
erase msg.txt
ren nmsg.txt time1.txt

cls
ren dte.txt msg.txt
edstda
erase msg.txt
ren nmsg.txt dte.txt

cls
ren dte1.txt msg.txt
edenda
erase msg.txt
ren nmsg.txt dte1.txt

cls
echo off

rem combine subfiles into one single timestamp file named msg.txt

cls
copy text3.txt+text5.txt+dataname.txt+otnam.txt+expname.txt+text3.txt nsg.txt
cls
copy dte.txt+text1.txt+time.txt+text2.txt+time1.txt nsg1.txt
cls
copy text4.txt+dte1.txt+text3.txt nsg2.txt
cls
copy nsg.txt + nsg1.txt + nsg2.txt msg.txt
cls

if exist time.txt erase time.txt
if exist time1.txt erase time1.txt
if exist dte.txt erase dte.txt
if exist dte1.txt erase dte1.txt
if exist dataname.txt erase dataname.txt
if exist expname.txt erase expname.txt
if exist nsg.txt erase nsg.txt
if exist nsg1.txt erase nsg1.txt
if exist nsg2.txt erase nsg2.txt
cls

type msg.txt
rem
echo off

rem
rem ----------------------------------------------------------------
rem rename the time stamp file (msg.txt) to datafile.log
```

```
rem ------------------------------------------------------------
rem

:start
:one
if "%one%"=="1" goto two
copy msg.txt %2.log
set one=1
goto endit

:two
if "%two%"=="2" goto three
copy msg.txt %3.log
set two=2
goto endit

:three
if "%three%"=="3" goto four
copy msg.txt %4.log
set three=3
goto endit

:four
if "%four%"=="4" goto five
copy msg.txt %5.log
set four=4
goto endit

:five
if "%five%"=="5" goto six
copy msg.txt %6.log
set five=5
goto endit

rem
rem ------------------------------------------------------------
rem this is where the main loop checks to see if the stack is full
rem control goes to sendital if the loop is done
rem ------------------------------------------------------------
rem

:six
if "%six%"=="6" goto sendital
copy msg.txt %7.log
set six=6
goto endit

:endit

rem
rem ------------------------------------------------------------
rem now go back to the beginning of the loop -------------------------
rem ------------------------------------------------------------
rem


goto begin

rem
rem ------------------------------------------------------------
rem The loop is completed. All input files have been processed -------
rem ------------------------------------------------------------
rem
```

```
:sendital
rem reset to the runfiles directory
cd\%default%
rem
rem
rem ----------------------------------------------------------------
rem Send data output to the proper directory based on the number of
rem datasets (%1) and the number of the paramater containing path2.
rem
rem If user has left off the path2 specification, use default data
rem directory.
rem ----------------------------------------------------------------

:xa
if not "%1"=="1" goto xb
if not "%4"=="" goto xb

if exist *.out copy *.out \%default1%
if exist *.out erase *.out
if exist *.log copy *.log \%default1%
if exist *.log erase *.log

:xb
if not "%1"=="2" goto xc
if not "%5"=="" goto xc

if exist *.out copy *.out \%default1%
if exist *.out erase *.out
if exist *.log copy *.log \%default1%
if exist *.log erase *.log


:xc
if not "%1"=="3" goto xd
if not "%6"=="" goto xd

if exist *.out copy *.out \%default1%
if exist *.out erase *.out
if exist *.log copy *.log \%default1%
if exist *.log erase *.log

:xd
if not "%1"=="4" goto xe
if not "%7"=="" goto xe

if exist *.out copy *.out \%default1%
if exist *.out erase *.out
if exist *.log copy *.log \%default1%
if exist *.log erase *.log

:xe
if not "%1"=="5" goto xf
if not "%8"=="" goto xf

if exist *.out copy *.out \%default1%
if exist *.out erase *.out
if exist *.log copy *.log \%default1%
if exist *.log erase *.log
:xf
if not "%1"=="6" goto xg
if not "%9"=="" goto xg

if exist *.out copy *.out \%default1%
if exist *.out erase *.out
```

```
if exist *.log copy *.log \%default1%
if exist *.log erase *.log
:xg

:vba
if not "%1"=="1" goto vbb
if "%4"=="" goto vbb

if exist *.out copy *.out \%4
if exist *.out erase *.out
if exist *.log copy *.log \%4
if exist *.log erase *.log

:vbb
if not "%1"=="2" goto vbc
if "%5"=="" goto vbc

if exist *.out copy *.out \%5
if exist *.out erase *.out
if exist *.log copy *.log \%5
if exist *.log erase *.log

:vbc
if not "%1"=="3" goto vbd
if "%6"=="" goto vbd

if exist *.out copy *.out \%6
if exist *.out erase *.out
if exist *.log copy *.log \%6
if exist *.log erase *.log

:vbd
if not "%1"=="4" goto vbe
if "%7"=="" goto vbe

if exist *.out copy *.out \%7
if exist *.out erase *.out
if exist *.log copy *.log \%7
if exist *.log erase *.log

:vbe
if not "%1"=="5" goto vbf
if "%8"=="" goto vbf

if exist *.out copy *.out \%8
if exist *.out erase *.out
if exist *.log copy *.log \%8
if exist *.log erase *.log

:vbf
if not "%1"=="6" goto vbg
if "%9"=="" goto vbg

if exist *.out copy *.out \%9
if exist *.out erase *.out
if exist *.log copy *.log \%9
if exist *.log erase *.log
:vbg
echo ..
echo ..
echo ..
rem ----------------------------------------------------------------
rem print the source and destination directories for the simulation
rem ----------------------------------------------------------------
```

```
rem
echo ..
echo ..
echo ..
rem
echo Using file %starprg% in directory %default%.
if "%usedef%"=="1" echo Using data in default data directory %default3%.

if "%1"=="1" if not "%3"=="" if not "%usedef%"=="1" echo Using data in directory %3.
if "%1"=="1" if not "%4"=="" if not "%usedef1%"=="1" echo Output is located in directory %4.
if "%1"=="1" if "%3"=="" echo Using data in default data directory %default3%.
if "%1"=="1" if "%4"=="" echo Output is located in default output directory %default1%.

if "%1"=="2" if not "%4"=="" if not "%usedef%"=="1" echo Using data in directory %4.
if "%1"=="2" if not "%5"=="" if not "%usedef1%"=="1" echo Output is located in directory %5.
if "%1"=="2" if "%4"=="" echo Using data in default data directory %default3%.
if "%1"=="2" if "%5"=="" echo Output is located in default output directory %default1%.

if "%1"=="3" if not "%5"=="" if not "%usedef%"=="1" echo Using data in directory %5.
if "%1"=="3" if not "%6"=="" if not "%usedef1%"=="1" echo Output is located in directory %6.
if "%1"=="3" if "%5"=="" echo Using data in default data directory %default3%.
if "%1"=="3" if "%6"=="" echo Output is located in default output directory %default1%.

if "%1"=="4" if not "%6"=="" if not "%usedef%"=="1" echo Using data in directory %6.
if "%1"=="4" if not "%7"=="" if not "%usedef1%"=="1" echo Output is located in directory %7.
if "%1"=="4" if "%6"=="" echo Using data in default data directory %default3%.
if "%1"=="4" if "%7"=="" echo Output is located in default output directory %default1%.

if "%1"=="5" if not "%7"=="" if not "%usedef%"=="1" echo Using data in directory %7.
if "%1"=="5" if not "%8"=="" if not "%usedef1%"=="1" echo Output is located in directory %8.
if "%1"=="5" if "%7"=="" echo Using data in default data directory %default3%.
if "%1"=="5" if "%8"=="" echo Output is located in default output directory %default1%.

if "%1"=="6" if not "%8"=="" if not "%usedef%"=="1" echo Using data in directory %8.
if "%1"=="6" if not "%9"=="" if not "%usedef1%"=="1" echo Output is located in directory %9.
if "%1"=="6" if "%8"=="" echo Using data in default data directory %default3%.
if "%1"=="6" if "%9"=="" echo Output is located in default output directory %default1%.

echo ..
echo ..
echo ..
:terminate

if "%default2%"=="root" cd\
if not "%default2%"=="root" cd\%default2%
```

APPENDIX C. SAMPLE PROBLEM 1

Input Data File (BWF5YR. DAT) for Sample Problem 1

```
WF5YR.OUT
RWF5YR.OUT
GWF5YR.OUT
W.F. ONLY -- 10*10*2, KZ/KH=.001 (5YRS),100-1000MD
 10  10  2
GEL (SWITCHES)
 0
GRID BLOCK LENGTHS
 -1  -1  0
 100.
 100.
 15.   15.
GRID BLOCK LENGTH MODIFICATIONS
  0  0  0  0
CAPROCK BASE DEPTHS TO TOP OF SAND
  0
  8000.
POROSITY AND PERMEABILITY DISTRIBUTIONS
 -1  0  0  0
 .20
 100.  1000.
 100.  1000.
 0.1    1.
POROSITY AND PERMEABILITY MODIFICATIONS
  0  0  0  0  0
TRANSMISSIBILITY MODIFICATIONS
  0  0  0  0
```

SAT	KRO	KRW	KRG	PCOW	PCGO
-0.10	0.	0.	0.	0.	0.
0.0	0.	0.	0.	0.	0.
0.02	0.	0.	0.	0.	0.
0.1	0.	0.	0.	0.	0.
0.2	0.	0.	0.	0.	0.
0.21	0.	0.	0.	0.	0.
0.22	0.	0.	0.	0.	0.
0.25	0.01014	0.0	0.	2.	0.
0.26	0.01355	0.000188	0.	1.975	0.
0.27	0.017099	0.000417	0.	1.951	0.
0.28	0.02083	0.001109	0.	1.9264	0.
0.29	0.02477483	0.002254	0.	1.902	0.
0.3	0.03	0.004	0.	1.877	0.
0.32	0.03815811	0.008301	0.	1.8283	0.
0.34	0.04852966	0.014426	0.	1.7792	0.
0.35	0.054178	0.02	0.	1.755	0.
0.37	0.066415	0.02662	0.	1.7057	0.
0.39	0.0799114	0.0367	0.	1.6566	0.
0.4	0.085	0.04	0.	1.632	0.
0.41	0.0946645	0.048312	0.	1.6075	0.
0.43	0.110683	0.06145	0.	1.5585	0.
0.45	0.128	0.076	0.	1.509	0.
0.46	0.137183	0.08403	0.	1.4849	0.
0.48	0.15666	0.101033	0.	1.4358	0.
0.5	0.18	0.12	0.	1.387	0.
0.525	0.207058	0.14521	0.	1.3255	0.
0.55	0.24	0.173492	0.	1.264	0.
0.575	0.27873	0.204637	0.	1.2028	0.
0.6	0.326	0.24	0.	1.142	0.
0.62	0.366631	0.268539	0.	1.0925	0.
0.65	0.438	0.31731	0.	1.019	0.
0.67	0.5077	0.352836	0.	0.9698	0.

```
0.7        0.63        0.41        0.     0.896        0.
0.73       0.77665     0.47573     0.     0.8226       0.
0.75       0.9         0.52275     0.     0.774        0.
0.78       0.9         0.6         0.     0.7          0.
1.0        0.9         0.6         0.     0.7          0.
1.1        0.9         0.6         0.     0.7          0.
 PBO   VSLOPE        BSLOPE   RSLOPE        PMAX   IREPRS
  10.   .000000      -.0000030    0.0   8000.    0
 P    MUO       BO       RSO
 14.7   3.0       1.00     0.0
 8000.0 3.0       1.00     0.0
 P    MUW       BW     RSW
 14.7    .80      1.0000   0.0
 8000.0   .80     1.00     0.0
 P    MUG   BG      CR
 14.7      .0107   0.0634    .0000040
8000.0    .0121   0.0202    .0000040
 RHOSCO  RHOSCW   RHOSCG      RHOROCK
  53.0            64.5        .0574            143.585
EQUILIBRIUM PRESSURE INITILIZATION/CONSTANT SATURATIONS
 0  0
 2511.   2400.    8000.    7000.
 .75      .25      .00
 KSN1 KSM1 KCO1  KTR KCOF
  0  0  0  0  0
 NMAX  FACT1 FACT2   TMAX   WORMAX   GORMAX   PAMIN  PAMAX
 200000    1.2       ..5       1825      0.0        500000.      0.       10000.
 KSOL MITR   OMEGA    TOL     TOL1    DSMAX   DPMAX
 2    3000    1.7        .1        0.      .03        30.
RECURRENT DATA
 40
1      1   0   0   0   0   0   0   0   0   363. 0
1.   0.01  1.  0.  0.  0.
RATES -- 1 WATER. INJ. WELL, 1 PROD. WELL (15 YRS)
 2  0  0
INJ
1      1   1   2   2  0   -535.0  0  0
0.25  0. 0.
0.25  0. 0.
PROD
10    10   1   2   1  0   0.  0  535.0
0.25  0. 0.
0.25  0. 0.
0    363   0   0   0   0   0   0   0   0      1. 0
1.   0.01 10.  0.  0.  0.
0      1   1   1   1   1   1   0   0   0      1. 0
1.   0.01  5.  0.  0.  0.
0    729   0   0   0   0   0   0   0   0      1. 0
1.   0.01 10.  0.  0.  0.
0      1   1   1   1   1   1   0   0   0   364. 0
1.   0.01  5.  0.  0.  0.
0    729   0   0   0   0   0   0   0   0      1. 0
1.   0.01  5.  0.  0.  0.
0      1   1   1   1   1   1   0   0   0   364. 0
1.   0.01  5.  0.  0.  0.
0    364   0   0   0   0   0   0   0   0   650. 0
1.   0.01  5.  0.  0.  0.
```

Part of Output File (BWF5YR.OUT) for Sample Problem 1

```
*****************************************************************
*                                                               *
*                                                               *
*                          NIPER:                               *
*        BLACK OIL PRIMARY AND SECONDARY RECOVERY MODEL         *
*            FOR PERMEABILITY MODIFICATION TREATMENT            *
*                        (VERSION 1.1)                          *
*                                                               *
*                                                               *
*****************************************************************


*******************************************************************************
*                                                                             *
*W.F. ONLY -- 10*10*2, KZ/KH=.001 (5YRS),100-1000MD                           *
*                                                                             *
*******************************************************************************


    GRID BLOCK LENGTH (DX) IS INITIALLY SET AT  100.0000 FOR ALL NODES


    GRID BLOCK WIDTH  (DY) IS INITIALLY SET AT  100.0000 FOR ALL NODES


    GRID SIZE (DZ) IN LAYER    1 IS INITIALLY SET AT   15.00 FOR ALL NODES

    GRID SIZE (DZ) IN LAYER    2 IS INITIALLY SET AT   15.00 FOR ALL NODES


     ********** NODE MIDPOINT ELEVATIONS **********

K = 1

  8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008.
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K = 2

8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
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POROSITY (PHI) IS INITIALLY SET AT 0.2000 FOR ALL NODES

PERMEABILITY (KX) IN LAYER 1 IS INITIALLY SET AT 100.00 FOR ALL NODES

PERMEABILITY (KX) IN LAYER 2 IS INITIALLY SET AT 1000.00 FOR ALL NODES

PERMEABILITY (KY) IN LAYER 1 IS INITIALLY SET AT 100.00 FOR ALL NODES

PERMEABILITY (KY) IN LAYER 2 IS INITIALLY SET AT 1000.00 FOR ALL NODES

PERMEABILITY (KZ) IN LAYER 1 IS INITIALLY SET AT 0.10 FOR ALL NODES

PERMEABILITY (KZ) IN LAYER 2 IS INITIALLY SET AT 1.00 FOR ALL NODES

***** EMPIRICAL DATA TABLE *****

SAT	KRO	KRW	KRG	PCOW	PCGO
-0.1000	0.0000	0.0000	0.0000	0.00	0.00
0.0000	0.0000	0.0000	0.0000	0.00	0.00
0.0200	0.0000	0.0000	0.0000	0.00	0.00
0.1000	0.0000	0.0000	0.0000	0.00	0.00
0.2000	0.0000	0.0000	0.0000	0.00	0.00
0.2100	0.0000	0.0000	0.0000	0.00	0.00
0.2200	0.0000	0.0000	0.0000	0.00	0.00
0.2500	0.0101	0.0000	0.0000	2.00	0.00
0.2600	0.0136	0.0002	0.0000	1.98	0.00
0.2700	0.0171	0.0004	0.0000	1.95	0.00
0.2800	0.0208	0.0011	0.0000	1.93	0.00

0.2900	0.0248	0.0023	0.0000	1.90	0.00
0.3000	0.0300	0.0040	0.0000	1.88	0.00
0.3200	0.0382	0.0083	0.0000	1.83	0.00
0.3400	0.0485	0.0144	0.0000	1.78	0.00
0.3500	0.0542	0.0200	0.0000	1.75	0.00
0.3700	0.0664	0.0266	0.0000	1.71	0.00
0.3900	0.0799	0.0367	0.0000	1.66	0.00
0.4000	0.0850	0.0400	0.0000	1.63	0.00
0.4100	0.0947	0.0483	0.0000	1.61	0.00
0.4300	0.1107	0.0615	0.0000	1.56	0.00
0.4500	0.1280	0.0760	0.0000	1.51	0.00
0.4600	0.1372	0.0840	0.0000	1.48	0.00
0.4800	0.1567	0.1010	0.0000	1.44	0.00
0.5000	0.1800	0.1200	0.0000	1.39	0.00
0.5250	0.2071	0.1452	0.0000	1.33	0.00
0.5500	0.2400	0.1735	0.0000	1.26	0.00
0.5750	0.2787	0.2046	0.0000	1.20	0.00
0.6000	0.3260	0.2400	0.0000	1.14	0.00
0.6200	0.3666	0.2685	0.0000	1.09	0.00
0.6500	0.4380	0.3173	0.0000	1.02	0.00
0.6700	0.5077	0.3528	0.0000	0.97	0.00
0.7000	0.6300	0.4100	0.0000	0.90	0.00
0.7300	0.7767	0.4757	0.0000	0.82	0.00
0.7500	0.9000	0.5228	0.0000	0.77	0.00
0.7800	0.9000	0.6000	0.0000	0.70	0.00
1.0000	0.9000	0.6000	0.0000	0.70	0.00
1.1000	0.9000	0.6000	0.0000	0.70	0.00

PBO	VSLOPE	BSLOPE	RSLOPE	PMAX	IREPRS
10.00	0.000E+00	-0.300E-05	0.00	8000.00	0

P	MUO	BO	RSO
14.7	3.0000	1.0000	0.00
8000.0	3.0000	1.0000	0.00

P	MUW	BW	RSW
14.7	0.8000	1.0000	0.00
8000.0	0.8000	1.0000	0.00

P	MUG	BG	CR
14.7	0.0107	0.634E-01	0.400E-05
8000.0	0.0121	0.202E-01	0.400E-05

RHOSCO	RHOSCW	RHOSCG	RHOROCK
53.0000	64.5000	0.0574	143.5850

***** SLOPES FOR COMPRESSIBILITY CALCULATIONS ****

P	BO	DBO/DP	RSO	DRSO/DP
8000.0	1.0000	0.0000E+00	0.0	0.0000E+00

P	BW	DBW/DP	RSW	DRSW/DP
8000.0	1.0000	0.0000E+00	0.0	0.0000E+00

P	BG	DBGDP
8000.0	0.2020E-01	-0.5410E-05

MAXIMUM NUMBER OF TIME-STEPS = 260000
FACTOR FOR INCREASING DELT = 1.200000 WHEN DSMAX AND DPMAX NOT EXCEEDED.
FACTOR FOR DECREASING DELT = 0.500000 WHEN DSMAX OR DPMAX IS EXCEEDED.
MAXIMUM SIMULATION TIME =1825.000000
MAXIMUM RESERVOIR WOR/TIME-STEP = 0. STB/STB
MAXIMUM RESERVOIR GOR/TIME-STEP = 500000. SCF/STB
MINIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP = 0.
MAXIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP = 10000.

SOLUTION METHOD IS LSOR:
MAXIMUM NUMBER OF ITERATIONS (MITR) = 3000
INITIAL ACCELERATION PARAMETER (OMEGA) = 1.7000
MAXIMUM PRESSURE RESIDUAL (TOL) = 0.1000
PARAMETER FOR CHANGING OMEGA (TOL1) = 0.0000

AUTOMATIC TIME STEP CRITERIA:
MAXIMUM ALLOWED SATURATION CHANGE (DSMAX) = 0.0300
MAXIMUM ALLOWED PRESSURE CHANGE (DPMAX) = 30.0000

RESERVOIR CONTAINS THE FOLLOWING RATE NODES (FOR VERTICAL WELLS)

NODE	OIL(STBD)	WATER(STBD)	GAS(MCFD)	TOTAL(RBD)	BHFP(PSIA)	PID
1 1 1	0.00	-535.00	0.00	0.00	0.00	2.429136
1 1 2	0.00	-535.00	0.00	0.00	0.00	24.291357
10 10 1	0.00	0.00	0.00	535.00	0.00	2.429136
10 10 2	0.00	0.00	0.00	535.00	0.00	24.291357

BLOCK 1 1 1 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 1 1 2 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 10 10 1 CONTAINS A RATE SPECIFIED PRODUCING WELL
BLOCK 10 10 2 CONTAINS A RATE SPECIFIED PRODUCING WELL

LAYER 1 INITIAL FLUID VOLUMES:

OIL IN PLACE (MILLION STB)	0.4037
WATER IN PLACE (MILLION STB)	0.1336
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

LAYER 2 INITIAL FLUID VOLUMES:

OIL IN PLACE (MILLION STB)	0.4038
WATER IN PLACE (MILLION STB)	0.1336
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

TOTAL INITIAL FLUID VOLUMES IN RESERVOIR:

OIL IN PLACE (MILLION STB)	0.8075

WATER IN PLACE (MILLION STB)	0.2671
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

******* INITIAL ARRAYS *******

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
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2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
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2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.

K = 2

2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
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2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.

********* OIL SATURATION *********

K = 1

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

K = 2

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

******** WATER SATURATION *********

K = 1

0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250

K = 2

0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250

********* GAS SATURATION *********

K = 1

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

K = 2

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

********** WELL REPORT FOR ALL ACTIVE WELLS ELAPSED TIME = 365.000000 DAYS FROM BEGINNING OF SIMULATION **********

WELL ID	LOCATION I	J	K	CALC BHFP	SPEC BHFP	SPEC PI	RATE OIL STB/D	RATE GAS MCF/D	RATE WATER STB/D	GOR	WOR	CUMULATIVE OIL MSTB	CUMULATIVE GAS MMCF	CUMULATIVE WATER MSTB
INJ	1	1	1	2685.	0.	2.429	0.	0.	-34.	0.	0.000	0.	0.	-9.
INJ	1	1	2	2692.	0.	24.291	0.	0.	-501.	0.	0.000	0.	0.	-186.
PROD	10	10	1	2265.	0.	2.429	65.	0.	0.	0.	0.000	20.	0.	0.
PROD	10	10	2	2270.	0.	24.291	198.	0.	272.	0.	1.376	164.	0.	12.
TOTALS							263.	0.	-263.			184.	0.	-184.

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*********************************************************************
*                                                                   *
*                                                                   *
*        SUMMARY REPORT: NIPER MODEL                                *
*                                                                   *
*                                                                   *
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ELAPSED TIME (DAYS) = 365.00 TIME STEP NUMBER = 139 TIME STEP SIZE (DAYS) = 1.00

CURRENT AVG RES PRESSURE = 2568.7 PREVIOUS AVG RES PRESSURE = 2568.0 PRESSURE DPMAX(1, 1, 1) = 22.1
OIL DSMAX(5, 10, 2) =-.8126E-03 GAS DSMAX(0, 0, 0) =0.0000E+00 WATER DSMAX(5, 10, 2) =0.8126E-03
OIL MATERIAL BALANCE (%) =0.4708E-03 GAS MATERIAL BALANCE (%) =0.0000E+00 WATER MATERIAL BALANCE (%) =0.2381E+00

OIL PRODUCTION RATE (STB/D) = 262.6 CUM. OIL PRODUCTION (STB) =0.1835E+06
GAS PRODUCTION RATE (MSCF/D)= 0.0 CUM. GAS PRODUCTION (MSCF) =0.0000E+00
WATER PRODUCTION RATE(STB/D)= 272.4 CUM. WATER PRODUCTION (STB) =0.1177E+05

GAS INJECTION RATE (MSCF/D) = 0.0 CUM. GAS INJECTION (MSCF) =0.0000E+00
WATER INJECTION RATE (STB/D)= 535.0 CUM. WATER INJECTION (STB) = 0.1953E+06

PRODUCING WOR (STB/STB) = 1.037 CUM. WOR (STB/STB) = 0.064
PRODUCING GOR (SCF/STB) = 0. CUM. GOR (SCF/STB) = 0.

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

2672. 2649. 2628. 2610. 2596. 2586. 2579. 2573. 2569. 2567.
2649. 2636. 2619. 2604. 2593. 2584. 2576. 2571. 2567. 2564.
2628. 2619. 2607. 2596. 2587. 2579. 2572. 2566. 2561. 2559.
2609. 2604. 2596. 2588. 2580. 2572. 2565. 2558. 2553. 2551.

2595.	2592.	2587.	2580.	2572.	2564.	2556.	2548.	2543.	2539.
2586.	2584.	2579.	2572.	2564.	2555.	2545.	2536.	2529.	2524.
2579.	2576.	2571.	2565.	2556.	2545.	2534.	2522.	2511.	2504.
2573.	2570.	2565.	2558.	2548.	2536.	2522.	2506.	2490.	2477.
2569.	2566.	2561.	2553.	2543.	2529.	2511.	2490.	2464.	2438.
2567.	2564.	2559.	2551.	2539.	2524.	2504.	2477.	2438.	2373.

K = 2

2662.	2643.	2630.	2620.	2612.	2604.	2598.	2593.	2589.	2588.
2643.	2635.	2626.	2617.	2609.	2602.	2596.	2590.	2587.	2585.
2630.	2626.	2619.	2612.	2605.	2597.	2591.	2586.	2582.	2580.
2620.	2617.	2612.	2605.	2598.	2591.	2584.	2578.	2574.	2572.
2612.	2609.	2604.	2598.	2591.	2583.	2576.	2569.	2563.	2560.
2604.	2602.	2597.	2591.	2583.	2575.	2565.	2556.	2549.	2545.
2598.	2595.	2591.	2584.	2576.	2565.	2554.	2542.	2531.	2524.
2593.	2590.	2585.	2578.	2569.	2556.	2542.	2525.	2508.	2495.
2589.	2587.	2581.	2574.	2563.	2549.	2531.	2508.	2479.	2450.
2587.	2585.	2579.	2571.	2560.	2545.	2524.	2495.	2450.	2374.

********* OIL SATURATION *********

K = 1

0.357	0.457	0.552	0.650	0.706	0.722	0.731	0.738	0.744	0.749
0.457	0.536	0.626	0.695	0.716	0.725	0.733	0.739	0.744	0.749
0.552	0.626	0.690	0.713	0.722	0.729	0.735	0.740	0.745	0.749
0.650	0.695	0.713	0.721	0.727	0.732	0.737	0.742	0.745	0.749
0.706	0.716	0.722	0.727	0.732	0.736	0.739	0.743	0.746	0.749
0.722	0.726	0.729	0.733	0.736	0.739	0.741	0.744	0.746	0.749
0.731	0.733	0.735	0.737	0.739	0.741	0.743	0.744	0.746	0.749
0.738	0.739	0.741	0.742	0.743	0.744	0.744	0.745	0.746	0.748
0.744	0.745	0.745	0.745	0.746	0.746	0.746	0.746	0.747	0.748
0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.748	0.748	0.749

K = 2

0.220	0.226	0.254	0.291	0.327	0.361	0.396	0.436	0.491	0.598
0.229	0.251	0.282	0.314	0.344	0.374	0.406	0.443	0.496	0.602
0.260	0.283	0.309	0.335	0.361	0.387	0.414	0.448	0.499	0.605
0.296	0.315	0.335	0.356	0.377	0.399	0.422	0.453	0.500	0.604
0.331	0.345	0.361	0.378	0.395	0.410	0.431	0.457	0.500	0.601
0.365	0.376	0.388	0.400	0.410	0.424	0.439	0.461	0.498	0.592
0.400	0.407	0.415	0.423	0.431	0.440	0.450	0.465	0.495	0.578
0.439	0.444	0.449	0.454	0.458	0.461	0.465	0.473	0.492	0.557
0.494	0.497	0.500	0.501	0.501	0.499	0.495	0.492	0.497	0.537
0.601	0.604	0.606	0.606	0.602	0.593	0.579	0.558	0.538	0.540

******** WATER SATURATION *********

K = 1

0.643	0.543	0.448	0.350	0.294	0.278	0.269	0.262	0.256	0.251
0.543	0.464	0.374	0.305	0.284	0.275	0.267	0.261	0.256	0.251
0.448	0.374	0.310	0.287	0.278	0.271	0.265	0.260	0.255	0.251
0.350	0.305	0.287	0.279	0.273	0.268	0.263	0.258	0.255	0.251
0.294	0.284	0.278	0.273	0.268	0.264	0.261	0.257	0.254	0.251
0.278	0.274	0.271	0.267	0.264	0.261	0.259	0.256	0.254	0.251
0.269	0.267	0.265	0.263	0.261	0.259	0.257	0.256	0.254	0.251
0.262	0.261	0.259	0.258	0.257	0.256	0.256	0.255	0.254	0.252

0.256	0.255	0.255	0.255	0.254	0.254	0.254	0.254	0.253	0.252
0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.252	0.252	0.251

K = 2

0.780	0.774	0.746	0.709	0.673	0.639	0.604	0.564	0.509	0.402
0.771	0.749	0.718	0.686	0.656	0.626	0.594	0.557	0.504	0.398
0.740	0.717	0.691	0.665	0.639	0.613	0.586	0.552	0.501	0.395
0.704	0.685	0.665	0.644	0.623	0.601	0.578	0.547	0.500	0.396
0.669	0.655	0.639	0.622	0.605	0.590	0.569	0.543	0.500	0.399
0.635	0.624	0.612	0.600	0.590	0.576	0.561	0.539	0.502	0.408
0.600	0.593	0.585	0.577	0.569	0.560	0.550	0.535	0.505	0.422
0.561	0.556	0.551	0.546	0.542	0.539	0.535	0.527	0.508	0.443
0.506	0.503	0.500	0.499	0.499	0.501	0.505	0.508	0.503	0.463
0.399	0.396	0.394	0.394	0.398	0.407	0.421	0.442	0.462	0.460

********** END OF REPORT
****

********** WELL REPORT FOR ALL ACTIVE WELLS ELAPSED TIME =1825.000000 DAYS FROM BEGINNING OF SIMULATION **********

WELL ID	LOCATION I	J	K	CALC BHFP	SPEC BHFP	SPEC PI	RATE OIL STB/D	RATE GAS MCF/D	RATE WATER STB/D	GOR	WOR	CUMULATIVE OIL MSTB	CUMULATIVE GAS MMCF	CUMULATIVE WATER MSTB
INJ	1	1	1	2717.	0.	2.429	0.	0.	-29.	0.	0.000	0.	0.	-51.
INJ	1	1	2	2723.	0.	24.291	0.	0.	-506.	0.	0.000	0.	0.	-925.
PROD	10	10	1	2479.	0.	2.429	24.	0.	1.	0.	0.023	75.	0.	0.
PROD	10	10	2	2485.	0.	24.291	20.	0.	490.	0.	24.977	241.	0.	660.
TOTALS							44.	0.	-44.			316.	0.	-316.

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*********************************************************************
*                                                                   *
*                                                                   *
*        SUMMARY REPORT: NIPER MODEL                                *
*                                                                   *
*                                                                   *
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ELAPSED TIME (DAYS) = 1825.00 TIME STEP NUMBER = 1678 TIME STEP SIZE (DAYS) = 1.00

CURRENT AVG RES PRESSURE = 2629.7 PREVIOUS AVG RES PRESSURE = 2629.8 PRESSURE DPMAX(1, 1, 1) = -7.2
OIL DSMAX(5, 5, 1) =-.1365E-03 GAS DSMAX(0, 0, 0) =0.0000E+00 WATER DSMAX(5, 5, 1) =0.1365E-03

OIL MATERIAL BALANCE (%) =-.2122E-03 GAS MATERIAL BALANCE (%) =0.0000E+00 WATER MATERIAL BALANCE (%) =0.1838E+00

OIL PRODUCTION RATE (STB/D) = 44.1 CUM. OIL PRODUCTION (STB) =0.3160E+06
GAS PRODUCTION RATE (MSCF/D)= 0.0 CUM. GAS PRODUCTION (MSCF) =0.0000E+00
WATER PRODUCTION RATE(STB/D)= 490.9 CUM. WATER PRODUCTION (STB) =0.6604E+06

GAS INJECTION RATE (MSCF/D) = 0.0 CUM. GAS INJECTION (MSCF) =0.0000E+00
WATER INJECTION RATE (STB/D)= 535.0 CUM. WATER INJECTION (STB) = 0.9764E+06

PRODUCING WOR (STB/STB) = 11.127 CUM. WOR (STB/STB) = 2.090
PRODUCING GOR (SCF/STB) = 0. CUM. GOR (SCF/STB) = 0.

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

2691.	2678.	2668.	2660.	2652.	2645.	2639.	2633.	2630.	2628.
2678.	2672.	2665.	2657.	2650.	2643.	2637.	2631.	2628.	2627.
2668.	2665.	2659.	2653.	2646.	2640.	2633.	2628.	2626.	2624.
2660.	2657.	2653.	2647.	2641.	2634.	2629.	2624.	2621.	2620.
2652.	2650.	2646.	2641.	2635.	2629.	2623.	2619.	2616.	2614.
2645.	2643.	2640.	2634.	2629.	2623.	2617.	2612.	2608.	2606.
2639.	2637.	2633.	2629.	2623.	2617.	2611.	2605.	2599.	2596.
2633.	2631.	2628.	2624.	2619.	2612.	2605.	2597.	2588.	2582.
2630.	2628.	2626.	2621.	2616.	2608.	2599.	2588.	2575.	2561.
2628.	2627.	2624.	2620.	2614.	2606.	2596.	2582.	2561.	2527.

K = 2

2697.	2677.	2665.	2656.	2650.	2645.	2641.	2638.	2636.	2635.
2677.	2669.	2661.	2654.	2649.	2644.	2640.	2637.	2635.	2634.
2665.	2661.	2656.	2651.	2646.	2641.	2637.	2634.	2632.	2631.
2657.	2654.	2651.	2646.	2642.	2638.	2634.	2631.	2628.	2627.
2650.	2649.	2646.	2642.	2638.	2633.	2629.	2626.	2623.	2621.
2645.	2644.	2641.	2638.	2634.	2629.	2624.	2619.	2616.	2613.
2641.	2640.	2637.	2634.	2629.	2624.	2618.	2612.	2607.	2603.
2638.	2637.	2634.	2631.	2626.	2619.	2612.	2604.	2595.	2589.
2636.	2635.	2632.	2628.	2623.	2616.	2607.	2595.	2582.	2568.
2635.	2634.	2631.	2627.	2621.	2613.	2603.	2589.	2568.	2534.

********* OIL SATURATION *********

K = 1

0.247	0.305	0.363	0.417	0.470	0.528	0.595	0.662	0.694	0.717
0.305	0.353	0.400	0.446	0.496	0.552	0.619	0.674	0.696	0.716
0.363	0.400	0.438	0.480	0.526	0.582	0.646	0.682	0.696	0.716
0.417	0.446	0.480	0.518	0.564	0.621	0.668	0.685	0.696	0.714
0.470	0.495	0.526	0.564	0.611	0.657	0.679	0.685	0.694	0.712
0.528	0.551	0.582	0.621	0.657	0.676	0.681	0.684	0.692	0.709
0.595	0.619	0.646	0.668	0.679	0.681	0.682	0.684	0.690	0.706
0.663	0.674	0.683	0.685	0.685	0.685	0.684	0.685	0.689	0.702
0.695	0.697	0.697	0.696	0.694	0.692	0.690	0.689	0.690	0.698
0.717	0.717	0.716	0.715	0.713	0.710	0.706	0.702	0.699	0.701

K = 2

0.220	0.220	0.221	0.225	0.234	0.249	0.268	0.291	0.324	0.370
0.220	0.221	0.224	0.229	0.240	0.256	0.274	0.294	0.326	0.370
0.222	0.224	0.228	0.236	0.248	0.263	0.278	0.297	0.327	0.370
0.227	0.230	0.237	0.246	0.258	0.269	0.282	0.299	0.327	0.369
0.237	0.242	0.249	0.258	0.267	0.275	0.286	0.301	0.327	0.366
0.253	0.258	0.264	0.270	0.276	0.282	0.290	0.303	0.325	0.362
0.272	0.276	0.279	0.283	0.286	0.290	0.296	0.306	0.323	0.356
0.295	0.297	0.299	0.301	0.303	0.304	0.306	0.311	0.322	0.348
0.327	0.328	0.329	0.329	0.328	0.326	0.324	0.322	0.324	0.340
0.373	0.373	0.373	0.371	0.369	0.364	0.358	0.349	0.341	0.342

******** WATER SATURATION *********

K = 1

0.753	0.695	0.637	0.583	0.530	0.472	0.405	0.338	0.306	0.283
0.695	0.647	0.600	0.554	0.504	0.448	0.381	0.326	0.304	0.284
0.637	0.600	0.562	0.520	0.474	0.418	0.354	0.318	0.304	0.284
0.583	0.554	0.520	0.482	0.436	0.379	0.332	0.315	0.304	0.286
0.530	0.505	0.474	0.436	0.389	0.343	0.321	0.315	0.306	0.288
0.472	0.449	0.418	0.379	0.343	0.324	0.319	0.316	0.308	0.291
0.405	0.381	0.354	0.332	0.321	0.319	0.318	0.316	0.310	0.294
0.337	0.326	0.317	0.315	0.315	0.315	0.316	0.315	0.311	0.298
0.305	0.303	0.303	0.304	0.306	0.308	0.310	0.311	0.310	0.302
0.283	0.283	0.284	0.285	0.287	0.290	0.294	0.298	0.301	0.299

K = 2

0.780	0.780	0.779	0.775	0.766	0.751	0.732	0.709	0.676	0.630
0.780	0.779	0.776	0.771	0.760	0.744	0.726	0.706	0.674	0.630
0.778	0.776	0.772	0.764	0.752	0.737	0.722	0.703	0.673	0.630
0.773	0.770	0.763	0.754	0.742	0.731	0.718	0.701	0.673	0.631
0.763	0.758	0.751	0.742	0.733	0.725	0.714	0.699	0.673	0.634
0.747	0.742	0.736	0.730	0.724	0.718	0.710	0.697	0.675	0.638
0.728	0.724	0.721	0.717	0.714	0.710	0.704	0.694	0.677	0.644
0.705	0.703	0.701	0.699	0.697	0.696	0.694	0.689	0.678	0.652
0.673	0.672	0.671	0.671	0.672	0.674	0.676	0.678	0.676	0.660
0.627	0.627	0.627	0.629	0.631	0.636	0.642	0.651	0.659	0.658

********** END OF REPORT
****

Output File (RWF5YR.OUT) for Sample Problem 1

W.F. ONLY -- 10*10*2, KZ/KH=.001 (5YRS),100-1000MD

SUMMARY REPORT

N	ETI (DAY)	PAVG (PSI)	OPR (STB/D)	COP (BBL)	GPR (MCF/D)	CGP (MCF)	FOR	WPR (STB/D)	CWP (BBL)	WOR (B/B)	PVWI	CPOI (LB)	WIR (B/D)	CWI (BBL)
49	40.72	2526.7	535	21786.2	0	0	0.02698	0	0.2	0	0.0204	0	535	21786.4
62	81.68	2532.3	535	43700.4	0	0	0.05412	0	0.4	0	0.0409	0	535	43700.9
73	123.19	2537.5	535	65903.7	0	0	0.08161	0	0.6	0	0.0617	0	535	65904.3
83	164.33	2542.3	535	87914	0	0	0.10887	0	0.8	0	0.0823	0	535	87914.8
92	209.42	2547.2	535	112039	0	0	0.13875	0	0.9	0	0.1049	0	535	112039.9
103	252.76	2553.1	535	135225.4	0	0	0.16746	0	1	0	0.1265	0	535	135226.4
114	293.01	2559.4	535	156759.9	0	0	0.19413	0	1.2	0	0.1467	0	535	156761.1
131	335.36	2565.9	325.3	174826.7	0	0	0.2165	209.7	4591.6	0.64	0.1679	0	535	179418.3
148	377.48	2569.7	252.6	186731.1	0	0	0.23125	282.4	15220.3	1.12	0.189	0	535	201951.3
163	418.02	2573.6	214.1	196131.2	0	0	0.24289	320.9	27506.9	1.5	0.2093	0	535	223637.9
180	458.55	2575.9	188.6	204282.5	0	0	0.25298	346.4	41039.1	1.84	0.2296	0	535	245321.4
203	499.8	2579.3	169.4	211641.3	0	0	0.26209	365.6	55752.1	2.16	0.2502	0	535	267393.2
228	540.07	2581.5	154	218139.5	0	0	0.27014	381	70796	2.47	0.2704	0	535	288935.2
254	580.8	2583.7	141.5	224148.5	0	0	0.27758	393.5	86578.9	2.78	0.2908	0	535	310727
282	621.94	2585.6	131.3	229750.4	0	0	0.28452	403.7	102989.6	3.07	0.3114	0	535	332739.8
313	662.11	2587.9	122.2	234828.5	0	0	0.29081	412.8	119402.5	3.38	0.3315	0	535	354230.9
346	702.75	2589.3	114.7	239631.3	0	0	0.29676	420.3	136340.3	3.67	0.3518	0	535	375971.3
384	743.68	2591.3	108.2	244179.1	0	0	0.30239	426.8	153687.3	3.95	0.3723	0	535	397866.1
422	784.47	2593.3	102.4	248464.4	0	0	0.3077	432.6	171225.7	4.23	0.3928	0	535	419689.9
463	824.51	2596.2	97.1	252450.7	0	0	0.31263	437.9	188663.9	4.51	0.4128	0	535	441114.3
505	864.57	2598.3	92.7	256254.3	0	0	0.31734	442.3	206293.4	4.77	0.4329	0	535	462547.4
550	904.79	2599.8	88.6	259899.8	0	0	0.32186	446.4	224162.2	5.04	0.453	0	535	484061.8
596	945.32	2601.6	84.7	263403.2	0	0	0.3262	450.3	242342.8	5.32	0.4733	0	535	505745.8
643	985.75	2603.8	80.9	266747.3	0	0	0.33034	454.1	260628.1	5.61	0.4935	0	535	527375.4
691	1026.72	2606.2	77.9	270004.5	0	0	0.33437	457.1	279291	5.87	0.514	0	535	549295.3
738	1066.84	2606.9	75.1	273075.8	0	0	0.33817	459.9	297685.8	6.13	0.5341	0	535	570761.5
783	1107.18	2608.7	72.1	276041.8	0	0	0.34185	462.9	316298	6.42	0.5543	0	535	592339.7
830	1147.53	2610.1	69.8	278898.6	0	0	0.34539	465.2	335028.1	6.67	0.5745	0	535	613926.6
879	1187.88	2612	67.2	281659.6	0	0	0.3488	467.8	353854.3	6.96	0.5947	0	535	635513.7
928	1228.6	2612.8	65	284351.3	0	0	0.35214	470	372950.2	7.23	0.6151	0	535	657301.2
978	1269.39	2614.5	62.9	286954.9	0	0	0.35536	472.1	392168.5	7.5	0.6355	0	535	679123.1
1029	1309.49	2615.9	60.8	289433.6	0	0	0.35843	474.2	411142.2	7.79	0.6556	0	535	700575.8
1079	1349.91	2617.5	59	291857.7	0	0	0.36143	476	430343.2	8.06	0.6759	0	535	722200.8
1129	1390.64	2619.1	57.3	294229	0	0	0.36437	477.7	449762.7	8.34	0.6963	0	535	743991.4
1180	1431.07	2619.4	55.9	296515.8	0	0	0.3672	479.1	469107	8.57	0.7165	0	535	765622.6
1232	1471.33	2621.1	54.3	298729.7	0	0	0.36994	480.7	488431.1	8.85	0.7367	0	535	787160.5
1283	1511.62	2622.6	52.8	300886.6	0	0	0.37262	482.2	507832.1	9.13	0.7568	0	535	808718.3
1335	1552.29	2623.7	51.4	303007.7	0	0	0.37524	483.6	527470.6	9.4	0.7772	0	535	830477.9
1385	1592.41	2624.6	50.2	305047.6	0	0	0.37777	484.8	546891.1	9.67	0.7973	0	535	851938.3
1437	1633.19	2626.2	48.9	307070.6	0	0	0.38027	486.1	566685.6	9.93	0.8177	0	535	873755.9
1488	1674.03	2626.1	48	309049.2	0	0	0.38272	487	586558.3	10.15	0.8381	0	535	895607.3
1539	1714.4	2627.8	46.8	310959.6	0	0	0.38509	488.2	606246.3	10.44	0.8584	0	535	917205.4
1589	1755.02	2629	45.7	312838.4	0	0	0.38742	489.3	626095.6	10.71	0.8787	0	535	938933.7
1640	1795.33	2628.9	44.9	314663.3	0	0	0.38968	490.1	645839.9	10.92	0.8989	0	535	960502.8

APPENDIX D. SAMPLE PROBLEM 2

Input Data File (B1YRPF.DAT) for Sample Problem 2

```
B1YRPF.OUT
R1YRPF.OUT
G1YRPF.OUT
1 YR WF + 500 D POLYMER FLOODING + WF --- 10*10*2,100-1000MD,KV/KH=0.001
 10   10   2
GEL (SWITCHES)
 1
GRID BLOCK LENGTHS
 -1  -1  0
 100.
 100.
 15.   15.
GRID BLOCK LENGTH MODIFICATIONS
  0  0  0  0
CAPROCK BASE DEPTHS TO TOP OF SAND
  0
  8000.
POROSITY AND PERMEABILITY DISTRIBUTIONS
 -1  0  0  0
 .20
 100.  1000.
 100.  1000.
 0.1    1.
POROSITY AND PERMEABILITY MODIFICATIONS
  0  0  0  0  0
TRANSMISSIBILITY MODIFICATIONS
  0  0  0  0
  SAT    KRO        KRW       KRG   PCOW    PCGO
  -0.10    0.          0.          0.    0.          0.
  0.0      0.          0.          0.    0.          0.
  0.02     0.          0.          0.    0.          0.
  0.1      0.          0.          0.    0.          0.
  0.2      0.          0.          0.    0.          0.
  0.21     0.          0.          0.    0.          0.
  0.22     0.          0.          0.    0.          0.
  0.25     0.01014     0.0         0.    2.          0.
  0.26     0.01355     0.000188    0.    1.975       0.
  0.27     0.017099    0.000417    0.    1.951       0.
  0.28     0.02083     0.001109    0.    1.9264      0.
  0.29     0.02477483  0.002254    0.    1.902       0.
  0.3      0.03        0.004       0.    1.877       0.
  0.32     0.03815811  0.008301    0.    1.8283      0.
  0.34     0.04852966  0.014426    0.    1.7792      0.
  0.35     0.054178    0.02        0.    1.755       0.
  0.37     0.066415    0.02662     0.    1.7057      0.
  0.39     0.0799114   0.0367      0.    1.6566      0.
  0.4      0.085       0.04        0.    1.632       0.
  0.41     0.0946645   0.048312    0.    1.6075      0.
  0.43     0.110683    0.06145     0.    1.5585      0.
  0.45     0.128       0.076       0.    1.509       0.
  0.46     0.137183    0.08403     0.    1.4849      0.
  0.48     0.15666     0.101033    0.    1.4358      0.
  0.5      0.18        0.12        0.    1.387       0.
  0.525    0.207058    0.14521     0.    1.3255      0.
  0.55     0.24        0.173492    0.    1.264       0.
  0.575    0.27873     0.204637    0.    1.2028      0.
  0.6      0.326       0.24        0.    1.142       0.
  0.62     0.366631    0.268539    0.    1.0925      0.
  0.65     0.438       0.31731     0.    1.019       0.
  0.67     0.5077      0.352836    0.    0.9698      0.
```

```
0.7        0.63        0.41        0.     0.896        0.
0.73       0.77665     0.47573     0.     0.8226       0.
0.75       0.9         0.52275     0.     0.774        0.
0.78       0.9         0.6         0.     0.7          0.
1.0        0.9         0.6         0.     0.7          0.
1.1        0.9         0.6         0.     0.7          0.
 PBO   VSLOPE        BSLOPE   RSLOPE        PMAX   IREPRS
  10.   .000000      -.0000030   0.0   8000.   0
 P   MUO       BO      RSO
 14.7   3.0     1.00    0.0
 8000.0  3.0    1.00    0.0
 P   MUW       BW    RSW
 14.7   .80     1.0000   0.0
 8000.0  .80    1.00    0.0
 P   MUG  BG     CR
 14.7     .0107  0.0634    .0000040
8000.0    .0121  0.0202    .0000040
 RHOSCO  RHOSCW  RHOSCG     RHOROCK
  53.0          64.5       .0574          143.585
---------CHEMICAL DATA FOR GELATION ----------
5          (ORDER FOR CENTRAL DIFFERENCE METHOD)
1.875E-3   1.875E-3   1.875E-3     (DISPERSION COEFF. IN FT^2/DAY)
1E-4   1E-4   1000     (REACTION CONSTANTS)
.0       .0       .0       .0              .0       ADSORPTION -- AA(1--5)
.0       .0       .0       4.273E-2        8.547E-2        BB(1--5)
.0       .0       .0       .0              1        RESISTANCE FACTOR -- CL(1--5)
.0       .0       .0       .0              .0       GAMA'(1--5)
3.98E-3          2.29E-6          1.695E-9          (PAM VISCOSITY)
4.825E-3         1.608E-6         3.6E-7            1000.    (GEL VISCOSITY)
1.471    1.960E-4        -2.882E-8        0.000   3.923E8    -2.116  (METER'S EQ.)
1.0   1.0   1.0   0.8   0.8  (IPV FOR 1ST LAYER)
1.0   1.0   1.0   0.8   0.8  (IPV FOR 2ND LAYER)
1000.   1400.  0.   3000.   0.
EQUILIBRIUM PRESSURE INITILIZATION/CONSTANT SATURATIONS
  0  0
 2511.   2400.   8000.   7000.
 .75     .25     .00
 KSN1 KSM1 KCO1  KTR KCOF
  0  0  0  0  0
 NMAX  FACT1 FACT2   TMAX   WORMAX   GORMAX   PAMIN  PAMAX
 200000    1.2      .5      1825     0.0       500000.    0.      10000.
 KSOL MITR   OMEGA    TOL    TOL1    DSMAX   DPMAX
  2    3000    1.7       .1      0.      .03       30.
 RECURRENT DATA
 40
 1      1   0   0   0   0   0   0   0   0   364.  0
 1.   0.01  1.  0.  0.  0.
 RATES -- 1 WATER. INJ. WELL, 1 PROD. WELL
  2  0  0
 INJ
 1    1   1   2   2  0   -535.0  0  0
 0.25  0.  0.
 0.25  0.  0.
 PROD
 10   10   1   2   1  0   0.  0  535.0
 0.25  0.  0.
 0.25  0.  0.
 0    363   0   0   0   0   0   0   0   0    10.  0
 1    0.01  5.  0.  0.  0.
 0      1   0   0   0   0   0   0   0   0    10.  0
 1    0.01  5.  0.  0.  0.
 1      1   0   0   0   0   0   0   0   0    10.  1
 1.   0.01  2.  0.  0.  0.
 RATES -- 1 POLYMER INJ. WELL, 1 PROD. WELL (POLYMER 500 DAYS AT 1YR)
```

```
 2  0  0
INJ
1        1    1    2    2  0    -535.0  0  0
 0.25   0.  0.
 0.25   0.  0.
 0.0    0.0   0.0    1500.0   0.0
PROD
 10    10    1    2    1  0    0.  0  535.0
 0.25   0.  0.
 0.25   0.  0.
 0    363    0    0    0    0    0    0    0    0    365.  1
 1.   0.01   2.   0.   0.   0.
 0      1    1    1    1    1    1    0    0    0    365.  1
 1.   0.01   2.   0.   0.   0.
 0    134    0    0    0    0    0    0    0    0    135.  1
 1.   0.01   2.   0.   0.   0.
 0      1    0    0    0    0    0    0    0    0    135.  1
 1.   0.01   2.   0.   0.   0.
 1      1    0    0    0    0    0    0    0    0    365.  1
 1.   0.01   2.   0.   0.   0.
RATES -- 1 WATER INJ. WELL, 1 PROD. WELL
 2  0  0
INJ
1        1    1    2    2  0    -535.0  0  0
 0.25   0.  0.
 0.25   0.  0.
 0.0    0.0   0.0    0.0   0.0
PROD
 10    10    1    2    1  0    0.  0  535.0
 0.25   0.  0.
 0.25   0.  0.
 0    228    0    0    0    0    0    0    0    0    230.  1
 1.   0.01   2.   0.   0.   0.
 0      1    1    1    1    1    0    0    0    0    230.  1
 1.   0.01   2.   0.   0.   0.
 0    729    0    0    0    0    0    0    0    0    700.  1
 1.   0.01   2.   0.   0.   0.
 0      1    1    1    1    1    0    0    0    0    700.  1
 1.   0.01   2.   0.   0.   0.
 0    359    0    0    0    0    0    0    0    0    700.  1
 1.   0.01   2.   0.   0.   0.
```

Part of Output File (B1YRPF.OUT) for Sample Problem 2

```
*****************************************************************
*                                                               *
*                                                               *
*                          NIPER:                               *
*        BLACK OIL PRIMARY AND SECONDARY RECOVERY MODEL         *
*              FOR PERMEABILITY MODIFICATION TREATMENT          *
*                          (VERSION 1.1)                        *
*                                                               *
*                                                               *
*****************************************************************


*******************************************************************************
*                                                                             *
*1 YR WF + 500 D POLYMER FLOODING + WF --- 10*10*2,100-1000MD,KV/KH=0.001      *
*                                                                             *
*******************************************************************************


      GRID BLOCK LENGTH (DX) IS INITIALLY SET AT  100.0000 FOR ALL NODES


      GRID BLOCK WIDTH  (DY) IS INITIALLY SET AT  100.0000 FOR ALL NODES


      GRID SIZE (DZ) IN LAYER    1 IS INITIALLY SET AT   15.00 FOR ALL NODES

      GRID SIZE (DZ) IN LAYER    2 IS INITIALLY SET AT   15.00 FOR ALL NODES


       ********** NODE MIDPOINT ELEVATIONS **********

 K = 1

  8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008.
  8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008.
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8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008.

K = 2

8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.

POROSITY (PHI) IS INITIALLY SET AT 0.2000 FOR ALL NODES

PERMEABILITY (KX) IN LAYER 1 IS INITIALLY SET AT 100.00 FOR ALL NODES

PERMEABILITY (KX) IN LAYER 2 IS INITIALLY SET AT 1000.00 FOR ALL NODES

PERMEABILITY (KY) IN LAYER 1 IS INITIALLY SET AT 100.00 FOR ALL NODES

PERMEABILITY (KY) IN LAYER 2 IS INITIALLY SET AT 1000.00 FOR ALL NODES

PERMEABILITY (KZ) IN LAYER 1 IS INITIALLY SET AT 0.10 FOR ALL NODES

PERMEABILITY (KZ) IN LAYER 2 IS INITIALLY SET AT 1.00 FOR ALL NODES

***** EMPIRICAL DATA TABLE *****

SAT	KRO	KRW	KRG	PCOW	PCGO
-0.1000	0.0000	0.0000	0.0000	0.00	0.00
0.0000	0.0000	0.0000	0.0000	0.00	0.00
0.0200	0.0000	0.0000	0.0000	0.00	0.00
0.1000	0.0000	0.0000	0.0000	0.00	0.00
0.2000	0.0000	0.0000	0.0000	0.00	0.00
0.2100	0.0000	0.0000	0.0000	0.00	0.00
0.2200	0.0000	0.0000	0.0000	0.00	0.00
0.2500	0.0101	0.0000	0.0000	2.00	0.00
0.2600	0.0136	0.0002	0.0000	1.98	0.00
0.2700	0.0171	0.0004	0.0000	1.95	0.00
0.2800	0.0208	0.0011	0.0000	1.93	0.00

0.2900	0.0248	0.0023	0.0000	1.90	0.00
0.3000	0.0300	0.0040	0.0000	1.88	0.00
0.3200	0.0382	0.0083	0.0000	1.83	0.00
0.3400	0.0485	0.0144	0.0000	1.78	0.00
0.3500	0.0542	0.0200	0.0000	1.75	0.00
0.3700	0.0664	0.0266	0.0000	1.71	0.00
0.3900	0.0799	0.0367	0.0000	1.66	0.00
0.4000	0.0850	0.0400	0.0000	1.63	0.00
0.4100	0.0947	0.0483	0.0000	1.61	0.00
0.4300	0.1107	0.0615	0.0000	1.56	0.00
0.4500	0.1280	0.0760	0.0000	1.51	0.00
0.4600	0.1372	0.0840	0.0000	1.48	0.00
0.4800	0.1567	0.1010	0.0000	1.44	0.00
0.5000	0.1800	0.1200	0.0000	1.39	0.00
0.5250	0.2071	0.1452	0.0000	1.33	0.00
0.5500	0.2400	0.1735	0.0000	1.26	0.00
0.5750	0.2787	0.2046	0.0000	1.20	0.00
0.6000	0.3260	0.2400	0.0000	1.14	0.00
0.6200	0.3666	0.2685	0.0000	1.09	0.00
0.6500	0.4380	0.3173	0.0000	1.02	0.00
0.6700	0.5077	0.3528	0.0000	0.97	0.00
0.7000	0.6300	0.4100	0.0000	0.90	0.00
0.7300	0.7767	0.4757	0.0000	0.82	0.00
0.7500	0.9000	0.5228	0.0000	0.77	0.00
0.7800	0.9000	0.6000	0.0000	0.70	0.00
1.0000	0.9000	0.6000	0.0000	0.70	0.00
1.1000	0.9000	0.6000	0.0000	0.70	0.00

PBO	VSLOPE	BSLOPE	RSLOPE	PMAX	IREPRS
10.00	0.000E+00	-0.300E-05	0.00	8000.00	0

P	MUO	BO	RSO
14.7	3.0000	1.0000	0.00
8000.0	3.0000	1.0000	0.00

P	MUW	BW	RSW
14.7	0.8000	1.0000	0.00
8000.0	0.8000	1.0000	0.00

P	MUG	BG	CR
14.7	0.0107	0.634E-01	0.400E-05
8000.0	0.0121	0.202E-01	0.400E-05

RHOSCO	RHOSCW	RHOSCG	RHOROCK
53.0000	64.5000	0.0574	143.5850

***** SLOPES FOR COMPRESSIBILITY CALCULATIONS ****

P	BO	DBO/DP	RSO	DRSO/DP
8000.0	1.0000	0.0000E+00	0.0	0.0000E+00

P	BW	DBW/DP	RSW	DRSW/DP
8000.0	1.0000	0.0000E+00	0.0	0.0000E+00

P	BG	DBGDP
8000.0	0.2020E-01	-0.5410E-05

**********CHEMICAL SYSTEM PARAMETERS**********

DISPERSION COEFFICIENT IN X DIRECTION = 0.18750E-02

DISPERSION COEFFICIENT IN Y DIRECTION = 0.18750E-02

DISPERSION COEFFICIENT IN Z DIRECTION = 0.18750E-02

REACTION RATE CONSTANTS K1= 0.10000E-03 K2= 0.10000E-03 N = 1000

ADSORPTION PARAMETERS :

A (1-5 COMPONENTS) : 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

B (1-5 COMPONENTS) : 0.00000E+00 0.00000E+00 0.00000E+00 0.42730E-01 0.85470E-01

RESIDUAL RESISTANCE FACTOR PARAMETERS :

CL (1-5 COMPONENTS) : 0.000 0.000 0.000 0.000 1.000

GAMMA (1-5 COMPONS) : 0.000 0.000 0.000 0.000 0.000

POLYMER RHEOLOGY PARAMETERS :

ALPHA1 = 0.39800E-02
ALPHA2 = 0.22900E-05
ALPHA3 = 0.16950E-08

SHEARA = 0.39230E+09
SHEARB = -0.21160E+01

GAMMA0 = 0.14710E+01
GAMMA1 = 0.19600E-03
GAMMA2 = -0.28820E-07
GAMMA3 = 0.00000E+00

GEL RHEOLOGY PARAMETERS :

BETA1 = 0.48250E-02
BETA2 = 0.16080E-05
BETA3 = 0.36000E-06
CRITICAL CONC. = 1000.000

IPV FACTORS (1-5 COMPONENTS) :

LAYER K = 1 : 1.000 1.000 1.000 0.800 0.800

LAYER K = 2 : 1.000 1.000 1.000 0.800 0.800

MAX CONCS. FOR COMPONENTS ARE:

1000.000 1400.000 0.000 3000.000 0.000

MAXIMUM NUMBER OF TIME-STEPS = 200000
FACTOR FOR INCREASING DELT = 1.200000 WHEN DSMAX AND DPMAX NOT EXCEEDED.
FACTOR FOR DECREASING DELT = 0.500000 WHEN DSMAX OR DPMAX IS EXCEEDED.
MAXIMUM SIMULATION TIME =1825.000000
MAXIMUM RESERVOIR WOR/TIME-STEP = 0. STB/STB
MAXIMUM RESERVOIR GOR/TIME-STEP = 500000. SCF/STB
MINIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP = 0.
MAXIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP = 10000.

SOLUTION METHOD IS LSOR:
MAXIMUM NUMBER OF ITERATIONS (MITR) = 3000
INITIAL ACCELERATION PARAMETER (OMEGA) = 1.7000
MAXIMUM PRESSURE RESIDUAL (TOL) = 0.1000
PARAMETER FOR CHANGING OMEGA (TOL1) = 0.0000

AUTOMATIC TIME STEP CRITERIA:
MAXIMUM ALLOWED SATURATION CHANGE (DSMAX) = 0.0300
MAXIMUM ALLOWED PRESSURE CHANGE (DPMAX) = 30.0000

RESERVOIR CONTAINS THE FOLLOWING RATE NODES (FOR VERTICAL WELLS)

NODE	OIL(STBD)	WATER(STBD)	GAS(MCFD)	TOTAL(RBD)	BHFP(PSIA)	PID
1 1 1	0.00	-535.00	0.00	0.00	0.00	2.429136
1 1 2	0.00	-535.00	0.00	0.00	0.00	24.291357
10 10 1	0.00	0.00	0.00	535.00	0.00	2.429136
10 10 2	0.00	0.00	0.00	535.00	0.00	24.291357

BLOCK 1 1 1 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 1 1 2 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 10 10 1 CONTAINS A RATE SPECIFIED PRODUCING WELL
BLOCK 10 10 2 CONTAINS A RATE SPECIFIED PRODUCING WELL

LAYER 1 INITIAL FLUID VOLUMES:

OIL IN PLACE (MILLION STB)	0.4037
WATER IN PLACE (MILLION STB)	0.1336
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

LAYER 2 INITIAL FLUID VOLUMES:

OIL IN PLACE (MILLION STB)	0.4038
WATER IN PLACE (MILLION STB)	0.1336
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

TOTAL INITIAL FLUID VOLUMES IN RESERVOIR:

OIL IN PLACE (MILLION STB)	0.8075
WATER IN PLACE (MILLION STB)	0.2671
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

******* INITIAL ARRAYS *******

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.

K = 2

2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.

********* OIL SATURATION *********

K = 1

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

K = 2

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

******** WATER SATURATION *********

K = 1

0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250

K = 2

0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250

********* GAS SATURATION *********

K = 1

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

K = 2

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

RESERVOIR CONTAINS THE FOLLOWING RATE NODES (FOR VERTICAL WELLS)

NODE	OIL(STBD)	WATER(STBD)	GAS(MCFD)	TOTAL(RBD)	BHFP(PSIA)	PID
1 1 1	0.00	-535.00	0.00	0.00	0.00	2.429136
1 1 2	0.00	-535.00	0.00	0.00	0.00	24.291357
10 10 1	0.00	0.00	0.00	535.00	0.00	2.429136
10 10 2	0.00	0.00	0.00	535.00	0.00	24.291357

BLOCK 1 1 1 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 1 1 2 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 10 10 1 CONTAINS A RATE SPECIFIED PRODUCING WELL
BLOCK 10 10 2 CONTAINS A RATE SPECIFIED PRODUCING WELL

********** WELL REPORT FOR ALL ACTIVE WELLS ELAPSED TIME = 730.000000 DAYS FROM BEGINNING OF SIMULATION **********

WELL ID	LOCATION I	J	K	CALC BHFP	SPEC BHFP	SPEC PI	RATE OIL STB/D	RATE GAS MCF/D	RATE WATER STB/D	GOR	WOR	CUMULATIVE OIL MSTB	CUMULATIVE GAS MMCF	CUMULATIVE WATER MSTB
INJ	1	1	1	4237.	0.	2.429	0.	0.	-56.	0.	0.000	0.	0.	-32.
INJ	1	1	2	4244.	0.	24.291	0.	0.	-479.	0.	0.000	0.	0.	-359.
PROD	10	10	1	2254.	0.	2.429	81.	0.	0.	0.	0.000	44.	0.	0.
PROD	10	10	2	2260.	0.	24.291	174.	0.	280.	0.	1.611	209.	0.	138.
TOTALS							255.	0.	-255.			252.	0.	-252.

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*        SUMMARY REPORT: NIPER MODEL                                *
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ELAPSED TIME (DAYS) = 730.00 TIME STEP NUMBER = 376 TIME STEP SIZE (DAYS) = 1.00

CURRENT AVG RES PRESSURE = 2681.5 PREVIOUS AVG RES PRESSURE = 2681.1 PRESSURE DPMAX(10, 10, 1) = 2.6
OIL DSMAX(6, 6, 2) =-.1278E-02 GAS DSMAX(0, 0, 0) =0.0000E+00 WATER DSMAX(6, 6, 2) =0.1278E-02
OIL MATERIAL BALANCE (%) =0.2398E-04 GAS MATERIAL BALANCE (%) =0.0000E+00 WATER MATERIAL BALANCE (%) =0.2064E+00

OIL PRODUCTION RATE (STB/D) = 254.8 CUM. OIL PRODUCTION (STB) =0.2522E+06
GAS PRODUCTION RATE (MSCF/D)= 0.0 CUM. GAS PRODUCTION (MSCF) =0.0000E+00
WATER PRODUCTION RATE(STB/D)= 280.2 CUM. WATER PRODUCTION (STB) =0.1383E+06

GAS INJECTION RATE (MSCF/D) = 0.0 CUM. GAS INJECTION (MSCF) =0.0000E+00
WATER INJECTION RATE (STB/D)= 535.0 CUM. WATER INJECTION (STB) = 0.3905E+06

PRODUCING WOR (STB/STB) = 1.100 CUM. WOR (STB/STB) = 0.548
PRODUCING GOR (SCF/STB) = 0. CUM. GOR (SCF/STB) = 0.

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

3613.	3164.	2925.	2798.	2730.	2687.	2656.	2640.	2630.	2626.
3164.	2997.	2859.	2772.	2717.	2678.	2650.	2635.	2626.	2622.
2925.	2859.	2791.	2738.	2696.	2662.	2640.	2626.	2617.	2613.
2798.	2772.	2738.	2704.	2671.	2644.	2627.	2614.	2605.	2600.
2730.	2717.	2696.	2671.	2646.	2627.	2611.	2598.	2588.	2583.
2687.	2678.	2662.	2644.	2627.	2610.	2594.	2579.	2568.	2562.
2656.	2650.	2640.	2627.	2611.	2594.	2576.	2559.	2544.	2534.
2640.	2635.	2626.	2614.	2598.	2579.	2559.	2536.	2515.	2499.
2630.	2626.	2617.	2605.	2588.	2568.	2544.	2515.	2481.	2449.
2626.	2622.	2613.	2600.	2583.	2562.	2534.	2499.	2449.	2367.

K = 2

3741.	3373.	3144.	2984.	2864.	2772.	2707.	2665.	2644.	2636.
3373.	3224.	3072.	2944.	2839.	2755.	2695.	2656.	2637.	2629.
3144.	3072.	2976.	2881.	2796.	2725.	2673.	2641.	2624.	2618.
2984.	2944.	2881.	2812.	2745.	2688.	2647.	2620.	2607.	2602.
2864.	2839.	2796.	2745.	2695.	2651.	2619.	2598.	2587.	2582.
2772.	2755.	2725.	2688.	2651.	2618.	2593.	2575.	2564.	2558.
2707.	2695.	2673.	2647.	2619.	2593.	2571.	2552.	2538.	2530.
2665.	2656.	2641.	2620.	2598.	2575.	2552.	2530.	2509.	2495.
2644.	2637.	2624.	2607.	2587.	2564.	2538.	2509.	2477.	2446.
2636.	2629.	2618.	2602.	2582.	2558.	2530.	2495.	2446.	2367.

********* OIL SATURATION *********

K = 1

0.220	0.226	0.291	0.417	0.525	0.605	0.692	0.734	0.742	0.748
0.226	0.268	0.371	0.481	0.558	0.634	0.711	0.737	0.743	0.748
0.291	0.371	0.465	0.537	0.596	0.677	0.728	0.739	0.743	0.748
0.417	0.481	0.537	0.584	0.653	0.717	0.735	0.740	0.744	0.748
0.525	0.558	0.596	0.653	0.712	0.733	0.737	0.740	0.743	0.748
0.605	0.634	0.677	0.717	0.733	0.737	0.739	0.740	0.743	0.747
0.692	0.712	0.728	0.735	0.738	0.739	0.740	0.741	0.743	0.747
0.734	0.737	0.739	0.740	0.740	0.740	0.741	0.741	0.743	0.746
0.743	0.743	0.744	0.744	0.743	0.743	0.743	0.743	0.744	0.747
0.748	0.748	0.748	0.748	0.748	0.747	0.747	0.746	0.747	0.750

K = 2

0.220	0.220	0.220	0.220	0.220	0.222	0.245	0.319	0.417	0.487
0.220	0.220	0.220	0.220	0.220	0.223	0.255	0.337	0.433	0.494
0.220	0.220	0.220	0.220	0.220	0.228	0.275	0.365	0.455	0.502
0.220	0.220	0.220	0.220	0.222	0.245	0.311	0.403	0.476	0.508
0.220	0.220	0.220	0.222	0.237	0.283	0.361	0.443	0.494	0.512
0.222	0.223	0.229	0.245	0.283	0.346	0.418	0.478	0.506	0.513
0.245	0.255	0.276	0.311	0.361	0.419	0.470	0.504	0.515	0.513
0.320	0.338	0.366	0.404	0.444	0.479	0.504	0.520	0.523	0.513
0.419	0.435	0.456	0.478	0.495	0.507	0.516	0.523	0.526	0.517

0.489 0.496 0.504 0.510 0.513 0.514 0.514 0.514 0.517 0.516

******** WATER SATURATION *********

K = 1

0.780	0.774	0.709	0.583	0.475	0.395	0.308	0.266	0.258	0.252
0.774	0.732	0.629	0.519	0.442	0.366	0.289	0.263	0.257	0.252
0.709	0.629	0.535	0.463	0.404	0.323	0.272	0.261	0.257	0.252
0.583	0.519	0.463	0.416	0.347	0.283	0.265	0.260	0.256	0.252
0.475	0.442	0.404	0.347	0.288	0.267	0.263	0.260	0.257	0.252
0.395	0.366	0.323	0.283	0.267	0.263	0.261	0.260	0.257	0.253
0.308	0.288	0.272	0.265	0.262	0.261	0.260	0.259	0.257	0.253
0.266	0.263	0.261	0.260	0.260	0.260	0.259	0.259	0.257	0.254
0.257	0.257	0.256	0.256	0.257	0.257	0.257	0.257	0.256	0.253
0.252	0.252	0.252	0.252	0.252	0.253	0.253	0.254	0.253	0.250

K = 2

0.780	0.780	0.780	0.780	0.780	0.778	0.755	0.681	0.583	0.513
0.780	0.780	0.780	0.780	0.780	0.777	0.745	0.663	0.567	0.506
0.780	0.780	0.780	0.780	0.780	0.772	0.725	0.635	0.545	0.498
0.780	0.780	0.780	0.780	0.778	0.755	0.689	0.597	0.524	0.492
0.780	0.780	0.780	0.778	0.763	0.717	0.639	0.557	0.506	0.488
0.778	0.777	0.771	0.755	0.717	0.654	0.582	0.522	0.494	0.487
0.755	0.745	0.724	0.689	0.639	0.581	0.530	0.496	0.485	0.487
0.680	0.662	0.634	0.596	0.556	0.521	0.496	0.480	0.477	0.487
0.581	0.565	0.544	0.522	0.505	0.493	0.484	0.477	0.474	0.483
0.511	0.504	0.496	0.490	0.487	0.486	0.486	0.486	0.483	0.484

********** END OF REPORT
****

********** WELL REPORT FOR ALL ACTIVE WELLS ELAPSED TIME =1825.000000 DAYS FROM BEGINNING OF SIMULATION **********

WELL ID	LOCATION I	J	K	CALC BHFP	SPEC BHFP	SPEC PI	RATE OIL STB/D	RATE GAS MCF/D	RATE WATER STB/D	GOR	WOR	CUMULATIVE OIL MSTB	CUMULATIVE GAS MMCF	CUMULATIVE WATER MSTB
INJ	1	1	1	3013.	0.	2.429	0.	0.	-16.	0.	0.000	0.	0.	-52.
INJ	1	1	2	3020.	0.	24.291	0.	0.	-519.	0.	0.000	0.	0.	-924.
PROD	10	10	1	2768.	0.	2.429	15.	0.	1.	0.	0.087	144.	0.	1.
PROD	10	10	2	2774.	0.	24.291	1.	0.	518.	0.679	.049	284.	0.	547.
TOTALS							16.	0.	-16.			428.	0.	-428.

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*        SUMMARY REPORT: NIPER MODEL                              *
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*                                                                 *
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ELAPSED TIME (DAYS) = 1825.00 TIME STEP NUMBER = 3676 TIME STEP SIZE (DAYS) = 1.00

CURRENT AVG RES PRESSURE = 2921.9 PREVIOUS AVG RES PRESSURE = 2921.9 PRESSURE DPMAX(2, 2, 1) = -2.0
OIL DSMAX(9, 9, 1) =-.6342E-04 GAS DSMAX(0, 0, 0) =0.0000E+00 WATER DSMAX(9, 9, 1) =0.6342E-04
OIL MATERIAL BALANCE (%) =-.5441E-04 GAS MATERIAL BALANCE (%) =0.0000E+00 WATER MATERIAL BALANCE (%) =0.1541E+00

OIL PRODUCTION RATE (STB/D) = 16.0 CUM. OIL PRODUCTION (STB) =0.4281E+06
GAS PRODUCTION RATE (MSCF/D)= 0.0 CUM. GAS PRODUCTION (MSCF) =0.0000E+00
WATER PRODUCTION RATE(STB/D)= 519.0 CUM. WATER PRODUCTION (STB) =0.5482E+06

GAS INJECTION RATE (MSCF/D) = 0.0 CUM. GAS INJECTION (MSCF) =0.0000E+00
WATER INJECTION RATE (STB/D)= 535.0 CUM. WATER INJECTION (STB) = 0.9764E+06

PRODUCING WOR (STB/STB) = 32.346 CUM. WOR (STB/STB) = 1.280
PRODUCING GOR (SCF/STB) = 0. CUM. GOR (SCF/STB) = 0.

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

```
3005. 2992. 2972. 2952. 2939. 2932. 2927. 2924. 2921. 2920.
2992. 2980. 2962. 2946. 2936. 2930. 2926. 2923. 2920. 2918.
2972. 2962. 2949. 2939. 2932. 2927. 2923. 2920. 2917. 2915.
2952. 2946. 2939. 2933. 2928. 2923. 2919. 2916. 2913. 2911.
2939. 2936. 2932. 2928. 2923. 2919. 2915. 2910. 2907. 2905.
2932. 2930. 2927. 2923. 2919. 2914. 2909. 2904. 2899. 2896.
2927. 2926. 2923. 2919. 2915. 2909. 2903. 2896. 2890. 2886.
2924. 2923. 2920. 2916. 2910. 2904. 2896. 2887. 2878. 2871.
2921. 2920. 2917. 2913. 2907. 2899. 2890. 2878. 2864. 2850.
2920. 2918. 2915. 2911. 2905. 2896. 2886. 2871. 2850. 2815.
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K = 2

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2991. 2970. 2958. 2949. 2943. 2938. 2935. 2933. 2931. 2930.
2970. 2962. 2954. 2947. 2941. 2937. 2933. 2931. 2930. 2929.
2958. 2954. 2948. 2943. 2938. 2934. 2931. 2929. 2927. 2926.
2949. 2947. 2943. 2939. 2934. 2930. 2927. 2925. 2922. 2921.
2943. 2941. 2938. 2934. 2930. 2926. 2922. 2919. 2916. 2914.
2938. 2937. 2934. 2930. 2926. 2922. 2917. 2913. 2909. 2905.
2935. 2933. 2931. 2927. 2922. 2917. 2911. 2906. 2900. 2894.
2933. 2931. 2929. 2925. 2919. 2913. 2906. 2898. 2889. 2880.
2931. 2930. 2927. 2922. 2916. 2909. 2900. 2889. 2875. 2860.
2931. 2929. 2926. 2921. 2914. 2905. 2894. 2880. 2860. 2824.
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********* OIL SATURATION *********

K = 1

0.220	0.220	0.226	0.265	0.335	0.389	0.423	0.470	0.557	0.632
0.220	0.222	0.242	0.299	0.361	0.403	0.433	0.483	0.572	0.638
0.226	0.242	0.286	0.343	0.387	0.415	0.443	0.495	0.583	0.641
0.265	0.299	0.343	0.381	0.406	0.425	0.452	0.505	0.590	0.642
0.335	0.361	0.387	0.406	0.420	0.435	0.461	0.514	0.592	0.642
0.389	0.403	0.415	0.425	0.435	0.449	0.474	0.521	0.590	0.640
0.423	0.433	0.443	0.452	0.461	0.474	0.494	0.531	0.585	0.636
0.470	0.484	0.495	0.505	0.514	0.521	0.531	0.549	0.583	0.628
0.557	0.573	0.584	0.590	0.592	0.590	0.585	0.583	0.593	0.625
0.633	0.638	0.641	0.642	0.643	0.641	0.636	0.628	0.625	0.634

K = 2

0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.222	0.248
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.222	0.247
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.221	0.246
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.221	0.244
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.221	0.241
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.221	0.238
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.235
0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.230
0.222	0.222	0.221	0.221	0.221	0.221	0.220	0.220	0.220	0.226
0.248	0.247	0.246	0.244	0.241	0.238	0.235	0.230	0.226	0.226

********** END OF REPORT
****

Part of Output File (G1YRPF.OUT) for Sample Problem 2

877.541 DAYS

COMPONENT = 1

0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

COMPONENT = 2

0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

COMPONENT = 3

0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

COMPONENT = 4

1.28E+03	1.48E+03	1.38E+03	1.05E+03	6.21E+02	3.09E+02	1.56E+02	7.53E+01	3.19E+01	1.30E+01
1.48E+03	1.43E+03	1.21E+03	8.22E+02	4.57E+02	2.42E+02	1.34E+02	6.27E+01	2.56E+01	9.97E+00
1.38E+03	1.21E+03	8.91E+02	5.47E+02	3.10E+02	1.84E+02	1.03E+02	4.38E+01	1.65E+01	6.07E+00
1.05E+03	8.22E+02	5.47E+02	3.36E+02	2.13E+02	1.34E+02	6.60E+01	2.44E+01	7.84E+00	2.66E+00
6.21E+02	4.58E+02	3.10E+02	2.13E+02	1.45E+02	8.16E+01	3.27E+01	9.07E+00	2.03E+00	6.21E-01
3.09E+02	2.43E+02	1.85E+02	1.34E+02	8.15E+01	3.64E+01	1.03E+01	1.35E+00	1.93E-01	6.05E-02
1.57E+02	1.34E+02	1.03E+02	6.60E+01	3.27E+01	1.03E+01	1.11E+00	1.42E-02	1.09E-04	1.23E-05
7.53E+01	6.26E+01	4.37E+01	2.43E+01	9.04E+00	1.35E+00	1.39E-02	2.33E-04	1.23E-04	2.41E-05
3.18E+01	2.55E+01	1.65E+01	7.79E+00	2.01E+00	1.91E-01	1.08E-04	1.22E-04	9.81E-05	3.60E-05
1.28E+01	9.84E+00	5.99E+00	2.62E+00	6.10E-01	5.94E-02	1.21E-05	2.39E-05	3.59E-05	7.93E-06
1.83E+02	9.06E+02	1.39E+03	1.49E+03	1.50E+03	1.50E+03	1.47E+03	1.37E+03	1.09E+03	5.57E+02
9.06E+02	1.36E+03	1.48E+03	1.50E+03	1.50E+03	1.50E+03	1.47E+03	1.35E+03	1.05E+03	5.21E+02
1.39E+03	1.48E+03	1.50E+03	1.50E+03	1.50E+03	1.49E+03	1.45E+03	1.31E+03	9.84E+02	4.68E+02
1.49E+03	1.50E+03	1.50E+03	1.50E+03	1.50E+03	1.48E+03	1.42E+03	1.25E+03	8.95E+02	4.04E+02
1.50E+03	1.50E+03	1.50E+03	1.50E+03	1.49E+03	1.45E+03	1.36E+03	1.15E+03	7.85E+02	3.39E+02
1.50E+03	1.50E+03	1.49E+03	1.48E+03	1.45E+03	1.39E+03	1.25E+03	1.02E+03	6.71E+02	2.84E+02
1.47E+03	1.47E+03	1.45E+03	1.42E+03	1.36E+03	1.25E+03	1.09E+03	8.59E+02	5.67E+02	2.50E+02
1.37E+03	1.35E+03	1.31E+03	1.25E+03	1.15E+03	1.02E+03	8.58E+02	6.82E+02	4.80E+02	2.40E+02
1.09E+03	1.05E+03	9.83E+02	8.94E+02	7.84E+02	6.69E+02	5.66E+02	4.80E+02	3.88E+02	2.45E+02

5.55E+02	5.19E+02	4.66E+02	4.02E+02	3.37E+02	2.82E+02	2.48E+02	2.39E+02	2.44E+02	2.23E+02

COMPONENT = 5

0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

RESIDUAL RESISTANCE FACTOR :

K = 1

1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

K = 2

1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

INCREASE IN WATER VISCOSITY IN CENTIPOISES :

K = 1

1.18E+01	1.57E+01	1.39E+01	8.51E+00	3.70E+00	1.48E+00	6.81E-01	3.13E-01	1.29E-01	5.20E-02
1.57E+01	1.48E+01	1.08E+01	5.65E+00	2.43E+00	1.11E+00	5.75E-01	2.58E-01	1.03E-01	3.99E-02
1.39E+01	1.08E+01	6.43E+00	3.09E+00	1.49E+00	8.17E-01	4.34E-01	1.79E-01	6.65E-02	2.43E-02
8.51E+00	5.65E+00	3.09E+00	1.64E+00	9.62E-01	5.76E-01	2.73E-01	9.84E-02	3.13E-02	1.06E-02
3.70E+00	2.43E+00	1.49E+00	9.63E-01	6.29E-01	3.40E-01	1.33E-01	3.63E-02	8.09E-03	2.47E-03
1.48E+00	1.11E+00	8.18E-01	5.77E-01	3.40E-01	1.48E-01	4.13E-02	5.40E-03	7.69E-04	2.41E-04
6.82E-01	5.76E-01	4.34E-01	2.73E-01	1.32E-01	4.13E-02	4.43E-03	5.66E-05	4.33E-07	0.00E+00
3.12E-01	2.58E-01	1.78E-01	9.82E-02	3.62E-02	5.37E-03	5.55E-05	9.29E-07	4.89E-07	0.00E+00
1.29E-01	1.03E-01	6.61E-02	3.11E-02	8.01E-03	7.60E-04	4.29E-07	4.87E-07	0.00E+00	0.00E+00
5.13E-02	3.94E-02	2.39E-02	1.04E-02	2.43E-03	2.36E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00

K = 2

7.92E-01	6.26E+00	1.33E+01	1.56E+01	1.60E+01	1.61E+01	1.57E+01	1.38E+01	9.01E+00	3.17E+00
6.26E+00	1.29E+01	1.54E+01	1.59E+01	1.61E+01	1.61E+01	1.56E+01	1.34E+01	8.45E+00	2.89E+00
1.33E+01	1.54E+01	1.59E+01	1.60E+01	1.61E+01	1.60E+01	1.52E+01	1.26E+01	7.57E+00	2.49E+00
1.56E+01	1.59E+01	1.60E+01	1.61E+01	1.61E+01	1.58E+01	1.46E+01	1.14E+01	6.45E+00	2.05E+00
1.60E+01	1.61E+01	1.61E+01	1.61E+01	1.59E+01	1.52E+01	1.34E+01	9.85E+00	5.23E+00	1.64E+00
1.61E+01	1.61E+01	1.60E+01	1.58E+01	1.52E+01	1.40E+01	1.15E+01	7.95E+00	4.11E+00	1.33E+00
1.57E+01	1.56E+01	1.52E+01	1.46E+01	1.34E+01	1.15E+01	8.96E+00	6.00E+00	3.22E+00	1.14E+00
1.38E+01	1.34E+01	1.26E+01	1.14E+01	9.85E+00	7.94E+00	6.00E+00	4.20E+00	2.56E+00	1.09E+00
9.00E+00	8.45E+00	7.56E+00	6.44E+00	5.21E+00	4.10E+00	3.21E+00	2.56E+00	1.94E+00	1.11E+00
3.16E+00	2.87E+00	2.48E+00	2.04E+00	1.63E+00	1.32E+00	1.13E+00	1.08E+00	1.11E+00	9.89E-01

Output File (R1YRPF.OUT) for Sample Problem 2

1 YR WF + 500 D POLYMER FLOODING + WF --- 10*10*2,100-1000MD,KV/KH=0.001

SUMMARY REPORT

N	ETI (DAY)	PAVG (PSI)	OPR (STB/D)	COP (BBL)	GPR (MCF/D)	CGP (MCF)	FOR	WPR (STB/D)	CWP (BBL)	WOR (B/B)	PVWI	CPOI (LB)	WIR (B/D)	CWI (BBL)
49	40.72	2526.7	535	21786.2	0	0	0.02698	0	0.2	0	0.0204	0	535	21786.4
62	81.21	2532.3	535	43445.6	0	0	0.0538	0	0.4	0	0.0407	0	535	43446.1
73	125.55	2537.6	535	67167.3	0	0	0.08318	0	0.6	0	0.0629	0	535	67168
81	165.55	2541.6	535	88567.2	0	0	0.10968	0	0.8	0	0.0829	0	535	88568
93	207.89	2549.1	535	111219	0	0	0.13773	0	0.9	0	0.1041	0	535	111219.9
106	250.08	2557.3	535	133792.5	0	0	0.16569	0	1	0	0.1252	0	535	133793.6
119	290.84	2564.4	535	155595.7	0	0	0.19269	0	1.2	0	0.1456	0	535	155596.9
134	332.79	2571.4	330.9	173931.1	0	0	0.21539	204.1	4110.1	0.62	0.1666	0	535	178041.3
163	373.53	2578.6	257.7	185632	0	0	0.22988	277.3	14204.9	1.08	0.187	2478.2	535	199836.9
187	415.3	2592.4	224.9	195500.2	0	0	0.24211	310.1	26687.9	1.38	0.2079	14620.5	535	222188
211	455.41	2604.5	197.3	203691.8	0	0	0.25225	337.7	39951.9	1.71	0.228	26276.3	535	243643.7
235	495.51	2616.3	177.8	210996.1	0	0	0.2613	357.2	54103.2	2.01	0.2481	37932.1	535	265099.4
259	535.62	2627.3	163.1	217683.5	0	0	0.26958	371.9	68871.5	2.28	0.2682	49587.9	535	286555
283	575.72	2637.8	154.7	223943.4	0	0	0.27733	380.3	84067.2	2.46	0.2882	61243.7	535	308010.6
307	615.83	2647.5	157.3	230123.5	0	0	0.28498	377.7	99342.7	2.4	0.3083	72899.5	535	329466.3
331	655.93	2657.6	174	236670.3	0	0	0.29309	361	114251.6	2.07	0.3284	84555.4	535	350921.9
355	696.31	2669.9	212.7	244329.1	0	0	0.30257	322.3	128194	1.52	0.3486	96290.3	535	372523
380	736.37	2683.8	259.8	253861.5	0	0	0.31438	275.2	140095	1.06	0.3687	107934	535	393956.4
404	776.47	2699.5	295.3	265192.2	0	0	0.32841	239.7	150219.9	0.81	0.3888	119589.9	535	415412.1
430	817.94	2717.3	318.7	278076.7	0	0	0.34437	216.3	159522.9	0.68	0.4095	131643.3	535	437599.6
454	858.05	2735.5	326.2	291093.2	0	0	0.36049	208.8	167962.1	0.64	0.4296	143299.1	535	459055.2
498	899.2	2752.3	324.9	304537.2	0	0	0.37714	210.1	176535.6	0.65	0.4502	145319.5	535	481072.8
524	940.4	2769.2	314.9	317664.6	0	0	0.39339	220.1	185450.3	0.7	0.4708	145319.5	535	503114.8
550	981.88	2786.6	301.7	330315.2	0	0	0.40906	233.3	194987.3	0.77	0.4916	145319.5	535	525302.3
581	1022.25	2803.2	278.6	341875.3	0	0	0.42338	256.4	205029.6	0.92	0.5118	145319.5	535	546904.9
623	1062.52	2817.9	259.6	352700.7	0	0	0.43678	275.4	215744.9	1.06	0.532	145319.5	535	568445.6
676	1102.52	2831.3	241.9	362712.8	0	0	0.44918	293.1	227136.5	1.21	0.552	145319.5	535	589849.5
743	1142.74	2844	225	372120.8	0	0	0.46083	310	239245.1	1.38	0.5721	145319.5	535	611366.1
823	1183.16	2856	210.4	380926.7	0	0	0.47174	324.6	252064.3	1.54	0.5924	145319.5	535	632991.2
916	1223.32	2866.9	194.7	389058.8	0	0	0.48181	340.3	265419.9	1.75	0.6125	145319.5	535	654478.7
1022	1263.49	2877.5	177.4	396532.3	0	0	0.49106	357.6	279432.4	2.02	0.6326	145319.5	535	675964.8
1141	1303.56	2887.1	156.6	403234.6	0	0	0.49936	378.4	294169.2	2.42	0.6527	145319.5	535	697404.2
1274	1343.77	2895.5	130.8	409024.1	0	0	0.50653	404.2	309890.5	3.09	0.6728	145319.5	535	718914.9
1420	1384	2902.5	100.8	413685.7	0	0	0.5123	434.2	326753.3	4.31	0.6929	145319.5	535	740439.2
1579	1424.06	2907.5	71.6	417119.2	0	0	0.51656	463.4	344750.2	6.47	0.713	145319.5	535	761869.8
1750	1464.17	2910.6	49.6	419512.3	0	0	0.51952	485.4	363818.4	9.8	0.7331	145319.5	535	783331.4
1933	1504.2	2912.9	36.1	421199	0	0	0.52161	498.9	383545.6	13.82	0.7531	145319.5	535	804745.6
2127	1544.27	2914.6	28.7	422481.7	0	0	0.5232	506.3	403700.4	17.67	0.7732	145319.5	535	826183.1
2330	1584.41	2915.9	24.4	423538.3	0	0	0.52451	510.6	424119	20.94	0.7933	145319.5	535	847657.9
2542	1624.51	2917.3	21.8	424460.2	0	0	0.52565	513.2	444648.8	23.58	0.8133	145319.5	535	869109.8
2761	1664.6	2918.3	20	425295.9	0	0	0.52668	515	465266.2	25.8	0.8334	145319.5	535	890562.6
2986	1704.65	2919.2	18.6	426068.3	0	0	0.52764	516.4	485919.3	27.71	0.8535	145319.5	535	911988.3
3214	1744.68	2920.2	17.6	426793.1	0	0	0.52854	517.4	506610.5	29.35	0.8735	145319.5	535	933403.8
3447	1784.86	2921	16.7	427482.6	0	0	0.52939	518.3	527414.4	30.95	0.8936	145319.5	535	954897
3676	1825	2921.9	16	428140.3	0	0	0.5302	519	548233.1	32.35	0.9137	145319.5	535	976374.3

APPENDIX E. SAMPLE PROBLEM 3

Input Data File (B1YRG5D.DAT) for Sample Problem 3

```
B1YRG5D.OUT
R1YRG5D.OUT
G1YRG5D.OUT
1YR W.F. + GEL(INJ,5D) + W.F. -- 10*10*2,1E-5, KZ/KH=.001 (5YRS)
 10   10   2
GEL (SWITCHES)
 1
GRID BLOCK LENGTHS
 -1  -1  0
 100.
 100.
 15.   15.
GRID BLOCK LENGTH MODIFICATIONS
  0  0  0  0
CAPROCK BASE DEPTHS TO TOP OF SAND
  0
  8000.
POROSITY AND PERMEABILITY DISTRIBUTIONS
 -1  0  0  0
 .20
 100.  1000.
 100.  1000.
  0.1   1.
POROSITY AND PERMEABILITY MODIFICATIONS
  0  0  0  0  0
TRANSMISSIBILITY MODIFICATIONS
  0  0  0  0
```

SAT	KRO	KRW	KRG	PCOW	PCGO
-0.10	0.	0.	0.	0.	0.
0.0	0.	0.	0.	0.	0.
0.02	0.	0.	0.	0.	0.
0.1	0.	0.	0.	0.	0.
0.2	0.	0.	0.	0.	0.
0.21	0.	0.	0.	0.	0.
0.22	0.	0.	0.	0.	0.
0.25	0.01014	0.0	0.	2.	0.
0.26	0.01355	0.000188	0.	1.975	0.
0.27	0.017099	0.000417	0.	1.951	0.
0.28	0.02083	0.001109	0.	1.9264	0.
0.29	0.02477483	0.002254	0.	1.902	0.
0.3	0.03	0.004	0.	1.877	0.
0.32	0.03815811	0.008301	0.	1.8283	0.
0.34	0.04852966	0.014426	0.	1.7792	0.
0.35	0.054178	0.02	0.	1.755	0.
0.37	0.066415	0.02662	0.	1.7057	0.
0.39	0.0799114	0.0367	0.	1.6566	0.
0.4	0.085	0.04	0.	1.632	0.
0.41	0.0946645	0.048312	0.	1.6075	0.
0.43	0.110683	0.06145	0.	1.5585	0.
0.45	0.128	0.076	0.	1.509	0.
0.46	0.137183	0.08403	0.	1.4849	0.
0.48	0.15666	0.101033	0.	1.4358	0.
0.5	0.18	0.12	0.	1.387	0.
0.525	0.207058	0.14521	0.	1.3255	0.
0.55	0.24	0.173492	0.	1.264	0.
0.575	0.27873	0.204637	0.	1.2028	0.
0.6	0.326	0.24	0.	1.142	0.
0.62	0.366631	0.268539	0.	1.0925	0.
0.65	0.438	0.31731	0.	1.019	0.
0.67	0.5077	0.352836	0.	0.9698	0.

```
0.7          0.63          0.41          0.    0.896          0.
0.73         0.77665       0.47573       0.    0.8226         0.
0.75         0.9           0.52275       0.    0.774          0.
0.78         0.9           0.6           0.    0.7            0.
1.0          0.9           0.6           0.    0.7            0.
1.1          0.9           0.6           0.    0.7            0.
 PBO   VSLOPE          BSLOPE   RSLOPE          PMAX   IREPRS
  10.  .000000         -.0000030    0.0  8000.    0
 P   MUO       BO       RSO
 14.7  3.0     1.00     0.0
 8000.0 3.0    1.00     0.0
 P   MUW       BW     RSW
 14.7  .80     1.0000   0.0
 8000.0 .80    1.00     0.0
 P   MUG  BG     CR
 14.7   .0107   0.0634   .0000040
8000.0  .0121   0.0202   .0000040
 RHOSCO  RHOSCW  RHOSCG     RHOROCK
  53.0          64.5       .0574          143.585
---------CHEMICAL DATA FOR GELATION -----------
5        (ORDER FOR CENTRAL DIFFERENCE METHOD)
1.875E-3   1.875E-3   1.875E-3     (DISPERSION COEFF. IN FT^2/DAY)
1E-5  1E-5   1000     (REACTION CONSTANTS)
.0       .0       .0       .0              .0       ADSORPTION -- AA(1--5)
.0       .0       .0       4.273E-2        8.547E-2        BB(1--5)
.0       .0       .0       .0              1        RESISTANCE FACTOR -- CL(1--5)
.0       .0       .0       .0              .0       GAMA'(1--5)
3.98E-3          2.29E-6          1.695E-9          (PAM VISCOSITY)
4.825E-3         1.608E-6         3.6E-7            1000.    (GEL VISCOSITY)
1.471    1.960E-4         -2.882E-8        0.000    3.923E8    -2.116  (METER'S EQ.)
1.0   1.0   1.0   0.8   0.8  (IPV FOR 1ST LAYER)
1.0   1.0   1.0   0.8   0.8  (IPV FOR 2ND LAYER)
2000  2800  4800  6000  7000
EQUILIBRIUM PRESSURE INITILIZATION/CONSTANT SATURATIONS
  0  0
 2511.   2400.   8000.   7000.
 .75     .25     .00
 KSN1 KSM1 KCO1  KTR KCOF
  0  0  0  0  0
 NMAX  FACT1 FACT2   TMAX   WORMAX   GORMAX   PAMIN  PAMAX
 200000    1.2      .5      1825     0.0       500000.    0.      10000.
 KSOL MITR   OMEGA    TOL     TOL1    DSMAX   DPMAX
 2    3000    1.7       .1      0.      .03       30.
RECURRENT DATA
 40
 1      1   0   0   0   0   0   0   0   0   364. 0
 1.   0.01  1.  0.  0.  0.
RATES -- 1 WATER. INJ. WELL, 1 PROD. WELL (1 YR)
 2  0  0
INJ
 1      1   1   2   2  0   -535.0  0  0
 0.25  0. 0.
 0.25  0. 0.
PROD
 10    10   1   2   1  0   0.  0  535.0
 0.25  0. 0.
 0.25  0. 0.
 0    363   0   0   0   0   0   0   0   0     10. 0
 1    0.01 10.  0.  0.  0.
 0      1   1   1   1   1   0   0   0   0     10. 0
 1    0.01  5.  0.  0.  0.
 1      1   1   1   1   1   0   0   0   0     10. 1
 .1   0.01   .1 0.  0.  0.
RATES -- 1 'GEL' INJ. WELL, 1 PROD. WELL (5 DAYS)
```

```
2  0  0
INJ
1      1    2    1    2  0    -535.0  0  0
0.25   0.  0.
1000.    1400.0   0.0    3000.0   0.0
PROD
10     10    1    2    1  0    0.  0  535.0
0.25   0.  0.
0.25   0.  0.
0      49    0    0    0    0    0    0    0    0      10.  1
.1    0.1      .1 0.   0.   0.
1      1    1    1    1    1    0    0    0    0      10.  1
.01  0.001 2.   0.   0.   0.
RATES -- 1 WATER INJ. WELL, 1 PROD. WELL
2  0  0
INJ
1      1    1    2    2  0    -535.0  0  0
0.25   0.  0.
0.25   0.  0.
0.0    0.0  0.0    0.0  0.0
PROD
10     10    1    2    1  0    0.  0  535.0
0.25   0.  0.
0.25   0.  0.
0    198    0    0    0    0    0    0    0    0    700.  1
.1    0.01  2.   0.   0.   0.
0      1    1    1    1    1    0    0    0    0    700.  1
.1    0.01  2.   0.   0.   0.
0    339    0    0    0    0    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0      1    1    1    1    1    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0    364    0    0    0    0    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0      1    1    1    1    1    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0    364    0    0    0    0    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0      1    1    1    1    1    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0    364    0    0    0    0    0    0    0    0    700.  1
1    0.01  5.   0.   0.   0.
0      1    1    1    1    1    0    0    0    0    700.  1
1    0.01  5..  0.   0.   0.
```

Part of Output File (B1YRG5D.OUT) for Sample Problem 3

```
*****************************************************************
*                                                               *
*                                                               *
*                          NIPER:                               *
*        BLACK OIL PRIMARY AND SECONDARY RECOVERY MODEL         *
*          FOR PERMEABILITY MODIFICATION TREATMENT              *
*                        (VERSION 1.1)                          *
*                                                               *
*                                                               *
*****************************************************************


*******************************************************************************
*                                                                             *
*1YR W.F. + GEL(INJ,5D) + W.F. -- 10*10*2,1E-5, KZ/KH=.001 (5YRS)             *
*                                                                             *
*******************************************************************************


      GRID BLOCK LENGTH (DX) IS INITIALLY SET AT  100.0000 FOR ALL NODES


      GRID BLOCK WIDTH  (DY) IS INITIALLY SET AT  100.0000 FOR ALL NODES


      GRID SIZE (DZ) IN LAYER    1 IS INITIALLY SET AT  15.00 FOR ALL NODES

      GRID SIZE (DZ) IN LAYER    2 IS INITIALLY SET AT  15.00 FOR ALL NODES


       ********** NODE MIDPOINT ELEVATIONS **********

  K = 1

   8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008. 8008.
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K = 2

8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023. 8023.
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POROSITY (PHI) IS INITIALLY SET AT 0.2000 FOR ALL NODES

PERMEABILITY (KX) IN LAYER 1 IS INITIALLY SET AT 100.00 FOR ALL NODES

PERMEABILITY (KX) IN LAYER 2 IS INITIALLY SET AT 1000.00 FOR ALL NODES

PERMEABILITY (KY) IN LAYER 1 IS INITIALLY SET AT 100.00 FOR ALL NODES

PERMEABILITY (KY) IN LAYER 2 IS INITIALLY SET AT 1000.00 FOR ALL NODES

PERMEABILITY (KZ) IN LAYER 1 IS INITIALLY SET AT 0.10 FOR ALL NODES

PERMEABILITY (KZ) IN LAYER 2 IS INITIALLY SET AT 1.00 FOR ALL NODES

***** EMPIRICAL DATA TABLE *****

SAT	KRO	KRW	KRG	PCOW	PCGO
-0.1000	0.0000	0.0000	0.0000	0.00	0.00
0.0000	0.0000	0.0000	0.0000	0.00	0.00
0.0200	0.0000	0.0000	0.0000	0.00	0.00
0.1000	0.0000	0.0000	0.0000	0.00	0.00
0.2000	0.0000	0.0000	0.0000	0.00	0.00
0.2100	0.0000	0.0000	0.0000	0.00	0.00
0.2200	0.0000	0.0000	0.0000	0.00	0.00
0.2500	0.0101	0.0000	0.0000	2.00	0.00
0.2600	0.0136	0.0002	0.0000	1.98	0.00
0.2700	0.0171	0.0004	0.0000	1.95	0.00
0.2800	0.0208	0.0011	0.0000	1.93	0.00

0.2900	0.0248	0.0023	0.0000	1.90	0.00
0.3000	0.0300	0.0040	0.0000	1.88	0.00
0.3200	0.0382	0.0083	0.0000	1.83	0.00
0.3400	0.0485	0.0144	0.0000	1.78	0.00
0.3500	0.0542	0.0200	0.0000	1.75	0.00
0.3700	0.0664	0.0266	0.0000	1.71	0.00
0.3900	0.0799	0.0367	0.0000	1.66	0.00
0.4000	0.0850	0.0400	0.0000	1.63	0.00
0.4100	0.0947	0.0483	0.0000	1.61	0.00
0.4300	0.1107	0.0615	0.0000	1.56	0.00
0.4500	0.1280	0.0760	0.0000	1.51	0.00
0.4600	0.1372	0.0840	0.0000	1.48	0.00
0.4800	0.1567	0.1010	0.0000	1.44	0.00
0.5000	0.1800	0.1200	0.0000	1.39	0.00
0.5250	0.2071	0.1452	0.0000	1.33	0.00
0.5500	0.2400	0.1735	0.0000	1.26	0.00
0.5750	0.2787	0.2046	0.0000	1.20	0.00
0.6000	0.3260	0.2400	0.0000	1.14	0.00
0.6200	0.3666	0.2685	0.0000	1.09	0.00
0.6500	0.4380	0.3173	0.0000	1.02	0.00
0.6700	0.5077	0.3528	0.0000	0.97	0.00
0.7000	0.6300	0.4100	0.0000	0.90	0.00
0.7300	0.7767	0.4757	0.0000	0.82	0.00
0.7500	0.9000	0.5228	0.0000	0.77	0.00
0.7800	0.9000	0.6000	0.0000	0.70	0.00
1.0000	0.9000	0.6000	0.0000	0.70	0.00
1.1000	0.9000	0.6000	0.0000	0.70	0.00

PBO	VSLOPE	BSLOPE	RSLOPE	PMAX	IREPRS
10.00	0.000E+00	-0.300E-05	0.00	8000.00	0

P	MUO	BO	RSO
14.7	3.0000	1.0000	0.00
8000.0	3.0000	1.0000	0.00

P	MUW	BW	RSW
14.7	0.8000	1.0000	0.00
8000.0	0.8000	1.0000	0.00

P	MUG	BG	CR
14.7	0.0107	0.634E-01	0.400E-05
8000.0	0.0121	0.202E-01	0.400E-05

RHOSCO	RHOSCW	RHOSCG	RHOROCK
53.0000	64.5000	0.0574	143.5850

***** SLOPES FOR COMPRESSIBILITY CALCULATIONS ****

P	BO	DBO/DP	RSO	DRSO/DP
8000.0	1.0000	0.0000E+00	0.0	0.0000E+00

P	BW	DBW/DP	RSW	DRSW/DP
8000.0	1.0000	0.0000E+00	0.0	0.0000E+00

P	BG	DBGDP
8000.0	0.2020E-01	-0.5410E-05

**********CHEMICAL SYSTEM PARAMETERS**********

DISPERSION COEFFICIENT IN X DIRECTION = 0.18750E-02

DISPERSION COEFFICIENT IN Y DIRECTION = 0.18750E-02

DISPERSION COEFFICIENT IN Z DIRECTION = 0.18750E-02

REACTION RATE CONSTANTS K1= 0.10000E-04 K2= 0.10000E-04 N = 1000

ADSORPTION PARAMETERS :

A (1-5 COMPONENTS) : 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

B (1-5 COMPONENTS) : 0.00000E+00 0.00000E+00 0.00000E+00 0.42730E-01 0.85470E-01

RESIDUAL RESISTANCE FACTOR PARAMETERS :

CL (1-5 COMPONENTS) : 0.000 0.000 0.000 0.000 1.000

GAMMA (1-5 COMPONS) : 0.000 0.000 0.000 0.000 0.000

POLYMER RHEOLOGY PARAMETERS :

ALPHA1 = 0.39800E-02
ALPHA2 = 0.22900E-05
ALPHA3 = 0.16950E-08

SHEARA = 0.39230E+09
SHEARB = -0.21160E+01

GAMMA0 = 0.14710E+01
GAMMA1 = 0.19600E-03
GAMMA2 = -0.28820E-07
GAMMA3 = 0.00000E+00

GEL RHEOLOGY PARAMETERS :

BETA1 = 0.48250E-02
BETA2 = 0.16080E-05
BETA3 = 0.36000E-06
CRITICAL CONC. = 1000.000

IPV FACTORS (1-5 COMPONENTS) :

LAYER K = 1 : 1.000 1.000 1.000 0.800 0.800

LAYER K = 2 : 1.000 1.000 1.000 0.800 0.800

MAX CONCS. FOR COMPONENTS ARE:

2000.000 2800.000 4800.000 6000.000 7000.000

MAXIMUM NUMBER OF TIME-STEPS = 26000
FACTOR FOR INCREASING DELT = 1.200000 WHEN DSMAX AND DPMAX NOT EXCEEDED.
FACTOR FOR DECREASING DELT = 0.500000 WHEN DSMAX OR DPMAX IS EXCEEDED.
MAXIMUM SIMULATION TIME =1825.000000
MAXIMUM RESERVOIR WOR/TIME-STEP = 0. STB/STB
MAXIMUM RESERVOIR GOR/TIME-STEP = 500000. SCF/STB
MINIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP = 0.
MAXIMUM AVERAGE RESERVOIR PRESSURE/TIME-STEP = 10000.

SOLUTION METHOD IS LSOR:
MAXIMUM NUMBER OF ITERATIONS (MITR) = 3000
INITIAL ACCELERATION PARAMETER (OMEGA) = 1.7000
MAXIMUM PRESSURE RESIDUAL (TOL) = 0.1000
PARAMETER FOR CHANGING OMEGA (TOL1) = 0.0000

AUTOMATIC TIME STEP CRITERIA:
MAXIMUM ALLOWED SATURATION CHANGE (DSMAX) = 0.0300
MAXIMUM ALLOWED PRESSURE CHANGE (DPMAX) = 30.0000

RESERVOIR CONTAINS THE FOLLOWING RATE NODES (FOR VERTICAL WELLS)

NODE	OIL(STBD)	WATER(STBD)	GAS(MCFD)	TOTAL(RBD)	BHFP(PSIA)	PID
1 1 1	0.00	-535.00	0.00	0.00	0.00	2.429136
1 1 2	0.00	-535.00	0.00	0.00	0.00	24.291357
10 10 1	0.00	0.00	0.00	535.00	0.00	2.429136
10 10 2	0.00	0.00	0.00	535.00	0.00	24.291357

BLOCK 1 1 1 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 1 1 2 CONTAINS A RATE SPECIFIED WATER INJECTION WELL
BLOCK 10 10 1 CONTAINS A RATE SPECIFIED PRODUCING WELL
BLOCK 10 10 2 CONTAINS A RATE SPECIFIED PRODUCING WELL

LAYER 1 INITIAL FLUID VOLUMES:
OIL IN PLACE (MILLION STB) 0.4037
WATER IN PLACE (MILLION STB) 0.1336
SOLUTION GAS IN PLACE (BILLION SCF) 0.0000
FREE GAS IN PLACE (BILLION SCF) 0.0000

LAYER 2 INITIAL FLUID VOLUMES:
OIL IN PLACE (MILLION STB) 0.4038
WATER IN PLACE (MILLION STB) 0.1336
SOLUTION GAS IN PLACE (BILLION SCF) 0.0000
FREE GAS IN PLACE (BILLION SCF) 0.0000

TOTAL INITIAL FLUID VOLUMES IN RESERVOIR:

OIL IN PLACE (MILLION STB)	0.8075
WATER IN PLACE (MILLION STB)	0.2671
SOLUTION GAS IN PLACE (BILLION SCF)	0.0000
FREE GAS IN PLACE (BILLION SCF)	0.0000

******* INITIAL ARRAYS *******

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
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2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.
2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.	2514.

K = 2

2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
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2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.
2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.	2521.

********* OIL SATURATION *********

K = 1

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

K = 2

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750

******** WATER SATURATION *********

K = 1

0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250

K = 2

0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250

********* GAS SATURATION *********

K = 1

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

K = 2

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

********** WELL REPORT FOR ALL ACTIVE WELLS ELAPSED TIME = 389.910004 DAYS FROM BEGINNING OF SIMULATION **********

WELL ID	LOCATION I	J	K	CALC BHFP	SPEC BHFP	SPEC PI	RATE OIL STB/D	RATE GAS MCF/D	RATE WATER STB/D	GOR	WOR	CUMULATIVE OIL MSTB	CUMULATIVE GAS MMCF	CUMULATIVE WATER MSTB
INJ	1	1	1	4080.	0.	2.429	0.	0.	-512.	0.	0.000	0.	0.	-19.
INJ	1	1	2	4087.	0.	24.291	0.	0.	-23.	0.	0.000	0.	0.	-190.
PROD	10	10	1	2210.	0.	2.429	77.	0.	0.	0.	0.000	22.	0.	0.
PROD	10	10	2	2216.	0.	24.291	169.	0.	289.	0.	1.711	168.	0.	19.
TOTALS							246.	0.	-246.			190.	0.	-190.

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*                                                                   *
*        SUMMARY REPORT: NIPER MODEL                                *
*                                                                   *
*                                                                   *
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ELAPSED TIME (DAYS) = 389.91 TIME STEP NUMBER = 249 TIME STEP SIZE (DAYS) = 0.10

CURRENT AVG RES PRESSURE = 2574.3 PREVIOUS AVG RES PRESSURE = 2574.3 PRESSURE DPMAX(1, 1, 1) = -4.8
OIL DSMAX(2, 4, 1) =-.5066E-03 GAS DSMAX(0, 0, 0) =0.0000E+00 WATER DSMAX(2, 4, 1) =0.5067E-03
OIL MATERIAL BALANCE (%) =-.6758E-04 GAS MATERIAL BALANCE (%) =0.0000E+00 WATER MATERIAL BALANCE (%) =0.2343E-01

OIL PRODUCTION RATE (STB/D) = 245.8 CUM. OIL PRODUCTION (STB) =0.1899E+06
GAS PRODUCTION RATE (MSCF/D)= 0.0 CUM. GAS PRODUCTION (MSCF) =0.0000E+00
WATER PRODUCTION RATE(STB/D)= 289.2 CUM. WATER PRODUCTION (STB) =0.1871E+05

GAS INJECTION RATE (MSCF/D) = 0.0 CUM. GAS INJECTION (MSCF) =0.0000E+00
WATER INJECTION RATE (STB/D)= 535.0 CUM. WATER INJECTION (STB) = 0.2086E+06

PRODUCING WOR (STB/STB) = 1.176 CUM. WOR (STB/STB) = 0.099
PRODUCING GOR (SCF/STB) = 0. CUM. GOR (SCF/STB) = 0.

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

3679. 3403. 3173. 2975. 2799. 2682. 2626. 2592. 2572. 2563.
3403. 3257. 3082. 2909. 2754. 2668. 2618. 2586. 2567. 2558.
3173. 3082. 2950. 2806. 2707. 2645. 2603. 2575. 2557. 2549.

2975.	2909.	2806.	2722.	2663.	2617.	2583.	2559.	2544.	2536.
2799.	2754.	2707.	2663.	2623.	2589.	2561.	2541.	2527.	2520.
2682.	2668.	2645.	2617.	2589.	2562.	2539.	2520.	2506.	2499.
2626.	2618.	2603.	2583.	2561.	2539.	2518.	2498.	2483.	2473.
2592.	2586.	2575.	2559.	2541.	2520.	2498.	2476.	2455.	2440.
2572.	2567.	2557.	2544.	2527.	2506.	2483.	2455.	2423.	2392.
2563.	2558.	2549.	2536.	2520.	2499.	2473.	2440.	2392.	2316.

K = 2

2552.	2540.	2535.	2531.	2528.	2524.	2520.	2517.	2515.	2514.
2540.	2537.	2534.	2530.	2526.	2522.	2519.	2515.	2513.	2512.
2535.	2534.	2531.	2528.	2523.	2519.	2515.	2511.	2509.	2507.
2531.	2530.	2528.	2524.	2519.	2514.	2509.	2505.	2502.	2500.
2528.	2526.	2523.	2519.	2514.	2508.	2502.	2496.	2492.	2489.
2524.	2522.	2519.	2514.	2508.	2501.	2493.	2485.	2479.	2475.
2520.	2519.	2515.	2509.	2502.	2493.	2483.	2472.	2462.	2456.
2517.	2515.	2511.	2505.	2496.	2485.	2472.	2456.	2440.	2428.
2515.	2513.	2509.	2502.	2492.	2479.	2462.	2440.	2413.	2386.
2514.	2512.	2507.	2500.	2489.	2475.	2456.	2428.	2386.	2315.

********* OIL SATURATION *********

K = 1

0.295	0.377	0.456	0.542	0.649	0.716	0.730	0.738	0.744	0.749
0.377	0.442	0.513	0.604	0.696	0.724	0.732	0.739	0.744	0.749
0.456	0.513	0.588	0.680	0.719	0.728	0.735	0.740	0.745	0.749
0.542	0.604	0.680	0.717	0.726	0.732	0.737	0.741	0.745	0.749
0.649	0.696	0.719	0.726	0.731	0.735	0.739	0.742	0.745	0.749
0.716	0.724	0.728	0.732	0.735	0.738	0.741	0.743	0.746	0.749
0.730	0.733	0.735	0.737	0.739	0.741	0.742	0.744	0.746	0.749
0.738	0.739	0.740	0.741	0.742	0.743	0.744	0.745	0.746	0.748
0.744	0.744	0.745	0.745	0.745	0.746	0.746	0.746	0.746	0.748
0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.748	0.748	0.749

K = 2

0.220	0.240	0.272	0.311	0.347	0.376	0.405	0.440	0.492	0.591
0.242	0.270	0.303	0.337	0.364	0.388	0.414	0.446	0.495	0.594
0.277	0.304	0.334	0.359	0.378	0.398	0.420	0.450	0.497	0.595
0.316	0.339	0.359	0.375	0.390	0.407	0.426	0.453	0.497	0.593
0.351	0.366	0.378	0.390	0.403	0.415	0.432	0.456	0.495	0.588
0.380	0.389	0.398	0.407	0.415	0.425	0.438	0.458	0.492	0.578
0.409	0.415	0.421	0.426	0.432	0.439	0.447	0.460	0.487	0.563
0.443	0.448	0.451	0.454	0.456	0.458	0.460	0.466	0.484	0.544
0.494	0.497	0.498	0.498	0.496	0.492	0.488	0.484	0.487	0.524
0.594	0.596	0.596	0.594	0.589	0.579	0.564	0.544	0.525	0.526

********** END OF REPORT
****

********** WELL REPORT FOR ALL ACTIVE WELLS ELAPSED TIME =1824.910030 DAYS FROM BEGINNING OF SIMULATION **********

WELL ID	LOCATION I	J	K	CALC BHFP	SPEC BHFP	SPEC PI	RATE OIL STB/D	RATE GAS MCF/D	RATE WATER STB/D	GOR	WOR	CUMULATIVE OIL MSTB	CUMULATIVE GAS MMCF	CUMULATIVE WATER MSTB
INJ	1	1	1	3201.	0.	2.429	0.	0.	-423.	0.	0.000	0.	0.	-628.
INJ	1	1	2	3207.	0.	24.291	0.	0.	-112.	0.	0.000	0.	0.	-348.
PROD	10	10	1	2173.	0.	2.429	23.	0.	19.	0.	0.827	109.	0.	6.
PROD	10	10	2	2178.	0.	24.291	37.	0.	456.	0.	12.215	293.	0.	568.
TOTALS							60.	0.	-60.			402.	0.	-402.

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*********************************************************************
*                                                                   *
*                                                                   *
*        SUMMARY REPORT: NIPER MODEL                                *
*                                                                   *
*                                                                   *
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ELAPSED TIME (DAYS) = 1824.91 TIME STEP NUMBER = 582 TIME STEP SIZE (DAYS) = 1.00

CURRENT AVG RES PRESSURE = 2586.8 PREVIOUS AVG RES PRESSURE = 2586.8 PRESSURE DPMAX(10, 10, 1) = 0.3
OIL DSMAX(7, 10, 1) =-.1674E-03 GAS DSMAX(0, 0, 0) =0.0000E+00 WATER DSMAX(7, 10, 1) =0.1674E-03
OIL MATERIAL BALANCE (%) =-.1617E-03 GAS MATERIAL BALANCE (%) =0.0000E+00 WATER MATERIAL BALANCE (%) =0.1601E+00

OIL PRODUCTION RATE (STB/D) = 60.3 CUM. OIL PRODUCTION (STB) =0.4021E+06
GAS PRODUCTION RATE (MSCF/D)= 0.0 CUM. GAS PRODUCTION (MSCF) =0.0000E+00
WATER PRODUCTION RATE(STB/D)= 474.7 CUM. WATER PRODUCTION (STB) =0.5742E+06

GAS INJECTION RATE (MSCF/D) = 0.0 CUM. GAS INJECTION (MSCF) =0.0000E+00
WATER INJECTION RATE (STB/D)= 535.0 CUM. WATER INJECTION (STB) = 0.9763E+06

PRODUCING WOR (STB/STB) = 7.879 CUM. WOR (STB/STB) = 1.428
PRODUCING GOR (SCF/STB) = 0. CUM. GOR (SCF/STB) = 0.

***** RESERVOIR PRESSURE DISTRIBUTION *****

K = 1

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2967. 2815. 2736. 2690. 2660. 2639. 2623. 2612. 2604. 2601.
2815. 2761. 2714. 2679. 2654. 2634. 2619. 2609. 2601. 2598.
2736. 2714. 2688. 2664. 2643. 2626. 2613. 2603. 2596. 2593.
2690. 2679. 2664. 2647. 2631. 2616. 2604. 2595. 2588. 2585.
2660. 2654. 2643. 2631. 2618. 2605. 2594. 2585. 2578. 2574.
2639. 2634. 2627. 2616. 2605. 2594. 2583. 2573. 2565. 2560.
2623. 2619. 2613. 2604. 2594. 2583. 2571. 2559. 2548. 2541.
2612. 2609. 2603. 2595. 2585. 2573. 2559. 2543. 2527. 2515.
```

2604.	2602.	2596.	2588.	2578.	2565.	2548.	2527.	2502.	2475.
2601.	2598.	2593.	2585.	2574.	2560.	2541.	2515.	2475.	2403.

K = 2

2601.	2595.	2590.	2586.	2582.	2578.	2575.	2572.	2570.	2569.
2595.	2592.	2588.	2584.	2580.	2577.	2573.	2571.	2569.	2568.
2590.	2588.	2585.	2582.	2578.	2574.	2571.	2568.	2566.	2565.
2586.	2584.	2582.	2578.	2575.	2571.	2567.	2563.	2561.	2560.
2582.	2581.	2578.	2575.	2571.	2566.	2562.	2557.	2554.	2553.
2578.	2577.	2574.	2571.	2566.	2561.	2555.	2550.	2546.	2543.
2575.	2573.	2571.	2567.	2562.	2555.	2548.	2541.	2535.	2531.
2572.	2571.	2568.	2563.	2557.	2550.	2541.	2531.	2521.	2514.
2570.	2569.	2566.	2561.	2554.	2546.	2535.	2521.	2505.	2488.
2569.	2568.	2565.	2560.	2553.	2543.	2531.	2514.	2488.	2446.

********* OIL SATURATION *********

K = 1

0.220	0.221	0.224	0.240	0.272	0.311	0.352	0.399	0.457	0.560
0.220	0.221	0.229	0.253	0.286	0.323	0.363	0.407	0.464	0.568
0.222	0.229	0.247	0.275	0.307	0.341	0.377	0.418	0.474	0.577
0.239	0.253	0.275	0.301	0.330	0.360	0.394	0.431	0.483	0.587
0.271	0.286	0.307	0.330	0.355	0.382	0.410	0.444	0.493	0.597
0.310	0.324	0.341	0.360	0.381	0.403	0.427	0.457	0.501	0.603
0.352	0.363	0.377	0.393	0.410	0.427	0.447	0.470	0.507	0.600
0.398	0.407	0.418	0.431	0.444	0.457	0.470	0.485	0.512	0.587
0.457	0.464	0.474	0.483	0.493	0.501	0.507	0.512	0.523	0.568
0.560	0.568	0.578	0.588	0.598	0.604	0.601	0.587	0.569	0.569

K = 2

0.220	0.220	0.227	0.241	0.262	0.285	0.310	0.339	0.378	0.442
0.221	0.223	0.233	0.249	0.269	0.290	0.313	0.340	0.377	0.441
0.226	0.233	0.245	0.261	0.279	0.296	0.317	0.342	0.377	0.439
0.240	0.249	0.262	0.275	0.289	0.304	0.322	0.343	0.376	0.436
0.261	0.270	0.279	0.289	0.300	0.313	0.327	0.345	0.374	0.432
0.285	0.291	0.297	0.306	0.314	0.322	0.332	0.345	0.370	0.424
0.310	0.315	0.320	0.324	0.328	0.332	0.337	0.346	0.364	0.413
0.339	0.342	0.344	0.345	0.346	0.346	0.346	0.348	0.359	0.399
0.379	0.380	0.379	0.378	0.375	0.371	0.365	0.360	0.361	0.385
0.443	0.443	0.442	0.440	0.435	0.427	0.416	0.403	0.387	0.387

********** END OF REPORT
****

Part of Output File (G1YRG5D.OUT) for Sample Problem 3

1779.709 DAYS

COMPONENT = 1

5.75E-44	6.46E-30	0.00E+00	2.00E-10	6.12E-07	7.63E-05	1.39E-03	6.65E-03	1.03E-02	4.77E-03
6.51E-30	1.24E-21	0.00E+00	2.10E-09	2.48E-06	1.72E-04	2.16E-03	7.98E-03	1.01E-02	3.99E-03
0.00E+00	0.00E+00	2.37E-11	1.05E-07	1.77E-05	4.97E-04	3.71E-03	9.70E-03	9.61E-03	3.12E-03
2.00E-10	2.11E-09	1.05E-07	5.66E-06	1.50E-04	1.54E-03	6.32E-03	1.12E-02	8.55E-03	2.29E-03
6.12E-07	2.49E-06	1.77E-05	1.51E-04	1.02E-03	4.21E-03	9.66E-03	1.18E-02	7.04E-03	1.59E-03
7.64E-05	1.72E-04	4.98E-04	1.54E-03	4.21E-03	8.68E-03	1.22E-02	1.09E-02	2.07E-02	3.40E-02
1.39E-03	2.17E-03	3.72E-03	6.32E-03	9.66E-03	1.22E-02	1.21E-02	2.60E-02	1.03E-01	1.66E-01
6.66E-03	8.00E-03	9.71E-03	1.12E-02	1.18E-02	1.09E-02	2.60E-02	1.07E-01	2.97E-01	5.08E-01
1.03E-02	1.01E-02	9.61E-03	8.54E-03	7.03E-03	2.05E-02	1.03E-01	2.96E-01	6.01E-01	1.02E+00
4.76E-03	3.98E-03	3.11E-03	2.28E-03	1.59E-03	3.33E-02	1.64E-01	5.03E-01	1.02E+00	1.37E+00
3.84E-22	2.54E-13	9.84E-10	1.79E-07	1.07E-05	3.77E-04	8.48E-03	1.24E-01	1.00E+00	3.04E+00
2.82E-13	1.81E-11	4.03E-09	3.60E-07	1.61E-05	4.71E-04	9.26E-03	1.26E-01	9.95E-01	3.04E+00
1.12E-09	4.43E-09	4.32E-08	1.03E-06	2.82E-05	6.09E-04	9.98E-03	1.25E-01	9.63E-01	3.01E+00
2.08E-07	4.12E-07	1.13E-06	5.90E-06	6.36E-05	8.16E-04	1.04E-02	1.18E-01	8.93E-01	2.90E+00
1.25E-05	1.86E-05	3.17E-05	6.81E-05	2.19E-04	1.19E-03	1.05E-02	1.05E-01	7.83E-01	2.70E+00
4.29E-04	5.33E-04	6.80E-04	8.93E-04	1.26E-03	2.43E-03	1.07E-02	8.75E-02	6.37E-01	2.37E+00
9.34E-03	1.02E-02	1.10E-02	1.14E-02	1.14E-02	1.14E-02	1.64E-02	7.11E-02	4.75E-01	1.91E+00
1.32E-01	1.36E-01	1.35E-01	1.27E-01	1.13E-01	9.36E-02	7.53E-02	9.06E-02	3.42E-01	1.40E+00
1.03E+00	1.03E+00	1.00E+00	9.31E-01	8.16E-01	6.65E-01	4.97E-01	3.54E-01	3.80E-01	9.79E-01
3.03E+00	3.04E+00	3.01E+00	2.92E+00	2.72E+00	2.39E+00	1.94E+00	1.41E+00	9.85E-01	1.00E+00

COMPONENT = 2

7.57E-44	9.03E-30	0.00E+00	2.80E-10	8.55E-07	1.07E-04	1.94E-03	9.30E-03	1.44E-02	6.66E-03
9.11E-30	1.74E-21	0.00E+00	2.94E-09	3.46E-06	2.40E-04	3.02E-03	1.12E-02	1.42E-02	5.57E-03
0.00E+00	0.00E+00	3.32E-11	1.47E-07	2.47E-05	6.95E-04	5.19E-03	1.36E-02	1.34E-02	4.36E-03
2.80E-10	2.96E-09	1.47E-07	7.91E-06	2.10E-04	2.15E-03	8.83E-03	1.57E-02	1.20E-02	3.20E-03
8.56E-07	3.48E-06	2.47E-05	2.10E-04	1.42E-03	5.89E-03	1.35E-02	1.65E-02	9.84E-03	2.23E-03
1.07E-04	2.41E-04	6.96E-04	2.16E-03	5.89E-03	1.21E-02	1.71E-02	1.52E-02	2.74E-02	4.46E-02
1.95E-03	3.03E-03	5.20E-03	8.84E-03	1.35E-02	1.71E-02	1.69E-02	3.46E-02	1.35E-01	2.17E-01
9.31E-03	1.12E-02	1.36E-02	1.57E-02	1.65E-02	1.52E-02	3.45E-02	1.39E-01	3.84E-01	6.57E-01
1.44E-02	1.42E-02	1.34E-02	1.19E-02	9.83E-03	2.72E-02	1.34E-01	3.83E-01	7.75E-01	1.31E+00
6.65E-03	5.56E-03	4.36E-03	3.19E-03	2.22E-03	4.36E-02	2.14E-01	6.51E-01	1.31E+00	1.75E+00
4.90E-22	3.24E-13	1.26E-09	2.28E-07	1.36E-05	4.82E-04	1.08E-02	1.58E-01	1.27E+00	3.87E+00
3.60E-13	2.31E-11	5.14E-09	4.60E-07	2.06E-05	6.03E-04	1.18E-02	1.61E-01	1.26E+00	3.87E+00
1.43E-09	5.65E-09	5.51E-08	1.32E-06	3.63E-05	7.82E-04	1.27E-02	1.59E-01	1.22E+00	3.82E+00
2.66E-07	5.26E-07	1.44E-06	7.61E-06	8.28E-05	1.05E-03	1.33E-02	1.50E-01	1.13E+00	3.69E+00
1.60E-05	2.38E-05	4.07E-05	8.84E-05	2.88E-04	1.55E-03	1.34E-02	1.34E-01	9.93E-01	3.43E+00
5.48E-04	6.82E-04	8.73E-04	1.15E-03	1.64E-03	3.15E-03	1.37E-02	1.11E-01	8.08E-01	3.01E+00
1.19E-02	1.31E-02	1.41E-02	1.46E-02	1.46E-02	1.45E-02	2.10E-02	9.05E-02	6.03E-01	2.43E+00
1.68E-01	1.72E-01	1.71E-01	1.62E-01	1.44E-01	1.19E-01	9.57E-02	1.15E-01	4.34E-01	1.77E+00
1.31E+00	1.31E+00	1.27E+00	1.18E+00	1.03E+00	8.43E-01	6.30E-01	4.50E-01	4.82E-01	1.24E+00
3.85E+00	3.87E+00	3.83E+00	3.70E+00	3.45E+00	3.03E+00	2.46E+00	1.80E+00	1.25E+00	1.27E+00

COMPONENT = 3

2.10E-44	3.23E-30	0.00E+00	4.65E-13	1.41E-09	1.78E-07	3.28E-06	1.59E-05	2.45E-05	1.12E-05
3.95E-30	2.65E-22	0.00E+00	4.83E-12	5.72E-09	4.01E-07	5.12E-06	1.91E-05	2.41E-05	9.34E-06
0.00E+00	0.00E+00	5.66E-14	2.42E-10	4.10E-08	1.17E-06	8.83E-06	2.32E-05	2.28E-05	7.31E-06
4.66E-13	4.86E-12	2.42E-10	1.31E-08	3.52E-07	3.65E-06	1.51E-05	2.69E-05	2.02E-05	5.29E-06
1.41E-09	5.75E-09	4.11E-08	3.53E-07	2.40E-06	1.01E-05	2.32E-05	2.82E-05	1.69E-05	4.33E-06
1.78E-07	4.03E-07	1.17E-06	3.65E-06	1.01E-05	2.09E-05	2.93E-05	2.66E-05	2.21E-03	4.41E-03
3.28E-06	5.14E-06	8.85E-06	1.51E-05	2.32E-05	2.93E-05	2.95E-05	2.67E-03	1.50E-02	2.37E-02
1.59E-05	1.91E-05	2.32E-05	2.69E-05	2.82E-05	2.66E-05	2.66E-03	1.58E-02	4.65E-02	8.02E-02
2.45E-05	2.41E-05	2.28E-05	2.02E-05	1.69E-05	2.18E-03	1.49E-02	4.64E-02	9.89E-02	1.75E-01
1.12E-05	9.33E-06	7.30E-06	5.28E-06	4.31E-06	4.30E-03	2.34E-02	7.95E-02	1.75E-01	2.43E-01
7.14E-23	4.67E-14	1.81E-10	3.29E-08	1.94E-06	6.78E-05	1.58E-03	2.40E-02	2.00E-01	5.91E-01
5.19E-14	3.33E-12	7.42E-10	6.63E-08	2.88E-06	8.34E-05	1.71E-03	2.45E-02	1.99E-01	5.93E-01
2.06E-10	8.15E-10	7.96E-09	1.87E-07	4.79E-06	1.05E-04	1.84E-03	2.42E-02	1.93E-01	5.88E-01
3.83E-08	7.58E-08	2.04E-07	9.60E-07	9.41E-06	1.32E-04	1.90E-03	2.29E-02	1.79E-01	5.69E-01
2.27E-06	3.34E-06	5.43E-06	1.02E-05	2.89E-05	1.80E-04	1.89E-03	2.04E-02	1.57E-01	5.31E-01
7.74E-05	9.48E-05	1.18E-04	1.47E-04	1.93E-04	3.74E-04	1.90E-03	1.69E-02	1.27E-01	4.67E-01
1.74E-03	1.90E-03	2.03E-03	2.09E-03	2.06E-03	2.03E-03	2.96E-03	1.37E-02	9.48E-02	3.78E-01
2.56E-02	2.63E-02	2.61E-02	2.46E-02	2.19E-02	1.81E-02	1.45E-02	1.74E-02	6.79E-02	2.76E-01
2.06E-01	2.06E-01	2.00E-01	1.86E-01	1.63E-01	1.33E-01	9.89E-02	7.03E-02	7.55E-02	1.94E-01
5.86E-01	5.91E-01	5.87E-01	5.70E-01	5.33E-01	4.70E-01	3.81E-01	2.79E-01	1.95E-01	1.99E-01

COMPONENT = 4

8.97E-44	8.48E-39	0.00E+00	1.59E-10	7.96E-08	3.74E-05	1.67E-03	1.59E-02	4.35E-02	3.27E-02
8.55E-39	2.91E-27	0.00E+00	2.88E-10	3.87E-07	9.45E-05	2.84E-03	2.07E-02	4.63E-02	2.96E-02
0.00E+00	0.00E+00	0.00E+00	5.71E-09	4.07E-06	3.36E-04	5.61E-03	2.81E-02	4.87E-02	2.56E-02
1.60E-10	2.89E-10	5.72E-09	8.51E-07	5.91E-05	1.40E-03	1.16E-02	3.78E-02	4.93E-02	2.11E-02
7.97E-08	3.89E-07	4.07E-06	5.91E-05	7.26E-04	5.53E-03	2.27E-02	4.78E-02	4.73E-02	1.68E-02
3.74E-05	9.50E-05	3.37E-04	1.40E-03	5.53E-03	1.75E-02	3.88E-02	5.49E-02	5.97E-02	8.48E-02
1.67E-03	2.86E-03	5.63E-03	1.16E-02	2.28E-02	3.88E-02	5.38E-02	6.69E-02	1.37E-01	3.14E-01
1.59E-02	2.07E-02	2.82E-02	3.79E-02	4.79E-02	5.49E-02	6.69E-02	1.20E-01	3.09E-01	7.15E-01
4.36E-02	4.64E-02	4.87E-02	4.93E-02	4.73E-02	5.96E-02	1.36E-01	3.08E-01	6.01E-01	1.08E+00
3.27E-02	2.95E-02	2.55E-02	2.11E-02	1.68E-02	8.32E-02	3.09E-01	7.09E-01	1.07E+00	1.26E+00
1.09E-30	1.87E-18	3.93E-15	1.18E-10	3.69E-08	8.79E-06	3.50E-04	7.78E-03	1.68E-01	1.55E+00
2.26E-18	1.74E-16	8.48E-14	1.99E-10	1.02E-07	1.55E-05	4.44E-04	8.00E-03	1.64E-01	1.53E+00
9.67E-15	1.11E-13	1.77E-12	1.54E-09	5.62E-07	3.48E-05	5.96E-04	8.04E-03	1.55E-01	1.48E+00
1.35E-10	2.27E-10	1.60E-09	1.08E-07	4.90E-06	9.27E-05	8.29E-04	7.78E-03	1.40E-01	1.37E+00
4.04E-08	1.08E-07	5.74E-07	4.93E-06	4.14E-05	2.56E-04	1.15E-03	7.16E-03	1.18E-01	1.22E+00
9.18E-06	1.61E-05	3.57E-05	9.42E-05	2.59E-04	6.63E-04	1.57E-03	6.24E-03	9.23E-02	1.01E+00
3.70E-04	4.69E-04	6.25E-04	8.59E-04	1.18E-03	1.59E-03	2.20E-03	5.38E-03	6.60E-02	7.58E-01
8.44E-03	8.73E-03	8.77E-03	8.45E-03	7.71E-03	6.67E-03	5.67E-03	6.55E-03	4.39E-02	5.10E-01
1.78E-01	1.75E-01	1.66E-01	1.50E-01	1.27E-01	9.90E-02	7.08E-02	4.67E-02	4.88E-02	3.11E-01
1.58E+00	1.56E+00	1.51E+00	1.40E+00	1.24E+00	1.03E+00	7.75E-01	5.21E-01	3.16E-01	3.19E-01

COMPONENT = 5

7.57E-44	2.24E-31	0.00E+00	1.49E-12	7.51E-10	3.51E-07	1.56E-05	1.48E-04	4.06E-04	3.05E-04
1.88E-31	1.61E-22	0.00E+00	2.69E-12	3.65E-09	8.86E-07	2.66E-05	1.93E-04	4.32E-04	2.75E-04
0.00E+00	0.00E+00	0.00E+00	5.40E-11	3.82E-08	3.15E-06	5.25E-05	2.62E-04	4.54E-04	2.38E-04
1.49E-12	2.70E-12	5.40E-11	8.01E-09	5.55E-07	1.31E-05	1.08E-04	3.52E-04	4.58E-04	1.91E-04
7.53E-10	3.67E-09	3.83E-08	5.55E-07	6.79E-06	5.17E-05	2.12E-04	4.44E-04	4.50E-04	2.01E-04
3.52E-07	8.91E-07	3.15E-06	1.31E-05	5.17E-05	1.63E-04	3.60E-04	5.30E-04	8.81E-02	3.05E-01
1.57E-05	2.67E-05	5.26E-05	1.09E-04	2.13E-04	3.60E-04	5.15E-04	6.98E-02	5.55E-01	1.41E+00
1.49E-04	1.94E-04	2.63E-04	3.53E-04	4.45E-04	5.30E-04	6.97E-02	4.51E-01	1.60E+00	3.57E+00
4.07E-04	4.32E-04	4.54E-04	4.58E-04	4.50E-04	8.71E-02	5.51E-01	1.60E+00	3.29E+00	5.74E+00
3.05E-04	2.75E-04	2.37E-04	1.91E-04	1.99E-04	2.98E-01	1.39E+00	3.54E+00	5.72E+00	6.80E+00
3.45E-28	1.64E-16	2.59E-12	2.09E-09	2.77E-07	2.59E-05	1.55E-03	6.15E-02	1.30E+00	9.44E+00
1.91E-16	1.37E-14	1.13E-11	3.84E-09	4.00E-07	3.09E-05	1.64E-03	6.14E-02	1.28E+00	9.36E+00
3.08E-12	1.30E-11	1.51E-10	9.40E-09	6.29E-07	3.71E-05	1.70E-03	5.93E-02	1.21E+00	9.07E+00
2.56E-09	4.64E-09	1.10E-08	5.32E-08	1.13E-06	4.40E-05	1.69E-03	5.45E-02	1.09E+00	8.49E+00
3.47E-07	4.97E-07	7.66E-07	1.32E-06	3.95E-06	5.34E-05	1.58E-03	4.66E-02	9.26E-01	7.58E+00
3.11E-05	3.70E-05	4.42E-05	5.17E-05	6.08E-05	1.15E-04	1.40E-03	3.66E-02	7.23E-01	6.32E+00
1.78E-03	1.90E-03	1.97E-03	1.95E-03	1.80E-03	1.58E-03	2.21E-03	2.70E-02	5.13E-01	4.81E+00
6.76E-02	6.81E-02	6.60E-02	6.05E-02	5.17E-02	4.05E-02	2.97E-02	3.60E-02	3.36E-01	3.27E+00
1.38E+00	1.36E+00	1.29E+00	1.16E+00	9.87E-01	7.71E-01	5.48E-01	3.57E-01	3.75E-01	2.03E+00
9.52E+00	9.47E+00	9.20E+00	8.63E+00	7.70E+00	6.43E+00	4.90E+00	3.33E+00	2.05E+00	2.08E+00

RESIDUAL RESISTANCE FACTOR :

K = 1

1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.06E+00	1.04E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.12E+00	1.24E+00	1.16E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.12E+00	1.34E+00	1.49E+00	1.42E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.06E+00	1.24E+00	1.49E+00	1.72E+00	1.79E+00
1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.04E+00	1.15E+00	1.41E+00	1.79E+00	2.20E+00

K = 2

9.88E+01	3.86E+01	2.04E+01	1.39E+01	1.03E+01	8.09E+00	6.49E+00	5.22E+00	4.10E+00	2.89E+00
3.85E+01	2.24E+01	1.57E+01	1.19E+01	9.46E+00	7.72E+00	6.38E+00	5.25E+00	4.17E+00	2.93E+00
2.03E+01	1.57E+01	1.25E+01	1.03E+01	8.64E+00	7.37E+00	6.29E+00	5.31E+00	4.27E+00	3.00E+00
1.38E+01	1.19E+01	1.03E+01	8.97E+00	7.93E+00	7.04E+00	6.23E+00	5.39E+00	4.40E+00	3.10E+00
1.02E+01	9.39E+00	8.60E+00	7.92E+00	7.32E+00	6.76E+00	6.18E+00	5.49E+00	4.57E+00	3.23E+00
7.98E+00	7.65E+00	7.33E+00	7.02E+00	6.74E+00	6.46E+00	6.12E+00	5.61E+00	4.78E+00	3.44E+00
6.39E+00	6.31E+00	6.24E+00	6.19E+00	6.16E+00	6.11E+00	5.98E+00	5.68E+00	5.03E+00	3.75E+00
5.14E+00	5.19E+00	5.25E+00	5.35E+00	5.46E+00	5.58E+00	5.67E+00	5.62E+00	5.24E+00	4.17E+00
4.04E+00	4.11E+00	4.21E+00	4.35E+00	4.53E+00	4.75E+00	5.01E+00	5.23E+00	5.22E+00	4.58E+00
2.84E+00	2.89E+00	2.96E+00	3.06E+00	3.20E+00	3.41E+00	3.72E+00	4.15E+00	4.57E+00	4.55E+00

INCREASE IN WATER VISCOSITY IN CENTIPOISES :

K = 1

0.00E+00	1.08E-33	0.00E+00	7.19E-15	3.63E-12	1.69E-09	6.72E-06	6.39E-05	1.75E-04	1.32E-04
9.09E-34	7.76E-25	0.00E+00	1.30E-14	1.76E-11	4.28E-09	1.14E-05	8.31E-05	1.86E-04	1.19E-04
0.00E+00	0.00E+00	0.00E+00	2.60E-13	1.85E-10	1.35E-06	2.26E-05	1.13E-04	1.96E-04	1.03E-04
7.20E-15	1.30E-14	2.61E-13	3.87E-11	2.68E-09	5.62E-06	4.67E-05	1.52E-04	1.99E-04	8.49E-05
3.63E-12	1.77E-11	1.85E-10	2.68E-09	2.92E-06	2.23E-05	9.15E-05	1.92E-04	1.90E-04	6.79E-05
1.70E-09	4.30E-09	1.35E-06	5.63E-06	2.23E-05	7.03E-05	1.56E-04	2.21E-04	6.63E-04	1.81E-03
6.74E-06	1.15E-05	2.27E-05	4.68E-05	9.17E-05	1.56E-04	2.17E-04	6.03E-04	3.22E-03	8.04E-03
6.41E-05	8.34E-05	1.13E-04	1.52E-04	1.93E-04	2.21E-04	6.02E-04	2.65E-03	8.96E-03	2.01E-02
1.75E-04	1.87E-04	1.96E-04	1.99E-04	1.90E-04	6.58E-04	3.20E-03	8.93E-03	1.83E-02	3.21E-02
1.32E-04	1.19E-04	1.03E-04	8.47E-05	6.77E-05	1.77E-03	7.92E-03	1.99E-02	3.19E-02	3.79E-02

K = 2

1.67E-30	7.89E-19	1.25E-14	1.01E-11	1.34E-09	1.25E-07	8.86E-06	3.28E-04	6.96E-03	5.19E-02
9.21E-19	6.62E-17	5.46E-14	1.85E-11	1.93E-09	1.49E-07	9.69E-06	3.28E-04	6.81E-03	5.14E-02
1.48E-14	6.26E-14	7.31E-13	4.53E-11	3.04E-09	1.79E-07	1.06E-05	3.18E-04	6.45E-03	4.98E-02
1.24E-11	2.24E-11	5.29E-11	2.57E-10	5.47E-09	2.12E-07	1.15E-05	2.94E-04	5.83E-03	4.66E-02
1.68E-09	2.40E-09	3.70E-09	6.36E-09	1.91E-08	1.28E-06	1.22E-05	2.53E-04	4.94E-03	4.15E-02
1.50E-07	1.79E-07	2.13E-07	2.49E-07	1.32E-06	3.19E-06	1.30E-05	2.01E-04	3.86E-03	3.46E-02
1.00E-05	1.10E-05	1.20E-05	1.28E-05	1.34E-05	1.39E-05	1.94E-05	1.51E-04	2.74E-03	2.62E-02
3.60E-04	3.63E-04	3.53E-04	3.26E-04	2.80E-04	2.22E-04	1.66E-04	2.00E-04	1.80E-03	1.78E-02
7.35E-03	7.24E-03	6.88E-03	6.22E-03	5.27E-03	4.12E-03	2.93E-03	1.91E-03	2.01E-03	1.10E-02
5.24E-02	5.21E-02	5.05E-02	4.73E-02	4.22E-02	3.52E-02	2.68E-02	1.81E-02	1.12E-02	1.13E-02

Output File (R1YRG5D.OUT) for Sample Problem 3

1YR W.F. + GEL(INJ,5D) + W.F. -- 10*10*2,1E-5, KZ/KH=.001 (5YRS)

SUMMARY REPORT

N	ETI (DAY)	PAVG (PSI)	OPR (STB/D)	COP (BBL)	GPR (MCF/D)	CGP (MCF)	FOR	WPR (STB/D)	CWP (BBL)	WOR (B/B)	PVWI	CPOI (LB)	WIR (B/D)	CWI (BBL)
49	40.72	2526.7	535	21786.2	0	0	0.02698	0	0.2	0	0.0204	0	535	21786.4
62	81.68	2532.3	535	43700.4	0	0	0.05412	0	0.4	0	0.0409	0	535	43700.9
73	123.19	2537.5	535	65903.7	0	0	0.08161	0	0.6	0	0.0617	0	535	65904.3
83	164.33	2542.3	535	87914	0	0	0.10887	0	0.8	0	0.0823	0	535	87914.8
92	209.42	2547.2	535	112039	0	0	0.13875	0	0.9	0	0.1049	0	535	112039.9
103	252.76	2553.1	535	135225.4	0	0	0.16746	0	1	0	0.1265	0	535	135226.4
114	293.01	2559.4	535	156759.9	0	0	0.19413	0	1.2	0	0.1467	0	535	156761.1
131	335.36	2565.9	325.3	174826.7	0	0	0.2165	209.7	4591.6	0.64	0.1679	0	535	179418.3
239	375.43	2571.2	258.9	186232.8	0	0	0.23063	276.1	14621.6	1.07	0.188	2906.2	535	200854.1
259	419.71	2573.4	230.5	196969.4	0	0	0.24393	304.5	27574.8	1.32	0.2101	2906.2	535	224543.9
268	460.21	2570.7	216.6	205971.9	0	0	0.25507	318.4	40239.8	1.47	0.2304	2906.2	535	246211.4
279	500.65	2568	206.9	214527.9	0	0	0.26567	328.1	53319.2	1.59	0.2507	2906.2	535	267846.8
290	542.49	2565.6	206.8	223166	0	0	0.27637	328.2	67065.5	1.59	0.2716	2906.2	535	290231.2
301	584.33	2566.8	201.7	231702	0	0	0.28694	333.3	80913.9	1.65	0.2926	2906.2	535	312615.6
312	625.49	2567.9	208.9	240143	0	0	0.29739	326.1	94493.5	1.56	0.3132	2906.2	535	334636.2
323	667.33	2570.6	202.8	248757.1	0	0	0.30806	332.2	108263.8	1.64	0.3341	2906.2	535	357020.5
334	709.17	2571.7	216.2	257499.6	0	0	0.31889	318.8	121905.7	1.47	0.3551	2906.2	535	379404.9
351	750.14	2575.6	213.2	266153.5	0	0	0.3296	321.8	135170.9	1.51	0.3756	2906.2	535	401323.9
362	794.83	2576.6	223	275860.7	0	0	0.34162	312	149372.2	1.4	0.3979	2906.2	535	425232.5
372	838.25	2577.7	226.9	285464.2	0	0	0.35352	308.1	162998.5	1.36	0.4197	2906.2	535	448462.2
382	881.67	2578.5	223.9	295162.9	0	0	0.36553	311.1	176529.5	1.39	0.4414	2906.2	535	471691.9
390	921.67	2578.8	218.6	304013.3	0	0	0.37649	316.4	189079.1	1.45	0.4615	2906.2	535	493091.9
398	961.67	2579.3	207.2	312523.7	0	0	0.38703	327.8	201968.8	1.58	0.4815	2906.2	535	514491.9
406	1001.67	2580.4	190.2	320441.4	0	0	0.39683	344.8	215451.1	1.81	0.5015	2906.2	535	535891.9
414	1041.67	2582	170.5	327613.6	0	0	0.40571	364.5	229678.9	2.14	0.5215	2906.2	535	557291.9
422	1081.67	2583.6	151.4	333992.2	0	0	0.41361	383.6	244700.3	2.53	0.5416	2906.2	535	578691.9
436	1124.71	2585.1	135.3	340099.2	0	0	0.42118	399.7	261620.3	2.96	0.5631	2906.2	535	601718.8
444	1164.71	2586	123.8	345236	0	0	0.42754	411.2	277883.4	3.32	0.5831	2906.2	535	623118.8
452	1204.71	2586.5	115.6	349996.3	0	0	0.43343	419.4	294523.1	3.63	0.6032	2906.2	535	644518.8
460	1244.71	2586.8	109.5	354477.8	0	0	0.43898	425.5	311441.7	3.89	0.6232	2906.2	535	665918.8
468	1284.71	2587	104.7	358745.5	0	0	0.44427	430.3	328573.9	4.11	0.6432	2906.2	535	687318.8
476	1324.71	2587.1	100.7	362843	0	0	0.44934	434.3	345876.5	4.31	0.6632	2906.2	535	708718.8
484	1364.71	2587.2	97.1	366788.4	0	0	0.45423	437.9	363331.1	4.51	0.6833	2906.2	535	730118.8
492	1404.71	2587.3	93.5	370594.1	0	0	0.45894	441.5	380925.3	4.72	0.7033	2906.2	535	751518.8
500	1444.71	2587.4	89.6	374247.3	0	0	0.46346	445.4	398672.1	4.97	0.7233	2906.2	535	772918.8
508	1484.71	2587.5	85.6	377738.3	0	0	0.46779	449.4	416581.1	5.25	0.7433	2906.2	535	794318.8
516	1524.71	2587.5	82.1	381083.4	0	0	0.47193	452.9	434636.1	5.51	0.7634	2906.2	535	815718.8
524	1564.71	2587.5	78.5	384287.8	0	0	0.4759	456.5	452831.7	5.81	0.7834	2906.2	535	837118.8
532	1604.71	2587.5	75.2	387350.9	0	0	0.47969	459.8	471168.6	6.12	0.8034	2906.2	535	858518.8
540	1644.71	2587.4	71.8	390281.4	0	0	0.48332	463.2	489638	6.45	0.8235	2906.2	535	879918.8
548	1684.71	2587.4	68.9	393087.8	0	0	0.4868	466.1	508231.7	6.77	0.8435	2906.2	535	901318.8
556	1724.71	2587.2	66.1	395779.3	0	0	0.49013	468.9	526940.1	7.09	0.8635	2906.2	535	922718.8
564	1764.71	2587	63.6	398371.4	0	0	0.49334	471.4	545748	7.41	0.8835	2906.2	535	944118.8
572	1804.71	2586.9	61.4	400862.5	0	0	0.49642	473.6	564656.9	7.71	0.9036	2906.2	535	965518.8