THE ROLE OF CAPILLARY FORCES IN THE NATURAL STATE OF FRACTURED GEOTHERMAL RESERVOIRS

A REPORT
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Abstract

A lot of experiments into the natural state of geothermal reservoirs have been conducted using porous medium models, even though geothermal systems are usually highly fractured. It is unclear whether a porous medium model is adequate in describing the natural state of a fractured geothermal reservoir. Because of this, a dual porosity model is often invoked. The question of how heat and mass is transferred in fractures has been widely investigated. The objective of this work was to further our understanding by investigating how heat and mass transfer is affected by capillary forces. Also, the question of how capillary forces affect the stability of a water-saturated region overlying a liquid-dominated two-phase zone was examined. The study was carried out by developing a two-dimensional numerical model representing a fractured geothermal reservoir. The numerical simulations were carried to steady state with the use of a commercial simulator TETRAD (version 12). Results indicate that due to capillary forces, the fractures act as heat pipes - transporting heat by the process of convection. The convection process was found to be enhanced if there is no capillary pressure in the fractures. It was also determined that only if capillary forces are present can a system consist of a water-saturated zone overlying a liquid-dominated two-phase zone remain stable.

Acknowledgments

The education that I received from Stanford University's Department of Petroleum Engineering is an asset that I will put into good use and will always treasure. I would like to thank my professors for the invaluable roles they played in the learning process, in particular, Dr. Roland N. Horne, my advisor and the principal investigator of the Stanford Geothermal Program for his guidance and support and Dr. Shaun D. Fitzgerald, who was my mentor during the first half of this research work.

Being a Stanford graduate student is indeed a serious business and I consider myself lucky to have friends and family who helped me cope with the demands of being one. My friends were there to provide support during the trying times and fun during the lighter moments. My Cyberfamily gave words of encouragement and kept me company through the high-tech world of the internet. My relatives and family looked after my well-being and made sure that I did not fall into the "starving graduate student" category. To all of you, my sincerest gratitude.

To my parents, who nurtured me and whom I love dearly, I dedicate this work to you.

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1. INTRODUCTION

Much of the experimental work which pertains to geothermal systems has involved studies on porous media. Although most geothermal reservoirs are observed to be fracture dominated, experimental results involving porous media are often still applied. It is unclear whether a porous medium model is adequate in describing a fractured geothermal reservoir since there are some situations where the fractured nature of the reservoir cannot be ignored. One case involves the injection of cold brine (normally around 160°C) as a means of pressure support or for environmental reasons. If the geothermal system were to behave like a homogeneous porous medium, the thermal front would advance uniformly with the cooler fluid sweeping away the heat from the rock. In reality, this will not be the case. There will be a preferential flow through the fractures and even though there is transfer of heat by conduction from the rock to the cold water passing through the fractures, the injected water will arrive much sooner than in the case of a porous medium. Because of this problem, a dual porosity model is often invoked. Instead of treating the reservoir as homogeneous, fractures are introduced by dividing the system into two types of interacting porous media as can be seen in Fig. 1.1. The matrix is assigned a permeability, k_m, and a porosity, ϕ_m, while the fracture is assigned a higher permeability, k_f, and a higher porosity, ϕ_f.

In a dual porosity model, the question of how heat is being transferred from the rock matrix to the fluid flowing in the fractures has been investigated. Previous works include those by Bodvarsson (1969, 1972), Drummond and McNabb (1972) and Nathenson (1975). The objective of this work was to further our understanding by investigating how heat and mass transfer is affected by capillary forces. To address this issue, it is worthwhile to investigate the heat pipe effect. The heat pipe mechanism (Eastman, 1968) allows the upward movement of heat in a system that exhibits a very small temperature gradient. Since this problem is reasonably understood from earlier work, studying the heat

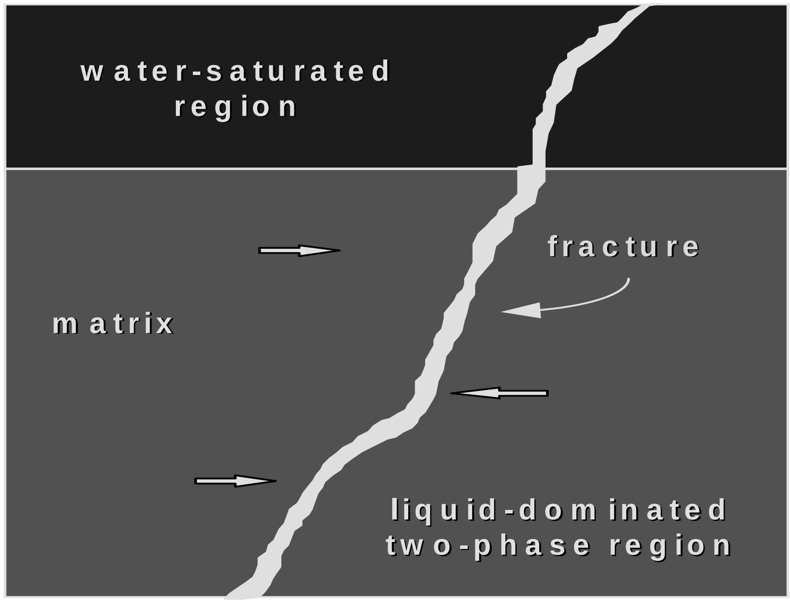

Figure 1.1: A dual porosity model.

pipe mechanism would enable us to understand the effect of capillary pressure on the behavior of fractured reservoirs.

White et al. (1971) proposed a conceptual model of a vapor-dominated geothermal reservoir. The model has a deep-seated convecting brine which is heated by a magmatic heat source. On top of this convecting brine is a two-phase region whose vapor and liquid phases undergo counterflow convection. This two-phase region is separated from the overlying zone of meteoric water and steam condensate by a caprock. For liquid-dominated systems, most of the conceptual models likewise invoke the presence of a caprock. Such is the case for the Tongonan geothermal reservoir in the Philippines (Grant and Studt, 1981) and the Wairakei geothermal field in New Zealand (Grindley, 1965).

Sondergeld and Turcotte (1977) did experimental studies on two-phase thermal convection in a porous medium. They were able to observe that a counterflowing two-phase zone can be stable beneath a water-saturated zone (Fig. 1.1). This experimental result suggests that geothermal reservoirs need not have to have a caprock. How is this possible? Will the presence of fractures destabilize the arrangements of fluids? What will be the influence of capillarity in permitting this configuration? One of the objectives of this study was to explore the stability of a water-saturated zone overlying a two-phase zone. The investigation on the stability of such systems was limited, however, to the case of a liquid-dominated two-phase reservoir.

To answer these questions, a numerical investigation was conducted utilizing the commercial program TETRAD (version 12). The approach utilized in this study involved the concept of building complexity. To start with, a one-dimensional numerical model was built in order to examine the heat pipe effect. This model was then extended to two dimensions. With this model the effect of capillary forces on heat and mass transfer as well as on stability was investigated by varying the capillary pressure curves.

This report begins with a review of the previous work done on the subject of the heat pipe mechanism and capillary pressure effects. This is followed by the preliminary work conducted detailing which numerical differencing scheme is appropriate for the study and the type of capillary pressure curves used. Following is a chapter that describes the effect capillary forces have on heat and mass transfer as well as on stability. Finally, the conclusions are presented.

2. REVIEW OF RELATED LITERATURE

For two-phase geothermal reservoirs, the heat pipe mechanism has been invoked to model the heat and mass transfer in the reservoir. Several numerical and experimental studies by different investigators were conducted and will be discussed in this section. Likewise, a review of the past works relating to capillary pressure will be presented.

2.1 Heat Pipe Mechanism

An experimental study of two-phase convection is a porous medium was conducted by Sondergeld and Turcotte (1977). They carried out their experiments in a sandbox which was initially water-saturated. The system was heated from below and cooled from above. As long as the temperature was below 100°C the horizontal isotherms were not perturbed. No observable convection took place without the steam present. As soon as the bottom layer reached 100°C, a two-phase zone developed. Their measurements indicated that a stable form of two-phase convection can exist below a water-saturated zone. As more heat was injected from the bottom, a dry steam zone of more than 110°C was produced.

To explain the convective heat transfer within the isothermal two-phase zone, a one-dimensional flow model was developed. Steam is being produced at the bottom and rises until it condenses at the upper boundary (Fig. 2.1). The condensate then drops to the bottom and the cycle is repeated. In order to be in steady state, the rate at which vapor is produced must equal to the rate at which it condenses.

From this boiling experiment Sondergeld and Turcotte (1977) were able to observe that phase change can drive convection and that a counterflowing two-phase zone can remain stable beneath a water-saturated zone. This experimental result suggests that geothermal reservoirs do not require a caprock.

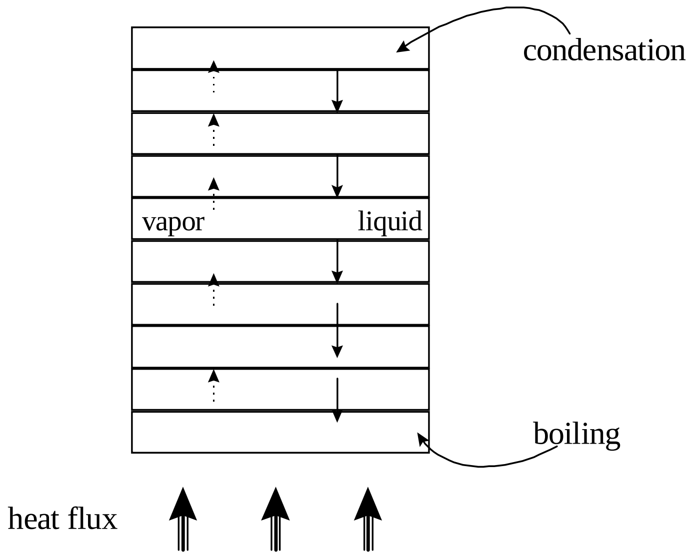

Fig. 2.1: A one-dimensional flow model showing the vapor and liquid phases in a countercurrent movement.

Afterwards, experiments involving boiling in low-permeability porous media were conducted by Bau and Torrance (1982). The experimental apparatus consists of a vertical circular cylinder which was filled up with a low permeability, water-saturated porous medium. The cylinder was heated from below and cooled from the top. As the bottom temperature reaches saturation temperature of 100°C, a nearly isothermal zone was observed. This zone is two-phase. In this wet-steam zone, heat is transferred by a vertical countercurrent of the liquid and vapor phases. This is the same mechanism invoked by Sondergeld and Turcotte to describe the flow of heat in their sandbox experiments. As the heat flux being injected at the bottom was increased the length of the two-phase zone likewise increased. Bau and Torrance observed that when the height of the two-phase zone was less than 70-80% of the bed height, the temperature in the overlying water-saturated porous zone was not changing with time. When the two-phase zone was longer than 70-80% of the bed height, periodic oscillations in the temperature and the measured heat flux were observed.

Based upon the prior work of Sondergeld and Turcotte, Bau and Torrance assumed a one-dimensional, vertical, countercurrent flow of the liquid and vapor in the two-phase zone. In order for the system to be in steady state, the vertical mass fluxes of liquid $\dot{m}_l$ must balance the vapor $\dot{m}_v$ within the two-phase region.

$$\dot{m}_l = -\dot{m}_v = -\dot{m} \tag{2.1}$$

Applying Darcy's law we obtain

$$\dot{m}_l = -\frac{\lambda F_l}{\nu_l}\left(\frac{dp}{dz} + \rho_l g\right) \tag{2.2}$$

$$\dot{m}_v = -\frac{\lambda F_v}{\nu_v}\left(\frac{dp}{dz} + \rho_v g\right) \tag{2.3}$$

where

$\lambda =$ permeability
F_l = liquid relative permeability
F_v = vapor relative permeability
p = pressure
ρ_l = liquid density
ρ_v = vapor density
g = acceleration due to gravity
ν_1 = liquid kinematic viscosity
ν_v = vapor kinematic viscosity
z = vertical coordinate

Expressing Equations 2.2 and 2.3 in terms of the pressure gradient we have

$$\frac{dp}{dz} = -\frac{\dot{m}_l \nu_l}{\lambda F_l} - \rho_l g \qquad (2.4)$$

$$\frac{dp}{dz} = -\frac{\dot{m}_v \nu_v}{\lambda F_v} - \rho_v g \qquad (2.5)$$

Subtracting Equation 2.5 from Equation 2.4 and making use of Equation 2.1 gives the following:

$$0 = \dot{m}\left(\frac{\nu_l}{\lambda F_l} + \frac{\nu_v}{\lambda F_v}\right) + \left(\rho_v - \rho_l\right) g \qquad (2.6)$$

Bau and Torrance made use of linear relative permeability curves as represented by the following equations:

$$F_l = S \qquad F_v = 1 - S \qquad (2.7)$$

where S is the liquid saturation.

Substituting Equation 2.7 into Equation 2.6 and solving for $\dot{m}$ gives

$$\dot{m} = \frac{\lambda S(1-S) g(\rho_l - \rho_v)}{\nu_l (1-S) + \nu_v S} \qquad (2.8)$$

The vertical heat flux, q, is related to the flux of steam and water by

$$q = h_{lv}\dot{m} \qquad (2.9)$$

where h_{lv} is the latent heat of vaporization.

From Equations 2.8 and 2.9, a non-dimensional heat flux, Γ, can be defined as

$$\Gamma = \frac{q\nu_v}{\lambda h_{lv} g(\rho_l - \rho_v)} = \frac{S(1-S)}{(1-S)\dfrac{\nu_l}{\nu_v} + S} \qquad (2.10)$$

The non-dimensional heat flux is a function of saturation. For a linear relative permeability curve, the relationship is shown in Fig. 2.2. The maximum occurs at a saturation of $S_{\max} = 0.1072$ and a non-dimensional heat flux of $\Gamma_{\max} = 0.797$. The graph shows us that for a particular non-dimensional heat flux, there are two possible stable one-dimensional heat pipe configurations - a vapor dominated and a liquid-dominated one. If the saturation in the two-phase region is less than $S_{\max}$ then we have a vapor-dominated heat pipe. Conversely, if the saturation in the two-phase region is greater than $S_{\max}$ then we have a liquid-dominated heat pipe.

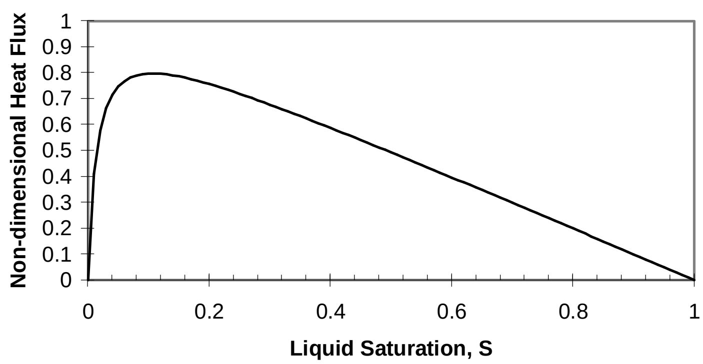

Figure 2.2: Graph of the non-dimensional heat flux as a function of the liquid saturation for a linear relative permeability function.

Bau and Torrance likewise predicted the height of the two-phase zone, the maximum heat flux (dry-out heat flux) and the necessary condition for the formation of the two-phase zone using the one-dimensional model.

Another study related to the one-dimensional heat pipe model was conducted by Udell (1985). In this investigation, the effects of capillarity were included. The study concluded that the effect of capillarity in porous media saturated with both vapor and liquid phases of a single component liquid is thecountercurrent flow of the two phases.

Udell and Jennings (1985) went a step further by doing an experimental and theoretical study of the thermal performance of a dual permeability porous system exhibiting the heat pipe effect. The experimental system consisted of two concentric cylinders packed with sand of different grain sizes which were separated by a fine-mesh screen. The outer cylinder had a larger permeability and porosity than the inner cylinder. The system was initially saturated with water, was heated from below and cooled at the top. The study revealed that the heat transfer in this heterogeneous medium was greater than that in the homogeneous medium Udell (1985) had investigated earlier. In fact, with the addition of the second medium which was 26.1 times more permeable, the length of the two-phase zone increased by a factor of 55.

With regard to numerical studies, Pruess (1985) constructed a numerical model of a vapor-dominated reservoir. The vertical slice of the model is shown in Fig. 2.3. the matrix permeability was 0.003 md while the porosity of the matrix was assigned to be 0.08. The fracture width was 2 mm and the fracture permeability and porosity were 335 md and 0.5, respectively. At the caprock, a temperature of 240°C and a pressure corresponding to the saturation pressure at that temperature were imposed.

Numerical simulations indicate that upon imposition of a heat flux of 1 W/m^2 at the base, a single-phase liquid-dominated geothermal reservoir in fractured rock with low matrix permeability will transform into a two-phase reservoir with boiling point-for-depth (BPD) temperature and pressure profiles (liquid-dominated heat pipe). With a brief and limited discharge of about 40 kg/s-km^2, the system will turn into a vapor-dominated system. If the system were porous, a vapor-dominated heat pipe is only possible if most of the original fluid in place is extracted such that the liquid saturation is near the irreducible

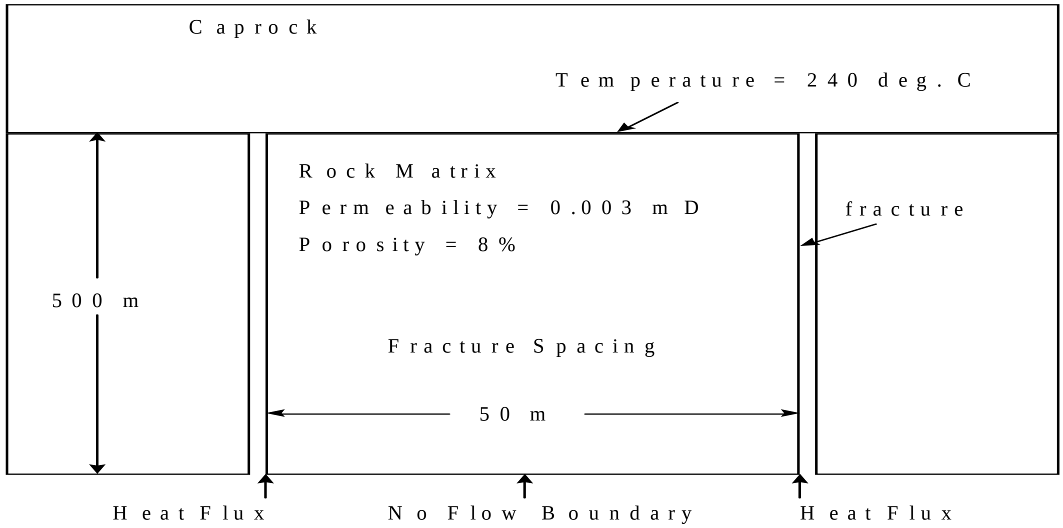

Figure 2.3: Vertical section of the reservoir model (from Pruess, 1985).

water saturation. This requires a large amount of discharge over an extended period. It is considered improbable that this constraint can be met in a natural hydrothermal convecting system. Hence, it is suggested that vapor-dominated reservoirs can only form in an area characterized by dual permeability.

From the numerical investigation conducted by Pruess (1985) the evolution of the liquid-dominated heat pipe came first. It was only after a series of steps, such as a venting process, that a vapor-dominated heat pipe was generated. For this particular system, it seems that the liquid-dominated heat pipe configuration is the more stable one.

Addressing the issue of stability, McGuinness and Pruess (1987) did a series of numerical investigations. Their study was motivated by the fact that in order for a numerical simulation to converge to a vapor-dominated heat pipe, it is necessary that the pressure and saturation be constant at the bottom end. They confirmed that a vapor-dominated heat pipe will be unstable if the constant pressure and saturation condition is at the top. Under this condition, the liquid-dominated heat pipe will remain stable.

From the recent results of the analysis of geothermal heat pipes, McGuinness and Young (1994) assessed the conceptual steady-state models of two-phase reservoirs. They made the observations that the popular model of liquid condensate overlying a vapor-dominated region is impossible for the usual choices of heat flow and permeability in a one-dimensional uniform reservoir. A steady state configuration for a liquid-dominated heat pipe on top of a vapor-dominated heat pipe is likewise impossible in a uniform one-dimensional system. Acceptable models, however, include those of a pure vapor under a vapor-dominated region and a pure liquid overlying a liquid-dominated region.

2.2 Capillarity

Capillary pressure is defined to be the pressure difference between the non-wetting and the wetting fluids. For a water-vapor system, the capillary pressure is

$$p_c = p_v - p_l \qquad (2.11)$$

where p_v and p_l are the vapor pressure and liquid pressure, respectively. In a porous medium where pore scales are encountered, the capillary pressure can be expressed as

$$p_c = \frac{2\gamma}{r} \qquad (2.12)$$

where γ is the interfacial tension and r is the rock pore size. At the pore size scale the effects of capillary forces are significant. The question is, how do we quantify capillarity? This can be addressed by looking into the adsorption process since the action of capillary forces in the porous medium are similar to those of the adsorptive forces in the sense that both cause the vapor to condense in the porous medium.

The adsorptive forces are the Van der Waals force of attraction. Due to these forces, steam adheres to the surface of the porous medium. The adsorption process begins with the monolayer deposition of the molecules. The next step involves multilayer adsorption which will then lead to capillary condensation.

There has been a lot of adsorption experiments conducted from which an adsorption isotherm can be generated. Several of these experiments will be referred to later in this section. Adsorption isotherms are shown in a graph of adsorbed mass, X, versus the relative pressure defined as p_{sat}/p_v where p_{sat} and p_v are the equilibrium vapor pressure and the lowered vapor pressure, respectively. The relationship between vapor pressure lowering and the curvature of the interface is described by the Kelvin equation:

$$RT\ln\left(\frac{p_{sat}}{p_v}\right)=\frac{2\upsilon_m\gamma}{r} \qquad (2.13)$$

where R is the universal gas constant, T is the absolute temperature and υ_m is the water molar volume. Substituting Equation 2.12 into 2.13 and noting that the molar volume is defined as ρ_l/M, where ρ_l and M are the liquid density and molecular weight of water, respectively, gives

$$p_c=\frac{RT\rho_l}{M}\ln\left(\frac{p_{sat}}{p_v}\right) \qquad (2.14)$$

The relationship between the mass adsorbed, X, and the water saturation, S, is given by the following equation:

$$S=\frac{1-\phi}{\phi}\frac{\rho_l}{\rho_r}X \qquad (2.15)$$

where ϕ is the porosity and ρ_r is the rock density. We thus have obtained from the adsorption isotherm a relationship between the capillary pressure and the water saturation.

Based on a typical Geysers adsorption isotherm such as those reported by Satik et al. (1996), Sta. Maria and Pingol (1996) converted the adsorption isotherm into a capillary pressure versus liquid saturation relationship and obtained capillary pressures that ranged from 0 to about 586 MPa (85,000 psi). The shape of the resulting capillary pressure curve can be approximated by the van Genuchten equation given by

$$p_c = p_o\left(S_{ef}^{-1/\lambda} - 1\right)^{1-\lambda} \tag{2.16}$$

where p_o and λ are constants. S_{ef} is the effective liquid saturation given by

$$S_{ef} = \frac{S - S_r}{1 - s_r} \tag{2.17}$$

where S_r is the residual water saturation (Pruess et al., 1992)

Melrose (1991) on the other hand, made use of measurements from three different techniques - porous plate, water vapor desorption, low temperature gas desorption/adsorption and mercury injection technique. When data were scaled down to air/brine conditions a capillary pressure of up to 69 MPa (10,000 psi) was obtained. These two studies showed us the possible range of capillary pressure values to be used in the simulation runs.

3. PRELIMINARY WORK

Prior to the development of the two-dimensional numerical model used in this study, a one-dimensional numerical model was constructed in order to duplicate some of the results obtained by previous investigators who worked on heat pipes. Having a one-dimensional numerical model that conforms with experimental and theoretical results reinforces the validity of the model. Being confident with the one-dimensional model, the two-dimensional model was constructed in a similar fashion to the one-dimensional case. Since the numerical model now had two dimensions, the question of which differencing scheme, whether a five-point differencing scheme or a nine-point differencing scheme, is appropriate for the numerical model was raised. Likewise, the type of capillary pressure functions to be used in the study had to be determined.

3.1 One-dimensional model

The one-dimensional model consisted of a 7 m x 50 m x 1 m block and ten 7 m x 50 m x 50 m blocks stacked on top of each other as shown in Fig. 3.1. The model represents a homogeneous system and the properties assigned to each block are summarized in Table

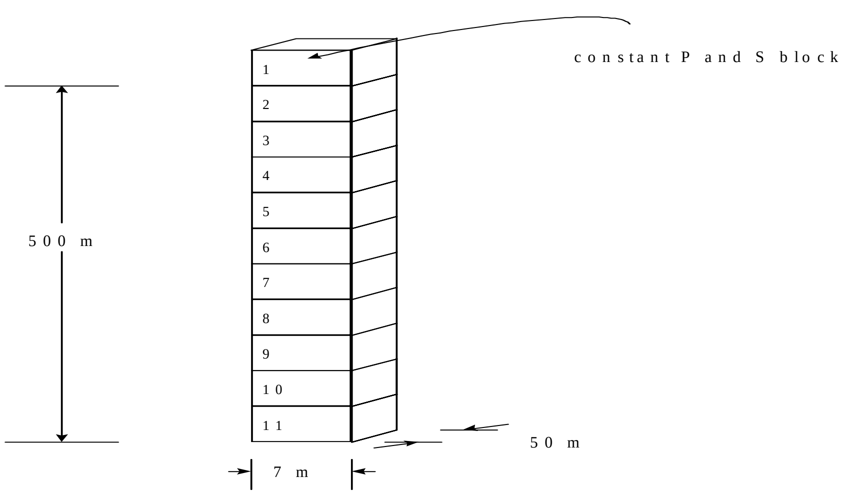

Figure 3.1: One-dimensional model of a heat pipe.

Table 3.1: Parameters of the one-dimensional model.

Property	Block 1 (Large volume element)	Blocks 2 - 11 (Matrix blocks)
Porosity	0.8	0.1
Permeability (mD)	2000	0.5
Rock density (kg/m^3)	2643	2643
Rock conductivity (W/m-°C)	2.88	2.88
Rock specific heat (kJ/kg-°C)	1.0718	1.0718
Heat flux (W/m^2) - block 11		1.0
Relative permeability	$k_{rl} = (S)^3$ $k_{rv} = (1-S)^3$	$k_{rl} = (S)^3$ $k_{rv} = (1-S)^3$

3.1. The topmost block was given a very large volume in order to impose a constant pressure and saturation condition at the top. The blocks were initially saturated with water. With a 1 W/m^2 heat flux imposed at the bottom block, numerical simulation was carried out until steady state conditions were attained.

The pressure, temperature and saturation profiles for the one-dimensional case are shown in Appendix A. The saturation profile indicated that we had two-phase conditions at a depth of 175 m (block no. 5) down to the bottom. Results indicated that in this two-phase region vapor rises up to block no. 5 while liquid trickles from block no. 5 down to the bottom. There was a counterflow of the liquid and the vapor phases within the two-phase zone. A plot of the dimensionless heat flux versus saturation is shown in Fig. 3.2. The analytical solution was derived for the cubic relative permeability curves (Table 3.1) using the same procedure as Bau and Torrance (1982). The dimensionless heat fluxes for each block were calculated using Equation 2.10. The points do not plot on the line representing the analytical solution but instead lie to the right of it. One possible explanation for this is that the heat transfer mechanism in this one-dimensional system involves both convection and conduction, whereas the analytical solution does not take conduction into account. The graph however shows that we were able to produce a liquid-dominated heat pipe since the water saturations were above the saturation corresponding to the maximum heat flux, in this case, 0.26.

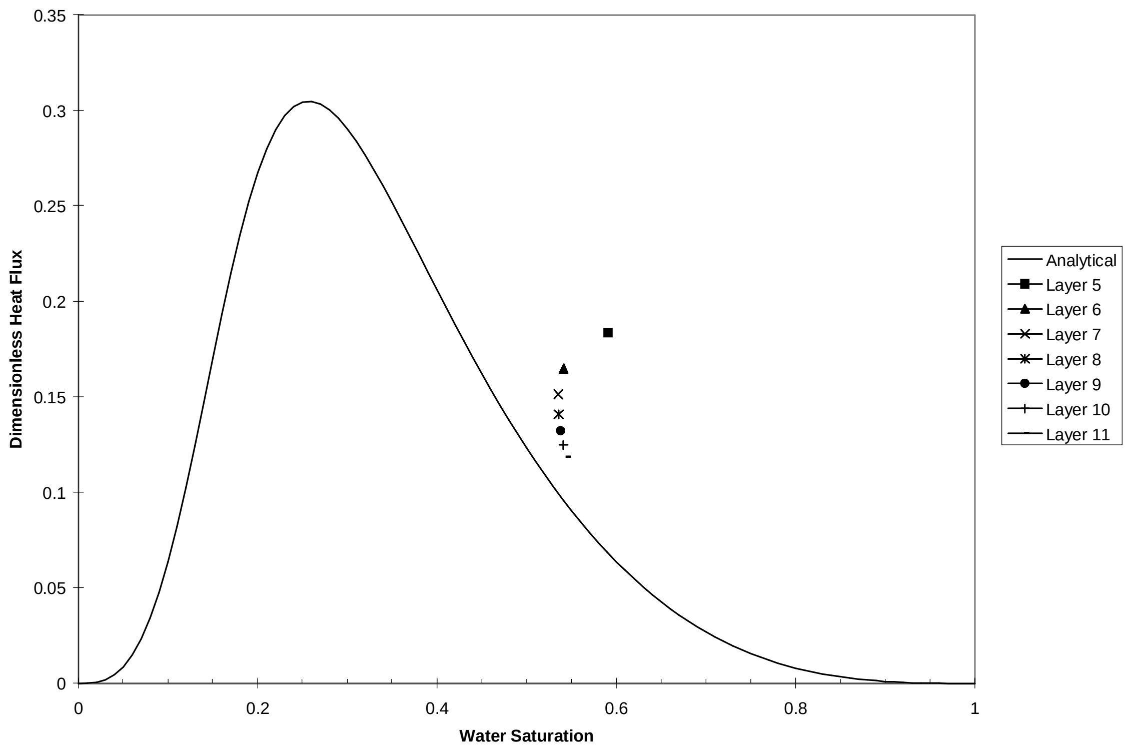

Figure 3.2: Plot of the dimensionless heat flux versus saturation for a cubic relative permeability curve.

3.2 Two-dimensional model

With the existing one-dimensional model, a two-dimensional grid was produced by having 20 grid blocks in the x direction instead of just having one and maintaining the number of layers in the z direction. The grid system is shown in Fig. 3.3.

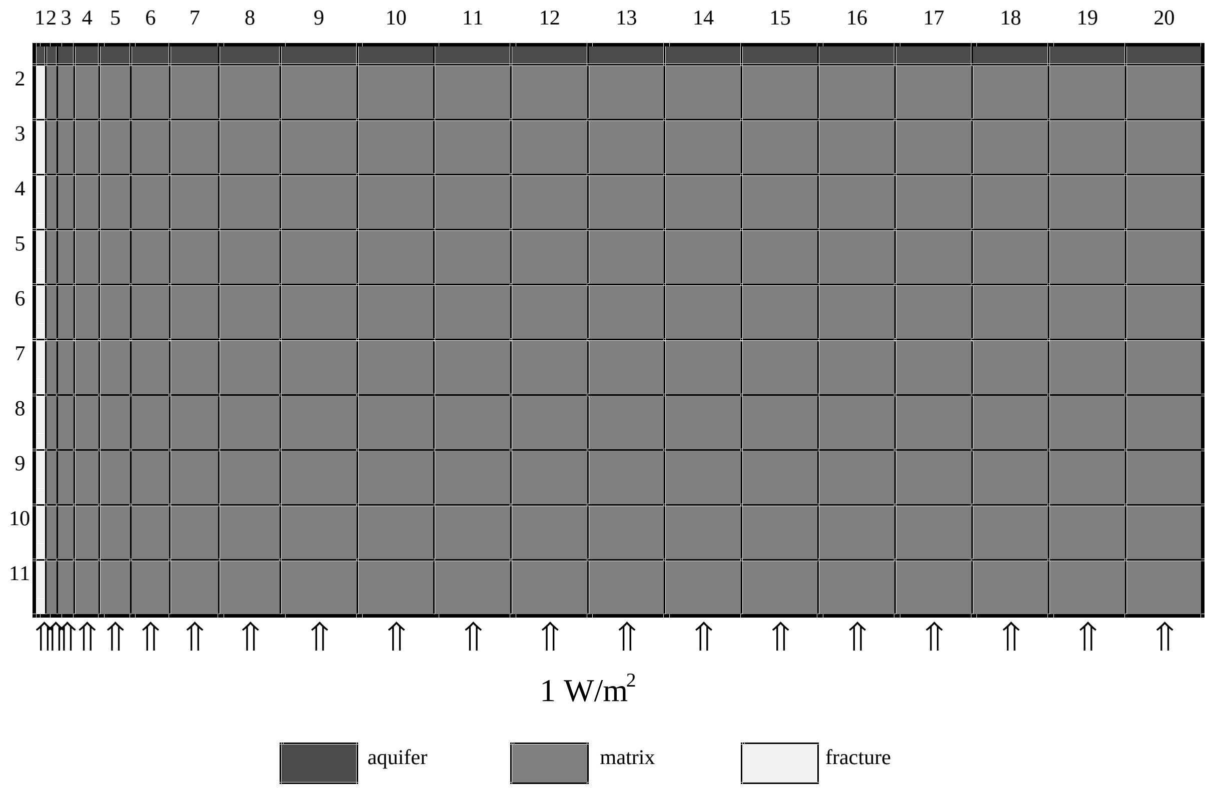

Figure 3.3: The 20 x 11 x 1 block model.

The model had dimensions of 7 m x 501 m x 50 m and consisted of 220 blocks. The first two columns had a length of 0.01 m, the third column had a length that is twice that of the previous one and this progression continued until the seventh column had a length of 0.32 m. The eighth column had a length of 0.36 and the remaining 12 columns had a length of 0.5 m. The depth and width of each grid block was 50 m. The blocks in the first layer were assigned very large volumes and were fully saturated with water hence these large volume blocks were termed the aquifer blocks. The rest of the blocks were labeled as matrix blocks. The same properties outlined in Table 3.1 were assigned to this two-dimensional numerical model. The same heat flux of 1 W/m^2 was delivered to the blocks at the bottom layer.

To achieve steady state, the model was ran up to a time of 4 x 10^6 days. The results showed no variation in the temperature, pressure and saturation values along the x direction in all the layers. Even though a two-dimensional grid was used, the system behaved like the one-dimensional case due to the fact that the system was homogeneous. As such, the temperature, pressure and saturation profiles for the two-dimensional case (Appendix B) are exactly the same as those in the one-dimensional case (Appendix A). Likewise, the graph of the non-dimensional heat flux as a function of water saturation looks exactly like Fig. 3.2. With this two-dimensional model, the stability of a water-dominated region over a liquid-dominated two-phase system was demonstrated.

The fact that the two-dimensional model with uniform matrix properties was able to duplicate the behavior of the one-dimensional model reinforces the validity of both models as well as that of the simulator itself. After having shown that a water-dominated region can be stable over a liquid-dominated two phase region, the next question was, how would this stability be affected by the presence of fractures.

The reason why the grid was designed as in Fig. 3.3 was in order to model a fracture on the left-hand side. Hornbrook and Faulder (1993) modeled a fracture by having large blocks (10 m wide) which were assigned a porosity of 0.0001 in order to simulate a 1 mm fracture. The fracture in this case was modeled by having blocks which were thin (0.01 m wide) and which were given a porosity of 0.5 in order to simulate a 0.005 m fracture. By specifying a larger permeability and porosity to the blocks in column 1 as compared to the matrix blocks (Fig. 3.3), a fracture at the left-hand side of the model was created. This two-dimensional model with both fracture and matrix blocks was the one used in the investigation.

3.2.1 Five-point versus nine-point differencing schemes

The standard approach in numerical simulation work is to make use of the five-point differencing scheme in the discretization of the differential equations describing reservoir flow. In a two-dimensional grid, the flow in and out of a computational grid point is influenced by the points directly to the sides, above and below it. With a higher order differencing scheme, such as a nine-point, the four computational grid points along the diagonals are also taken into account. Pruess (1991) indicated that although there are cases where the five-point differencing scheme is appropriate, there are certain situations where the nine-point differencing scheme is better. Pruess showed that a higher-order differencing scheme substantially diminishes the grid orientation effects. The study done by Hornbrook and Faulder (1993) asserted that the nine-point differencing scheme was more appropriate. The question then was, which differencing scheme is appropriate for the two-dimensional system in this study?

To address this issue, we made use of a 5 x 1 x 11 block numerical model whose properties were similar to the model described in Section 3.2. The dimensions, however, were 25 m x 50 m x 501 m. Using the five-point differencing scheme, the steady state solution was simulated. Three other simulation runs utilizing the five-point differencing scheme were performed using different models. The second model had 10 blocks in the x direction while the third and fourth ones had 14 and 18 blocks, respectively. The numerical runs indicated that with the five-point differencing scheme, the results obtained were consistent. The steady state solution was independent of the grid system used.

A second set of simulation runs was conducted using the same set of models. However, this time the nine-point differencing scheme was utilized. Results indicated that the steady state solution for each run was dependent on the grid system used.

A comparison between experimental and numerical results was done in order to further examine the applicability of the five-point differencing scheme. The experimental results obtained by Bau and Torrance (1982) for a porous bed with permeability of 8.5 d were simulated using a radial grid model. The centerline temperatures obtained from experiments were compared to those obtained from the numerical model where a five-point differencing scheme was used. Fig. 3.4 shows that the numerical results replicate the experimental results especially in the two-phase regions.

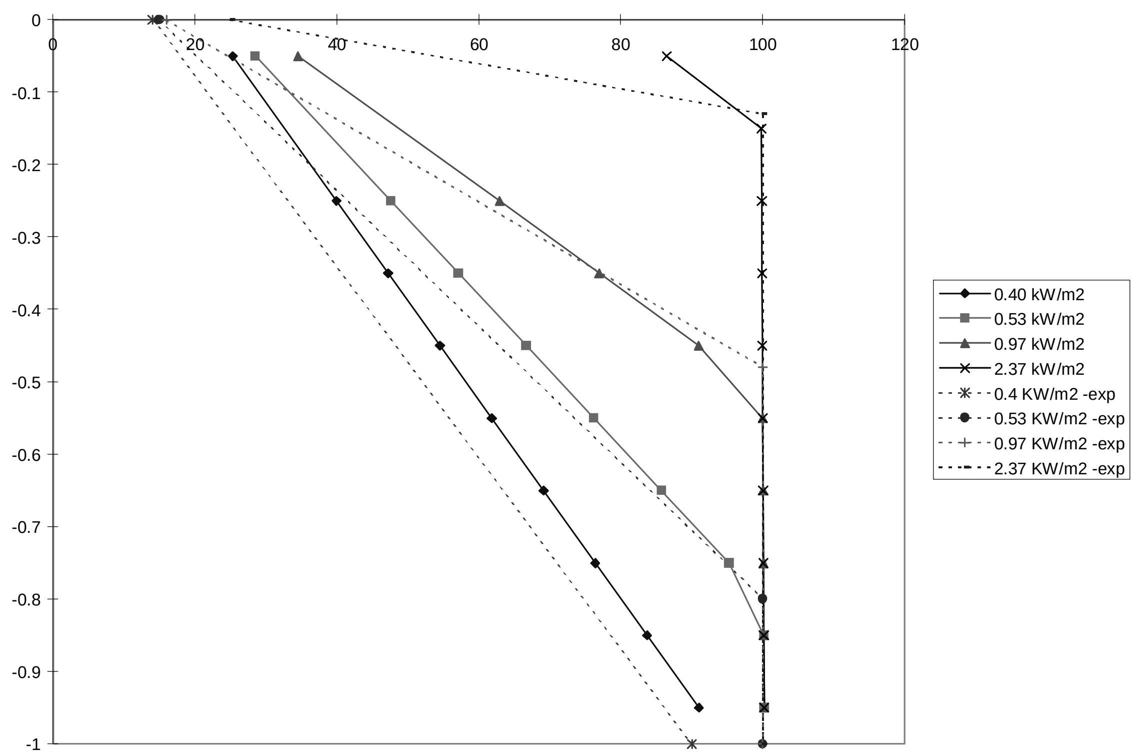

Figure 3.4: A comparison between the centerline temperatures obtained from Bau and Torrance's (1982) experiment and the radial grid numerical model.

From these observations, we determined that the five-point differencing scheme was more appropriate than the nine-point differencing scheme for this type of problem. Hence, all the subsequent numerical runs used the five-pointdifferencing scheme.

3.2.2 Capillary Pressures

The two-dimensional model described earlier has three different domains - the aquifer, the matrix and the fracture blocks. A primary issue in the study was to determine the appropriate capillary pressure functions for the different domains.

For the aquifer blocks, since we wanted all of the liquid to be mobile we imposed zero capillary pressure. For the matrix blocks, the capillary pressure curves were similar to those derived from a typical Geysers isotherm, as described by Equation 2.16. For the fracture blocks, we first thought that since the fracture has a large equivalent pore size, the capillary pressure would approach zero and hence would be independent of the saturation. Simulation runs were carried out using constant capillary pressures that ranged from 0 to 200 kPa for the fracture blocks. The simulation runs did not converge to a steady state solution. Hence, a linear capillary pressure function was used instead. A linear capillary pressure function was also utilized by Pruess (1985) and Hornbrook and Faulder (1993) for the fracture blocks in their studies.

4. THE EFFECT OF CAPILLARITY ON STABILITY AND FLUID FLOW BETWEEN THE FRACTURE AND THE MATRIX

We have established in Section 3.2 that a water-saturated zone can remain stable over a liquid-dominated two-phase region. The question is, what would happen to this stability when a fracture is added to the system. Will the system become unstable and flip over? What role do capillary forces have on the observed stability? If the system is in fact stable even with the presence of the fracture, how do capillary forces affect the heat and mass transfer between the fracture and the matrix? These issues will be discussed in this section.

4.1 The two-dimensional models

The two-dimensional model constructed in Section 3.2 was utilized. The matrix and fracture properties are summarized in Table 4. There were five models used in this study, each differing in the type of capillary pressure function imposed on the fracture blocks.

Table 4.1: Parameters of the two-dimensional model used in the simulation.

Property	Aquifer	Matrix	Fracture
Porosity	0.8	0.1	0.5
Permeability (md)	2000.0	0.5	50.0
Rock density (kg/m^3)	2643	same	same
Rock conductivity (W/m-°C)	2.88	same	same
Rock specific heat (kJ/kg-°C)	1.0718	same	same
Heat flux (W/m^2) - blocks 201-220		1.0	1.0
Relative permeability	$k_{rl} = (S)^3$	same	same
	$k_{rv} = (1-S)^3$	same	same

The matrix capillary pressure is described by the equation

$$p_c = 100\left(S^{-1/0.6} - 1\right)^{0.4} \tag{4.1}$$

while the fracture capillary pressure is described by the equation

$$p_{cf} = -A(S) + A \tag{4.2}$$

where S is the water saturation and A is the maximum fracture capillary pressure in kPa. There was no capillary pressure function assigned to the aquifer blocks. The capillary pressure functions used in the different models are shown in Table 4.2. The graphs of capillary pressure versus saturation for the various models are shown in Appendix G. The input decks for all the models are found in Appendices T to X.

Table 4.2: The capillary pressures used for the different models.

Model	Aquifer	Matrix	Fracture
I	0	$p_{cm} = 0$	$p_{cf} = 0$
II	0	$p_{cm} = 100\left(S^{-1/0.6} - 1\right)^{0.4}$	$p_{cf} = -200S + 200$
III	0	$p_{cm} = 100\left(S^{-1/0.6} - 1\right)^{0.4}$	$p_{cf} = -100S + 100$
IV	0	$p_{cm} = 100\left(S^{-1/0.6} - 1\right)^{0.4}$	$p_{cf} = -50S + 50$
V	0	$p_{cm} = 100\left(S^{-1/0.6} - 1\right)^{0.4}$	$p_{cf} = 0$

Using TETRAD version 12, simulations were carried out for up to 4 x 10^6 days in order to reach steady state.

4.2 Results and Discussion

For Model I where no capillary pressures were prescribed, the two-phase region underneath the water-saturated zone collapsed. The temperature, pressure and saturation profiles (Appendix C) indicate that we have a water-saturated region occupying the entire system.

For Model II where a van Genuchten type of capillary pressure curve was prescribed for the matrix blocks and a linear capillary pressure curve with a maximum value of 200 kPa was prescribed for the fracture blocks, an oscillatory behavior was observed for the temperature, pressure and saturation profiles with time. The period of oscillation was 3.5 cycles per 1×10^5 days.

For Model III where the maximum capillary pressure in the fracture blocks is 100 kPa, a water-saturated region remains stable on top of the two-phase zone. The saturation distribution is shown in Fig. 4.1. It was not unlikely that the fracture blocks, being highly permeable, would easily become saturated with water from the overlying four layers of fully water-saturated rock matrix. The numerical results obtained, however, indicate otherwise. In fact, the fracture has an average steam saturation of 80% while the adjacent matrix blocks are on the average 75% saturated with water (Appendix D).

The dimensionless heat flux for the fracture blocks in the two-phase region were calculated using Equation 2.10. These points when plotted versus saturation would lie towards the vapor-dominated heat pipe solution (Fig. 4.2). It can be noted that the point from Layer 5 is far from the analytical curve. This point actually belongs to the block that serves as an interface between the water-saturated and the vapor-dominated regions. Figure 4.2 indicates that the fracture blocks in Layers 6 to 11 form a vapor-dominated heat pipe.

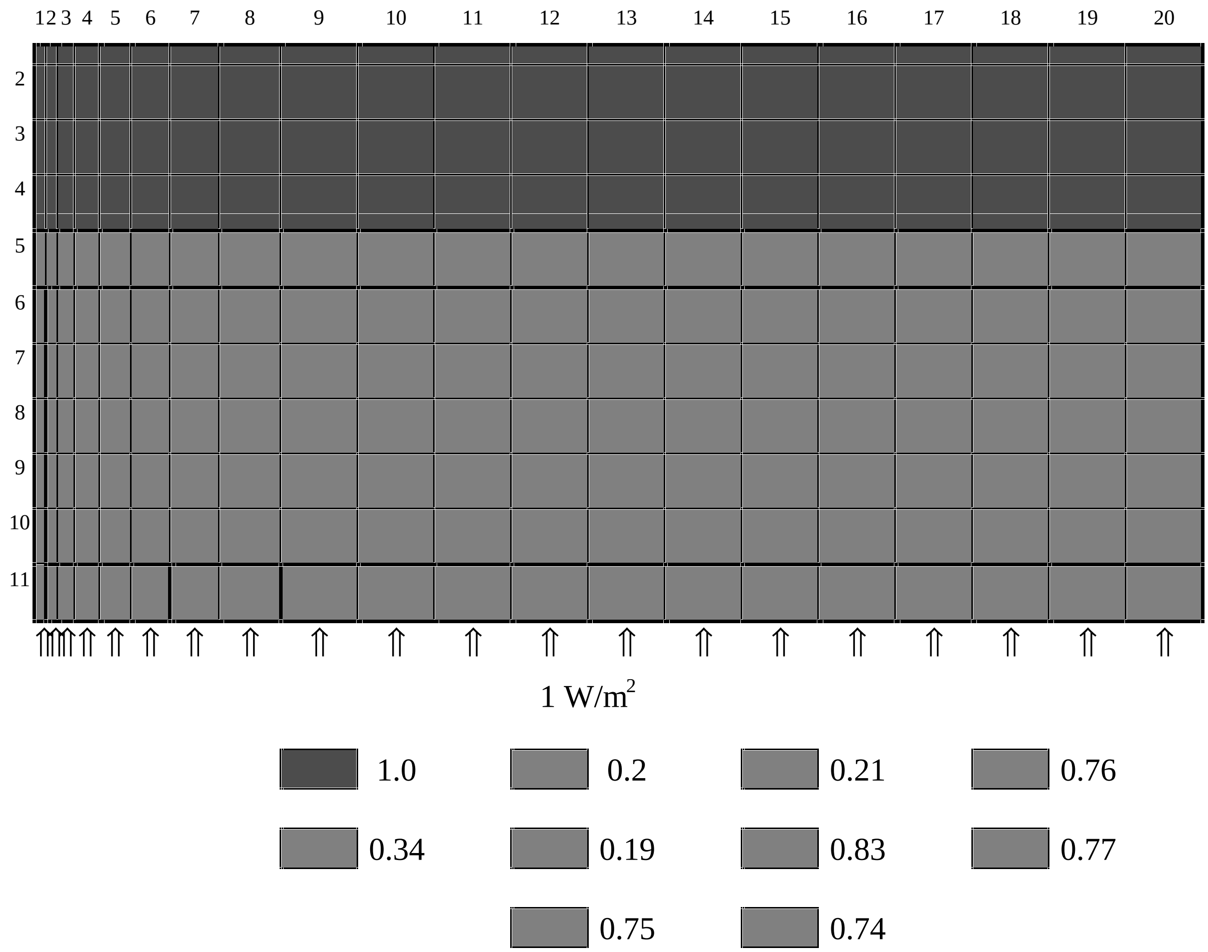

Figure 4.1: Liquid saturation distribution for Model III.

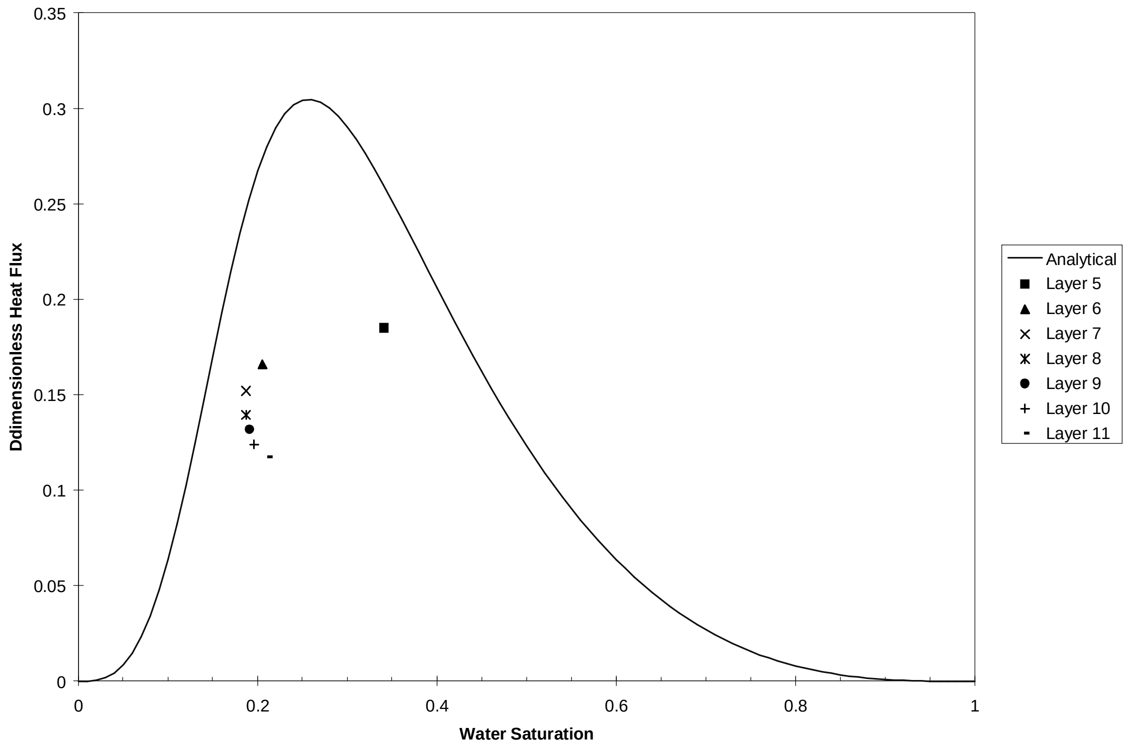

Figure 4.2: Plot of the dimensionless heat flux versus saturation for the fracture blocks of Model III.

For Model IV, the maximum capillary pressure in the fracture blocks was decreased by 50 kPa. The saturation field is shown in Fig. 4.3 while the temperature, pressure and saturation in the fracture blocks are shown in Appendix E. When the maximum capillary pressure in the fracture blocks was decreased to 50 kPa, the amount of water retained in the fracture blocks decreased. From Appendix E, the average steam saturation in the fracture blocks within the two-phase zone is 85%. Correspondingly, the amount of fluid in the matrix blocks increased. The average water saturation in the matrix blocks became 93%. Calculations for the heat flux within the fracture blocks would indicate that we do have a vapor-dominated heat pipe (Fig. 4.4). The points are much nearer to the line representing the analytical solution.

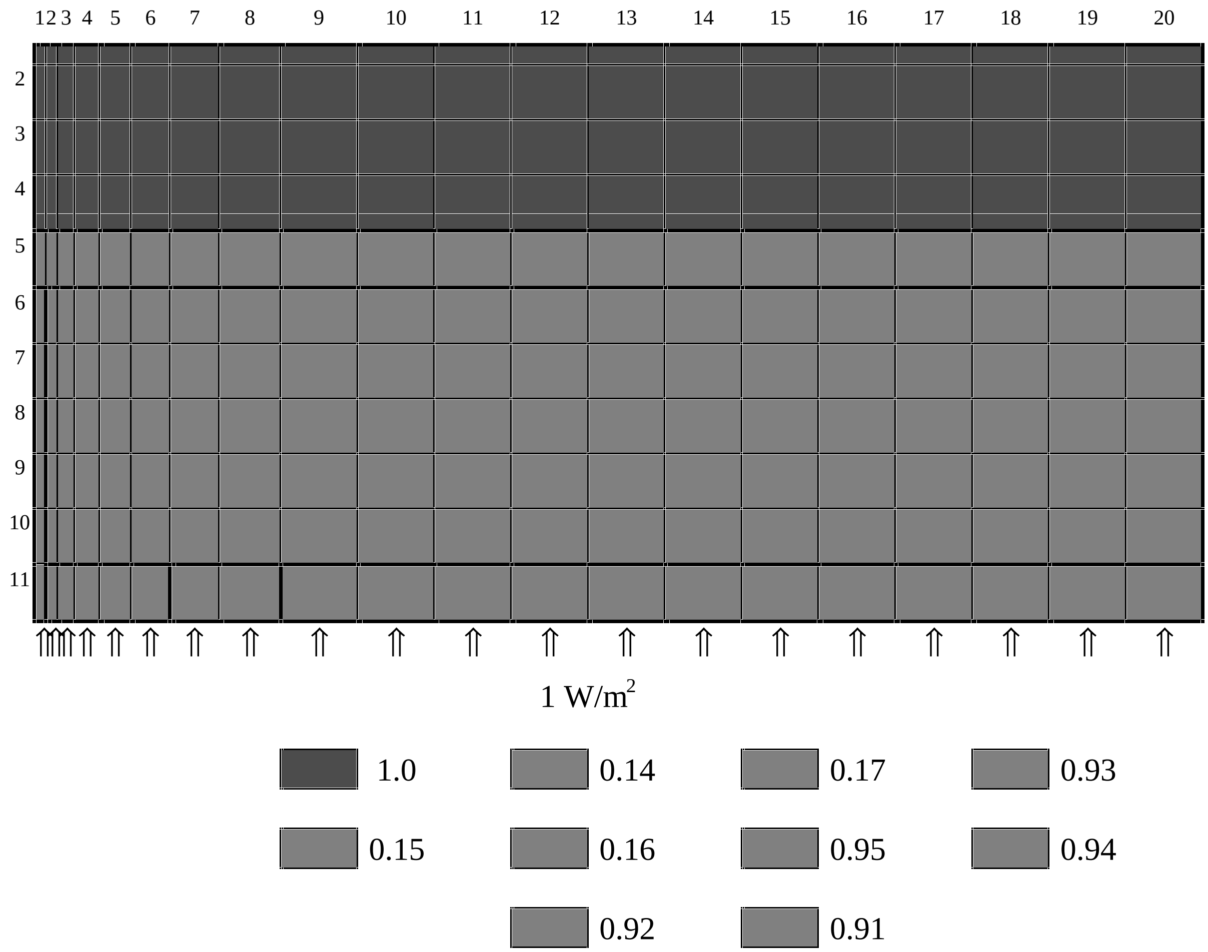

Figure 4.3: Liquid saturation distribution for Model IV.

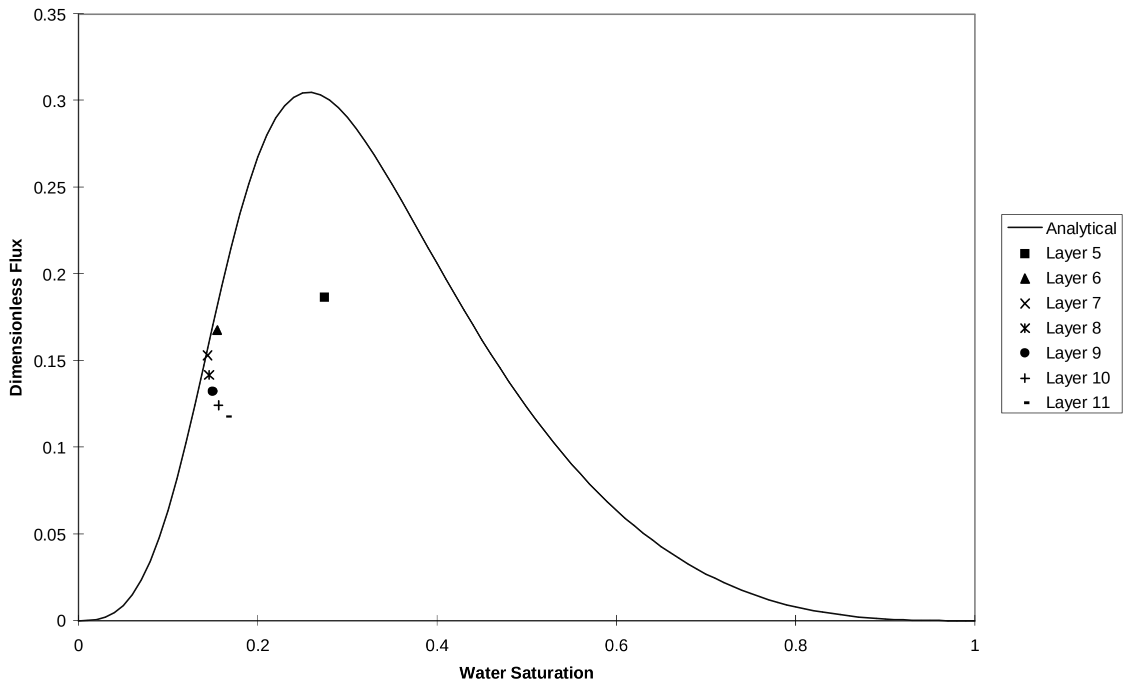

Fig. 4.4: Plot of the dimensionless heat flux versus saturation for the fracture blocks of Model IV.

The results from Model V show that the matrix blocks are almost entirely water-saturated (Fig. 4.5). Examination of the pressure, temperature and saturation distribution within the fracture blocks (Appendix F) and the plot of the dimensionless flux versus saturation (Fig. 4.6) indicates that the fracture is actually a vapor-dominated heat pipe. When compared to Model IV, the saturations are not significantly different.

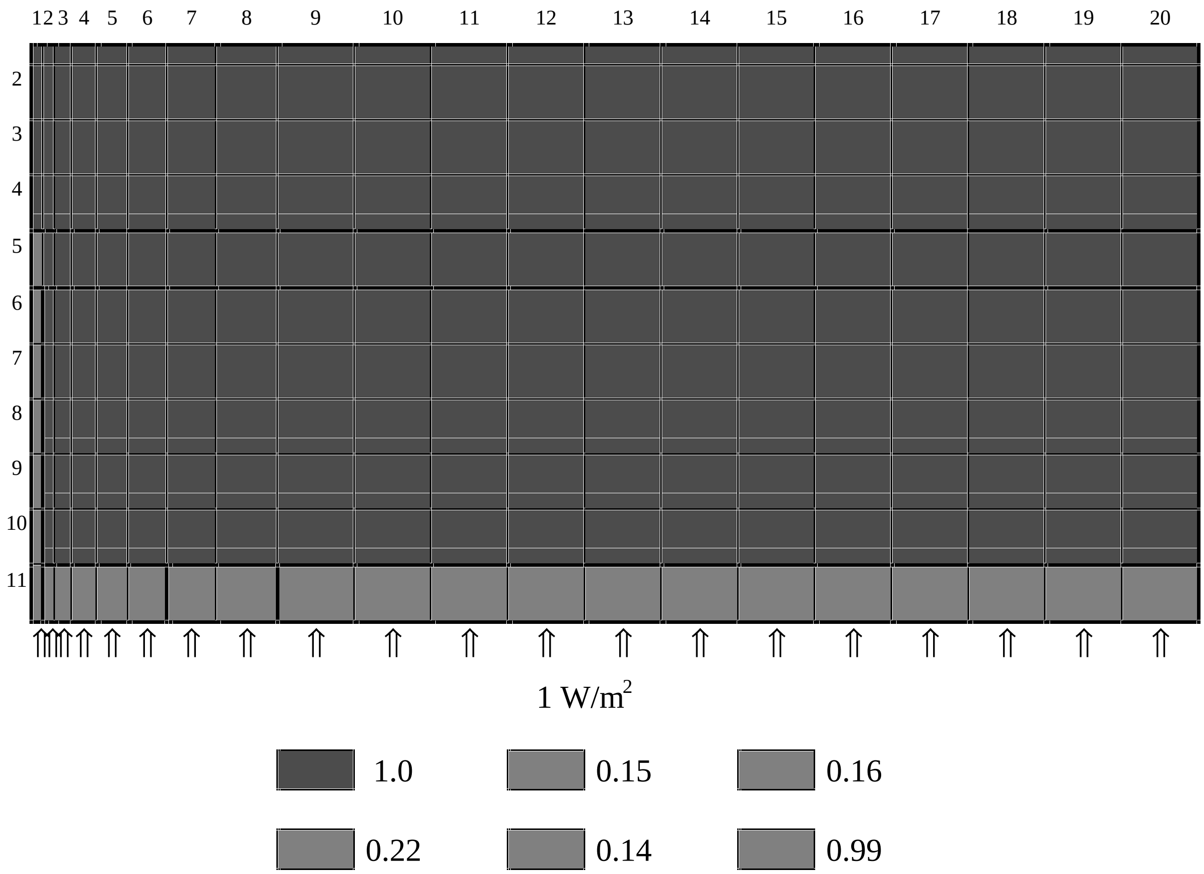

Figure 4.5: Liquid saturation distribution for Model V.

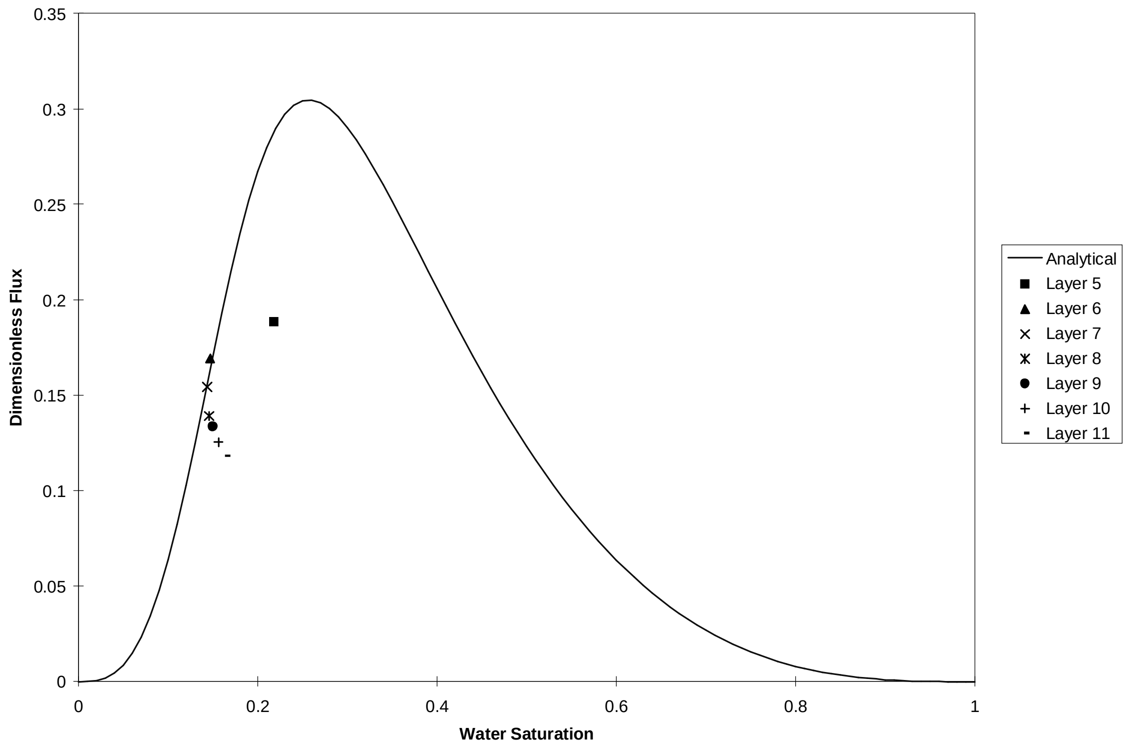

Figure 4.6: Plot of the dimensionless heat flux versus saturation for the fracture blocks of Model V.

On the issue of stability, Model I indicates that numerically it is not possible to maintain a water-saturated region on top of a liquid-dominated two-phase fractured reservoir if no capillary pressure functions are specified for both the matrix and the fracture blocks. However, Model V gave the result that even if no capillary pressures were specified for the fracture blocks, a small two-phase zone could still exist below a water-saturated zone. Combining these observations, we can say that not specifying capillary pressures in the matrix blocks would destroy the stability of water over a liquid-dominated two-phase region.

From Models III to V, it can be observed that the fracture acted like a heat pipe and as the maximum capillary pressure specified on the fracture blocks is diminished, the average steam saturation increases. This is due to the fact that capillary forces tend to suck the liquid phase into the pores of the porous medium. In the presence of vapor, the capillary forces through adsorption would induce capillary condensation and the net effect is to have a higher liquid saturation. Not specifying capillary pressures in the fracture increases the heat pipe effect. This is good if we want to look at it in terms of heat transfer. Heat is transmitted more effectively since the mode of heat transfer is through convection. Steam rises through the fractures and on reaching the water-saturated region, loses energy, condenses and trickles down. Liquid is also transferred from the matrix blocks into the fracture where it boils off and rises as steam. Numerical results indicate that as the capillary pressure in the fracture is diminished, the rate at which liquid is transferred from the matrix into the fracture is increased. Likewise, the steam flux going through the fracture is increased. In other words, convection is enhanced and so is heat transfer.

5. CONCLUSIONS

Capillary forces play an important role in determining the natural state of fractured geothermal reservoirs. Capillarity tends to keep the vapor phase in the fractures and the liquid phase in the matrix. In this manner, the fractures are not fully saturated with liquid and the possibility of having a heat pipe is increased. In Models III to V, the fractures were actually vapor-dominated heat pipes. Not having capillary pressure in the fracture blocks enhances the heat pipe effect, and also increases the transfer of liquid from the matrix into the fracture. Having low or no capillary pressure specified in the fracture blocks would improve the convection process and hence speed up heat transfer.

Based on the results obtained from Model II, it seems that the appropriate value for capillary pressures in fractures should not reach 200 kPa. This is reasonable due to the inverse relationship capillary pressure has with the mean pore radius (Equation 2.12). Since the mean pore radius is “large,” small capillary pressures are expected.

Capillary pressures are likewise important as far as the stability of a water-saturated region on top of a liquid-dominated two-phase zone is concerned. Not specifying a matrix capillary pressure (Model I) will cause the two-phase zone to collapse under the water-saturated zone.

The two-dimensional fractured model demonstrates that due to capillary forces, a liquid-dominated two-phase zone will remain stable under a water-saturated region. Normally, one would think that due to the presence of a high permeability conduit, the liquid would gush through the fracture and quench the two-phase zone, however, this is not necessarily the case.

The numerical stability of this system suggests that it is not necessary to model a geothermal system as having a caprock on top. This is the same observation made by Sondergeld and Turcotte (1977) based on their experimental results.

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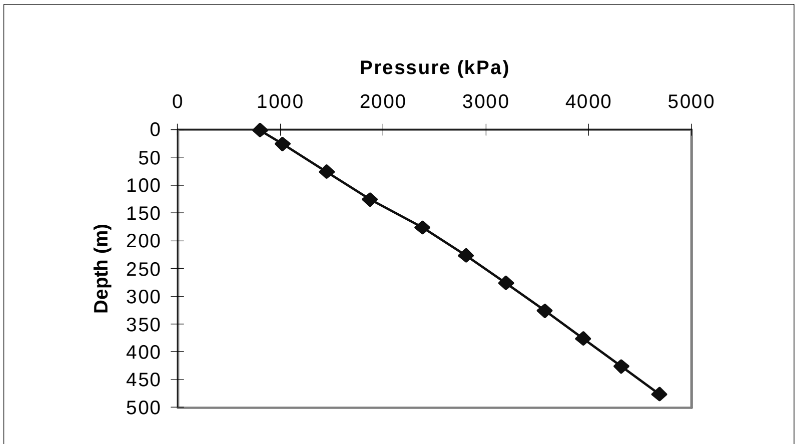
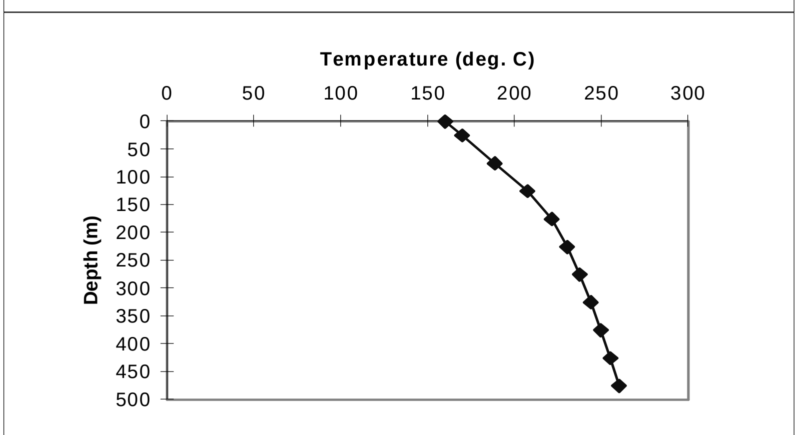
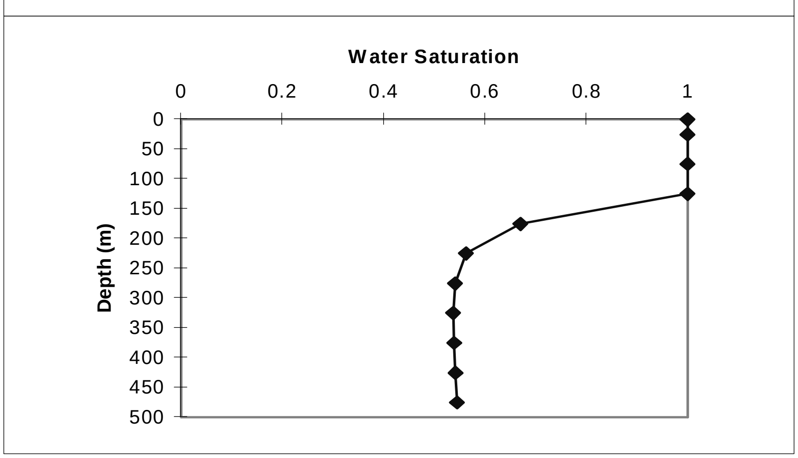
Appendices

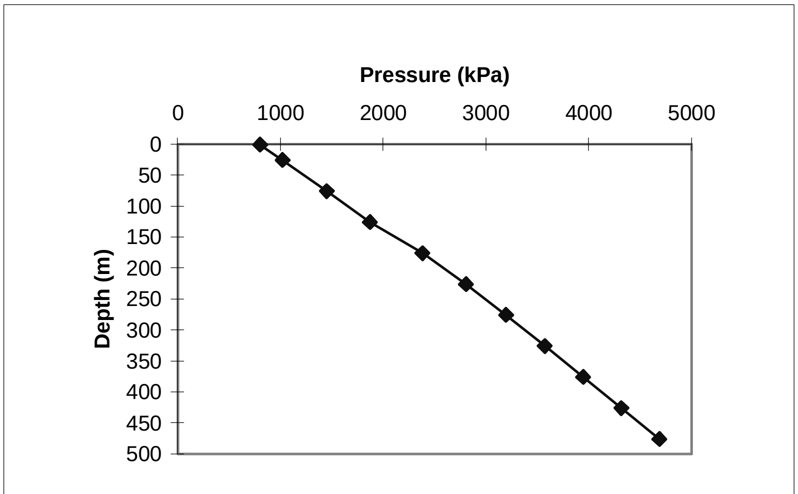
A. Result Plots for the One-Dimensional Case (Centerline)

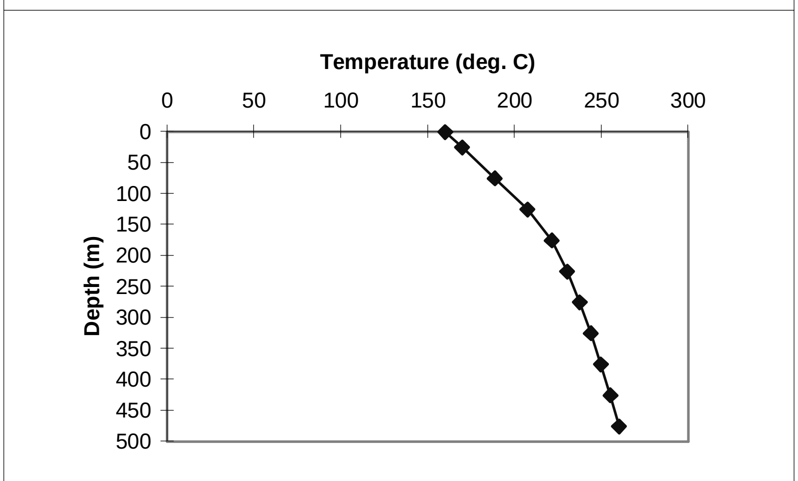


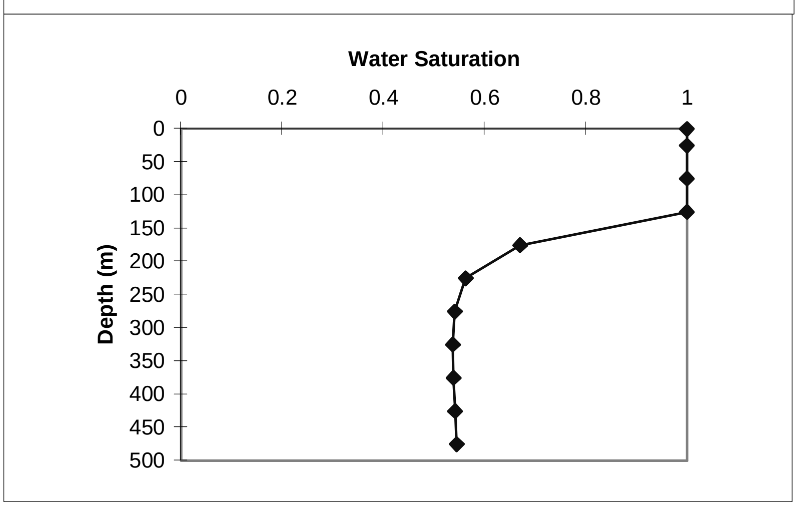




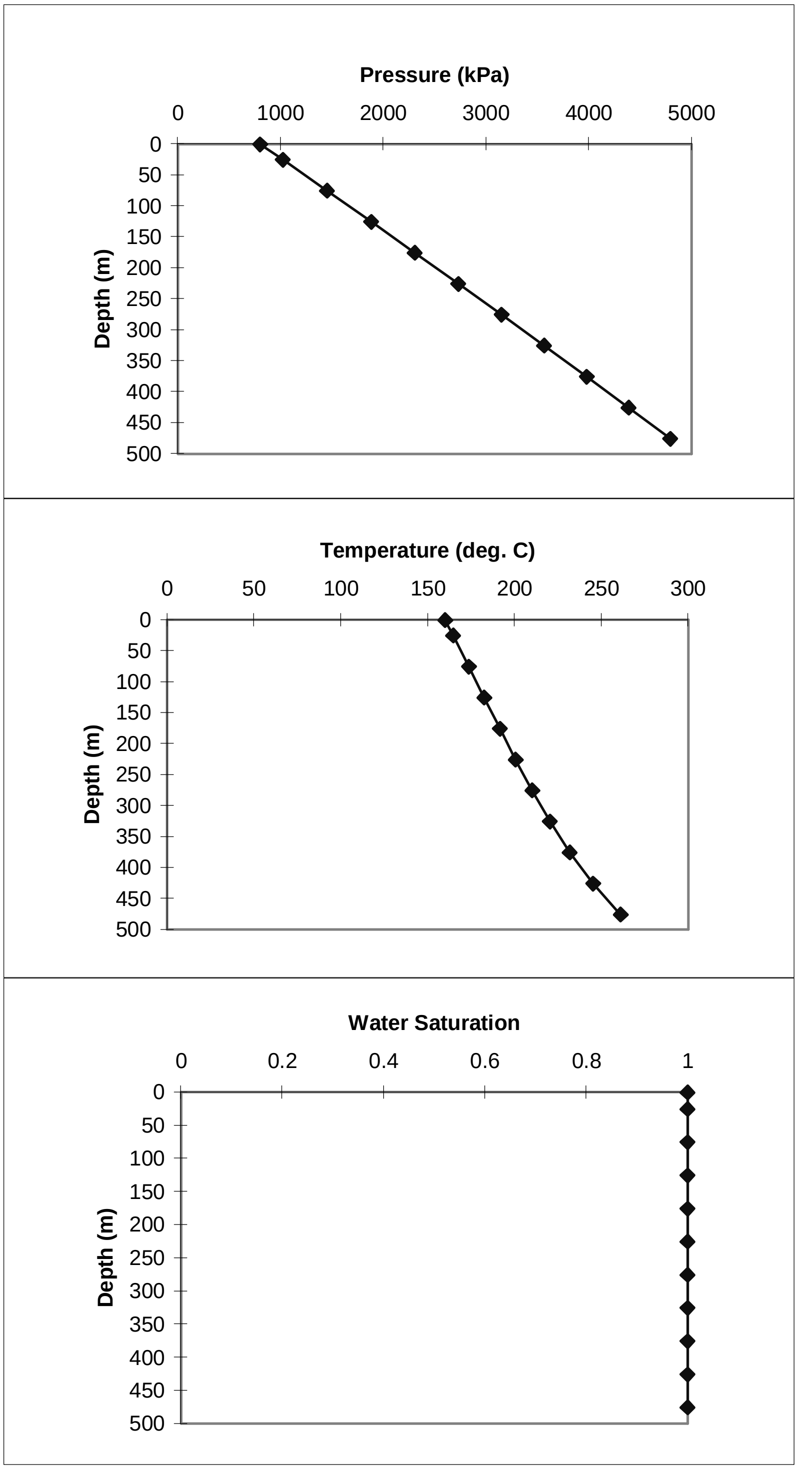
B. Result Plots for the Two-Dimensional Case (Centerline)



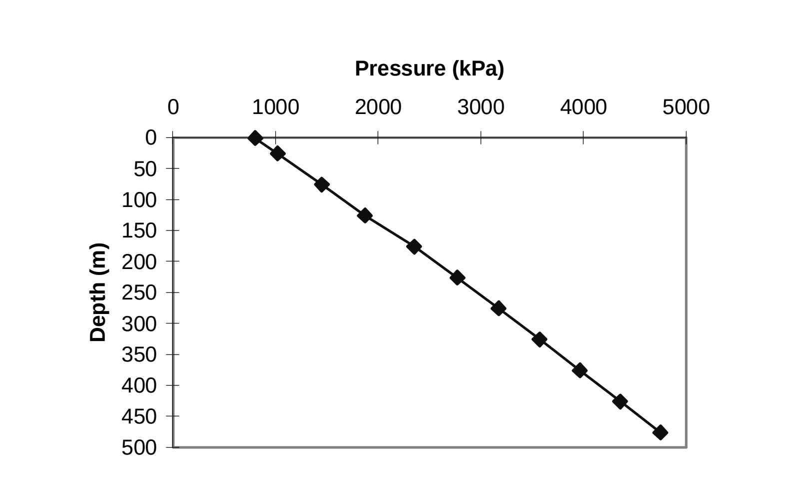


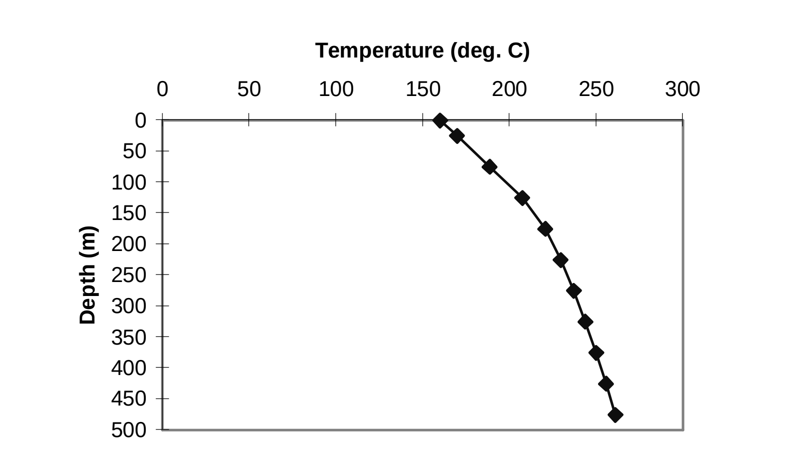


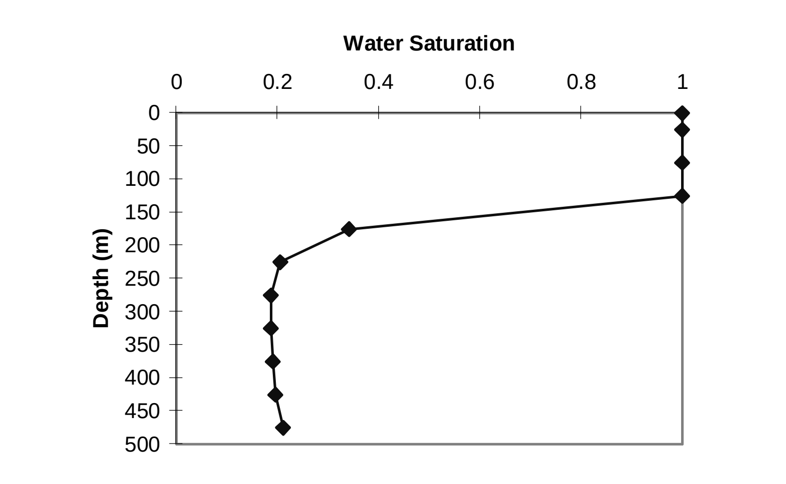
C. Result Plots for Model I (Fracture Blocks)



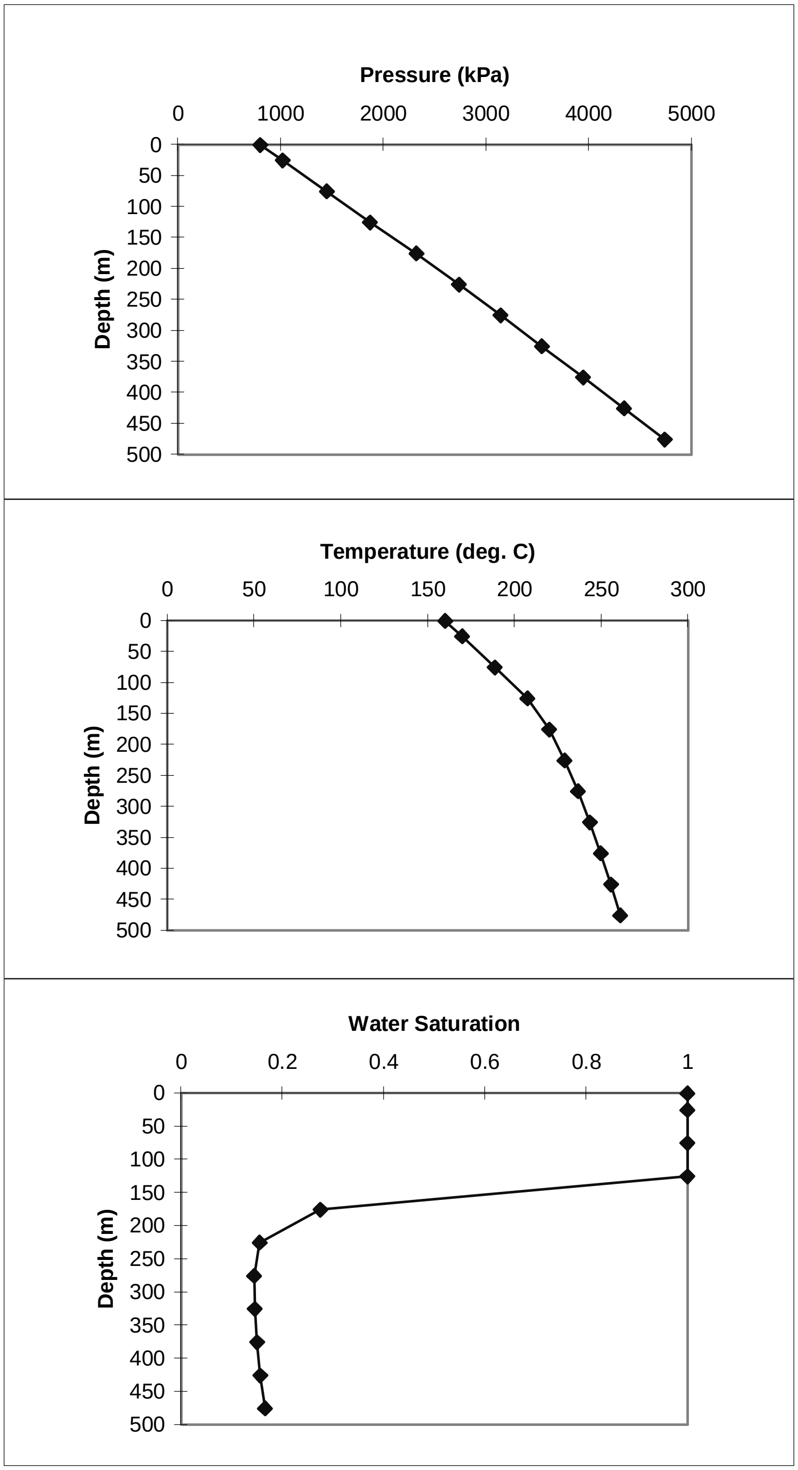
D. Result Plots for Model III (Fracture Blocks)



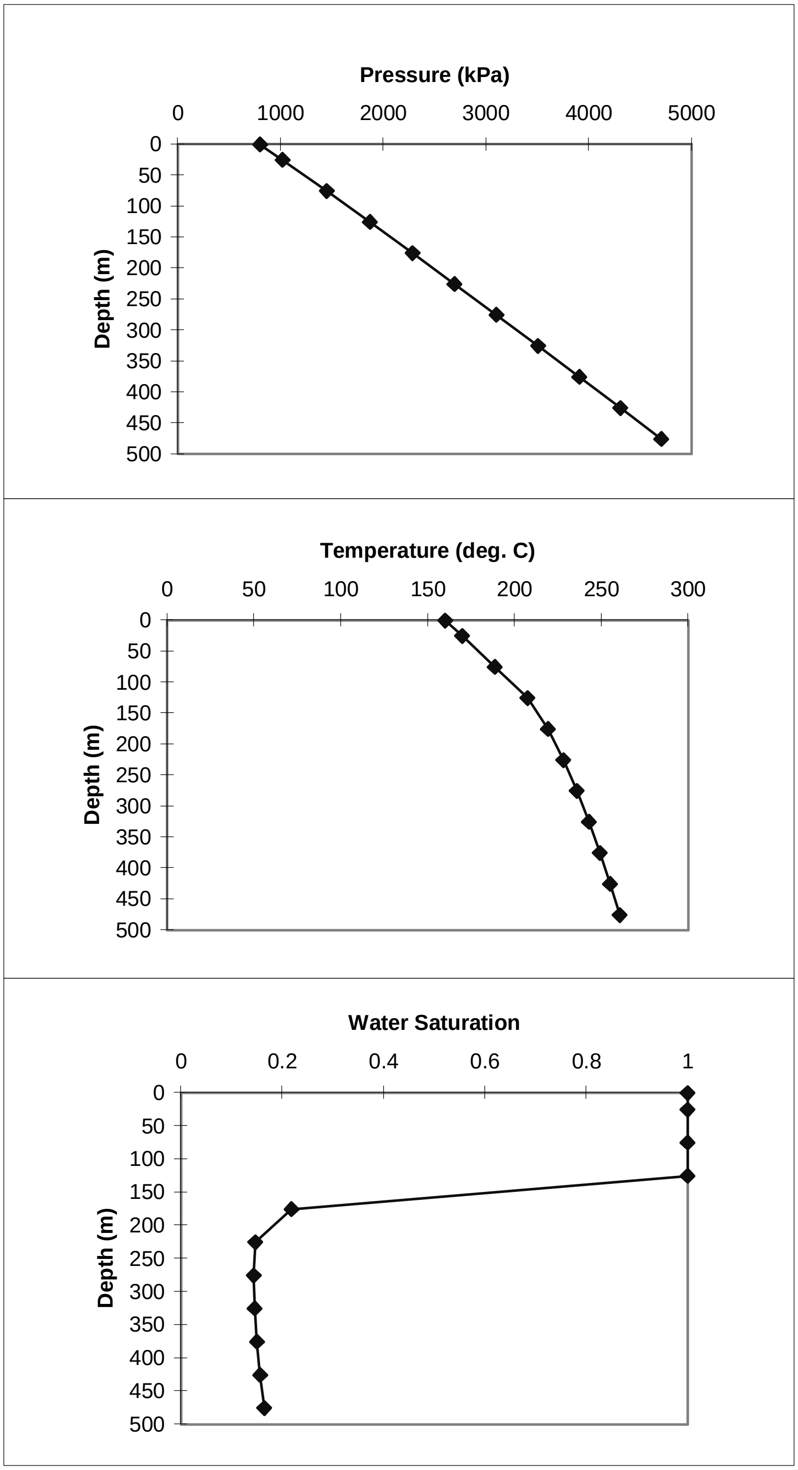




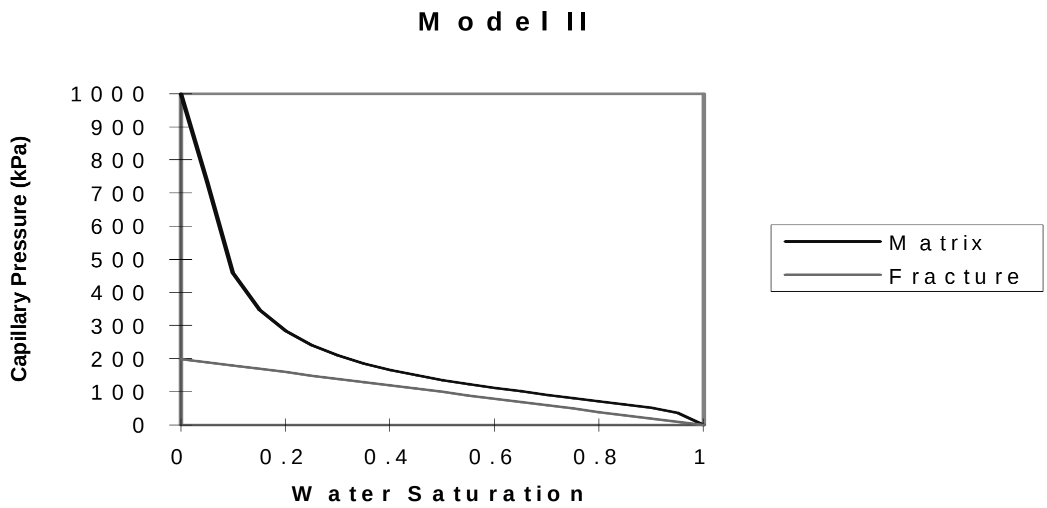
E. Result Plots for Model IV (Fracture Blocks)

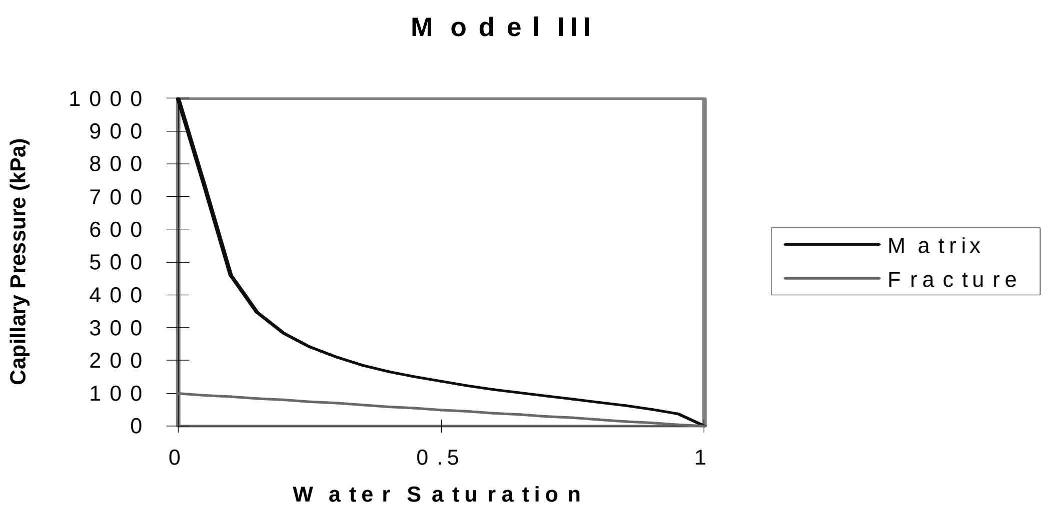


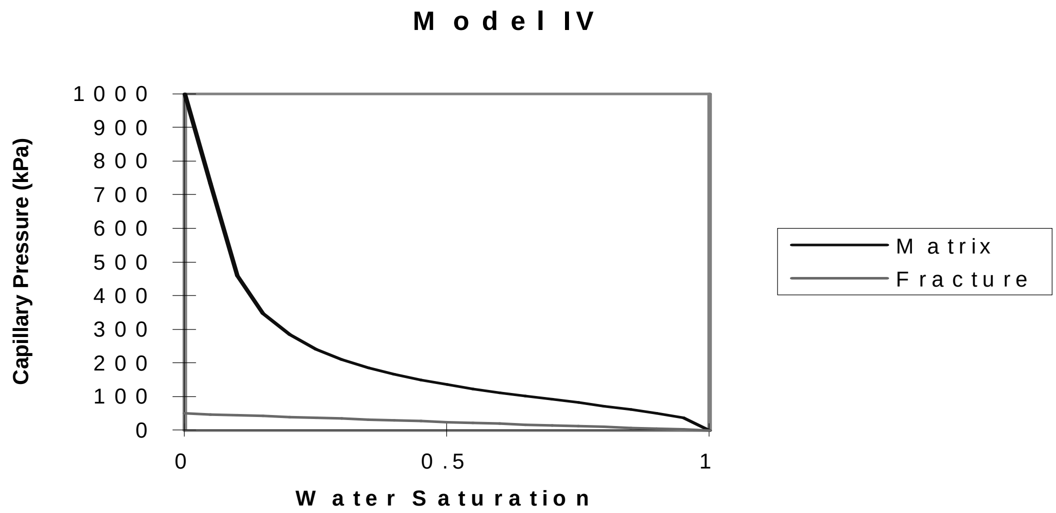
F. Result Plot for Model V (Fracture Blocks)



G. Capillary Pressures Used in Models II, III, IV and V






Model IV
Capillary Pressure (kPa)
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800
700
600
500
400
300
200
100
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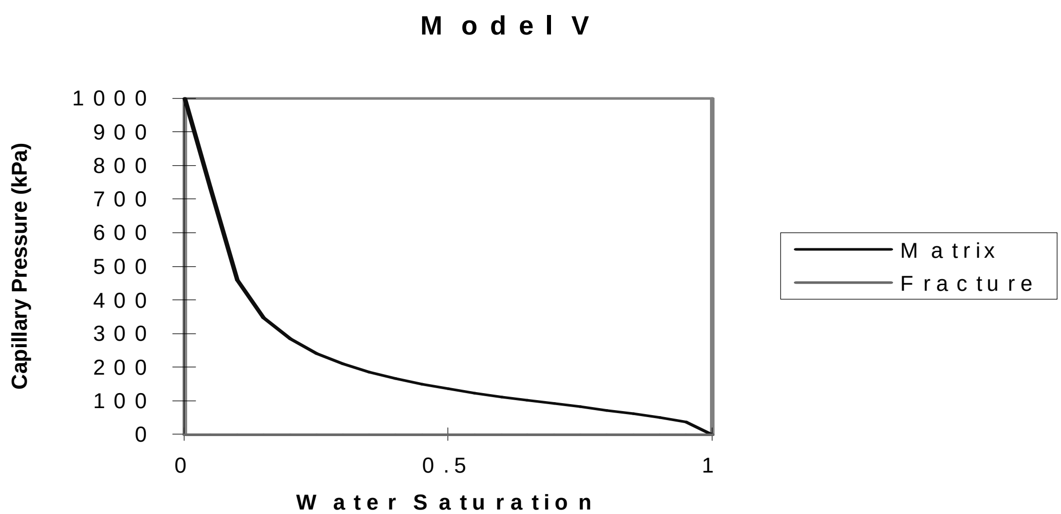
0
0.5
1
Water Saturation
Matrix
Fracture


Model V
Capillary Pressure (kPa)
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900
800
700
600
500
400
300
200
100
0
0
0.5
1
Water Saturation
Matrix
Fracture

H. TETRAD Data Deck for the Five-Point Differencing Scheme Evaluation: 5 x 1 x 11 Block Model

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0.25 0.015625 0.421875 0.
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18.015
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’TEMPMOD’  6 10 1 169.4
’TEMPMOD’ 11 15 1 188.2
’TEMPMOD’ 16 20 1 207.0
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’RECUR’
’COMMENT’  ’    ’
’COMMENT’ ’*********************************************************’
’COMMENT’  ’***********  RECURRENT INPUT PARAMETERS  *************’
’COMMENT’ ’*********************************************************’
’COMMENT’  ’    ’
’TIMEYR’ 0
’COMMENT’  ’TIME AND TIME STEP ON "TIME" WILL BE IN DAYS’
’TIME’ 0.0 0.2
’COMMENT’  ’    ’
’COMMENT’  ’***************** DEFINE ENERGY FLUX *****************’
’ENFLUX’  51 55 1 1.728
’COMMENT’  ’    ’
’COMMENT’
’COMMENT’  ’**************  OBSERVATION WELLS ********************’
’PRODUCER’ ’OBSW1’ 1 3
```

```
          1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
          6
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
          16
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
          21
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
          26
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          31
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          36
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          41
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          46
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
```

51

0.140 0.007 0.0 0.0

,,

25.,,,

'TIME' 8000000.0 0.0

I. TETRAD Data Deck for the Five-Point Differencing Scheme Evaluation: 10 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 10 X 11 X 1 BLOCK MODEL'
'COMMENT'  'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT'  '************************************************************'
'COMMENT'  '*************  RESERVOIR INPUT PARAMETER  *************'
'COMMENT'  '************************************************************'
'COMMENT'  '    '
'COMMENT'  '*************  DEFINE X, Y AND Z DIMENSIONS
*************'
'COMMENT'  '    '
'DIMEN'     10    11   1    20000
'COMMENT'  '    '
'COMMENT'  '*******************  DEFINE GRIDS ***********************'
'DELX' 1
10 10*2.5
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
'BVMULT' 1 10 1 100000000000000.
'COMMENT'  '**************  OUTPUT FILE CONTROLS  *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
```

```
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '******************  DEFINE POROSITIES  *******************'
'PORMOD' 1 10 1 0.95
'PORMOD' 12 110 1 0.1
'PORMOD' 11 101 10 0.1
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 10 1 2000. 2000. 2000.
'PERMMOD' 12 110 1 0.50.5 0.5
'PERMMOD' 11 101 10 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '**************  NUMERICAL CONTROLS  *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*******************************************************'
'COMMENT'  '*************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*******************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
```

```
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 10 1 3
'RKREG' 12 110 1 3
'RKREG' 11 101 10 3
'COMMENT'
'COMMENT'  '***************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE GAS DENSITY  *******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS VISCOSITY  *****************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  ********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  ***************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
```

```
'COMMENT'  '*************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE INITIAL PRESSURE  ****************'
'PRESMOD' 1 10 1 800.0
'PRESMOD' 11 20 1 1020.
'PRESMOD' 21 30 1 1456.
'PRESMOD' 31 40 1 1881.
'PRESMOD' 41 50 1 1923.
'PRESMOD' 51 60 1 1965.
'PRESMOD' 61 70 1 2006.
'PRESMOD' 71 80 1 2048.
'PRESMOD' 81 90 1 2090.
'PRESMOD' 91 100 1 2132.
'PRESMOD' 101 110 1 2173.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION *******'
'SATMOD'  1  40 1  0.0 0.0
'SATMOD'  41 110  1  0.85 0.0
'COMMENT'  '    '
'COMMENT'  '************** DEFINE INITIAL BLOCK TEMPERATURE ******'
'TEMPMOD'  1 10 1 160.
'TEMPMOD' 11 20 1 169.4
'TEMPMOD' 21 30 1 188.2
'TEMPMOD' 31 40 1 207.0
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*********************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '****************** DEFINE ENERGY FLUX *****************'
'ENFLUX'  101 110 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '*****************  OBSERVATION WELLS ******************'
'PRODUCER' 'OBSW1' 1 3
        1
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
            11
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
            31
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
            41
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
            51
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
            61
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
            71
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
            81
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
            91
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
             101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '    '
'TIME' 8000000.0 0.0
```

J. TETRAD Data Deck for the Five-Point Differencing Scheme Evaluation: 14 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT' '    '
'COMMENT' 'DATA DECK FOR A 14 X 11 X 1 BLOCK MODEL'
'COMMENT' 'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT' '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT' 'SIMULATING HEAT PIPE EFFECT '
'COMMENT' 'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT' '    '
'COMMENT' '    '
'COMMENT' '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT' 'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT' '    '
'COMMENT' '**************************************************************'
'COMMENT' '************** RESERVOIR INPUT PARAMETER **************'
'COMMENT' '**************************************************************'
'COMMENT' '    '
'COMMENT' '************* DEFINE X, Y AND Z DIMENSIONS
***************'
'COMMENT' '    '
'DIMEN'     14    11   1    20000
'COMMENT' '    '
'COMMENT' '********************* DEFINE GRIDS ***********************'
'DELX' 2
8  8*1.25
6  6*2.5
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
'BVMULT' 1 14 1 100000000000000.
'COMMENT' '    '
'COMMENT' '**************** OUTPUT FILE CONTROLS *****************'
'COMMENT' '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
```

```
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '******************  DEFINE POROSITIES  *******************'
'PORMOD' 1 14 1 0.95
'PORMOD' 16 154 1 0.1
'PORMOD' 15 141 14 0.1
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 14 1 2000. 2000. 2000.
'PERMMOD' 16 154 1 0.50.5 0.5
'PERMMOD' 15 141 14 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '****************  NUMERICAL CONTROLS  *****************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '**************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
```

```
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT' '    '
'RKREG' 1 14 1 3
'RKREG' 16 154 1 3
'RKREG' 15 141 14 3
'COMMENT'
'COMMENT' '***************** DEFINE WATER DENSITY *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT' '    '
'COMMENT' '******************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT' '    '
'COMMENT' '****************  DEFINE LIQUID VISCOSITY ****************'
'LIQVIS'
0.0 0.0
'COMMENT' '    '
'COMMENT' '*****************  DEFINE GAS VISCOSITY  *****************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT' '    '
'COMMENT' '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT' '    '
'COMMENT' '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0  0.0
'COMMENT' '    '
'COMMENT' '**************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT' '    '
'COMMENT' '**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **'
'LIQTCON' 249.2 0.0 15.56
```

```
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE ****************'
'PRESMOD' 1 14 1 800.0
'PRESMOD' 15 28 1 1020.
'PRESMOD' 29 42 1 1456.
'PRESMOD' 43 56 1 1881.
'PRESMOD' 57 70 1 1923.
'PRESMOD' 71 84 1 1965.
'PRESMOD' 85 98 1 2006.
'PRESMOD' 99 112 1 2048.
'PRESMOD' 113 126 1 2090.
'PRESMOD' 127 140 1 2132.
'PRESMOD' 141 154 1 2173.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION *******'
'SATMOD'  1  56 1  0.0 0.0
'SATMOD'  57 154  1  0.85 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE ******'
'TEMPMOD'  1 14 1 160.
'TEMPMOD' 15 28 1 169.4
'TEMPMOD' 29 42 1 188.2
'TEMPMOD' 43 56 1 207.0
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*********************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '***************** DEFINE ENERGY FLUX *****************'
'ENFLUX'  141 154 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '***************  OBSERVATION WELLS ********************'
```

```
'PRODUCER' 'OBSW1' 1 3
            1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
            15
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
            43
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
            57
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
            71
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
            85
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
            99
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
            113
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
            127
0.140 0.007 0.0 0.0
,,
25.,,,
```

```
'PRODUCER' 'OBSW11' 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '    '
'TIME' 8000000.0 0.0
```

K. TETRAD Data Deck for the Five-Point Differencing Scheme Evaluation: 18 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 18 X 11 X 1 BLOCK MODEL'
'COMMENT'  'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '************************************************************'
'COMMENT'  '************** RESERVOIR INPUT PARAMETER **************'
'COMMENT' '************************************************************'
'COMMENT'  '    '
'COMMENT'  '************** DEFINE X, Y AND Z DIMENSIONS
**************'
'COMMENT'  '    '
'DIMEN'     18    11   1    20000
'COMMENT'  '    '
'COMMENT'  '********************** DEFINE GRIDS ***********************'
'DELX' 3
8  8*0.625
4  4*1.25
6  6*2.5
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
'BVMULT' 1 18 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 18 1 3 1.
'COMMENT'  '*************** OUTPUT FILE CONTROLS ******************'
'COMMENT'  '    '
```

```
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE POROSITIES  ********************'
'PORMOD' 1 18 1 0.95
'PORMOD' 20 198 1 0.1
'PORMOD' 19 181 18 0.1
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE PERMEABILITIES ******************'
'PERMMOD' 1 18 1 2000. 2000. 2000.
'PERMMOD' 20 198 1 0.50.5 0.5
'PERMMOD' 19 181 14 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***************  NUMERICAL CONTROLS  ******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '**************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
```

```
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 18 1 3
'RKREG' 20 198 1 3
'RKREG' 19 181 18 3
'COMMENT'
'COMMENT'  '****************  DEFINE WATER DENSITY  *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE GAS VISCOSITY  *****************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  ********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
```

```
’COMMENT’  ’    ’
’COMMENT’  ’**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **’
’LIQTCON’ 249.2 0.0 15.56
57.316,,,
’COMMENT’
’COMMENT’  ’************  GAS THERMAL CONDUCTIVITY  ***************’
’GASTCON’
4.361,,,
’COMMENT’  ’    ’
’COMMENT’  ’***************  DEFINE INITIAL PRESSURE  ****************’
’PRESMOD’ 1 18 1 800.0
’PRESMOD’ 19 36 1 1020.
’PRESMOD’ 37 54 1 1456.
’PRESMOD’ 55 72 1 1881.
’PRESMOD’ 73 90 1 1923.
’PRESMOD’ 91 108 1 1965.
’PRESMOD’ 109 126 1 2006.
’PRESMOD’ 127 144 1 2048.
’PRESMOD’ 145 162 1 2090.
’PRESMOD’ 163 180 1 2132.
’PRESMOD’ 181 198 1 2173.
’COMMENT’  ’    ’
’COMMENT’  ’*************** DEFINE INITIAL WATER SATURATION ******’
’SATMOD’  1  72 1  0.0 0.0
’SATMOD’  73 198  1  0.85 0.0
’COMMENT’  ’    ’
’COMMENT’  ’*************** DEFINE INITIAL BLOCK TEMPERATURE *****’
’TEMPMOD’  1 18 1 160.
’TEMPMOD’ 19 36 1 169.4
’TEMPMOD’ 37 54 1 188.2
’TEMPMOD’ 55 72 1 207.0
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’RECUR’
’COMMENT’  ’    ’
’COMMENT’  ’*********************************************************’
’COMMENT’  ’***********  RECURRENT INPUT PARAMETERS  *************’
’COMMENT’  ’*********************************************************’
’COMMENT’  ’    ’
’TIMEYR’ 0
’COMMENT’  ’TIME AND TIME STEP ON "TIME" WILL BE IN DAYS’
’TIME’ 0.0 0.2
’COMMENT’  ’    ’
’COMMENT’  ’***************** DEFINE ENERGY FLUX *****************’
’ENFLUX’  181 198 1 1.728
```

```
'COMMENT' '    '
'COMMENT'
'COMMENT' '****************** OBSERVATION WELLS *******************'
'PRODUCER' 'OBSW1' 1 3
        1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
        19
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
        55
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
        73
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
        91
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
        109
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
        127
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
        145
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
        163
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT'  '    '
'TIME' 8000000.0 0.0
```

L. TETRAD Data Deck for the Nine-Point Differencing Scheme Evaluation: 5 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR THE 5 X 11 X 1 BLOCK MODEL'
'COMMENT'  'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.33333 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 9-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '**************************************************************'
'COMMENT'  '************** RESERVOIR INPUT PARAMETER **************'
'COMMENT' '**************************************************************'
'COMMENT'  '    '
'COMMENT'  '************** DEFINE X, Y AND Z DIMENSIONS
**************'
'COMMENT'  '    '
'DIMEN'     5    11   1    20000
'COMMENT'  '    '
'COMMENT'  '********************** DEFINE GRIDS ***********************'
'DELX' 1
5 5*5.0
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
'BVMULT' 1 5 1 100000000000000.
'COMMENT'  '**************** OUTPUT FILE CONTROLS *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
```

```
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '******************  DEFINE POROSITIES  *******************'
'PORMOD' 1 5 1 0.95
'PORMOD' 7 55 1 0.1
'PORMOD' 6 51 5 0.1
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 5 1 2000. 2000. 2000.
'PERMMOD' 7 55 1 0.50.5 0.5
'PERMMOD' 6 51 5 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '****************  NUMERICAL CONTROLS  *****************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '*************   PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
```

```
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
’COMMENT’  ’    ’
’RKREG’ 1 5 1 3
’RKREG’ 7 55 1 3
’RKREG’ 6 51 5 3
’COMMENT’
’COMMENT’  ’****************  DEFINE WATER DENSITY  *****************’
’LIQDEN’
1000.03 4.64E-07 9.00E-4 101.33 15.5
’DENCS’ 1000.03
1
18.015
’COMMENT’  ’    ’
’COMMENT’  ’******************  DEFINE GAS DENSITY  ******************’
’CRITG’
22105.97 647.23 3.37737E-03
’COMMENT’  ’    ’
’COMMENT’  ’***************  DEFINE LIQUID VISCOSITY *****************’
’LIQVIS’
0.0 0.0
’COMMENT’  ’    ’
’COMMENT’  ’****************  DEFINE GAS VISCOSITY  *****************’
’GASVIS’
-10.2E-04 3.611E-05 1.0 0.0 1.0
’COMMENT’  ’    ’
’COMMENT’  ’*********  DEFINE LATENT HEAT OF VAPORIZATION  ********’
’LATHVAP’
2256.92  647.23  373.15  0.38
’COMMENT’  ’    ’
’COMMENT’  ’********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******’
’LIQSH’ 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
’COMMENT’  ’    ’
’COMMENT’  ’****************  DEFINE GAS SPECIFIC HEATS  *************’
’GASSH’
2.3446 0.0 0.0 0.0 0.0
’COMMENT’  ’    ’
’COMMENT’  ’**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **’
’LIQTCON’ 249.2 0.0 15.56
57.316,,,
’COMMENT’
```

```
'COMMENT'  '**************  GAS THERMAL CONDUCTIVITY  *************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***************** DEFINE INITIAL PRESSURE ***************'
'PRESMOD' 1 5 1 800.0
'PRESMOD' 6 10 1 1020.
'PRESMOD' 11 15 1 1456.
'PRESMOD' 16 20 1 1881.
'PRESMOD' 21 25 1 1923.
'PRESMOD' 26 30 1 1965.
'PRESMOD' 31 35 1 2006.
'PRESMOD' 36 40 1 2048.
'PRESMOD' 41 45 1 2090.
'PRESMOD' 46 50 1 2132.
'PRESMOD' 51 55 1 2173.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  20 1  0.0 0.0
'SATMOD'  21 55  1  0.85 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 5 1 160.
'TEMPMOD'  6 10 1 169.4
'TEMPMOD' 11 15 1 188.2
'TEMPMOD' 16 20 1 207.0
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '**********************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '**********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '***************** DEFINE ENERGY FLUX *****************'
'ENFLUX'  51 55 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '**************  OBSERVATION WELLS ********************'
'PRODUCER' 'OBSW1' 1 3
```

```
            1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
            6
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
            16
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
            21
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
            26
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
            31
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
            36
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
            41
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
            46
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
```

51
0.140 0.007 0.0 0.0
,,
25.,,,
’TIME’ 8000000.0 0.0

M. TETRAD Data Deck for the Nine-Point Differencing Scheme Evaluation: 10 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 10 X 11 X 1 BLOCK MODEL'
'COMMENT'  'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.33333 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 9-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '*************************************************************'
'COMMENT'  '*************  RESERVOIR INPUT PARAMETER  *************'
'COMMENT' '*************************************************************'
'COMMENT'  '    '
'COMMENT'  '*************  DEFINE X, Y AND Z DIMENSIONS
*************'
'COMMENT'  '    '
'DIMEN'     10    11   1    20000
'COMMENT'  '    '
'COMMENT'  '********************  DEFINE GRIDS ***********************'
'DELX' 1
10 10*2.5
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
'BVMULT' 1 10 1 100000000000000.
'COMMENT'  '***************  OUTPUT FILE CONTROLS  *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
```

```
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '******************  DEFINE POROSITIES  *******************'
'PORMOD' 1 10 1 0.95
'PORMOD' 12 110 1 0.1
'PORMOD' 11 101 10 0.1
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 10 1 2000. 2000. 2000.
'PERMMOD' 12 110 1 0.50.5 0.5
'PERMMOD' 11 101 10 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '**************  NUMERICAL CONTROLS  *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '*************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
```

```
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT' '    '
'RKREG' 1 10 1 3
'RKREG' 12 110 1 3
'RKREG' 11 101 10 3
'COMMENT'
'COMMENT' '***************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT' '    '
'COMMENT' '****************  DEFINE GAS DENSITY  *******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT' '    '
'COMMENT' '**************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT' '    '
'COMMENT' '***************  DEFINE GAS VISCOSITY  ******************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT' '    '
'COMMENT' '*********  DEFINE LATENT HEAT OF VAPORIZATION  ********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT' '    '
'COMMENT' '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT' '    '
'COMMENT' '**************  DEFINE GAS SPECIFIC HEATS  ***************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT' '    '
'COMMENT' '**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
```

```
'COMMENT'  '************* GAS THERMAL CONDUCTIVITY **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE ****************'
'PRESMOD' 1 10 1 800.0
'PRESMOD' 11 20 1 1020.
'PRESMOD' 21 30 1 1456.
'PRESMOD' 31 40 1 1881.
'PRESMOD' 41 50 1 1923.
'PRESMOD' 51 60 1 1965.
'PRESMOD' 61 70 1 2006.
'PRESMOD' 71 80 1 2048.
'PRESMOD' 81 90 1 2090.
'PRESMOD' 91 100 1 2132.
'PRESMOD' 101 110 1 2173.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION *******'
'SATMOD'  1  40 1  0.0 0.0
'SATMOD'  41 110  1  0.85 0.0
'COMMENT'  '    '
'COMMENT'  '************** DEFINE INITIAL BLOCK TEMPERATURE ******'
'TEMPMOD'  1 10 1 160.
'TEMPMOD' 11 20 1 169.4
'TEMPMOD' 21 30 1 188.2
'TEMPMOD' 31 40 1 207.0
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT'  '*********************************************************'
'COMMENT'  '*********** RECURRENT INPUT PARAMETERS *************'
'COMMENT'  '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '****************** DEFINE ENERGY FLUX ******************'
'ENFLUX'  101 110 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '***************** OBSERVATION WELLS ******************'
'PRODUCER' 'OBSW1' 1 3
        1
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
          11
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
          31
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
          41
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
          51
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          61
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          71
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          81
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          91
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '   '
'TIME' 8000000.0 0.0
```

N. TETRAD Data Deck for the Nine-Point Differencing Scheme Evaluation: 14 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT' '   '
'COMMENT' 'DATA DECK FOR A 14 X 11 X 1 BLOCK MODEL'
'COMMENT' 'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT' '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT' 'SIMULATING HEAT PIPE EFFECT '
'COMMENT' 'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT' '   '
'COMMENT' '   '
'COMMENT' '   '
'TYPE' 4 1 1 0.33333 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT' 'GEOTHERMAL, SINGLE COMPONENT, 9-PT. DIFFERENCING'
'COMMENT' '   '
'COMMENT' '************************************************************'
'COMMENT' '************** RESERVOIR INPUT PARAMETER **************'
'COMMENT' '************************************************************'
'COMMENT' '   '
'COMMENT' '************* DEFINE X, Y AND Z DIMENSIONS
***************'
'COMMENT' '   '
'DIMEN'    14   11   1   20000
'COMMENT' '   '
'COMMENT' '********************** DEFINE GRIDS ***********************'
'DELX' 2
8 8*1.25
6 6*2.5
'DELY' 2
1 1*1.0
10 10*50.
'DELZ' 1
1 1*50.0
'FTOPS' 00
'BVMULT' 1 14 1 100000000000000.
'COMMENT' '   '
'COMMENT' '**************** OUTPUT FILE CONTROLS *****************'
'COMMENT' '   '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
```

```
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '******************  DEFINE POROSITIES  *******************'
'PORMOD' 1 14 1 0.95
'PORMOD' 16 154 1 0.1
'PORMOD' 15 141 14 0.1
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 14 1 2000. 2000. 2000.
'PERMMOD' 16 154 1 0.50.5 0.5
'PERMMOD' 15 141 14 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '****************  NUMERICAL CONTROLS  *****************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '**************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
```

```
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 14 1 3
'RKREG' 16 154 1 3
'RKREG' 15 141 14 3
'COMMENT'
'COMMENT'  '***************** DEFINE WATER DENSITY *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '******************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE LIQUID VISCOSITY ****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE GAS VISCOSITY  ****************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0  0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **'
'LIQTCON' 249.2 0.0 15.56
```

```
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE ****************'
'PRESMOD' 1 14 1 800.0
'PRESMOD' 15 28 1 1020.
'PRESMOD' 29 42 1 1456.
'PRESMOD' 43 56 1 1881.
'PRESMOD' 57 70 1 1923.
'PRESMOD' 71 84 1 1965.
'PRESMOD' 85 98 1 2006.
'PRESMOD' 99 112 1 2048.
'PRESMOD' 113 126 1 2090.
'PRESMOD' 127 140 1 2132.
'PRESMOD' 141 154 1 2173.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION *******'
'SATMOD'  1  56 1  0.0 0.0
'SATMOD'  57 154  1  0.85 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE ******'
'TEMPMOD'  1 14 1 160.
'TEMPMOD' 15 28 1 169.4
'TEMPMOD' 29 42 1 188.2
'TEMPMOD' 43 56 1 207.0
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '**********************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '**********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '****************** DEFINE ENERGY FLUX ******************'
'ENFLUX'  141 154 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '***************  OBSERVATION WELLS ********************'
```

```
’PRODUCER’ ’OBSW1’ 1 3
        1
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW2’ 1 3
        15
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW4’ 1 3
        43
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW5’ 1 3
        57
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW6’ 1 3
        71
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW7’ 1 3
        85
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW8’ 1 3
        99
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW9’ 1 3
        113
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW10’ 1 3
        127
0.140 0.007 0.0 0.0
,,
25.,,,
```

```
'PRODUCER' 'OBSW11' 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '    '
'TIME' 8000000.0 0.0
```

O. TETRAD Data Deck for the Nine-Point Differencing Scheme Evaluation: 18 x 1 x 11 Block Model

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 18 X 11 X 1 BLOCK MODEL'
'COMMENT'  'REGULAR GRID WITHOUT CAPILLARITY'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12     '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '************************************************************'
'COMMENT'  '************** RESERVOIR INPUT PARAMETER  **************'
'COMMENT' '************************************************************'
'COMMENT'  '    '
'COMMENT'  '************** DEFINE X, Y AND Z DIMENSIONS
**************'
'COMMENT'  '    '
'DIMEN'     18    11   1    20000
'COMMENT'  '    '
'COMMENT'  '********************** DEFINE GRIDS ***********************'
'DELX' 3
8  8*0.625
4  4*1.25
6  6*2.5
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
'BVMULT' 1 18 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 18 1 3 1.
'COMMENT'  '**************** OUTPUT FILE CONTROLS  ******************'
'COMMENT'  '    '
```

```
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE POROSITIES  ********************'
'PORMOD' 1 18 1 0.95
'PORMOD' 20 198 1 0.1
'PORMOD' 19 181 18 0.1
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE PERMEABILITIES ******************'
'PERMMOD' 1 18 1 2000. 2000. 2000.
'PERMMOD' 20 198 1 0.50.5 0.5
'PERMMOD' 19 181 14 0.50.5 0.5
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***************  NUMERICAL CONTROLS  ******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '**************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
```

```
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT' '    '
'RKREG' 1 18 1 3
'RKREG' 20 198 1 3
'RKREG' 19 181 18 3
'COMMENT'
'COMMENT' '****************  DEFINE WATER DENSITY  *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT' '    '
'COMMENT' '*****************  DEFINE GAS DENSITY  *******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT' '    '
'COMMENT' '***************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT' '    '
'COMMENT' '****************  DEFINE GAS VISCOSITY  *****************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT' '    '
'COMMENT' '*********  DEFINE LATENT HEAT OF VAPORIZATION  ********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT' '    '
'COMMENT' '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT' '    '
'COMMENT' '***************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
```

```
'COMMENT'  '    '
'COMMENT'  '**  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES  **'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  ***************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE INITIAL PRESSURE  ****************'
'PRESMOD' 1 18 1 800.0
'PRESMOD' 19 36 1 1020.
'PRESMOD' 37 54 1 1456.
'PRESMOD' 55 72 1 1881.
'PRESMOD' 73 90 1 1923.
'PRESMOD' 91 108 1 1965.
'PRESMOD' 109 126 1 2006.
'PRESMOD' 127 144 1 2048.
'PRESMOD' 145 162 1 2090.
'PRESMOD' 163 180 1 2132.
'PRESMOD' 181 198 1 2173.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  72 1  0.0 0.0
'SATMOD'  73 198  1  0.85 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 18 1 160.
'TEMPMOD' 19 36 1 169.4
'TEMPMOD' 37 54 1 188.2
'TEMPMOD' 55 72 1 207.0
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT'  '*********************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT'  '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '***************** DEFINE ENERGY FLUX *****************'
'ENFLUX'  181 198 1 1.728
```

```
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '*****************  OBSERVATION WELLS *******************'
'PRODUCER' 'OBSW1' 1 3
          1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
          19
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
          55
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
          73
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
          91
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          109
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          127
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          145
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          163
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '   '
'TIME' 8000000.0 0.0
```

P. TETRAD Data Deck - Bau and Torrance's (1982) Experiment: 0.4 kW/m^2

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 5 X 1 X 11 BLOCK MODEL'
'COMMENT'  'RADIAL GRID WITHOUT CAPILLARITY'
'COMMENT'  'SIMULATING THE EXP. OF BAU AND TORRANCE'
'COMMENT'  '3CM WATER LEVEL AT THE TOP'
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'TYPE'  4  1 1 0.0 0.0
'GRAV' 0.0 0.0 9.81 0.0 0.0
'COMMENT'
'COMMENT'  '    '
'COMMENT' '*************************************************************'
'COMMENT'  '************* RESERVOIR INPUT PARAMETER *************'
'COMMENT' '*************************************************************'
'COMMENT'  '    '
'COMMENT'  '************ DEFINE X, Y AND Z DIMENSIONS
***************'
'COMMENT'  '    '
'DIMEN'     5   1   11    2000
'COMMENT'  '    '
'COMMENT'  '******************** DEFINE GRIDS **********************'
'DELX' 1
5  5*0.0095
'DELZ' 2
1      1*0.03
10     10*0.02
'RADIAL' 0 0.0
'FTOPS' 0 0
'BVMULT'  1 5 1 10000000000000000000.
'COMMENT'  '*************** OUTPUT FILE CONTROLS *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 0 0 0 0 0 8 0 0
'OUTPROP' 0 0 0 4 0 6 7 0 9 0
'OUTMISC' 4 0 0 0 0 0 0 0 0 0
'PLOT' 5 0
```

```
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE POROSITIES  *********************'
'PORMOD' 1 5 1 0.95
'PORMOD' 6 55 1 0.37
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE PERMEABILITIES *******************'
'PERMMOD' 1 5 1 10000000. 10000000. 10000000.
'PERMMOD' 6 55 1 8500. 8500. 8500.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***************  NUMERICAL CONTROLS  ******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0000001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '**********************************************************'
'COMMENT'  '*************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '**********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.00 1.00  0.
0.05 0.05 0.95  0.
0.10 0.10 0.90  0.
0.15 0.15 0.85  0.
0.20 0.20 0.80  0.
0.25 0.25 0.75  0.
0.30 0.30 0.70  0.
0.35 0.35 0.65  0.
0.40 0.40 0.60  0.
0.45 0.45 0.55  0.
0.50 0.50 0.50  0.
0.55 0.55 0.45  0.
0.60 0.60 0.40  0.
0.65 0.65 0.35  0.
0.70 0.70 0.30  0.
0.75 0.75 0.25  0.
0.80 0.80 0.20  0.
0.85 0.85 0.15  0.
0.90 0.90 0.10  0.
0.95 0.95 0.05  0.
```

```
1.00 1.00 0.00  0.
'COMMENT'  '    '
'RKREG' 1 5 1 3
'RKREG' 6 55 1 3
'COMMENT'
'COMMENT'  '***************** DEFINE WATER DENSITY *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE GAS VISCOSITY
******************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION
*********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0  0.0
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 79.49 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
```

```
4.361,,,
’COMMENT’ ’    ’
’COMMENT’ ’**************** DEFINE INITIAL PRESSURE ****************’
’PRES’ 100. 0.0 9.81
’COMMENT’ ’    ’
’COMMENT’ ’**********  DEFINE INITIAL WATER SATURATION  ***********’
’SATMOD’  1  55 1  0.0 0.0
’COMMENT’ ’    ’
’COMMENT’ ’********** DEFINE INITIAL BLOCK TEMPERATURE **********’
’TEMPMOD’  1 55 1 15.
’COMMENT’ ’    ’
’COMMENT’ ’    ’
’RECUR’
’COMMENT’ ’    ’
’COMMENT’ ’*********************************************************’
’COMMENT’ ’*************  RECURRENT INPUT PARAMETERS  ************’
’COMMENT’ ’*********************************************************’
’COMMENT’ ’    ’
’TIMEYR’ 0
’COMMENT’ ’TIME AND TIME STEP ON "TIME" WILL BE IN DAYS’
’TIME’ 0.0 0.2
’COMMENT’ ’    ’
’COMMENT’ ’    ’
’COMMENT’
’COMMENT’ ’********************** ENFLUX ***************************’
’ENFLUX’   51 55 1 1728000.
’COMMENT’
’COMMENT’ ’***************  OBSERVATION WELLS ********************’
’PRODUCER’ ’OBSW1’ 1 3
          1
0.140 0.001 0.0 0.0
,,
0.015,,,
’PRODUCER’ ’OBSW2’ 1 3
          6
0.140 0.001 0.0 0.0
,,
0.04,,,
’PRODUCER’ ’OBSW3’ 1 3
          16
0.140 0.001 0.0 0.0
,,
0.08,,,
’PRODUCER’ ’OBSW4’ 1 3
          21
```

```
0.140 0.001 0.0 0.0
,,
0.10,,,
'PRODUCER' 'OBSW5' 1 3
          26
0.140 0.001 0.0 0.0
,,
0.12,,,
'PRODUCER' 'OBSW6' 1 3
          31
0.140 0.001 0.0 0.0
,,
0.14,,,
'PRODUCER' 'OBSW7' 1 3
          36
0.140 0.001 0.0 0.0
,,
0.16,,,
'PRODUCER' 'OBSW8' 1 3
          41
0.140 0.001 0.0 0.0
,,
0.18,,,
'PRODUCER' 'OBSW9' 1 3
          46
0.140 0.001 0.0 0.0
,,
0.20,,,
'PRODUCER' 'OBSW10' 1 3
          51
0.140 0.001 0.0 0.0
,,
0.22,,,
'COMMENT' '    '
'TIME' 10000. 0.0
```

Q. TETRAD Data Deck - Bau and Torrance's (1982) Experiment: 0.53 kW/m^2

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 5 X 1 X 11 BLOCK MODEL'
'COMMENT'  'RADIAL GRID WITHOUT CAPILLARITY'
'COMMENT'  'SIMULATING THE EXP. OF BAU AND TORRANCE'
'COMMENT'  '3CM WATER LEVEL AT THE TOP'
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'TYPE'  4  1 1 0.0 0.0
'GRAV' 0.00.0 9.81 0.0 0.0
'COMMENT'
'COMMENT'  '    '
'COMMENT' '*******************************************************'
'COMMENT'  '**************  RESERVOIR INPUT PARAMETER  **************'
'COMMENT' '*******************************************************'
'COMMENT'  '    '
'COMMENT'  '*************  DEFINE X, Y AND Z DIMENSIONS
***************'
'COMMENT'  '    '
'DIMEN'     5   1   11    2000
'COMMENT'  '    '
'COMMENT'  '*********************  DEFINE GRIDS  *************************'
'DELX' 1
5  5*0.0095
'DELZ' 2
1      1*0.03
10     10*0.02
'RADIAL' 0 0.0
'FTOPS' 00
'BVMULT'  1 5 1 10000000000000000000.
'COMMENT'  '****************  OUTPUT FILE CONTROLS  *******************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
```

```
7 ’P/Z’ ’QWPMASS’ ’QGPENER’ ’QWPENER’ ’PAV’ ’TAV’ ’SGAV’
’COMMENT’  ’    ’
’COMMENT’  ’****************** DEFINE POROSITIES ********************’
’PORMOD’ 1 5 1 0.95
’PORMOD’ 6 55 1 0.37
’COMMENT’  ’    ’
’COMMENT’  ’*************** DEFINE PERMEABILITIES ******************’
’PERMMOD’ 1 5 1 10000000. 10000000. 10000000.
’PERMMOD’ 6 55 1 8500. 8500. 8500.
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’COMMENT’  ’*************** NUMERICAL CONTROLS ******************’
’NORM’ 500.  0.1 .2 30
’NEWT’  15  .0000001,,,,,,
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’PROPERTY’
’COMMENT’ ’**********************************************************’
’COMMENT’  ’************* PROPERTY INPUT PARAMETERS *************’
’COMMENT’ ’**********************************************************’
’COMMENT’  ’    ’
’COMMENT’  ’** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **’
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’RELGW’ 3 21 0 0.01 0.0
0.00 0.00 1.00  0.
0.05 0.05 0.95  0.
0.10 0.10 0.90  0.
0.15 0.15 0.85  0.
0.20 0.20 0.80  0.
0.25 0.25 0.75  0.
0.30 0.30 0.70  0.
0.35 0.35 0.65  0.
0.40 0.40 0.60  0.
0.45 0.45 0.55  0.
0.50 0.50 0.50  0.
0.55 0.55 0.45  0.
0.60 0.60 0.40  0.
0.65 0.65 0.35  0.
0.70 0.70 0.30  0.
0.75 0.75 0.25  0.
0.80 0.80 0.20  0.
0.85 0.85 0.15  0.
0.90 0.90 0.10  0.
0.95 0.95 0.05  0.
```

```
1.00 1.00 0.00  0.
'COMMENT'  '    '
'RKREG' 1 5 1 3
'RKREG' 6 55 1 3
'COMMENT'
'COMMENT'  '***************** DEFINE WATER DENSITY *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE GAS VISCOSITY
*******************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION
*********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0  0.0
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 79.49 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
```

```
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE ****************'
'PRES' 100. 0.0 9.81
'COMMENT'  '    '
'COMMENT'  '**********  DEFINE INITIAL WATER SATURATION  ***********'
'SATMOD'  1  55 1  0.0 0.0
'COMMENT'  '    '
'COMMENT'  '********** DEFINE INITIAL BLOCK TEMPERATURE **********'
'TEMPMOD'  1 55 1 15.
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*********************************************************'
'COMMENT'  '*************  RECURRENT INPUT PARAMETERS  ************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '********************** ENFLUX ***************************'
'ENFLUX'   51 55 1 2289600.
'COMMENT'
'COMMENT'  '***************  OBSERVATION WELLS ********************'
'PRODUCER' 'OBSW1' 1 3
          1
0.140 0.001 0.0 0.0
,,
0.015,,,
'PRODUCER' 'OBSW2' 1 3
          6
0.140 0.001 0.0 0.0
,,
0.04,,,
'PRODUCER' 'OBSW3' 1 3
          16
0.140 0.001 0.0 0.0
,,
0.08,,,
'PRODUCER' 'OBSW4' 1 3
          21
```

```
0.140 0.001 0.0 0.0
,,
0.10,,,
'PRODUCER' 'OBSW5' 1 3
          26
0.140 0.001 0.0 0.0
,,
0.12,,,
'PRODUCER' 'OBSW6' 1 3
          31
0.140 0.001 0.0 0.0
,,
0.14,,,
'PRODUCER' 'OBSW7' 1 3
          36
0.140 0.001 0.0 0.0
,,
0.16,,,
'PRODUCER' 'OBSW8' 1 3
          41
0.140 0.001 0.0 0.0
,,
0.18,,,
'PRODUCER' 'OBSW9' 1 3
          46
0.140 0.001 0.0 0.0
,,
0.20,,,
'PRODUCER' 'OBSW10' 1 3
          51
0.140 0.001 0.0 0.0
,,
0.22,,,
'COMMENT' '    '
'TIME' 10000. 0.0
```

R. TETRAD Data Deck - Bau and Torrance's (1982) Experiment: 0.97 kW/m^2

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 5 X 1 X 11 BLOCK MODEL'
'COMMENT'  'RADIAL GRID WITHOUT CAPILLARITY'
'COMMENT'  'SIMULATING THE EXP. OF BAU AND TORRANCE'
'COMMENT'  '3CM WATER LEVEL AT THE TOP'
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'TYPE'  4  1 1 0.0 0.0
'GRAV' 0.00.0 9.81 0.0 0.0
'COMMENT'
'COMMENT'  '    '
'COMMENT' '************************************************************'
'COMMENT'  '*************  RESERVOIR INPUT PARAMETER  **************'
'COMMENT' '************************************************************'
'COMMENT'  '    '
'COMMENT'  '************  DEFINE X, Y AND Z DIMENSIONS
***************'
'COMMENT'  '    '
'DIMEN'     5   1   11    2000
'COMMENT'  '    '
'COMMENT'  '********************  DEFINE GRIDS  ***********************'
'DELX' 1
5  5*0.0095
'DELZ' 2
1       1*0.03
10     10*0.02
'RADIAL' 0 0.0
'FTOPS' 00
'BVMULT'  1 5 1 100000000000000000000.
'COMMENT'  '***************  OUTPUT FILE CONTROLS  ******************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
```

```
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT' '    '
'COMMENT' '****************** DEFINE POROSITIES *********************'
'PORMOD' 1 5 1 0.95
'PORMOD' 6 55 1 0.37
'COMMENT' '    '
'COMMENT' '**************** DEFINE PERMEABILITIES *******************'
'PERMMOD' 1 5 1 10000000. 10000000. 10000000.
'PERMMOD' 6 55 1 8500. 8500. 8500.
'COMMENT' '    '
'COMMENT' '    '
'COMMENT' '**************** NUMERICAL CONTROLS *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0000001,,,,,,
'COMMENT' '    '
'COMMENT' '    '
'PROPERTY'
'COMMENT' '************************************************************'
'COMMENT' '************** PROPERTY INPUT PARAMETERS **************'
'COMMENT' '************************************************************'
'COMMENT' '    '
'COMMENT' '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT' '    '
'COMMENT' '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.00 1.00  0.
0.05 0.05 0.95  0.
0.10 0.10 0.90  0.
0.15 0.15 0.85  0.
0.20 0.20 0.80  0.
0.25 0.25 0.75  0.
0.30 0.30 0.70  0.
0.35 0.35 0.65  0.
0.40 0.40 0.60  0.
0.45 0.45 0.55  0.
0.50 0.50 0.50  0.
0.55 0.55 0.45  0.
0.60 0.60 0.40  0.
0.65 0.65 0.35  0.
0.70 0.70 0.30  0.
0.75 0.75 0.25  0.
0.80 0.80 0.20  0.
0.85 0.85 0.15  0.
0.90 0.90 0.10  0.
0.95 0.95 0.05  0.
```

```
1.00 1.00 0.00  0.
'COMMENT'  '    '
'RKREG' 1 5 1 3
'RKREG' 6 55 1 3
'COMMENT'
'COMMENT'  '***************** DEFINE WATER DENSITY *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE GAS VISCOSITY
*******************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION
*********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0  0.0
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 79.49 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
```

```
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE ****************'
'PRES' 100. 0.0 9.81
'COMMENT'  '    '
'COMMENT'  '**********  DEFINE INITIAL WATER SATURATION  ***********'
'SATMOD'  1  55 1  0.0 0.0
'COMMENT'  '    '
'COMMENT'  '********** DEFINE INITIAL BLOCK TEMPERATURE **********'
'TEMPMOD'  1 55 1 15.
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*********************************************************'
'COMMENT'  '*************  RECURRENT INPUT PARAMETERS  ************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '********************* ENFLUX ***************************'
'ENFLUX'   51 55 1 4190400.
'COMMENT'
'COMMENT'  '***************  OBSERVATION WELLS ********************'
'PRODUCER' 'OBSW1' 1 3
          1
0.140 0.001 0.0 0.0
,,
0.015,,,
'PRODUCER' 'OBSW2' 1 3
          6
0.140 0.001 0.0 0.0
,,
0.04,,,
'PRODUCER' 'OBSW3' 1 3
          16
0.140 0.001 0.0 0.0
,,
0.08,,,
'PRODUCER' 'OBSW4' 1 3
          21
```

```
0.140 0.001 0.0 0.0
,,
0.10,,,
'PRODUCER' 'OBSW5' 1 3
         26
0.140 0.001 0.0 0.0
,,
0.12,,,
'PRODUCER' 'OBSW6' 1 3
         31
0.140 0.001 0.0 0.0
,,
0.14,,,
'PRODUCER' 'OBSW7' 1 3
         36
0.140 0.001 0.0 0.0
,,
0.16,,,
'PRODUCER' 'OBSW8' 1 3
         41
0.140 0.001 0.0 0.0
,,
0.18,,,
'PRODUCER' 'OBSW9' 1 3
         46
0.140 0.001 0.0 0.0
,,
0.20,,,
'PRODUCER' 'OBSW10' 1 3
         51
0.140 0.001 0.0 0.0
,,
0.22,,,
'COMMENT' '   '
'TIME' 10000. 0.0
```

S. TETRAD Data Deck - Bau and Torrance's (1982) Experiment: 2.37 kW/m^2

```
'NOMESS'
'COMMENT' ' '
'COMMENT' 'DATA DECK FOR A 5 X 1 X 11 BLOCK MODEL'
'COMMENT' 'RADIAL GRID WITHOUT CAPILLARITY'
'COMMENT' 'SIMULATING THE EXP. OF BAU AND TORRANCE'
'COMMENT' '3CM WATER LEVEL AT THE TOP'
'COMMENT' 'RUN THIS DECK USING TETRAD VERSION 12 '
'COMMENT' ' '
'COMMENT' ' '
'COMMENT' ' '
'COMMENT' 'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'TYPE' 4 1 1 0.0 0.0
'GRAV' 0.0 0.0 9.81 0.0 0.0
'COMMENT'
'COMMENT' ' '
'COMMENT' '*************************************************************'
'COMMENT' '************* RESERVOIR INPUT PARAMETER **************'
'COMMENT' '*************************************************************'
'COMMENT' ' '
'COMMENT' '************ DEFINE X, Y AND Z DIMENSIONS
***************'
'COMMENT' ' '
'DIMEN' 5 1 11 2000
'COMMENT' ' '
'COMMENT' '******************** DEFINE GRIDS **********************'
'DELX' 1
5 5*0.0095
'DELZ' 2
1 1*0.03
10 10*0.02
'RADIAL' 0 0.0
'FTOPS' 0 0
'BVMULT' 1 5 1 100000000000000000000.
'COMMENT' '*************** OUTPUT FILE CONTROLS *****************'
'COMMENT' ' '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4 2 0 0 0 0 0 8 0 0
'OUTPROP' 0 0 0 4 0 6 7 0 9 0
'OUTMISC' 4 0 0 0 0 0 0 0 0 0
'PLOT' 5 0
```

```
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE POROSITIES  *********************'
'PORMOD' 1 5 1 0.95
'PORMOD' 6 55 1 0.37
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE PERMEABILITIES *******************'
'PERMMOD' 1 5 1 10000000. 10000000. 10000000.
'PERMMOD' 6 55 1 8500. 8500. 8500.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***************  NUMERICAL CONTROLS  ******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0000001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*********************************************************'
'COMMENT'  '*************  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'COMMENT'  '** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE **'
'COMMENT'  '    '
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.00 1.00  0.
0.05 0.05 0.95  0.
0.10 0.10 0.90  0.
0.15 0.15 0.85  0.
0.20 0.20 0.80  0.
0.25 0.25 0.75  0.
0.30 0.30 0.70  0.
0.35 0.35 0.65  0.
0.40 0.40 0.60  0.
0.45 0.45 0.55  0.
0.50 0.50 0.50  0.
0.55 0.55 0.45  0.
0.60 0.60 0.40  0.
0.65 0.65 0.35  0.
0.70 0.70 0.30  0.
0.75 0.75 0.25  0.
0.80 0.80 0.20  0.
0.85 0.85 0.15  0.
0.90 0.90 0.10  0.
0.95 0.95 0.05  0.
```

```
1.00 1.00 0.00  0.
'COMMENT'  '    '
'RKREG' 1 5 1 3
'RKREG' 6 55 1 3
'COMMENT'
'COMMENT'  '***************** DEFINE WATER DENSITY *****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*****************  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE LIQUID VISCOSITY *****************'
'LIQVIS'
0.0 0.0
'COMMENT'  '    '
'COMMENT'  '****************  DEFINE GAS VISCOSITY
******************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION
*********'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  *******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0  0.0
'COMMENT'  '    '
'COMMENT'  '***************  DEFINE GAS SPECIFIC HEATS  **************'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 79.49 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
```

```
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE ****************'
'PRES' 100. 0.0 9.81
'COMMENT'  '    '
'COMMENT'  '**********  DEFINE INITIAL WATER SATURATION  ***********'
'SATMOD'  1  55 1  0.0 0.0
'COMMENT'  '    '
'COMMENT'  '********** DEFINE INITIAL BLOCK TEMPERATURE **********'
'TEMPMOD'  1 55 1 15.
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*********************************************************'
'COMMENT'  '*************  RECURRENT INPUT PARAMETERS  ************'
'COMMENT' '*********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '********************** ENFLUX ***************************'
'ENFLUX'   51 55 1 10238400.
'COMMENT'
'COMMENT'  '***************  OBSERVATION WELLS ********************'
'PRODUCER' 'OBSW1' 1 3
          1
0.140 0.001 0.0 0.0
,,
0.015,,,
'PRODUCER' 'OBSW2' 1 3
          6
0.140 0.001 0.0 0.0
,,
0.04,,,
'PRODUCER' 'OBSW3' 1 3
          16
0.140 0.001 0.0 0.0
,,
0.08,,,
'PRODUCER' 'OBSW4' 1 3
          21
```

```
0.140 0.001 0.0 0.0
,,
0.10,,,
'PRODUCER' 'OBSW5' 1 3
          26
0.140 0.001 0.0 0.0
,,
0.12,,,
'PRODUCER' 'OBSW6' 1 3
          31
0.140 0.001 0.0 0.0
,,
0.14,,,
'PRODUCER' 'OBSW7' 1 3
          36
0.140 0.001 0.0 0.0
,,
0.16,,,
'PRODUCER' 'OBSW8' 1 3
          41
0.140 0.001 0.0 0.0
,,
0.18,,,
'PRODUCER' 'OBSW9' 1 3
          46
0.140 0.001 0.0 0.0
,,
0.20,,,
'PRODUCER' 'OBSW10' 1 3
          51
0.140 0.001 0.0 0.0
,,
0.22,,,
'COMMENT' '   '
'TIME' 10000. 0.0
```

T. TETRAD Data Deck: Model I

```
’NOMESS’
’COMMENT’  ’    ’
’COMMENT’  ’DATA DECK FOR A 20 X 10 X 1 BLOCK MODEL’
’COMMENT’  ’IRREGULAR GRID WITH CAPILLARITY’
’COMMENT’  ’TOP LAYER CONNECTED TO A HEAT SINK’
’COMMENT’  ’WITH NO CAPILLARY PRESSURE ASSIGNED TO THE’
’COMMENT’  ’     FRACTURE BLOCKS’
’COMMENT’  ’1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK’
’COMMENT’  ’SIMULATING HEAT PIPE EFFECT ’
’COMMENT’  ’RUN THIS DECK USING TETRAD VERSION 12     ’
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’TYPE’  4  1 1 0.0 0.0
’SIZE’
’GRAV’ 0.0 9.81 0.00.0 0.0
’COMMENT’  ’GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING’
’COMMENT’  ’    ’
’COMMENT’ ’****************************************************’
’COMMENT’  ’*********  RESERVOIR INPUT PARAMETER  **************’
’COMMENT’ ’****************************************************’
’COMMENT’  ’    ’
’COMMENT’  ’*********  DEFINE X, Y AND Z DIMENSIONS ***’
’COMMENT’  ’    ’
’DIMEN’      20    11   1    20000
’COMMENT’  ’    ’
’COMMENT’  ’*********  DEFINE GRIDS *****************************’
’DELX’ 8
2 2*0.01
1 1*0.02
1 1*0.04
1 1*0.08
1 1*0.16
1 1*0.32
1 1*0.36
12 12*0.50
’DELY’ 2
1  1*1.0
10  10*50.
’DELZ’ 1
1  1*50.0
’FTOPS’ 00
```

```
'BVMULT' 1 20 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 20 1 3 1.
'COMMENT'  '**********  OUTPUT FILE CONTROLS  *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE POROSITIES  ********************'
'PORMOD' 1 20 1 0.8
'PORMOD' 21 201 20 0.5
'PORMOD' 22 40 1 0.1
'PORMOD' 42 60 1 0.1
'PORMOD' 62 80 1 0.1
'PORMOD' 82 100 1 0.1
'PORMOD' 102 120 1 0.1
'PORMOD' 122 140 1 0.1
'PORMOD' 142 160 1 0.1
'PORMOD' 162 180 1 0.1
'PORMOD' 182 200 1 0.1
'PORMOD' 202 220 1 0.1
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 20 1 2000. 2000. 2000.
'PERMMOD' 22 220 1 .5 .5 .5
'PERMMOD' 21 201 20 50. 50. 50.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***********  NUMERICAL CONTROLS  ******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .1,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '****************************************************'
'COMMENT'  '***********  PROPERTY INPUT PARAMETERS  ************'
'COMMENT' '****************************************************'
'COMMENT'  '    '
```

```
'COMMENT'  '*** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE
**'
'COMMENT'  '    '
'RELGW' 1 21 0 0.01 0.0
0.00 0.000000 1.000000 1000.000
0.05 0.000125 0.857375  734.800
0.10 0.001000 0.729000  460.137
0.15 0.003375 0.614125  348.140
0.20 0.008000 0.512000  284.230
0.25 0.015625 0.421875  241.670
0.30 0.027000 0.343000  210.620
0.35 0.042875 0.274625  186.540
0.40 0.064000 0.216000  167.020
0.45 0.091125 0.166375  150.620
0.50 0.125000 0.125000  136.450
0.55 0.166375 0.091125  123.890
0.60 0.216000 0.064000  112.520
0.65 0.274625 0.042875  101.980
0.70 0.343000 0.027000   92.010
0.75 0.421875 0.015625   82.340
0.80 0.512000 0.008000   72.690
0.85 0.614125 0.003375   62.680
0.90 0.729000 0.001000   51.660
0.95 0.857375 0.000125   38.040
1.00 1.000000 0.000000    0.000
'COMMENT'  '    '
'RELGW' 2 21 0 0.01 0.0
0.00 0.000000 1.000000 100.
0.05 0.000125 0.857375  95.
0.10 0.001000 0.729000  90.
0.15 0.003375 0.614125  85.
0.20 0.008000 0.512000  80.
0.25 0.015625 0.421875  75.
0.30 0.027000 0.343000  70.
0.35 0.042875 0.274625  65.
0.40 0.064000 0.216000  60.
0.45 0.091125 0.166375  55.
0.50 0.125000 0.125000  50.
0.55 0.166375 0.091125  45.
0.60 0.216000 0.064000  40.
0.65 0.274625 0.042875  35.
0.70 0.343000 0.027000  30.
0.75 0.421875 0.015625  25.
0.80 0.512000 0.008000  20.
0.85 0.614125 0.003375  15.
```

```
0.90 0.729000 0.001000  10.
0.95 0.857375 0.000125   5.
1.00 1.000000 0.000000   0.
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 20 1 3
'RKREG' 22 220 11
'RKREG' 21 201 20 3
'COMMENT'
'COMMENT'  '**************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LIQUID VISCOSITY ******************'
'LIQVIS'
0.0 0.0
```

```
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS VISCOSITY  ********************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  ***********'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE *************'
'PRESMOD' 1 20 1 800.0
'PRESMOD' 21 40 1 911.0
'PRESMOD' 41 60 1 1130.
'PRESMOD' 61 80 1 1350.
'PRESMOD' 81 100 1 1560.
'PRESMOD' 101 120 1 1770.
'PRESMOD' 121 140 1 1980.
'PRESMOD' 141 160 1 2155.
'PRESMOD' 161 180 1 2330.
'PRESMOD' 181 200 1 2505.
'PRESMOD' 201 220 1 2680.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  140  1  0.0 0.0
'SATMOD'  141 220  1  0.13 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 20 1 160.
```

```
'TEMPMOD' 21 40 1 164.7
'TEMPMOD' 41 60 1 174.1
'TEMPMOD' 61 80 1 183.5
'TEMPMOD' 81 100 1 192.9
'TEMPMOD' 101 120 1 202.3
'TEMPMOD' 121 140 1 211.7
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '**********************************************************'
'COMMENT'  '************  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '**********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '***************** DEFINE ENERGY FLUX *******************'
'ENFLUX'  201 220 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '**************  OBSERVATION WELLS ***********************'
'PRODUCER' 'OBSW1' 1 3
        1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
        21
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
        61
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
        81
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
        101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          121
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          161
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          201
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT'  '    '
'TIME' 4000000.0 0.0
```

U. TETRAD Data Deck: Model II

```
’NOMESS’
’COMMENT’  ’    ’
’COMMENT’  ’DATA DECK FOR A 20 X 11 X 1 BLOCK MODEL’
’COMMENT’  ’IRREGULAR GRID WITH CAPILLARITY’
’COMMENT’  ’TOP LAYER CONNECTED TO A HEAT SINK’
’COMMENT’  ’WITH NO CAPILLARY PRESSURE ASSIGNED TO THE’
’COMMENT’  ’     FRACTURE BLOCKS’
’COMMENT’  ’1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK’
’COMMENT’  ’SIMULATING HEAT PIPE EFFECT ’
’COMMENT’  ’RUN THIS DECK USING TETRAD VERSION 12    ’
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’TYPE’  4  1 1 0.0 0.0
’SIZE’
’GRAV’ 0.0 9.81 0.00.0 0.0
’COMMENT’  ’GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING’
’COMMENT’  ’    ’
’COMMENT’ ’****************************************************’
’COMMENT’  ’*********  RESERVOIR INPUT PARAMETER  **************’
’COMMENT’ ’****************************************************’
’COMMENT’  ’    ’
’COMMENT’  ’*********  DEFINE X, Y AND Z DIMENSIONS ***’
’COMMENT’  ’    ’
’DIMEN’     20    11   1    20000
’COMMENT’  ’    ’
’COMMENT’  ’*********  DEFINE GRIDS ****************************’
’DELX’ 8
2 2*0.01
1 1*0.02
1 1*0.04
1 1*0.08
1 1*0.16
1 1*0.32
1 1*0.36
12 12*0.50
’DELY’ 2
1  1*1.0
10  10*50.
’DELZ’ 1
1  1*50.0
’FTOPS’ 00
```

```
'BVMULT' 1 20 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 20 1 3 1.
'COMMENT'  '**********  OUTPUT FILE CONTROLS  ******************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE POROSITIES  *********************'
'PORMOD' 1 20 1 0.8
'PORMOD' 21 201 20 0.5
'PORMOD' 22 40 1 0.1
'PORMOD' 42 60 1 0.1
'PORMOD' 62 80 1 0.1
'PORMOD' 82 100 1 0.1
'PORMOD' 102 120 1 0.1
'PORMOD' 122 140 1 0.1
'PORMOD' 142 160 1 0.1
'PORMOD' 162 180 1 0.1
'PORMOD' 182 200 1 0.1
'PORMOD' 202 220 1 0.1
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE PERMEABILITIES ******************'
'PERMMOD' 1 20 1 2000. 2000. 2000.
'PERMMOD' 22 220 1 .5 .5 .5
'PERMMOD' 21 201 20 50. 50. 50.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***********  NUMERICAL CONTROLS  *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .1,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*****************************************************'
'COMMENT'  '***********  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
```

```
'COMMENT'  '*** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE
**'
'COMMENT'  '    '
'RELGW' 1 21 0 0.01 0.0
0.00 0.000000 1.000000 1000.000
0.05 0.000125 0.857375  734.800
0.10 0.001000 0.729000  460.137
0.15 0.003375 0.614125  348.140
0.20 0.008000 0.512000  284.230
0.25 0.015625 0.421875  241.670
0.30 0.027000 0.343000  210.620
0.35 0.042875 0.274625  186.540
0.40 0.064000 0.216000  167.020
0.45 0.091125 0.166375  150.620
0.50 0.125000 0.125000  136.450
0.55 0.166375 0.091125  123.890
0.60 0.216000 0.064000  112.520
0.65 0.274625 0.042875  101.980
0.70 0.343000 0.027000   92.010
0.75 0.421875 0.015625   82.340
0.80 0.512000 0.008000   72.690
0.85 0.614125 0.003375   62.680
0.90 0.729000 0.001000   51.660
0.95 0.857375 0.000125   38.040
1.00 1.000000 0.000000    0.000
'COMMENT'  '    '
'RELGW' 2 21 0 0.01 0.0
0.00 0.000000 1.000000 100.
0.05 0.000125 0.857375  95.
0.10 0.001000 0.729000  90.
0.15 0.003375 0.614125  85.
0.20 0.008000 0.512000  80.
0.25 0.015625 0.421875  75.
0.30 0.027000 0.343000  70.
0.35 0.042875 0.274625  65.
0.40 0.064000 0.216000  60.
0.45 0.091125 0.166375  55.
0.50 0.125000 0.125000  50.
0.55 0.166375 0.091125  45.
0.60 0.216000 0.064000  40.
0.65 0.274625 0.042875  35.
0.70 0.343000 0.027000  30.
0.75 0.421875 0.015625  25.
0.80 0.512000 0.008000  20.
0.85 0.614125 0.003375  15.
```

```
0.90 0.729000 0.001000  10.
0.95 0.857375 0.000125   5.
1.00 1.000000 0.000000   0.
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 20 1 3
'RKREG' 22 220 1 3
'RKREG' 21 201 20 3
'COMMENT'
'COMMENT'  '**************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LIQUID VISCOSITY ******************'
'LIQVIS'
0.0 0.0
```

```
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS VISCOSITY  ********************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  ***********'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE *************'
'PRESMOD' 1 20 1 800.0
'PRESMOD' 21 40 1 911.0
'PRESMOD' 41 60 1 1130.
'PRESMOD' 61 80 1 1350.
'PRESMOD' 81 100 1 1560.
'PRESMOD' 101 120 1 1770.
'PRESMOD' 121 140 1 1980.
'PRESMOD' 141 160 1 2155.
'PRESMOD' 161 180 1 2330.
'PRESMOD' 181 200 1 2505.
'PRESMOD' 201 220 1 2680.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  140  1  0.0 0.0
'SATMOD'  141 220  1  0.13 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 20 1 160.
```

```
'TEMPMOD' 21 40 1 164.7
'TEMPMOD' 41 60 1 174.1
'TEMPMOD' 61 80 1 183.5
'TEMPMOD' 81 100 1 192.9
'TEMPMOD' 101 120 1 202.3
'TEMPMOD' 121 140 1 211.7
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '********************************************************'
'COMMENT'  '************  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '********************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '***************** DEFINE ENERGY FLUX *******************'
'ENFLUX'  201 220 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '**************  OBSERVATION WELLS **********************'
'PRODUCER' 'OBSW1' 1 3
          1
0.140 0.007 0.0 0.0
''
25.,,,
'PRODUCER' 'OBSW2' 1 3
          21
0.140 0.007 0.0 0.0
''
25.,,,
'PRODUCER' 'OBSW4' 1 3
          61
0.140 0.007 0.0 0.0
''
25.,,,
'PRODUCER' 'OBSW5' 1 3
          81
0.140 0.007 0.0 0.0
''
25.,,,
'PRODUCER' 'OBSW6' 1 3
          101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          121
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          161
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          201
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '    '
'TIME' 4000000.0 0.0
```

V. TETRAD Data Deck: Model III

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 20 X 10 X 1 BLOCK MODEL'
'COMMENT'  'IRREGULAR GRID WITH CAPILLARITY'
'COMMENT'  'TOP LAYER CONNECTED TO A HEAT SINK'
'COMMENT'  'WITH DIFFERENT CAPILLARY PRESSURES ASSIGNED TO THE'
'COMMENT'  '     FRACTURE AND MATRIX BLOCKS'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '*****************************************************'
'COMMENT'  '*********  RESERVOIR INPUT PARAMETER  **************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE X, Y AND Z DIMENSIONS ***'
'COMMENT'  '    '
'DIMEN'     20    11   1    20000
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GRIDS *****************************'
'DELX' 8
2 2*0.01
1 1*0.02
1 1*0.04
1 1*0.08
1 1*0.16
1 1*0.32
1 1*0.36
12 12*0.50
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
```

```
'BVMULT' 1 20 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 20 1 3 1.
'COMMENT'  '**********  OUTPUT FILE CONTROLS  ******************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE POROSITIES  *********************'
'PORMOD' 1 20 1 0.8
'PORMOD' 21 201 20 0.5
'PORMOD' 22 40 1 0.1
'PORMOD' 42 60 1 0.1
'PORMOD' 62 80 1 0.1
'PORMOD' 82 100 1 0.1
'PORMOD' 102 120 1 0.1
'PORMOD' 122 140 1 0.1
'PORMOD' 142 160 1 0.1
'PORMOD' 162 180 1 0.1
'PORMOD' 182 200 1 0.1
'PORMOD' 202 220 1 0.1
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE PERMEABILITIES ******************'
'PERMMOD' 1 20 1 2000. 2000. 2000.
'PERMMOD' 22 220 1 .5 .5 .5
'PERMMOD' 21 201 20 50. 50. 50.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***********  NUMERICAL CONTROLS  *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0000001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '****************************************************'
'COMMENT'  '***********  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '****************************************************'
'COMMENT'  '    '
```

```
'COMMENT'  '*** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE
**'
'COMMENT'  '    '
'RELGW' 1 21 0 0.01 0.0
0.00 0.000000 1.000000 1000.000
0.05 0.000125 0.857375  734.800
0.10 0.001000 0.729000  460.137
0.15 0.003375 0.614125  348.140
0.20 0.008000 0.512000  284.230
0.25 0.015625 0.421875  241.670
0.30 0.027000 0.343000  210.620
0.35 0.042875 0.274625  186.540
0.40 0.064000 0.216000  167.020
0.45 0.091125 0.166375  150.620
0.50 0.125000 0.125000  136.450
0.55 0.166375 0.091125  123.890
0.60 0.216000 0.064000  112.520
0.65 0.274625 0.042875  101.980
0.70 0.343000 0.027000   92.010
0.75 0.421875 0.015625   82.340
0.80 0.512000 0.008000   72.690
0.85 0.614125 0.003375   62.680
0.90 0.729000 0.001000   51.660
0.95 0.857375 0.000125   38.040
1.00 1.000000 0.000000    0.000
'COMMENT'  '    '
'RELGW' 2 21 0 0.01 0.0
0.00 0.000000 1.000000 100.
0.05 0.000125 0.857375  95.
0.10 0.001000 0.729000  90.
0.15 0.003375 0.614125  85.
0.20 0.008000 0.512000  80.
0.25 0.015625 0.421875  75.
0.30 0.027000 0.343000  70.
0.35 0.042875 0.274625  65.
0.40 0.064000 0.216000  60.
0.45 0.091125 0.166375  55.
0.50 0.125000 0.125000  50.
0.55 0.166375 0.091125  45.
0.60 0.216000 0.064000  40.
0.65 0.274625 0.042875  35.
0.70 0.343000 0.027000  30.
0.75 0.421875 0.015625  25.
0.80 0.512000 0.008000  20.
0.85 0.614125 0.003375  15.
```

```
0.90 0.729000 0.001000  10.
0.95 0.857375 0.000125   5.
1.00 1.000000 0.000000   0.
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 20 1 3
'RKREG' 22 220 11
'RKREG' 21 201 20 2
'COMMENT'
'COMMENT'  '**************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LIQUID VISCOSITY ******************'
'LIQVIS'
0.0 0.0
```

```
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS VISCOSITY  ********************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  ***********'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE *************'
'PRESMOD' 1 20 1 800.0
'PRESMOD' 21 40 1 911.0
'PRESMOD' 41 60 1 1130.
'PRESMOD' 61 80 1 1350.
'PRESMOD' 81 100 1 1560.
'PRESMOD' 101 120 1 1770.
'PRESMOD' 121 140 1 1980.
'PRESMOD' 141 160 1 2155.
'PRESMOD' 161 180 1 2330.
'PRESMOD' 181 200 1 2505.
'PRESMOD' 201 220 1 2680.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  140  1  0.0 0.0
'SATMOD'  141 220  1  0.13 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 20 1 160.
```

```
’TEMPMOD’ 21 40 1 164.7
’TEMPMOD’ 41 60 1 174.1
’TEMPMOD’ 61 80 1 183.5
’TEMPMOD’ 81 100 1 192.9
’TEMPMOD’ 101 120 1 202.3
’TEMPMOD’ 121 140 1 211.7
’COMMENT’  ’    ’
’COMMENT’  ’    ’
’RECUR’
’COMMENT’  ’    ’
’COMMENT’  ’*****************************************************’
’COMMENT’  ’***********  RECURRENT INPUT PARAMETERS  ************’
’COMMENT’  ’*****************************************************’
’COMMENT’  ’    ’
’TIMEYR’ 0
’COMMENT’  ’TIME AND TIME STEP ON "TIME" WILL BE IN DAYS’
’TIME’ 0.0 0.2
’COMMENT’  ’    ’
’COMMENT’  ’**************** DEFINE ENERGY FLUX *****************’
’ENFLUX’  201 220 1 1.728
’COMMENT’  ’    ’
’COMMENT’
’COMMENT’  ’*************  OBSERVATION WELLS ********************’
’PRODUCER’ ’OBSW1’ 1 3
        1
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW2’ 1 3
        21
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW4’ 1 3
        61
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW5’ 1 3
        81
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW6’ 1 3
        101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          121
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          161
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          201
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '    '
'TIME' 4000000.0 0.0
```

W. TETRAD Data Deck: Model IV

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 20 X 11 X 1 BLOCK MODEL'
'COMMENT'  'IRREGULAR GRID WITH CAPILLARITY'
'COMMENT'  'TOP LAYER CONNECTED TO A HEAT SINK'
'COMMENT'  'WITH DIFFERENT CAPILLARY PRESSURES ASSIGNED TO THE'
'COMMENT'  '     FRACTURE AND MATRIX BLOCKS'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12     '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '*****************************************************'
'COMMENT'  '*********  RESERVOIR INPUT PARAMETER  **************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE X, Y AND Z DIMENSIONS ***'
'COMMENT'  '    '
'DIMEN'      20    11   1    20000
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GRIDS *****************************'
'DELX' 8
2 2*0.01
1 1*0.02
1 1*0.04
1 1*0.08
1 1*0.16
1 1*0.32
1 1*0.36
12 12*0.50
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
```

```
'BVMULT' 1 20 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 20 1 3 1.
'COMMENT'  '**********  OUTPUT FILE CONTROLS  *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE POROSITIES  *********************'
'PORMOD' 1 20 1 0.8
'PORMOD' 21 201 20 0.5
'PORMOD' 22 40 1 0.1
'PORMOD' 42 60 1 0.1
'PORMOD' 62 80 1 0.1
'PORMOD' 82 100 1 0.1
'PORMOD' 102 120 1 0.1
'PORMOD' 122 140 1 0.1
'PORMOD' 142 160 1 0.1
'PORMOD' 162 180 1 0.1
'PORMOD' 182 200 1 0.1
'PORMOD' 202 220 1 0.1
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 20 1 2000. 2000. 2000.
'PERMMOD' 22 220 1 .5 .5 .5
'PERMMOD' 21 201 20 50. 50. 50.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***********  NUMERICAL CONTROLS  *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0000001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '***************************************************'
'COMMENT'  '***********  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '***************************************************'
'COMMENT'  '    '
```

```
'COMMENT'  '*** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE
**'
'COMMENT'  '    '
'RELGW' 1 21 0 0.01 0.0
0.00 0.000000 1.000000 1000.000
0.05 0.000125 0.857375  734.800
0.10 0.001000 0.729000  460.137
0.15 0.003375 0.614125  348.140
0.20 0.008000 0.512000  284.230
0.25 0.015625 0.421875  241.670
0.30 0.027000 0.343000  210.620
0.35 0.042875 0.274625  186.540
0.40 0.064000 0.216000  167.020
0.45 0.091125 0.166375  150.620
0.50 0.125000 0.125000  136.450
0.55 0.166375 0.091125  123.890
0.60 0.216000 0.064000  112.520
0.65 0.274625 0.042875  101.980
0.70 0.343000 0.027000   92.010
0.75 0.421875 0.015625   82.340
0.80 0.512000 0.008000   72.690
0.85 0.614125 0.003375   62.680
0.90 0.729000 0.001000   51.660
0.95 0.857375 0.000125   38.040
1.00 1.000000 0.000000    0.000
'COMMENT'  '    '
'RELGW' 2 21 0 0.01 0.0
0.00 0.000000 1.000000 50.
0.05 0.000125 0.857375 47.5
0.10 0.001000 0.729000 45.
0.15 0.003375 0.614125 42.5
0.20 0.008000 0.512000 40.
0.25 0.015625 0.421875 37.5
0.30 0.027000 0.343000 35.
0.35 0.042875 0.274625 32.5
0.40 0.064000 0.216000 30.
0.45 0.091125 0.166375 27.5
0.50 0.125000 0.125000 25.
0.55 0.166375 0.091125 22.5
0.60 0.216000 0.064000 20.
0.65 0.274625 0.042875 17.5
0.70 0.343000 0.027000 15.
0.75 0.421875 0.015625 12.5
0.80 0.512000 0.008000 10.
0.85 0.614125 0.003375  7.5
```

```
0.90 0.729000 0.001000  5.
0.95 0.857375 0.000125  2.5
1.00 1.000000 0.000000  0.0
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 20 1 3
'RKREG' 22 220 11
'RKREG' 21 201 20 2
'COMMENT'
'COMMENT'  '**************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LIQUID VISCOSITY ******************'
'LIQVIS'
0.0 0.0
```

```
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS VISCOSITY  ********************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  ***********'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE *************'
'PRESMOD' 1 20 1 800.0
'PRESMOD' 21 40 1 911.0
'PRESMOD' 41 60 1 1130.
'PRESMOD' 61 80 1 1350.
'PRESMOD' 81 100 1 1560.
'PRESMOD' 101 120 1 1770.
'PRESMOD' 121 140 1 1980.
'PRESMOD' 141 160 1 2155.
'PRESMOD' 161 180 1 2330.
'PRESMOD' 181 200 1 2505.
'PRESMOD' 201 220 1 2680.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  140  1  0.0 0.0
'SATMOD'  141 220  1  0.13 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 20 1 160.
```

```
'TEMPMOD' 21 40 1 164.7
'TEMPMOD' 41 60 1 174.1
'TEMPMOD' 61 80 1 183.5
'TEMPMOD' 81 100 1 192.9
'TEMPMOD' 101 120 1 202.3
'TEMPMOD' 121 140 1 211.7
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*****************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE ENERGY FLUX ******************'
'ENFLUX'  201 220 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '*************  OBSERVATION WELLS ********************'
'PRODUCER' 'OBSW1' 1 3
          1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
          21
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
          61
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
          81
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
          101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW7' 1 3
          121
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW8' 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW9' 1 3
          161
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW10' 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW11' 1 3
          201
0.140 0.007 0.0 0.0
,,
25.,,,
'COMMENT' '    '
'TIME' 4000000.0 0.0
```

X. TETRAD Data Deck: Model V

```
'NOMESS'
'COMMENT'  '    '
'COMMENT'  'DATA DECK FOR A 20 X 11 X 1 BLOCK MODEL'
'COMMENT'  'IRREGULAR GRID WITH CAPILLARITY'
'COMMENT'  'TOP LAYER CONNECTED TO A HEAT SINK'
'COMMENT'  'WITH DIFFERENT CAPILLARY PRESSURES ASSIGNED TO THE'
'COMMENT'  '    FRACTURE AND MATRIX BLOCKS'
'COMMENT'  '1.0 W/SQ.M BEING INJECTED INTO THE BOTTOM BLOCK'
'COMMENT'  'SIMULATING HEAT PIPE EFFECT '
'COMMENT'  'RUN THIS DECK USING TETRAD VERSION 12    '
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '    '
'TYPE'  4  1 1 0.0 0.0
'SIZE'
'GRAV' 0.0 9.81 0.00.0 0.0
'COMMENT'  'GEOTHERMAL, SINGLE COMPONENT, 5-PT. DIFFERENCING'
'COMMENT'  '    '
'COMMENT' '*****************************************************'
'COMMENT'  '*********  RESERVOIR INPUT PARAMETER  **************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE X, Y AND Z DIMENSIONS ***'
'COMMENT'  '    '
'DIMEN'     20    11   1    20000
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GRIDS *****************************'
'DELX' 8
2 2*0.01
1 1*0.02
1 1*0.04
1 1*0.08
1 1*0.16
1 1*0.32
1 1*0.36
12 12*0.50
'DELY' 2
1  1*1.0
10  10*50.
'DELZ' 1
1  1*50.0
'FTOPS' 00
```

```
'BVMULT' 1 20 1 100000000000000.
'COMMENT' 'LEASE' 1 4 1
'COMMENT' 'LEASE' 5 24 1 2
'TMULT' 1 20 1 3 1.
'COMMENT'  '**********  OUTPUT FILE CONTROLS  *****************'
'COMMENT'  '    '
'UNITS' 11 0 1
'COMMENT' 'METRIC SYSTEM'
'PRINT' 0 1 0 1 -3
'OUTFUN' 4  2 00 0 0 0 8 0 0
'OUTPROP' 00 0 4 0 6 7 0 9 0
'OUTMISC' 4 00 0 0 0 0 0 0 0
'PLOT' 5 0
7 'P/Z' 'QWPMASS' 'QGPENER' 'QWPENER' 'PAV' 'TAV' 'SGAV'
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE POROSITIES  ********************'
'PORMOD' 1 20 1 0.8
'PORMOD' 21 201 20 0.5
'PORMOD' 22 40 1 0.1
'PORMOD' 42 60 1 0.1
'PORMOD' 62 80 1 0.1
'PORMOD' 82 100 1 0.1
'PORMOD' 102 120 1 0.1
'PORMOD' 122 140 1 0.1
'PORMOD' 142 160 1 0.1
'PORMOD' 162 180 1 0.1
'PORMOD' 182 200 1 0.1
'PORMOD' 202 220 1 0.1
'COMMENT'  '    '
'COMMENT'  '***********  DEFINE PERMEABILITIES *****************'
'PERMMOD' 1 20 1 2000. 2000. 2000.
'PERMMOD' 22 220 1 .5 .5 .5
'PERMMOD' 21 201 20 50. 50. 50.
'COMMENT'  '    '
'COMMENT'  '    '
'COMMENT'  '***********  NUMERICAL CONTROLS  *******************'
'NORM' 500.  0.1 .2 30
'NEWT'  15  .0000001,,,,,,
'COMMENT'  '    '
'COMMENT'  '    '
'PROPERTY'
'COMMENT' '*****************************************************'
'COMMENT'  '***********  PROPERTY INPUT PARAMETERS  *************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
```

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'COMMENT'  '*** ANALYTIC RELATIVE PERM CURVES AND CAP PRESSURE
**'
'COMMENT'  '    '
'RELGW' 1 21 0 0.01 0.0
0.00 0.000000 1.000000 1000.000
0.05 0.000125 0.857375  734.800
0.10 0.001000 0.729000  460.137
0.15 0.003375 0.614125  348.140
0.20 0.008000 0.512000  284.230
0.25 0.015625 0.421875  241.670
0.30 0.027000 0.343000  210.620
0.35 0.042875 0.274625  186.540
0.40 0.064000 0.216000  167.020
0.45 0.091125 0.166375  150.620
0.50 0.125000 0.125000  136.450
0.55 0.166375 0.091125  123.890
0.60 0.216000 0.064000  112.520
0.65 0.274625 0.042875  101.980
0.70 0.343000 0.027000   92.010
0.75 0.421875 0.015625   82.340
0.80 0.512000 0.008000   72.690
0.85 0.614125 0.003375   62.680
0.90 0.729000 0.001000   51.660
0.95 0.857375 0.000125   38.040
1.00 1.000000 0.000000    0.000
'COMMENT'  '    '
'RELGW' 2 21 0 0.01 0.0
0.00 0.000000 1.000000 50.
0.05 0.000125 0.857375 47.5
0.10 0.001000 0.729000 45.
0.15 0.003375 0.614125 42.5
0.20 0.008000 0.512000 40.
0.25 0.015625 0.421875 37.5
0.30 0.027000 0.343000 35.
0.35 0.042875 0.274625 32.5
0.40 0.064000 0.216000 30.
0.45 0.091125 0.166375 27.5
0.50 0.125000 0.125000 25.
0.55 0.166375 0.091125 22.5
0.60 0.216000 0.064000 20.
0.65 0.274625 0.042875 17.5
0.70 0.343000 0.027000 15.
0.75 0.421875 0.015625 12.5
0.80 0.512000 0.008000 10.
0.85 0.614125 0.003375  7.5
```

```
0.90 0.729000 0.001000  5.
0.95 0.857375 0.000125  2.5
1.00 1.000000 0.000000  0.0
'COMMENT'  '    '
'RELGW' 3 21 0 0.01 0.0
0.00 0.000000 1.000000 0.
0.05 0.000125 0.857375 0.
0.10 0.001000 0.729000 0.
0.15 0.003375 0.614125 0.
0.20 0.008000 0.512000 0.
0.25 0.015625 0.421875 0.
0.30 0.027000 0.343000 0.
0.35 0.042875 0.274625 0.
0.40 0.064000 0.216000 0.
0.45 0.091125 0.166375 0.
0.50 0.125000 0.125000 0.
0.55 0.166375 0.091125 0.
0.60 0.216000 0.064000 0.
0.65 0.274625 0.042875 0.
0.70 0.343000 0.027000 0.
0.75 0.421875 0.015625 0.
0.80 0.512000 0.008000 0.
0.85 0.614125 0.003375 0.
0.90 0.729000 0.001000 0.
0.95 0.857375 0.000125 0.
1.00 1.000000 0.000000 0.
'COMMENT'  '    '
'RKREG' 1 20 1 3
'RKREG' 22 220 11
'RKREG' 21 201 20 2
'COMMENT'
'COMMENT'  '**************** DEFINE WATER DENSITY ****************'
'LIQDEN'
1000.03 4.64E-07 9.00E-4 101.33 15.5
'DENCS' 1000.03
1
18.015
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS DENSITY  ******************'
'CRITG'
22105.97 647.23 3.37737E-03
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LIQUID VISCOSITY ******************'
'LIQVIS'
0.0 0.0
```

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'COMMENT'  '    '
'COMMENT'  '*********  DEFINE GAS VISCOSITY  ********************'
'GASVIS'
-10.2E-04 3.611E-05 1.0 0.0 1.0
'COMMENT'  '    '
'COMMENT'  '*********  DEFINE LATENT HEAT OF VAPORIZATION  *******'
'LATHVAP'
2256.92  647.23  373.15  0.38
'COMMENT'  '    '
'COMMENT'  '********  DEFINE ROCK AND WATER SPECIFIC HEATS  ******'
'LIQSH' 1.0718 0.0 15.56 2643.0459
4.050528 2.73847E-3 15.56 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '**************  DEFINE GAS SPECIFIC HEATS  ***********'
'GASSH'
2.3446 0.0 0.0 0.0 0.0
'COMMENT'  '    '
'COMMENT'  '***  DEFINE ROCK AND LIQUID THERMAL CONDUCTIVITIES
**'
'LIQTCON' 249.2 0.0 15.56
57.316,,,
'COMMENT'
'COMMENT'  '************  GAS THERMAL CONDUCTIVITY  **************'
'GASTCON'
4.361,,,
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE INITIAL PRESSURE *************'
'PRESMOD' 1 20 1 800.0
'PRESMOD' 21 40 1 911.0
'PRESMOD' 41 60 1 1130.
'PRESMOD' 61 80 1 1350.
'PRESMOD' 81 100 1 1560.
'PRESMOD' 101 120 1 1770.
'PRESMOD' 121 140 1 1980.
'PRESMOD' 141 160 1 2155.
'PRESMOD' 161 180 1 2330.
'PRESMOD' 181 200 1 2505.
'PRESMOD' 201 220 1 2680.
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL WATER SATURATION ******'
'SATMOD'  1  140  1  0.0 0.0
'SATMOD'  141 220  1  0.13 0.0
'COMMENT'  '    '
'COMMENT'  '*************** DEFINE INITIAL BLOCK TEMPERATURE *****'
'TEMPMOD'  1 20 1 160.
```

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'TEMPMOD' 21 40 1 164.7
'TEMPMOD' 41 60 1 174.1
'TEMPMOD' 61 80 1 183.5
'TEMPMOD' 81 100 1 192.9
'TEMPMOD' 101 120 1 202.3
'TEMPMOD' 121 140 1 211.7
'COMMENT'  '    '
'COMMENT'  '    '
'RECUR'
'COMMENT'  '    '
'COMMENT' '*****************************************************'
'COMMENT'  '***********  RECURRENT INPUT PARAMETERS  *************'
'COMMENT' '*****************************************************'
'COMMENT'  '    '
'TIMEYR' 0
'COMMENT'  'TIME AND TIME STEP ON "TIME" WILL BE IN DAYS'
'TIME' 0.0 0.2
'COMMENT'  '    '
'COMMENT'  '**************** DEFINE ENERGY FLUX ******************'
'ENFLUX'  201 220 1 1.728
'COMMENT'  '    '
'COMMENT'
'COMMENT'  '*************  OBSERVATION WELLS ********************'
'PRODUCER' 'OBSW1' 1 3
        1
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW2' 1 3
        21
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW4' 1 3
        61
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW5' 1 3
        81
0.140 0.007 0.0 0.0
,,
25.,,,
'PRODUCER' 'OBSW6' 1 3
        101
```

```
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW7’ 1 3
          121
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW8’ 1 3
          141
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW9’ 1 3
          161
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW10’ 1 3
          181
0.140 0.007 0.0 0.0
,,
25.,,,
’PRODUCER’ ’OBSW11’ 1 3
          201
0.140 0.007 0.0 0.0
,,
25.,,,
’COMMENT’ ’    ’
’TIME’ 4000000.0 0.0
```