Increasing Potential of Production in Tight Gas Carbonate Rock

by Well Stimulation

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การเพิ่มศักยภาพการผลิตก๊าซในหินคาร์บอเนตโดยการกระตุ้นหลุมเจาะ

นายปริญญา นรพักตร์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตร์มหาบัณฑิต

สาขาวิชาเทคโนโลยีธรณี

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ปริญญา นรพักตร์: การเพิ่มศักยภาพการผลิตก๊าซในหินคาร์บอเนตโดยการกระตุ้นหลุมเจาะ (INCREASING POTENTIAL OF PRODUCTION IN TIGHT GAS CARBONATE ROCK BY WELL STIMULATION) อาจารย์ที่ปรึกษา: ผศ. เกรียงไกร ไตรสาร, 262หน้า.

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พลังงานจากปิโตเลียม ถือได้ว่าเป็นปัจจัยที่สำคัญที่สุดปัจจัยหนึ่งในการพัฒนาเศรษฐกิจของประเทศ การสำรวจและการพัฒนาแหล่งปิโตรเลียมในประเทศไทยประสบความสำเร็จพอควร ลดการพึ่งพาปิโตรเลียมจากต่างประเทศ แต่การสำรวจและพัฒนาแหล่งปิโตรเลียมในภาคตะวันออกเฉียงเหนือของประเทศไทยยังไม่ประสบความสำเร็จเท่าที่ควร มีการค้นพบและผลิตปิโตรเลียมที่อำเภอน้ำพอง จังหวัดขอนแก่นเพียงแห่งเดียว และพบอีกแหล่งที่อำเภอภูฮ่อม จังหวัดอุดรธานี แต่ยังไม่มีการผลิต ซึ่งถือว่าน้อยมากเมื่อเปรียบเทียบกับแอ่งปิโตรเลียมที่กระจัดกระจายอยู่ทั่วภาคตะวันออกเฉียงเหนือของประเทศ ซึ่งส่วนใหญ่อยู่ในแหล่งหินปูนยุคเพอร์เมียน ความพรุน (Porosity) และความไหลผ่านได้ (Permeability) มีค่าน้อย ทำให้ผลิตลำบาก มีอัตราการผลิตน้อย ดังนั้นจุดประสงค์ในการศึกษานี้เพื่อทราบค่าความพรุน ความไหลผ่านได้ ของหินปูนยุคเพอร์เมียนในภาคตะวันออกเฉียงเหนือ หาข้อมูลพื้นฐาน ศักยภาพ ปริมาณสำรอง และประสิทธิภาพการผลิตปิโตรเลียมในภาคตะวันออกเฉียงเหนือ ศึกษาผลการเพิ่มอัตราการผลิตและประสิทธิภาพการผลิตปิโตรเลียมจากการกระตุ้นหลุมเจาะ (Well stimulation) โดยโปรแกรมที่พัฒนาขึ้นเอง เปรียบเทียบกับ แบบจำลองคอมพิวเตอร์ที่ใช้ซอฟต์แวร์สำเร็จรูป ซึ่งมีขั้นตอนดังนี้ 1) รวบรวมข้อมูลเกี่ยวกับลักษณะของหินคาร์บอเนตยุคเพอร์เมียน การสำรวจ การกระตุ้นหลุมเจาะ และการผลิตปิโตรเลียมในภาคตะวันออกเฉียงเหนือจากที่เคยมีผู้ศึกษามาก่อน 2) วิเคราะห์ข้อมูลหลุมเจาะเพื่อนำมาประกอบใน การศึกษา 3) เก็บตัวอย่างหินที่เป็นหินโผล่ (Outcrop) อย่างน้อย 10 ตัวอย่าง และศึกษาคุณ

สมบัติทางฟิสิกส์จากหินตัวอย่าง เพื่อหาความพรุนและความไหลผ่านได้ ในห้องปฏิบัติการ 4) เขียนและพัฒนาโปรแกรมคอมพิวเตอร์เพื่อคำนวณ ปริมาณกรดที่ใช้ ระยะแตกของหิน ในการทำการกระตุ้นหลุมเจาะ อัตราการผลิตและศักยภาพการผลิตปิโตรเลียม 5) สร้างแบบจำลองคอมพิวเตอร์แหล่งผลิตปิโตรเลียม (Reservoir simulation) กับโปรแกรม Work Bench เพื่อหาอัตราและประสิทธิการผลิต การศึกษาในครั้งนี้ สามารถรู้ถึงผลการกระตุ้นหลุมเจาะ ในแหล่งก๊าซหินปูนเนื้อแน่น เพื่อเพิ่มศักยภาพและอัตราการผลิตปิโตรเลียมในภาคตะวันออกเฉียงเหนือของประเทศไทย ข้อมูลที่ได้จะมีประโยชน์ในการวางแผนการจัดหาแหล่งพลังงาน ผลการศึกษาความพรุนของหินคาร์บอเนตประมาณ 4% ค่าความไหลผ่านได้ก่อนทำการกระตุ้นหลุมเจาะประมาณ 0.2 มิลลิดาร์ซี ใช้แบบจำลองปริมาณก๊าซ 3 แสนล้านลูกบาศก์ฟุต หลุมผลิต 6 หลุม หลังจากทำการกระตุ้นหลุมเจาะโดยใช้กรด 4,440 บาเรลต่อหลุม ทำให้เกิดแนวแตกเป็นแนวดิ่งไกลออกจากหลุม รัศมี 540 ฟุต จะทำให้ค่าความไหลผ่านได้เฉลี่ยในโซนของแนวแตกเปลี่ยนไปเป็น 18.97 มิลลิดาร์ซี ทำให้อัตราการผลิตเริ่มต้นเพิ่มขึ้นจาก 24 เป็น 73 ล้านลูกบาศก์ฟุตต่อวัน ผลการวิเคราะห์เศษฐศาสตร์ปิโตรเลียม ถ้าไม่ได้ทำการกระตุ้นหลุมเจาะ จะไม่สามารถคืนทุนได้จากการเจาะหลุมผลิตเพิ่ม แต่ถ้าทำการกระตุ้นหลุมเจาะ จะสามารถคืนทุนได้โดยอัตราการคืนทุนร้อยละ 18.17 สามารถคืนทุนได้ในปีที่ 3 ของการผลิตและผลจากโปรแกรมที่พัฒนาขึ้นเองได้ผลใกล้เคียง

สาขาวิชาเทคโนโลยีธรณี ลายมือชื่อนักศึกษา.....................................

ปีการศึกษา 2545 ลายมือชื่ออาจารย์ที่ปรึกษา............................

PARINYA NONRAPUG: INCREASING POTENTIAL OF PRODUCTION IN TIGHT GAS CARBONATE ROCK BY WELL STIMULATION
THESIS ADVISOR: ASST.PROF. KRIANGKRAI TRISARN, M.S. 262 PP.
ISBN 974-533-226-7

CARBONATE ROCK/POROSITY/PERMEABILITY/WELL STIMULATION/ SIMULATION

The petroleum energy is the most important factor for Thailand economic development. Petroleum exploration and development in the country are moderately successful. Now we can reduce the petroleum import from abroad and can establish the stable energy supply for the economic and social development of our country. The exploration and development of the petroleum reservoirs in northeast Thailand are still not successful. Only two-gas fields are discovered. One is producing petroleum in Nam Phong district, Khon Kean province (Assavarittiprom, 1995) and the other in Phu Horm distric, Udonthani province is not producing. There are few petroleum reservoirs discovered, despite the number of potential structures in overall area of the Northeast. Most of reservoirs in the northeast are in the Permian carbonate rock (Pradidtan, 1995). The porosity and permeability of the Permian carbonate rock are very small, so production rate is low and very difficult to predict the actual performance and efficiency. The purpose of this study is to analyze carbonate rock to find porosity, reserve, production rate, and well stimulation performance. Well stimulation will be applied to the tight gas rock to increase the production rate and efficiency. The methodologies for this study are as follows: 1) Compiling the porosity and permeability data obtained from the concessionaire results, the technical and research papers, 2) Analyzing the well data for using in this study, 3) Collecting 10 carbonate rock samples and measuring their porosity and permeability values in laboratory, 4) Writing and developing computer program to calculate fracturing and acid fracturing performance, production rate and petroleum production efficiency (Tank model) and 5) Creating simulation model (Reservoir simulation). Therefore the expected results from this study are to improve the knowledge of well stimulation for the reservoir potential and the increase of production rate. Reservoir simulation model includes the ability to use the software approximation of the petroleum production efficiency in the northeast Thailand. Moreover, it can also be used as the reference data for studying petroleum potential and petroleum production efficiency in northeastern Thailand. The average porosity value of limestone specimen is 4%. The average permeability is 0.2 md. The reservoir model has gas in place of 300 BCF. There are six production wells. The well stimulation shows fracturing radius of 540 feet for 4,440 bbl of acid per well. Average permeability value at fracturing zone will change to 18.97 md with the production rate are increasing from 24 MMSCF/D to 73 MMSCF/D. Result of economic analysis after well stimulation is 18.17% internal rate of return. Pay back period will be at the third year of the production. Tank model also shows the comparable results.

สาขาวิชาเทคโนโลยีธรณี ลายมือชื่อนักศึกษา…………………………………..

ปีการศึกษา 2545 ลายมือชื่ออาจารย์ที่ปรึกษา………………………..

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Mr. Parinya Nonrapug

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LIST OF SYMBOLS AND ABBREVIATIONS

A	=	Annual cash flow
A_c	=	Cross section area perpendicular to fluid flow
A_f	=	Fracture area
A_{fc}	=	Area of filter
A or A_x	=	Cross sectional area of plug
Atm / sec	=	Atmosphere per second
B	=	Barrel
BCF	=	Billion cubic feet
BHP	=	Bottom hole pressure
BP	=	Barometric pressure in the atmosphere unit
BPD	=	Barrel per day
BTU	=	British thermal unit
BV	=	Bulk volume
B_g	=	Gas formation volume factor
B_o	=	Oil formation volume factor
B_w	=	Water formation volume factor
B_1, B_2	=	Collections of terms that include saturation, PVT terms and production terms

B_1^{n}	=	Collections of terms that include saturation, PVT terms and production terms at level n
B_2^{n+1}	=	Collections of terms that include saturation, PVT terms and production terms at level n+1
CAPEX	=	Capital cost
cp	=	Centipoise
C	=	Isothermal compressibility factor, negative annual cash flow value
C	=	Fracture fluid coefficient
°C	=	Degree in Celsius unit
D	=	Diameter
D	=	Day
ESCAL	=	Escalation
f	=	Fanning friction factor
Fac.	=	Facility
G	=	Cumulative gas in place
G_f	=	Fracture gradient
G_P	=	Cumulative gas production
GD	=	Grain density
Gth	=	Gross thickness
GOR	=	Gas oil ratio
GV	=	Grain volume
h	=	Height

Hh	=	Hydraulic horsepower
HTOP	=	High of top structure
I	=	Assumed value
i	=	Discount rate
IncTax	=	Income tax
IRR	=	Internal rate of return
K_{gas}	=	Overburden permeability
K_f	=	Permeability in fracture
K_{fz}	=	Permeability in fracture zone
k_g	=	Gas permeability
k_o	=	Oil permeability
k_w	=	Water permeability
km	=	Overburden permeability
L	=	Length
M	=	Month
MM	=	Million
MMSCF / D	=	Million standard cubic feet per day
MSL	=	Mean sea level
m^3	=	Cubic meter
mm	=	Millimeter
mm^3	=	Cubic millimeter
NPV	=	Net present value

N_{Re}	=	Reynolds number
NTh	=	Net thickness
n	=	Amount of year
OPEC	=	Operating cost
P	=	Pressure
P_2	=	Down stream pressure
P^n	=	Pressure at this time step
P^{n+1}	=	Pressure at the next time step
P_b	=	Billet equilibrated pressure
P_{cg}	=	Gas capillary pressure
P_{cw}	=	Water capillary pressure
P_f	=	Chamber equilibrated pressure
P_g	=	Gas pressure
P_o	=	Oil pressure
P_{ob}	=	Reference billet equilibrated pressure
P_{of}	=	Reference chamber pressure
P_{os}	=	Reference chamber with helium pressure
P_s	=	Chamber with helium equilibrated pressure
P_{sc}	=	Pressure at standard condition
P_w	=	Water pressure
P_1	=	Upstream pressure

Phi	=	Porosity
P_s	=	Surface of injection pressure
PIR	=	Profit to investment ratio
PV	=	Pore volume
ΔP_f	=	The friction pressure drop Surface of injection pressure
ΔP_s	=	Hydraulic pressure
Q	=	Flow rate
q_g	=	Gas rate
r	=	Radius
RHS_i	=	Result of the multiplication equation on the left hand side
R_f	=	Fracture radiant
SCF	=	Standard cubic foot
sqkm	=	Square-kilometer
S_g	=	Gas saturation
S_o	=	Oil saturation
S_w	=	Water saturation
t	=	Time
t_s	=	Spending time
T	=	Temperature
T_{sc}	=	Temperature at standard condition
US$	=	United State dollar
Rev	=	Revenue
RV	=	Reference volume

R_{so} = Oil saturation resistivity

R_{sw} = Water saturation resistivity

W = Width of fracture

V = Velocity

V_{bi} = Volume of billet removed

V_{bil}^{2} = Volume of billets

V_I = Volume injection

V_{sp} = Spurt loss

Z = Gas compressibility factor

Äx = Distance in x-direction

Äy = Distance in y-direction

Äz = Distance in z-direction

% = Percent

ð = Constant value equal to 3.1416

Ö$_g$,Ö$_o$,Ö$_w$ = Flux or phase potential of gas, oil and water

ö = Porosity

ö$_g$ = Gas porosity

ö$_o$ = Oil porosity

ö$_w$ = Water porosity

ã$_g$ = Specific Gravity of Gas

∈ = Relative pipe roughness

ñ$_g$ = Gas density

$\tilde{n}_o$ = Oil density

$\tilde{n}_w$ = Water density

$\ddot{e}_g$ = Gas mobility

λ_o = Oil mobility

$\ddot{e}_w$ = Water mobility

μ_{ai} or μ_{N2} = Gas viscosity which varies with temperature

μ_g = Gas viscosity

μ_o = Oil viscosity

μ_w = Water viscosity

υ = Velocity

CHAPTER 1

INTRODUCTION

1.1 Problem and rationale

The petroleum energy is the most important factor for Thailand economic development. Petroleum exploration and development in the country are moderately successful. Now, we can produce up to 40% of petroleum consumption required in our country, and can reduce the petroleum import from abroad. We can establish the stable energy supply for the economic and social development of our country. Future oil and gas production in the country will be dependent upon reservoir characterization technologies and reservoir simulation. Intense computer simulation is essential for effective reservoir management which is to determine the optimum conditions needed to maximize the economic recovery of hydrocarbons from a prudently operated field (John, 1997). The petroleum reservoir simulation is an important component in the development of more efficient techniques in petroleum recovery. Current simulators, used routinely in industry, are fundamentally limited in the size and complicated problems that they can handle (Borns, 2001). Significantly, collect data and reservoir description are essential in simulation. Ideally, all available information describing reservoir heterogeneity and a large number of important fluid and rock properties should be used in the simulators.

The exploration and development of the petroleum reservoirs in the northeast Thailand are still not successful. Only two-gas fields are discovered. One is producing petroleum in Nam Phong district, Khon Kean province (Assavarittiprom, 1995) and the other in Phu Horm district, Udonthanee province is not producing. There are few petroleum reservoirs discovered, despite the number of potential structures in overall area of the Northeastern. Most of reservoirs in the northeastern are located in carbonate rock in Permian era (Pradidtan, 1995). The porosity and permeability of the carbonate rock in Permian era are very small, so production rate is low and very difficult to predict the actual performance and efficiency. Furthermore, the analytical data of Esso who is the concessionaire of gas reservoir in Nam Phong is limited and confidential. The well stimulation in this study can increase both porosity and permeability of carbonate rock in northeastern as a result production rate and efficiency is increased. Moreover, the petroleum production ran in other exploration reservoir consequently in the area are estimated.

1.2 Research objectives

To study, experiment and analyze carbonate rock to find porosity, permeability, reserve and production efficiency of Permian carbonate rock in the northeast of Thailand. To calculate reserve and production efficiency in potential gas field. The data, reserve and petroleum production efficiency, are collected and analyzed from northeast of Thailand. Study production rate and petroleum production efficiency increasing from well stimulation. Compare the results between Tank model, self developed program, and computer simulation software.

1.3 Scope and limitations of the study

The project will scope the study on the rock formation in the areas of the exposed outcrops and drilled cores. Well stimulation increases production rate and petroleum production efficiency in the gas reservoir potential. The reservoir simulation is done and limited at the data availability and some reasonable assumption

1.4 Expected results and assumption

a. The results of the study is the ability to calculate gas in place, reserve, production rate, production efficiency from the discovered gas reservoirs and further potential reservoirs that are carbonate reservoirs in the northeastern of Thailand.

b. The results of laboratory are

1) The average porosity is 4% in limestone.

2) The average permeability is less than 0.2 mD.

c. The assumption of simulation are

1) The gas production wells are 6.

2) Before stimulation the total gas production rate of six wells is started at 35-36 MMSCF/D, and it will be at this rate for 4-6 years. Total gas production rate in the 6th year will be declined about 15-20% per year until the end of gas production in the 24th year.

3) If well stimulation process is commence, the gas production rate of six wells is started at 72-73 MMSCF/D, and it will be at this rate for 2-3 years. Total gas production rate in the 4th year will be declined about 15-20% per year until the end of production in the 18th year.

d. The assumption of Tank model are

1) The gas production is one well.

2) The gas production rate of one well is started at 3.5 MMSCF/D, and it will be at this rate for 5 years. The gas production rate in the 5th year will be declined about 15-20% per year until the end of production gas in the 24th year.

3) If well stimulation process is performed, the gas production rate of one well is started at 12 MMSCF/D, and it will be at this rate for 2-3 years. The gas production rate in the 4th year will be declined about 15-20% per year until the end of production gas in the 18th year.

4) Before stimulation the total gas production rate of six wells is started at 18-19 MMSCF/D, and it will be at this rate for 4 years. Total gas production rate in the 6th year will be declined about 15-20% per year until the end of gas production in the 25th year. The final production gas rate at last production year is 10 MMSCF/D for economic limit.

5) If well stimulation process is commence, the gas production rate of six wells is started at 72 MMSCF/D, and it will be at this rate for 2-3 years. Total gas production rate in the 4th year will be declined about 15-20% per year until the end of production in the 18th year. The final production gas rate at last production year is 10 MMSCF/D for economic limit.

e. The results of economic calculation are

1) Internal rate of return should be more than the discounted factor at the time (more than 7.25%).

2) Profit investment ratio is in range 0.8-1.

3) Pay back period should be begun at 2nd or 3rd year production.

1.5 The benefits of the study

a. Well stimulation is useful for increasing petroleum production rate.

b. The data is useful in planning to predict the energy resource for industrial and economic developing in the northeast and the country.

c. Experiences in term of programming application, simulation model, testing, including equipment in laboratory and software utilization.

d. Earning the experience in developing the simulation model, testing apparatus in laboratory and software computer.

e. Knowing how to do reservoir description.

f. Getting more detail information in the reservoir properties.

1.6 Procedures

a. Collect relevant data and the characteristics of carbonate rock and well stimulation that had been studied, experimented, and researched.

b. Collect relevant data in petroleum exploration, well stimulation and petroleum production in the northeastern.

c. Analyze data for utilization in this study.

d. Collect more than 10 rock samples and then study their physical property in the laboratory.

e. Analyze porosity and permeability of rock samples.

f. Analyze and assess data from the laboratory, compare with the result from logs and the concessionaire.

g. Study in well stimulation method to increase the production rate and efficiency of petroleum production.

h. Write and develop computer program for calculating production rate and petroleum production efficiency in many well-stimulated methods.

i. Create simulation model by using analyzed data. Calculate stimulated well, checking porosity and permeability. Use the developed program to predict production rate and time in petroleum production

j. Use the analyzed data to create simulation model (Reservoir Simulation) and use commercial software to run simulation, compare the results with self developed program

CHAPTER 2

LITERATURE REVIEW

2.1 Acid fracture design

Acid fracturing design is written by Hall et al. They designed the fracture stimulation treatment at the Nam Phong field that is located in northeastern Thiland for a cased whole completion by using PVRGE program to estimating acid with fracture job results for various parameters. In the PVFRGE modeling, a formation interval of five 100 feet perforated sections was stimulated with 28 wt% HCl at treating rates from 5 bpm to 15 bpm. The treating rate was limited to 15 bpm based on the availability of pumping equipment in Thailand. THE PVFRGE model is an approximation to the actual ball sealer well stimulation program in which all operations are open initially and fewer perforations are open as balls seat as the job progresses. Fracture length was calculated for matrix permeabilities of 0.1 and 1.0 md and volumes of 500, 1,000 and 1,500 gal/perforation. The results of the parametric study show that fracture length increases with both higher pump rate and larger job size, and length decreases with increasing matrix permeability.

2.2 Jonah gas field

Jonah gas field is written by Thomasson, R. M. Jonah gas field is a unique structurally controlled sweet spot within the basin-centered area of the Green River basin of Wyoming. By year-end 2000 Jonah contained over 335 wells with a per well average producible reserve of between 6 and 7 bcf. The field was first discovered in 1975 by the Davis Oil Co.

1) Wardell Federal, which had an initial flow rate of 303 Mcfd of gas.

2) Oil was later rediscovered in 1985 by the Home Petroleum 1-4 Jonah Federal, tested for an initial 470 Mcfd.

Jonah was again rediscovered in 1993 when the McMurry Oil Co. 1-5 Jonah Federal tested 3.7 MMcfd and 40 bopd. The increase in production rates is attributed to improved technology in the form of better stimulation techniques.

Completion technology continues to improve so that today in a pay section similar to that found in the McMurry 1-5 Jonah Federal the initial rate might be 10 to 12 MMcfd. EUR averaged 2 bcf/well before 1994. Improved frac technology has raised the EUR steadily since 1992. For 1997 it was 6.76 bcf 24. The year-end 2000 configuration of the field contains 335 wells.

Current development has not yet established the field's eastern limit. Jonah field has a 3,000 ft gas column. Gas is trapped laterally and updip by a set of shear zones. These shear zones allow the development of a geopressured sweet spot that is some 3,000 ft higher than the top of regional deep-basin type overpressures. There is essentially no structural displacement of the main reservoir section.

The shear zones that seal the sweet spot both laterally and updip originate in the basement and have little vertical throw. However, the field itself is highly broken by faults that control anomalous overpressure displacements of as much as 600 ft in separated fault blocks within the field. This extensive internal faulting and fracturing has allowed gas to migrate vertically upward through tight rocks to a shallower reservoir, which now experiences less diagenesis and thus has higher porosity than is present in the underlying sediments associated with source rock gas generation. Current development indicates at least 2.5 tcf recoverable.

2.3 Hydraulic fracturing in the Ghawar field carbonate and sandstone reservoirs

Hydraulic fracturing in the Ghawar field carbonate and sandstone reservoirs is written by Bybee (2002). They report that gas wells in the Ghawar field are fractured to enhance gas recovery. More than 50 wells in the Khuff carbonates have been acid fractured, and approximately 15 wells in the pre-Khuff sandstones have been proppant fractured. The Jauf and Unayzah reservoirs form the productive pre-Khuff formation where high-permeability, unconsolidated sand layers are often encountered. One major objective of fracturing sandstone is to reduce sand production. It is a challenge to optimize the treatments because of the area spread of the reservoirs and variations in reservoir characteristics. A 3D hydraulic-fracturing model is used to simulate acid reaction and proppant transport, and reservoir simulation models are used for production and transient data evaluation.

Estimated kh for Well SP-2 is approximately 50 md-ft. Very little sand is expected during production even at very high drawdown pressure. The perforation interval selected is 50 ft in the best section of the reservoir. Approximately 400,000 lbm of 20/40-mesh intermediate-strength proppant is pumped in this well in January 2002. Although proppant flowback control agent is to be added to the intermediate-strength proppant, a very minimal amount is added because of mechanical problems during pumping. Cleanup profile for this well showed initial solids flowback with no solids produced toward the end of the test.

Estimated kh for Well SP-3 is approximately 10 md-ft. Initial design calls for a resin-coated/intermediate-strength proppant combination, but because of mechanical problems, no resin-coated proppant is pumped. The well shows only marginal sanding at the topmost portion of the reservoir, and it is expected that the sand would hold because of the overall low quality of the well. However, a post-fracture production test shows a significant amount of sand. A recent study shows that the formation loses approximately 25% of its strength when saturated with fracturing fluids.

The Khuff formation is a deep gas carbonate reservoir that consists of dolomite and limestone sections. These sections can have streaks of shale, anhydrite, or low-permeability sections within the layers that may act as no-flow or fracture barriers. Formation heterogeneity between wells is significant with developed porosity sections in one well not present in an offset well.

The early acid-fracturing program consist of pumping a viscous pad followed by 28% HCl. This design is an attempt to create fingering of the acid in the pad stages. Acid volumes rang from 1,500 to 2,000 gal/ft of treatment interval. A closed-fracture acidizing stage with 28% HCl is pumped at a very low rate at the end of the treatment to increase the near-wellbore etching and conductivity. Although treatments are pumped at rates greater than 50 bbl/min, the net pressure loss results in shorter fracture lengths. As a result, current treatments are designed with three to four stages of alternating pad and acid, with acid volumes of 800 to 1,200 gal/ft. This redesign has sustaining positive net pressure during the treatment. Emulsified acid is introduced in an attempt to obtain deeper stimulation-fluid penetration. Currently, three acid formulas are being used in treating the Khuff.

- Emulsified acid with a 70:30 acid to diesel ratio.
- Gelled acid.
- 15% HCl/9% formic acid when treating down chrome tubulars.

2.4 Arcasolve stimulation of natural fracture networks in Austin Chalk

Arcasolve stimulation of natural fracture networks in Austin Chalk is written by Harris and McKay (2002). They report that a 100 ft vertical interval is treated as follows: 1300 bbls slick water pre-flush, 300 bbls Arcasolve formulation 2 175 bbls slick water post-flush, and all stages are pumped at approximately 10 bbls/min. The well is shut in for 72 hours and back production of injected fluids initiated via swabbing until produced water is relatively free from particulates. The down-hole pump is re-installed on day 5 (post treatment) and oil production, water production, gas production and calcium levels in the produced water are monitored over the following 50 days.

Arcasolve is a catalyst based technology for the in-situ production of acid within oil/gas well-bores and reservoirs. The technology has been proven in the field for deep matrix acidizing of oil producer and water injector wells and Cleansorb is developing the use of Arcasolve for a range of other acidizing applications with US and European based operators.

Preparation and injection of Arcasolve fluid is carried out according to plan with no operational problems. Field tests results of pre-Arcasolve production are 17 mcfd gas, 10 bpd oil, and 16 bpd water. Results of peak production are 38 mcfd gas, 27 bpd oil, and 57 bpd water. Results of production at day 50 are 17 mcfd gas, 10 bpd oil, and 16 bpd water. By day 50 all the 1880 bbls of injected treatment fluid had been recovered from the well. Following the trial the well is taken off production prior to capping as originally planned.

2.5 Woodada gasfield

Woodada gasfield is written by Owad-Jones and Ellis (2002). They report that the reservoir properties consisting of log-interpreted porosity and water saturation, core porosity and permeability, and net and gross gas pay for the Beekeeper Formation reservoir in each well, are listed in Table 2.1. Reliable parameters for water saturation determinations are not available. Interpretation of the wireline logs in the productive dolarenite reservoir of the Beekeeper Formation indicates an average porosity of 7.5% (range 3-13%) and a water saturation of up to 75% in the gas column. Although core was cut in the Beekeeper Formation in Woodada 2, 3 and 14, the dolarenite is only cored in Woodada 3 below the GWC. Core analysis indicates porosity of 1.3-2.5% and permeability of 0.01-0.04 md. Permeability, interpreted from testing, is measured at approximately 5 md in the Woodada wells and 450 md in the East Lake Logue wells. The significant permeability difference between the two areas is probably a function of the degree of fracturing in the Beekeeper Formation. High fracturing in the vicinity of the East Lake Logue wells is expected to be related to the close proximity of the main controlling fault.

Table 2.1 Hydrocarbon reservoir thickness and quality, Woodada field.

Well	Gas column		Porosity (%)		Permeability (md)
	Gross (m)	Net (m)	Log	Core	
Woodada 1	7.0	~7.0	3-13	-	~5
Woodada 2	5.0	5.0	nd	-	~5
Woodada 3	-	-	nd	1.3-2.5	0.01-0.04
Woodada 4	10.0	10.0	nd	-	~5
Woodada 5	2.0	2.0	nd	-	~5
Woodada 6	6.0	6.0	8	-	~5
Woodada 8	2.5	2.5	nd	-	~5
Woodada 9	-	-	-	-	~5
Woodada 10	8.0	8.0	10-15	-	~5
Woodada 11	9.0+	9.0+	nd	-	~5
Woodada 12	5.0	5.0	nd	-	~5
Woodada 14	-	-	nd	-	~5
Woodada 15	-	-	nd	-	~5
Woodada 16	nd	nd	nd	-	nd
East Lake Logue 1	6.0	6.0	10-20	-	~450
East Lake Logue 2	7.0+	7.0+	nd	-	~450
Indoon 1	2.0	2.0	nd	-	-

Note: No data available for Woodada 16

The Woodada gas is predominantly methane (89.7%), with ethane (0.9%), propane (0.5%), carbon dioxide (4.1%), and nitrogen (2.4%). In the East Lake Logue wells, the nitrogen content is higher at 5.2 to 8.6%, suggesting greater communication with basement rocks. The associated oil swabbed from the reservoir in Woodada 3 consists of 94.7% saturates, 4.1% aromatics and 1.2% NSOs. The fluid parameters of the hydrocarbons reservoired in the Woodada field are summarised in Table 2.2.

The Woodada field comprises a single gas pool in the dolarenite and fractured limestone reservoir of the Beekeeper Formation. The pool has a maximum gross gas column of 195 m down to the original GWC at -2315 mSS. The gas in the East Lake Logue fault compartment shows lower pressure than the gas in the Woodada fault compartment. Gas expansion provides the main drive for Woodada field production. Over the life of the field, the production history has varied considerably, reflecting different mechanisms of production in the reservoir, as well as occasional production restrictions. In some wells, fractures play an important role while in others production depends upon the dolarenite. Acid stimulation has consistently proven to be an effective production enhancement. In recent years, water rate increases have been observed in wells producing from lower in the formation, however the GWC has remained virtually unchanged. Reservoir production over time has remained remarkably consistent with the standard P/Z plot.

Woodada 1, the discovery well of the Woodada field, is drilled in onshore Exploration Permit EP-100 during April to June 1980 by Strata Oil NL, acting on behalf of the operator, Hughes and Hughes. Woodada 1 intersect gas pay in the Beekeeper Formation. Production testing produces a maximum stabilized flow of

Table 2.2 Hydrocarbon fluid and reservoir parameters, Woodada field.

Structural crest	~-2060 m
Gas/water contact	-2315 m (original)
Max gross pay	195 m
Water saturation	75%
Porosity	3-13% (7.5%)
Permeability	460 md (East Lake Logue) ~5 md (Woodada)
Gas viscosity	0.021cp at reservoir conditions
Gas density	0.77 kg/m^3 at STP
Gas gravity	0.64
Condensate gravity	53.6° API
Gas formation volume factor	0.006
Temperature	120°C
Initial pressure	23 318 kpa (3382 psia)
Current pressure	10 345 kpa (1500 psia)
Drive mechanism	gas expansion

Note: Majority of information supplied by operator, 30 June 1999

945.8 km^3/d (33.4 MMcf/d) of gas through a 25.4 mm (1") choke. Appraisal of the discovery follows in 1980 and early 1981 with the drilling of Woodada 2, 3 and 4. Woodada 2, 1.2 km east of Woodada 1, confirmed the extension of the field within a separate fault block. Woodada 3, 4.9 km north-northeast of Woodada 1, intersects the reservoir structurally low and below the GWC. Fluorescence and bleeding oil are observed in the fractured limestone, and subsequent swabbing, following acid stimulation, produced oil-cut water. Woodada 4, situated 4.35 km south of Woodada 1, intersected the reservoir higher than Woodada 1, however only small flows of gas are obtained, probably due to poor fracturing. Hudbay Oil (Australia) Ltd. take over the permit and in 1982, drilled Woodada 5 and 6, Indoon 1 and East Lake Logue 1. Woodada 5, 2.6 km north of Woodada 1, intersects a thinner reservoir section and fails to maintain hydrocarbon flow even after acid stimulation. Woodada 6, 1.7 km south and updip of Woodada 1, and Indoon 1, 9.8 km south, flowed gas on acid stimulation and confirmed the extension of the field to the south. East Lake Logue 1, 4.5 km south-southeast of Woodada 1, intersected gas-saturated reservoir in a separate and downthrown fault block from the main part of the Woodada field. The Woodada 7 location is abandoned due to flooding and has not been drilled.

Strata Oil NL then became the new operator of the permit, and from August 1983 to March 1984, drilled the Woodada 8, 9 and 10 wells. Woodada 8, 7.2 km south of Woodada 1, etween Woodada 4 and Indoon 1, flowed gas only after acid stimulation. Woodada 9, 850 m east of Indoon 1, intersected a 23 m thick Beekeeper Formation, with no significantreservoir. Woodada 10, 2.4 km south-southwest of Woodada 1, flows gas on acid stimulation.

Gas production from the Woodada field begin in May 1982, with gas collected by a gas-gathering system, and after separation and dehydration, is piped 11 km northeast of the field to the Parmelia Pipeline and then to Perth. Sale of Woodada gas is restricted to the SEC, and when they cease to purchase gas in March 1987, the field is shut-in until November 1987. Production, although initially high, is limited until December 1989 due to market restrictions.

From March to July 1991, further development of the field is carried out, with the drilling of Woodada 11 and 12. Woodada 11, 3.7 km south of Woodada 1, on the crest of the structure, and Woodada 12, 4.3 km south-southwest of Woodada 1, both flow gas on test. In September to October 1992, East Lake Logue 2, approximately 150 m northeast of East Lake Logue 1, flowed gas on test. All three wells are production wells. In 1994, a new contract to supply gas to Midland Brick commenced, and the year also saw the installation of gas compression facilities, and an extensive seismic programme. In late 1994, Woodada 14 and 14 sidetrack are drilled close to the crest of the structure, 250 m west of Woodada 4, but failed to produce significant amounts of gas.

Acid Fracture Design, Jonah gas field, Hydraulic Fracturing in the Ghawar field, Arcasolve of natural fracture net work in Austin Chalk and Woodada gasfield show that are increased production rate and efficiency of field by well stimulation method. Therefore well stimulation is interacting to study in this topic.

CHAPTER 3

LABORATORY EXPERIMENTS ON CARBONATE ROCK

3.1 Objective

The objective is to determine values of porosity and permeability of specimens. Experiments include porosity measurement and permeability measurement. The porosity values are determined by using the porosimeter. The permeability values are determined by the overburden poro-perm cell instrument. All experiments are conducted under isothermal conditions about 20 $^{\circ}$C.

3.2 Sample collection

Carbonate rock (Limestone) samples have been collected randomly from various fields. They are collected from Saraburi, Phetchabun, Lop Buri and Loei provinces. The rock samples were aged in Permian era. Table 3.1 lists seventeen stops on sample collection. Areas studies are shown in Appendix C.

3.3 Sample preparation

The samples have been prepared into a proper size by using coring machine that is shown in Figure 3.1. The core samples are called specimens. The shape of specimen is cylinder. They were measured porosity and permeability values in

Table 3.1 Samples collections and descriptions.

Collected Date	Stops	Outcrop	Field locations	Rock type	Fresh Color	Weathering Color
25/9/01	1	Road-cut	Kaeng Khoi, Saraburi province	Limestone	Dark Gray	Dark Gray
25/9/01	2	Mine	Khao Kho, Saraburi province	Limestone	Medium-Dark Gray	Light Gray
25/9/01	3	Mine	Kaeng Khoi, Saraburi province	Limestone	Dark Gray	Light Gray
25/9/01	4	Road-cut	Khao Kho, Saraburi province	Limestone	Light-Medium Gray	Light Gray
25/9/01	5	Mine	Khao Kho, Saraburi province	Limestone	Light Gray	Light Gray
25/9/01	6	Road-cut	Kaeng Khoi, Saraburi province	Limestone	Medium Gray	Light-Medium Gray
25/9/01	7	Road-cut	Muaklek, saraburi province	Limestone	Medium-Dark Gray	Light-Medium Gray
26/9/01	8	Mine	Pak Chong, Nakhon Ratchasima province	Limestone	Dark Gray	Medium Gray
26/9/01	9	Mine	Pak Chong, Nakhon Ratchasima province	Limestone	Medium Gray	Light-Medium Gray
26/9/01	10	Outcrop	Kaeng Khoi, Saraburi province	Limestone	Light Gray	Light Gray
29/9/01	11	Mine	Muang, Loei province	Limestone	Light Gray	Light Gray
29/9/01	12	Road-cut	Arawan, Loei province	Limestone	Medium Gray	Light Gray
29/9/01	13	Road-cut	78 km Chompae-Loamsak, Phetchabun province	Limestone	Light Gray	Light Gray
29/9/01	14	Road-cut	39 km Chompae-Loamsak, Phetchabun province	Limestone	Dark Gray	Dark Gray
30/9/01	15	Mine	Khao Somposhn, Chaibadal, Lopburi	Limestone	Light-Medium Gray	Light Gray
30/9/01	16	Outcrop	Muaklek, saraburi province	Limestone	Dark Gray	Dark Gray
30/9/01	17	Outcrop	Muaklek, saraburi province	Limestone	Light Gray	Light Gray

Figure 3.1 Coring Machine is the instrument that uses for drilling the rock samples with cylinder shape.

laboratory. The L/D ratios of them are 1.33. The specimen size is 1.5 inches (38.55 millimeters) in diameter. The samples were cut by cutting machine using fresh water as cutting fluid (Figure 3.2). The physical characteristics (mineral composition, grain size, density, color, etc.) are described. The specimens were baked in the oven with low temperature between 50-60 °C in 24 hours or until they became dried. The examples of specimen are shown in Figure 3.3. Preparation of these samples follows, as much as practical, the ASTM standards (ASTM D4543-85, 1998). The identification of specimens is given, which includes rock type, core number, core diameter, type of experiment and sample number. Limestone is fine to coarse grain. The average density of carbonate rock is 2,705 kg/m^3. The color is light to dark gray but some specimens are found calcite vein.

3.4 Porosity measurement

The porosimeter is instrument to measure porosity. It is shown in Figure 3.4. Clean and dried specimens are selected for determining the porosity. The porosity is determined by a combination of two of following three physical properties (Grain volume, bulk volume and pore volume). Grain volume can be determined from helium injection by passing helium through the specimen. Helium is an inert gas. Small molecular size of helium passes to penetrate micro-pores more readily than other gases. Helium does not react with, nor does the specimen absorb it. It does not affect the instrument. It is suitable for using in the test. The specimen has placed to the schematic cell. Relationships of reference pressure, billet pressure, billet volume and specimen volume are received after injecting helium to the schematic cell. They

Figure 3.2 Cutting machine using fresh water as cutting fluid.

Figure 3.3 The specimen shape is cylinder. The specimen size is two inches in length and one and a half five inches in diameter.

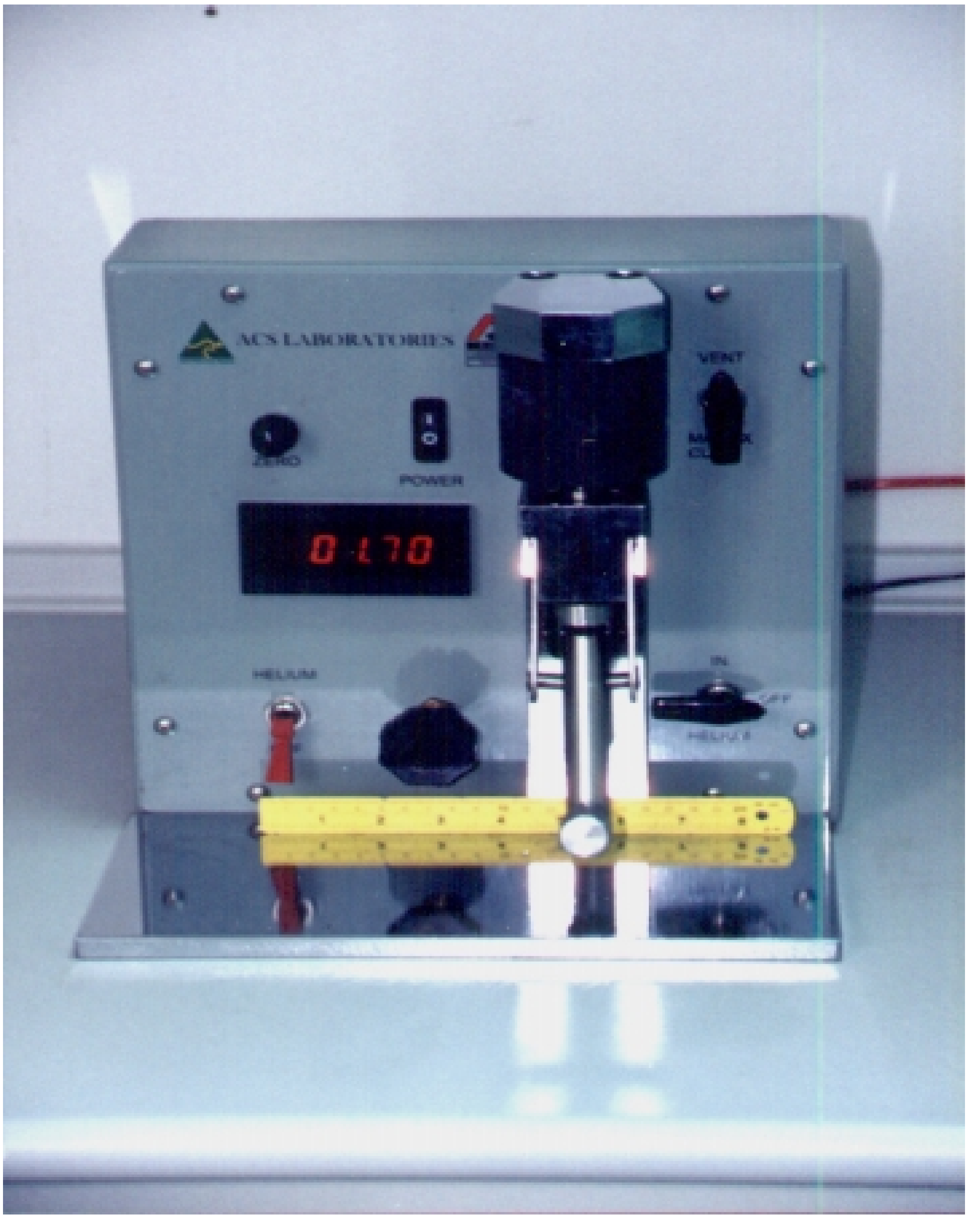


Figure 3.4 The porosimeter instrument is used for measuring the porosity of the specimens.

are used for determining grain volume. Bulk volume is calculated from the relationship between length and diameter of the specimen. Pore volume is the different value of bulk volume and grain volume. Porosity is determined from the pore volume divided by the bulk volume of specimen.

3.4.1 The processes of porosimeter operation

a. Connect Helium gas supplied to the port at the rear of the instrument.

b. The instrument should be set up in a constant temperature environment. The pressure transducer should be calibrated and equipment leak checked on set up and checked periodically after that.

c. Turned on the electronic and allowed to warm up (5-10 minutes).

d. Zero the readout.

e. With the helium value in the "off" position and the top "vent" position. Adjust the zero potentiometer to a point where the digital readout reads 0.00.

f. Turn the helium supply at the bottle and the Porosimeter. (red toggle valve)

g. Warm up the transducer by pressuring up and down several times.

h. Determine the Reference Volume of the reference chamber (RV).

   1) Fill the matrix cup with billets and seal of the cup in the porosimeter. The matrix cup must be the same position for each reading (for reference and grain volume measurements) to ensure that there is no change in volume.

   2) Fill the reference chamber with helium to 100 psig. Record pressure as "Pof".

3) Open the reference chamber to the sample chamber. Record pressure as "Pf".
4) Remove the appropriate billet is from the sample chamber. The volume of the billet removed should be approximately equal to the pore volume of the samples being tested (typically billet 1 for porous carbonate rock). Record the volume of the billet removed as V_{bil} (cm^3). The billets are shown in the Figure 3.5.
5) Repeat the step 2) and 3) this time record the reference chamber pressure as "Pob" and the equilibrated pressure of the sample chamber as "Pb".
6) These pressure measurements are repeated until three conservative identical readings are obtained. The "RV" is obtained at the start of each sample run and then at 20 sample intervals.
7) Always use 100 psig for the reference pressure.

Reference volume calculations is follow this:

$$[illegible] \frac{P_{ob}}{P_b} - \frac{P_{of}}{P_f}, \tag{3.1}$$

or if P_{ob} and P_{of}= 100.00 psi

$$RV = \frac{[illegible]\,100}{P_f - P_b}. \tag{3.2}$$

i. Grain volume (GV) is determined by following this:

1) The clean and dried core sample in the matrix cup. If the sample is short, then fill the excess space with a billet(s).

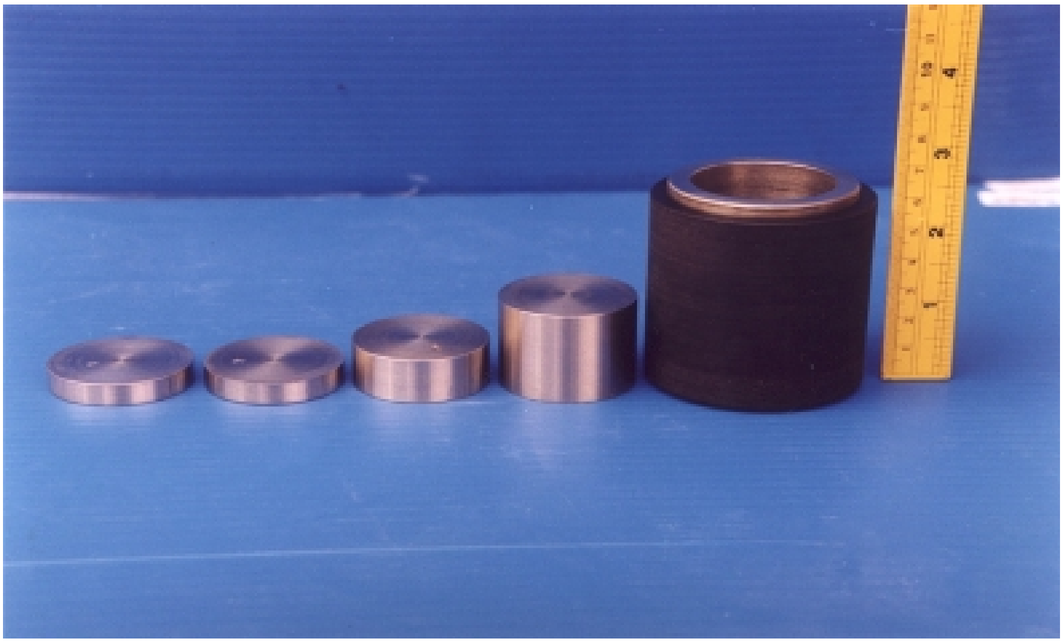


Figure 3.5 Billets are input in the chamber. When test the specimen, specimen is put into the chamber then billet number 1 is put in the chamber, too. Billet number 1 is the agent of the pore volume of carbonate rock.

2) Record the identification number of the billets left out of the cup. The volumes of these billets (V_{bil}^2) are used in the calculation and are found in Table 3.2. Seal the cup at atmospheric conditions and isolate the cup from the atmosphere.
3) Fill the reference chamber with helium to 100 psig. Record the pressure as "Pos".
4) Introduce the helium into the matrix cup and allow the pressure to stabilize. Record the stabilized pressure as "Ps".
5) Through knowledge of the previously determine "RV", The "Ps" is use to calculate the grain volume,

$$GV = V_{bil}^2 + RV \; \frac{P_{of}}{P_f} \; \frac{P_{os}}{P_s} \; . \tag{3.3}$$

j. Sample weight determination

Sample weight is determined by using the weight balance for measuring the dry weight of specimens. The sample is weighed to 2 decimal places.

k. Bulk volume determination

Bulk volume (BV) is calculated from the relationship of length and diameter following this:

$$BV = \pi L[D/2]^2 . \tag{3.4}$$

l. Pore Volume determination

$$PV = BV - GV. \tag{3.5}$$

Table 3.2 The volumes of the matrix cup billets that are used with the porosimeter. The volume of the billet removed should be approximately equal to the pore volume of the sample test.

1" Billet	Billet Number	Volume (cm^3)
	1	4.63
	2	4.59
	3	9.22
	4	18.49
1 ½" Billets	Billet Number	Volume (cm^3)
	1	10.18
	2	10.2
	3	20.39
	4	40.74

m. Porosity

$$\phi\% = \frac{PV}{BV} \times 100. \quad (3.6)$$

The porosity results are calculated by using the parameters from porosimeter instrument are shown in the Table 3.3.

n. Grain density determination

Grain density (GD) is determined from core samples as past of routine core analysis. The grain density is obtained by dividing the dry weight (Wt) of the framework material of the samples by its volume (GV). The sample must be cleaned and dried to remove hydrocarbon and water so that only rock material is being analyzed.

$$GD\,(g/cm^3) = \frac{GV\,(cm^3)}{DryWeight\,(G)}. \quad (3.7)$$

3.5 Permeability measurement

The overburden poro-perm cell is the instrument for measuring the specimens to find permeability. The overburden poro-perm cell has been designed to perform porosity and permeability measurements on specimens under simulated reservoir overburden conditions. It uses an air actuated hydraulic pump to achieve a simulated reservoir confining pressure on the specimen.

The permeability determination of specimen is used air (or nitrogen) which specified initial pressure (upstream pressure) let flow through the length of specimen. The specimen is sealed in 2 sides so that the flowing air cannot leak from specimens.

Table 3.3 Porosity results are calculated by using parameters from porosimeter instrument.

Sample No.	Rock Type	Vol. Billet Removed (mm^3)	P_f (psia)	P_b (psia)	Dry Weigth (g)	P_{os} (psia)	P_s (psia)	Volume Removed (mm^3)	Temp. (^oC)	Length (mm)	Diameter (mm)	RV (mm^3)	GV (mm^3)	BV (mm^3)	PV (mm^3)	Porosity (%)	GD (g/cc)
1	Limestone	10.18	88.99	72.78	161.29	100.0215	71.27	71.33	16	50.05	38.35	40.67	59.95	57.81	1.20	2.1	2.690
2	Limestone	10.18	88.99	72.78	154.15	100.03	68.35	71.33	16	51.20	38.28	40.67	57.51	58.93	3.64	6.2	2.681
3	Limestone	10.18	88.99	72.78	160.66	100.00	70.88	71.33	16	52.15	38.12	40.67	59.65	59.52	1.50	2.5	2.693
4	Limestone	10.18	88.99	72.78	160.18	100.04	71.22	71.33	16	51.92	38.30	40.67	59.90	59.82	1.25	2.1	2.673
5	Limestone	10.18	88.99	72.78	154.43	100.01	68.08	71.33	16	49.77	38.33	40.67	57.29	57.43	3.86	6.7	2.696
6	Limestone	10.18	88.99	72.78	156.82	100.01	69.24	71.33	16	50.57	38.27	40.67	58.29	58.17	2.86	4.9	2.690
7	Limestone	10.18	88.99	72.78	156.42	100.01	68.98	71.33	16	50.35	38.33	40.67	58.07	58.10	3.08	5.3	2.694
8	Limestone	10.18	88.99	72.78	157.51	100.02	69.45	71.33	16	50.02	38.22	40.67	58.46	57.39	2.69	4.7	2.696
9	Limestone	10.18	88.97	72.62	161.75	100.03	68.98	71.33	16	50.68	38.23	40.23	58.22	58.17	2.93	5.0	2.779
10	Limestone	10.18	88.97	72.62	159.64	100.01	70.32	71.33	16	51.45	38.13	40.23	59.34	58.75	1.81	3.1	2.689
11	Limestone	10.18	88.97	72.62	173.60	100.01	69.85	71.33	16	51.27	38.30	40.23	58.96	59.07	2.19	3.7	2.946
12	Limestone	10.18	88.97	72.62	159.64	100.02	71.04	71.33	16	52.23	38.27	40.23	59.92	60.08	1.23	2.1	2.665
13	Limestone	10.18	88.97	72.62	158.37	100.03	70.11	71.33	16	51.45	38.20	40.23	59.16	58.97	1.99	3.4	2.678
14	Limestone	10.18	88.97	72.62	162.15	100.01	71.51	71.33	16	52.33	38.27	40.23	60.29	60.19	0.86	1.4	2.692
15	Limestone	10.18	88.97	72.62	158.10	100.02	79.99	71.33	16	51.23	38.25	40.23	59.07	58.87	2.08	3.5	2.676
16	Limestone	10.18	88.97	72.62	154.66	100.00	68.47	71.33	16	50.98	38.18	40.23	57.80	58.37	3.35	5.7	2.674
17	Limestone	10.18	88.97	72.62	155.15	100.02	68.40	71.33	16	50.43	38.28	40.23	57.73	58.04	3.42	6.9	2.690

The flow rate of air from the other end of specimen is measured. The permeability of the sample is calculated by using the upstream pressure and flow rate during the test, at atmospheric pressure, viscosity of air and the length and cross sectional area of specimen. The relationship of time, viscosity, flow rate and cross sectional area are used for determining permeability. This study uses the overburden poro- perm cell for testing specimens to find only permeability. Permeability is the indicator of the ability of a porous medium to transmit fluids. The measurement of permeability of a porous rock is a measurement of the fluid conductivity of the particular material. Measuring permeability is expressed unit in mD.

3.5.1 The overburden poro-perm cell operations

a. The overburden poro-perm cell (Figure 3.6) should be set up in a constant temperature environment. The pressure transducers should be calibrated and the equipment leak checked on installation. The transducers calibration should be checked from time to time and re-calibrated as needed.

b. Connect external helium, air and water supplies are to the entry ports at the rear of the instrument.

Connect the water drain port is to an external drain line.

3.5.2 The sample loading and cell pressuring operations

a. Place thick walled rubber sleeve platen over the platen end of the down stream end piece and secure with retaining ring.

b. Insert right cylinder sample into the thick walled rubber sleeve, ensuring the sample is butted neatly up against the platen.

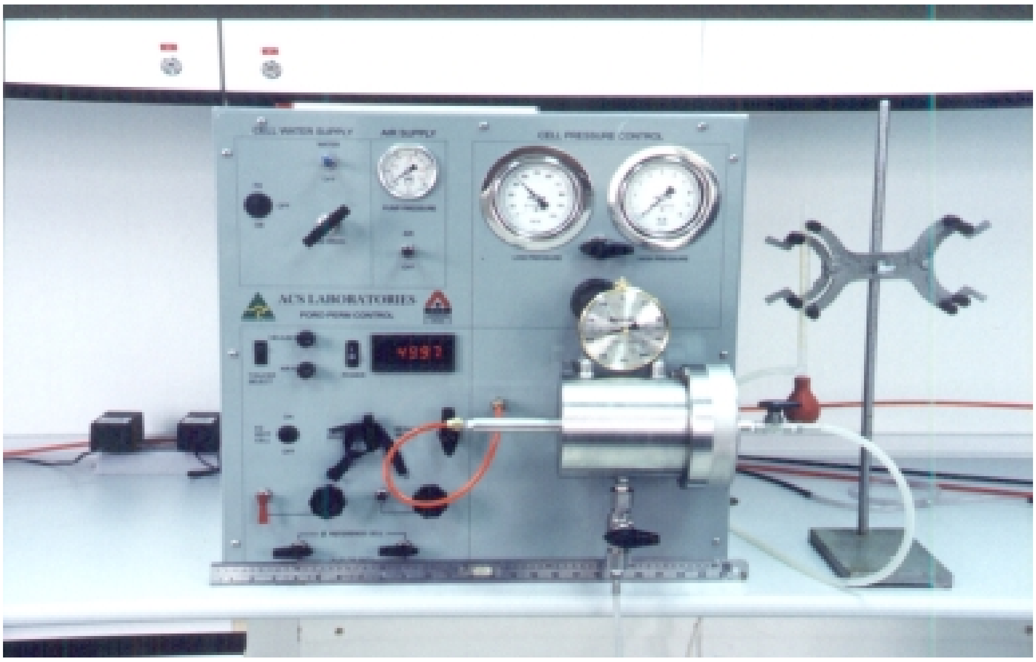


Figure 3.6 The overburden poro-perm cell instrument is used for testing the specimens to find permeability value**.**

c. Insert upstream platen into the rubber sleeve end, ensuring the platen is butted neatly up against the sample, and secure with retaining ring.

d. The sample holder is inserted into the hydrostatic cell, to a point where the base of the downstream end platen is flush with the lip of the cell.

e. Secure the cell by screwing on the end cap.

f. Pressure up hydrostatic cell by following this

   1) Open "OB DRAIN" valves and turned on "WATER" supply valve (blue toggle valve).

   2) Closed the drain valve at the bottom of the hydrostatic cell.

   3) When the cell is full close the "OB DRAIN" valve. A full cell will be evidenced by the noise of water draining though the drain hose at the back of the equipment.

   4) Turn on "AIR SUPPLY" valve (black toggle valve).

   5) Select the correct "CELL PRESSURE CONTROL" gauge to cover the pressure you intend to go up to.

   6) Turn the "CELL PRESSURE CONTROL" air supply regulator in a clockwise direction until the desired pressure is obtained.

   7) The cell is now pressured up and you are ready to perform your porosity or permeability tests.

3.5.3 The cell depressuring and sample unloading operations

a. De-pressure the hydrostatic cell

   1) Completely back off the "CELL PRESSURE CONTROL" air supply regulator in an anti-clockwise direction and turn off the "AIR" supply valve (black toggle valve).

2) Turn off the "WATER" supply valve (blue toggle valve).

3) Release the pressure in the cell by opening the drain valve on the bottom of the cell.

4) Open the "OB DRAIN" valve to allow the water to drain from the cell.

b. Once the water is completely drained from the hydrostatic cell, unscrew the cell end cap and remove the sample holder from the cell.

c. Remove the retainer rings and the end platens from the rubber sleeve and extract the sample. It is important to have a towel handy at this point to wipe excess water from the sample holder as you remove the sample to stop the sample getting wet.

3.5.4 The details of the overburden poro-perm cell equipment

a. Air and water supply plumbed into the instrument. Overburden poro-perm cell - equipped with a hydrostatic cell with necessary pressure gauges. An air driven hydraulic is pumped to allow permeability measurements to be made at high confining pressures. It includes the following components:

1) Valves to control and direct gas and water flow.

2) Regulator to control gas pressure.

3) Stainless steel hydrostatic cell to withstand 10,000 psi.

4) An air driven hydraulic pumps to pressure up the cell.

5) Pressure gauges to monitor cell pressure.

6) Rubber sleeve and stainless steel end pieces to hold the sample in the cell.

b. A series of calibrated flow tubes of different volumes to monitor the flow rate of air through the plug (unit - cm^3/sec).

c. Stop Watch.

d. Vernier calipers to measure the plug dimensions (unit-cm).

e. Thermometer.

3.5.5 The permeability measurement procedures

a. The plug sample is measured the dimensions. The sample must be a right cylinder. The length and diameter of the plug are taken several measurements of with vernier calipers. The average length (L) and diameter (D) of the sample are recorded in centimeters to two decimal places.

b. Turn on external air and water supply.

c. Turn on the electronics "POWER" switch and warm up 5 -10 minutes.

d. Switch "TRANSDUCER SELECT" switch to "AIR Ka"

e. Switch "TRANSDUCER SELECT" valve to "Ka"

f. Switch "REGULATOR SELECT" valve to "Ka"

g. Zero the digital readout by adjusting the "AIR Ka" potentiometer.

h. Load the sample into the sample holder assembly and load into the hydrostatic cell.

i. Fill the hydrostatic cell with water; ensure the correct "CELL PRESSURE CONTROL" gauge is selected.

j. Pressure up to the desired overburden pressure.

k. Connect and tighten the supply tube to the upstream side of the cell.

l. Open the vent valve on the down streamside of the cell.

m. With the valves on either side of the "Ka FLOW PATH" open, turn on the air supply valve (black toggle valve).

n. Attach the bubble tube, via a rubber hose, to the down stream end of the hydrostatic cell, that is the downstream end of the sample. The bubble tube must be clean and wet before a measurement is made. The rubber hose must be checked regularly during testing to ensure it is not partially blocked with water from the bubble tube or sand from friable samples.

o. Adjust the "AIR" regulator (upstream pressure -P_1) to obtain the desired flow rate. A very high flow rate causes turbulence in the airflow that leads to inaccurate results. Ideally the upstream pressure and flow tube should be chosen in conjunction to achieve a repeatable flow-rate measurement of around 20 second, (e.g. 1 psig upstream pressure / flow volume of 100 cm^3/ flow time of 20 seconds).

p. Once a stabilized flow-rate is established record the following;

   1) Upstream Pressure (p_1) – psig
   2) Flow Volume - cm^3
   3) Flow Time – second
   4) Barometric Pressure – atmosphere
   5) Temperature - °C

q. On completion of the test, the "AIR" supply valve is turned off, the supply tube is disconnected from the upstream side of the hydrostatic cell and disconnect the flow tube on the down stream side of the cell.

r. Depressurise the hydrostatic cell is. The cell is allowed to drain. The sample holder is removed and the sample is removed from the sample holder.

Overburden permeability can be determined at numerous confining pressures by increasing the confining pressure prior to each flow measurement.

3.5.6 Overburden permeability calculations

The following equation (a form of Darcy's Law) is used to calculate permeability. All pressures need to be in unit of atmosphere (atm):

$$K_{gas} = \frac{2000 \times BP \times \mu_{gas} \times Q \times L}{[(P_1 \times 0.06805 + BP)^2 - (BP)^2] \times A}, \qquad (3.8)$$

$$K_{gas}(\text{actual}) = K_{gas}(\text{apparent}) \times 0.9716. \qquad (3.9)$$

Where BP is barometric pressure in the atmosphere unit (BP millibar x 0.0009869 = BP atmosphere). μ_{air} or μ_{N2} is the viscosity of gas which varies with temperature. The unit is centipoises. Q is flow rate that measured from flow volume (cm^3) divided by flow time (sec). L is the length of plug. The unit is centimeter (cm). P_1 is the upstream pressure. The unit is psig. 0.06805 is conversion factor for psi to atmosphere. A is an cross sectional area of plug. It is calculated from π(D/2). 0.9716 is conversion factor for the expansion of air due to saturation with water vapor in the bubble tube.

$$\mu_{air} = -8 \text{ x } 10^{-7}\, T^2 + 8 \text{ x } 10^{-5}\, T + 0.0171, \qquad (3.10)$$

$$\mu_{N2} = -8 \text{ x } 10^{-7}\, T^2 + 8 \text{ x } 10^{-5}\, T + 0.0158, \qquad (3.11)$$

where T is the temperature. The unit is Celsius degree (°C).

Table 3.4 Permeability measurement.

Stop	L(cm)	D (cm)	A (cm^2)	Temp (°C)	mg	P1	BP	V (cm^3)	Time(Sec)	Q (cm^3/Sec)	Kactural (mD)
1	5.005	3.835	11.55103	32	0.017541	58.08	982	0.1	226.29	0.000442	0.000265
2	5.12	3.828	11.5089	28	0.017413	55.12	987	0.1	251	0.000398	0.000267
3	5.215	3.812	11.41289	29	0.017447	58.17	984	0.1	240.51	0.000416	0.000261
4	5.192	3.83	11.52093	28	0.017413	58.17	986	0.1	319.24	0.000313	0.000194
5	4.977	3.833	11.53898	32	0.017541	58.33	982	0.1	429.75	0.000233	0.000138
6	5.057	3.827	11.50289	27	0.017377	57.8	986	0.1	309.84	0.000323	0.000197
7	5.035	3.833	11.53898	30	0.01748	57.78	983	0.1	239.66	0.000417	0.000254
8	5.002	3.822	11.47285	30	0.01748	55.15	983	0.1	186	0.000538	0.000353
9	5.068	3.823	11.47885	27	0.017377	55.45	987	0.1	67.13	0.00149	0.000978
10	5.145	3.813	11.41888	28	0.017413	57.81	986	0.1	277.3933	0.00036	0.000226
11	5.127	3.83	11.52093	27	0.017377	56.88	987	0.1	151.14	0.000662	0.00042
12	5.223	3.827	11.50289	26	0.017339	57.8	988	0.1	217.3533	0.00046	0.000289
13	5.145	3.82	11.46084	26	0.017339	57.78	987	0.1	257	0.000389	0.000242
14	5.233	3.827	11.50289	26	0.017339	57.65	988	0.1	174.965	0.000572	0.000362
15	5.123	3.825	11.49087	27	0.017377	57.88	987	0.1	270.92	0.000369	0.000228
16	5.098	3.818	11.44885	27	0.017377	57.74	987	0.1	290.65	0.000344	0.000213
17	5.043	3.828	11.5089	29	0.017447	57.81	983	0.1	427.98	0.000234	0.000142

3.6 Conclusions

The rock specimens are collected from Saraburi, Phetchabun, Lop Buri and Loei provinces. They are limestone and dolomite. 17 limestone specimens are analyesd. The porosity of specimen is determined by using the porosimeter. The average porosity value is 4% for limestone specimen. The permeability of specimen is determined by using the overburden poro-perm cell. The average permeability value is 0.000296 mD, but it cannot be used to represent the permeability value in reservoir because the permeability value in outcrop and reservoir are difference. The outcrop were cemented. The core with natural fracture as in reservoir could not be collected and tested. The permeability values used in simulator are come from assumption, well test data, collection data in reference papers and simulation history match. The average permeability is 0.2 mD.

CHAPTER 4

TANK MODEL

4.1 Theory

The concepts and techniques of flow equation in porous media and circular pipe are applied for creating Tank model. The Tank model is used for analyzing the behavior of petroleum reservoir system. It is developed in Visual Basic 6 program, which runs on Window. Flowchart of Tank model and step summary of Tank model are shown in Figures 4.1 and 4.2.

4.2 Fundamental of Tank model

The gas reservoir is represented by Tank model. It uses flow equation, material balance and others by following conditions.

1) Gas flow equation
   - Flow in porous media
   - Flow in circular pipe
2) Material balance
   - Material balance of gas reservoir
3) Gas properties
   - Compressibility factor of gas
   - Gas formation volume factor
   - Gas viscosity

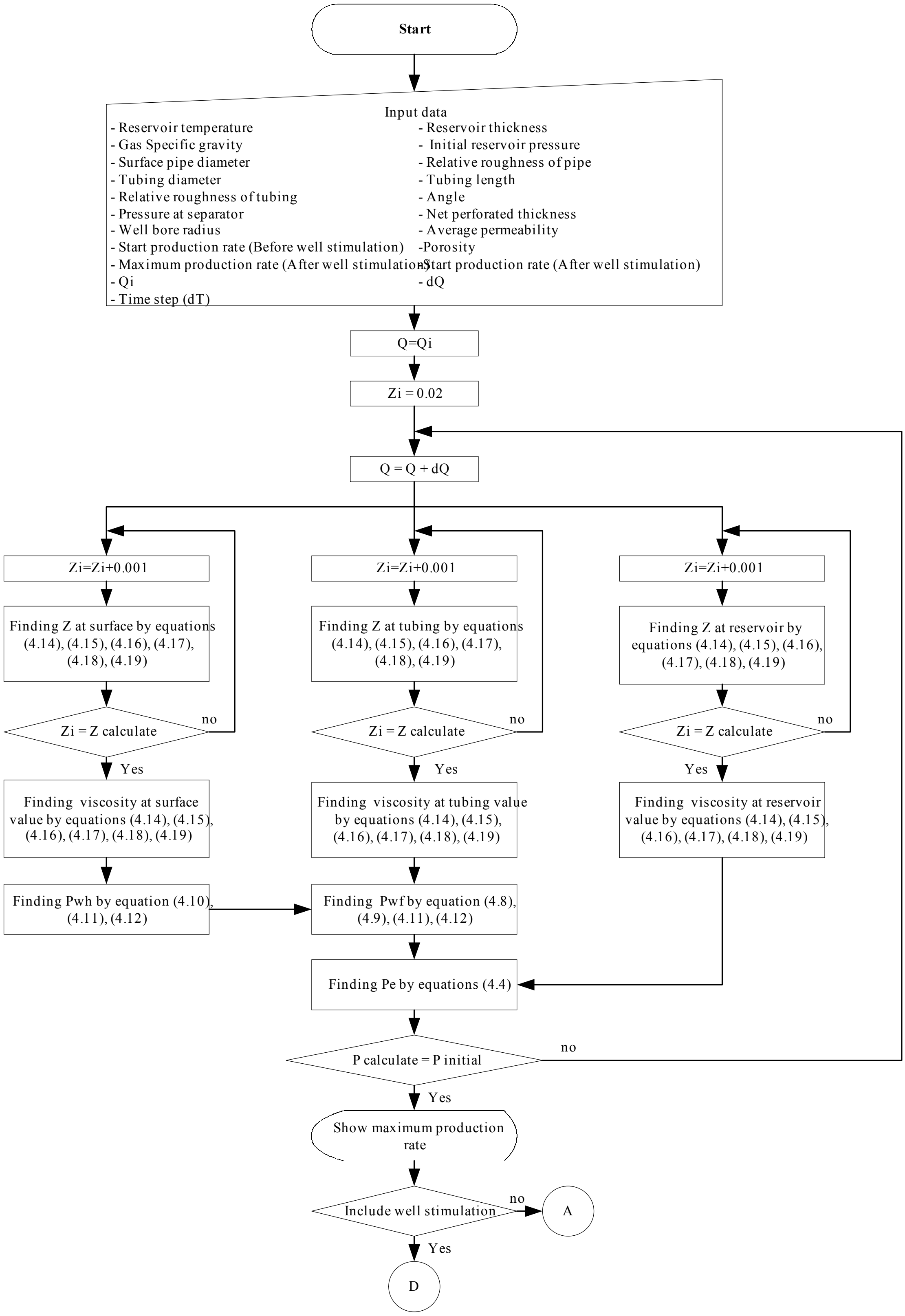


Figure 4.1 Flowchart of Tank model.

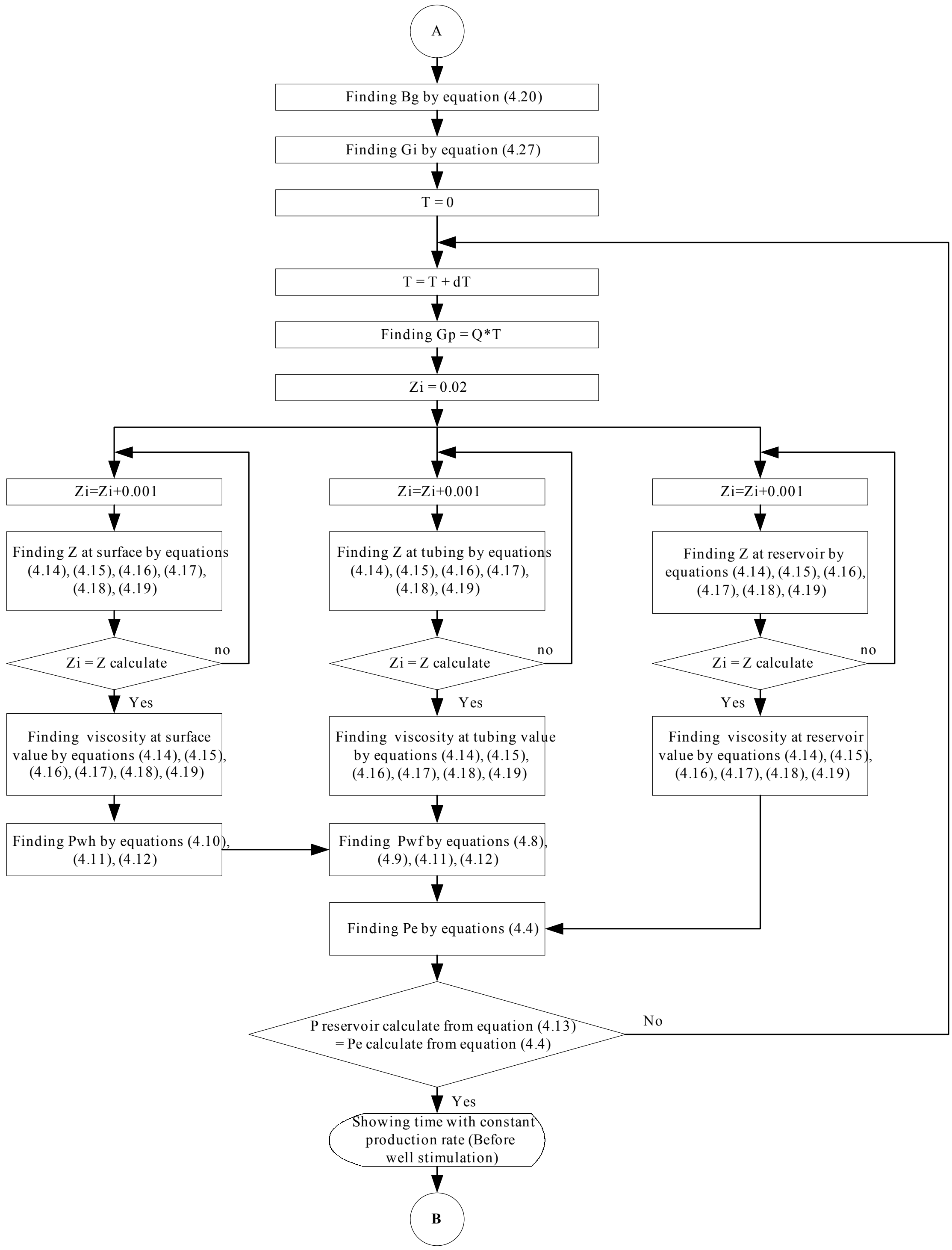


Figure 4.1 Flowchart of Tank model. (continued)

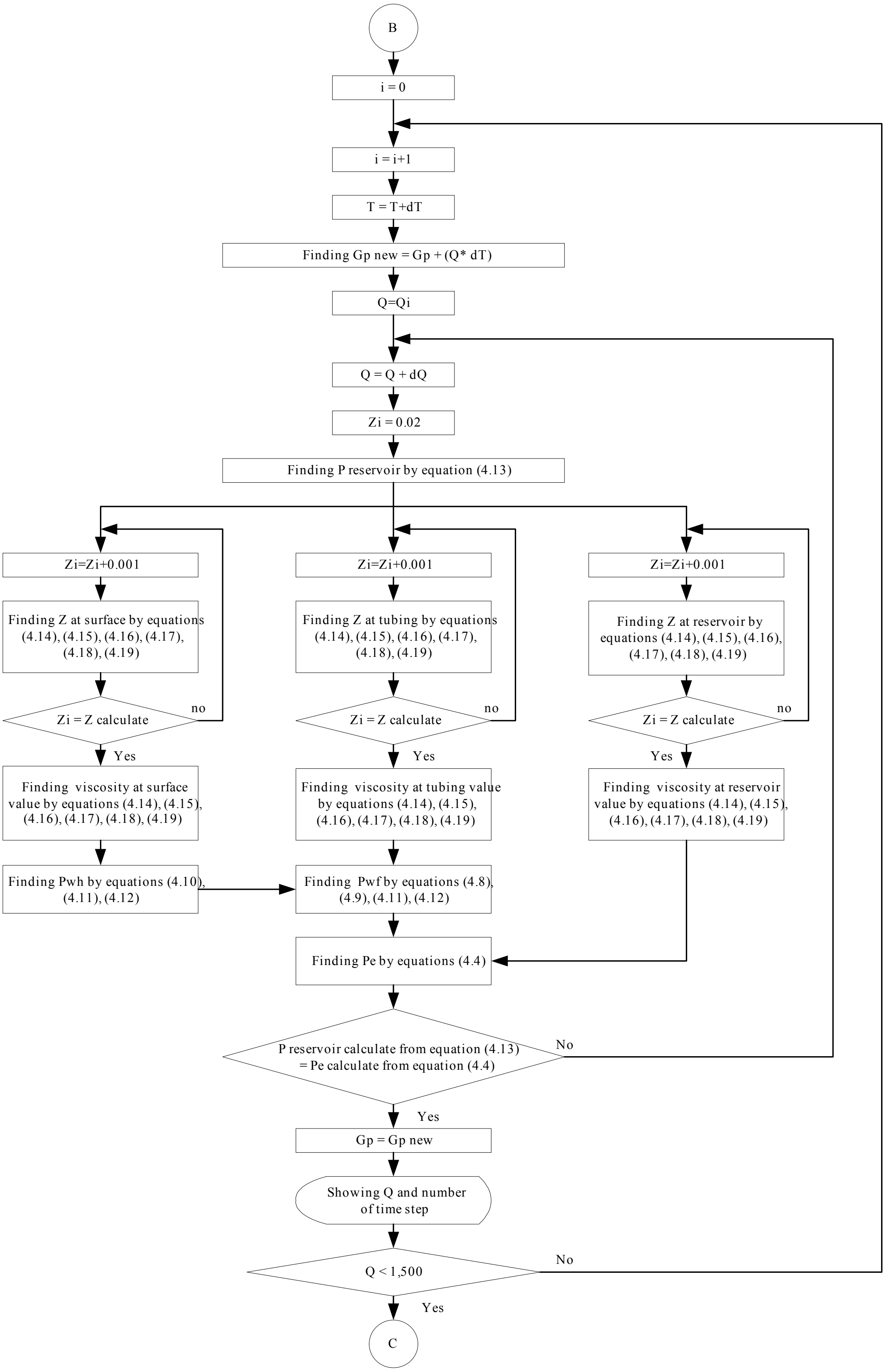


Figure 4.1 Flowchart of Tank model. (continued)

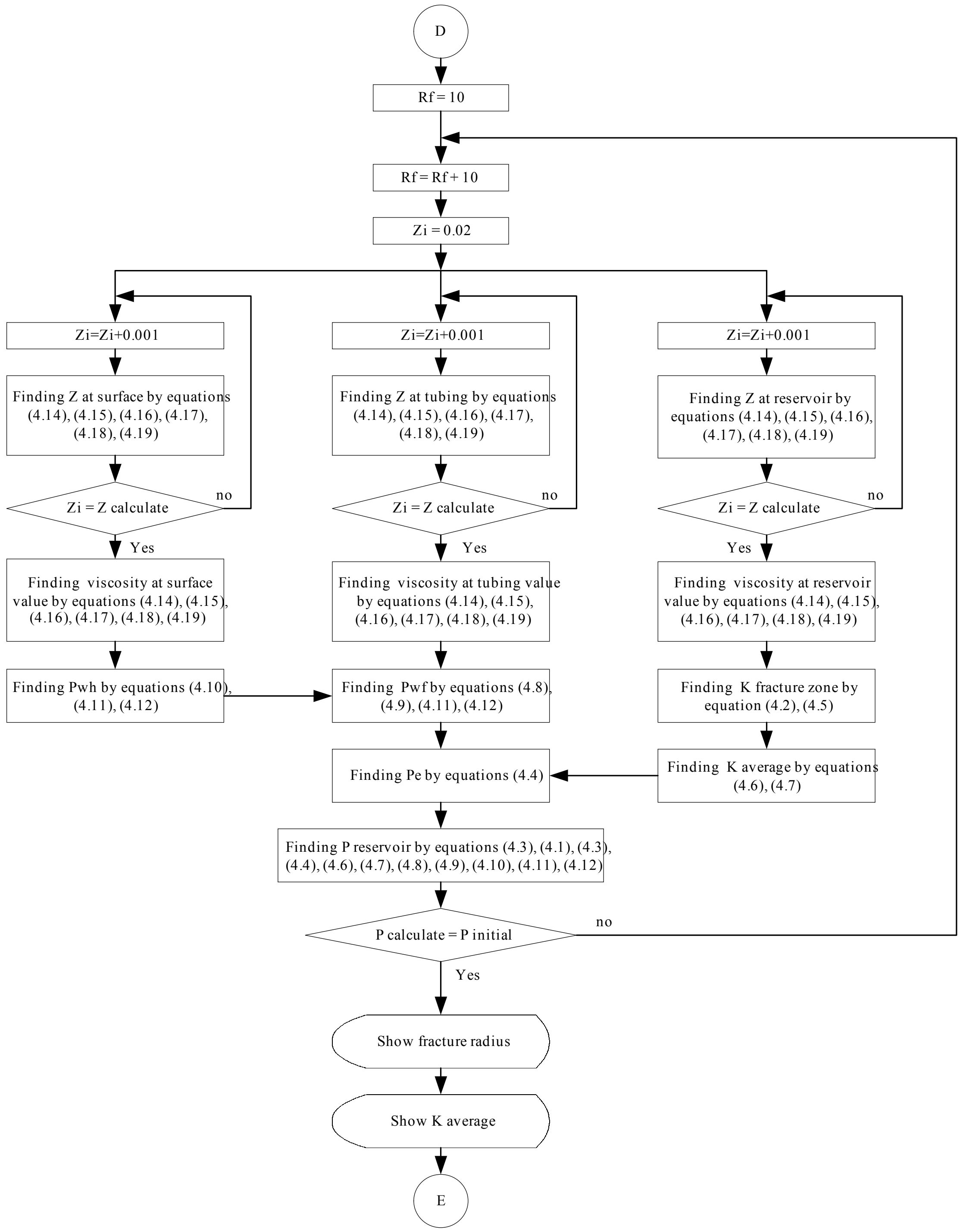


Figure 4.1 Flowchart of Tank model. (continued)

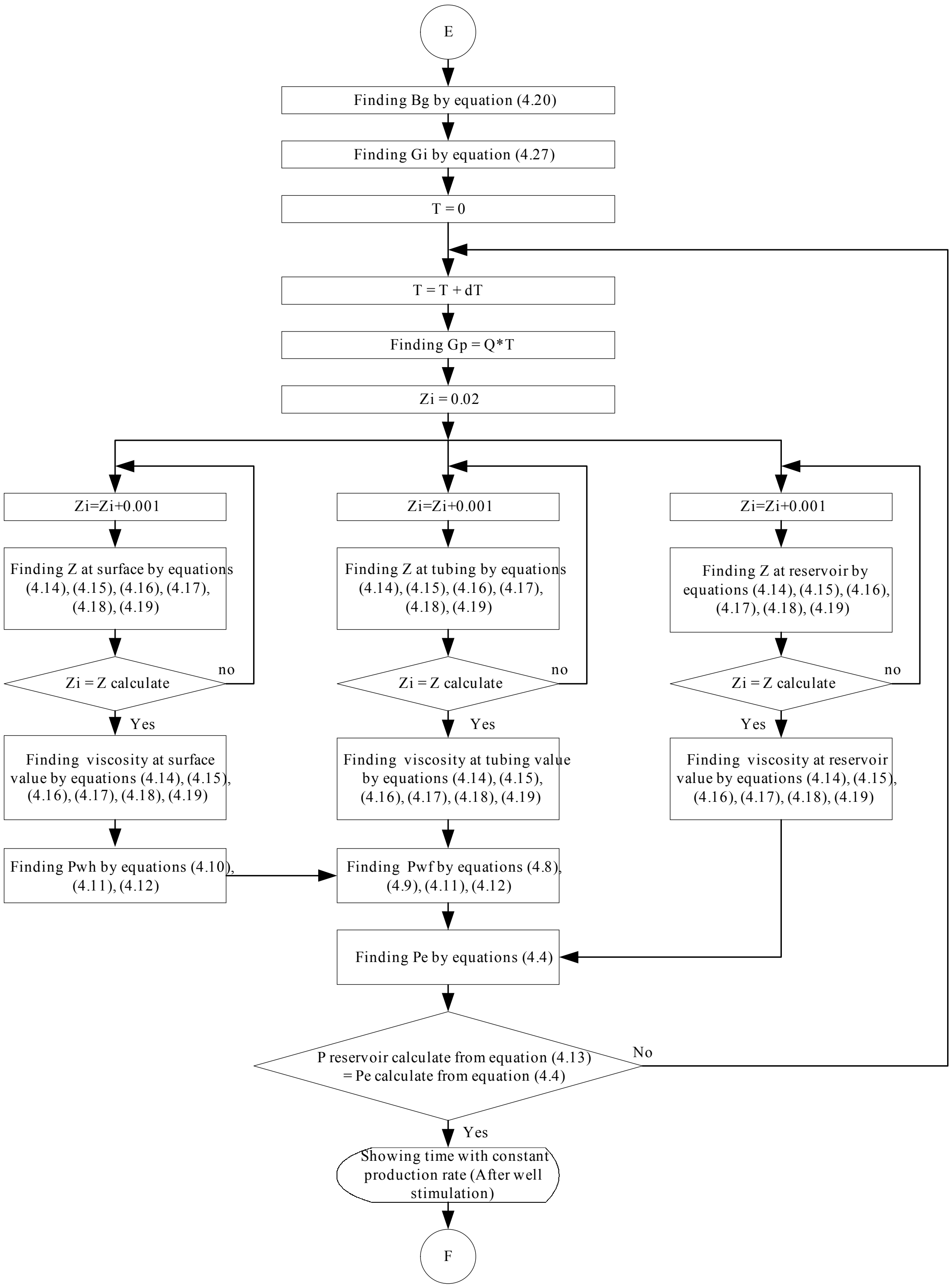


Figure 4.1 Flowchart of Tank model. (continued)

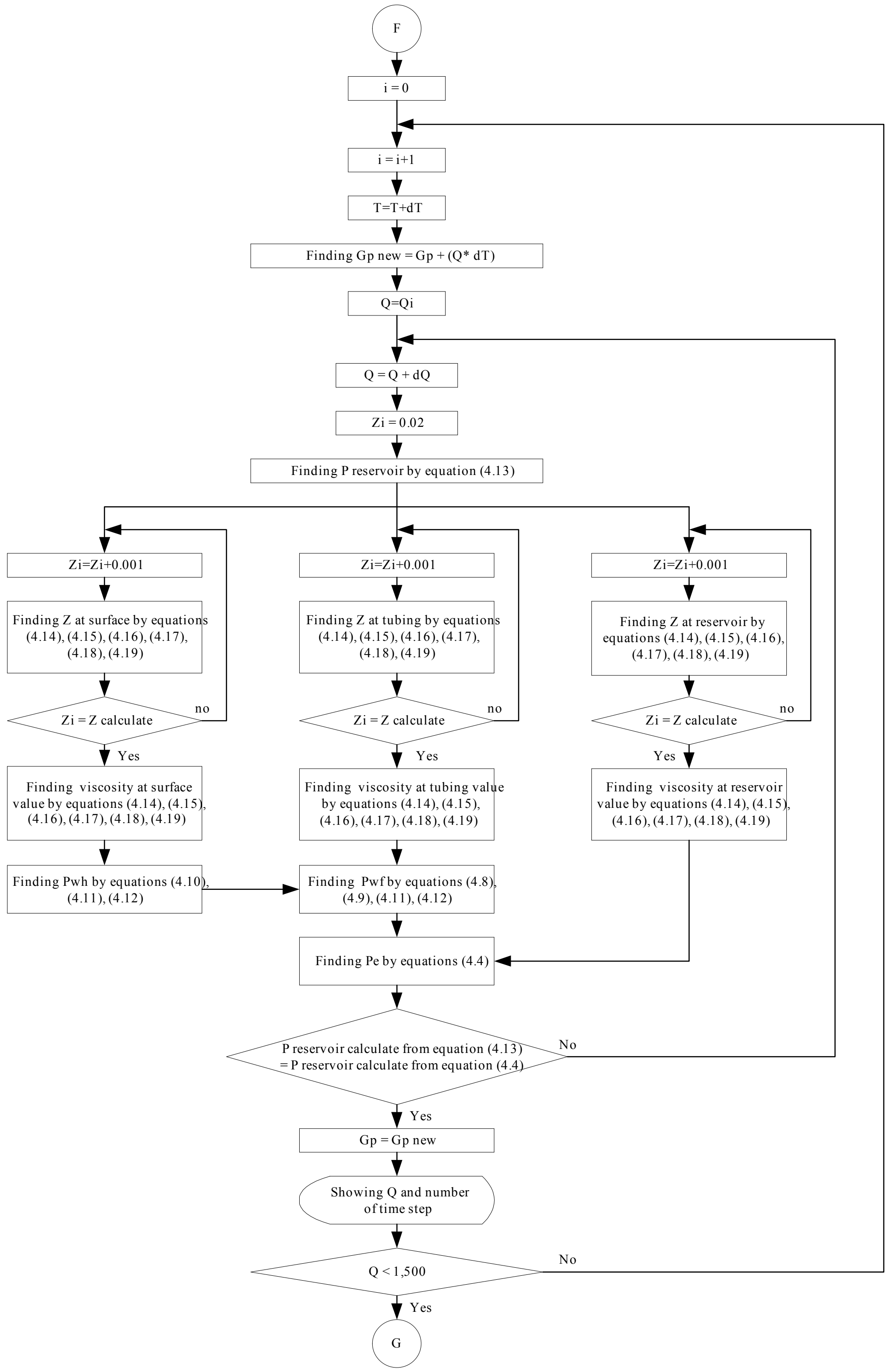


Figure 4.1 Flowchart of Tank model. (continued)

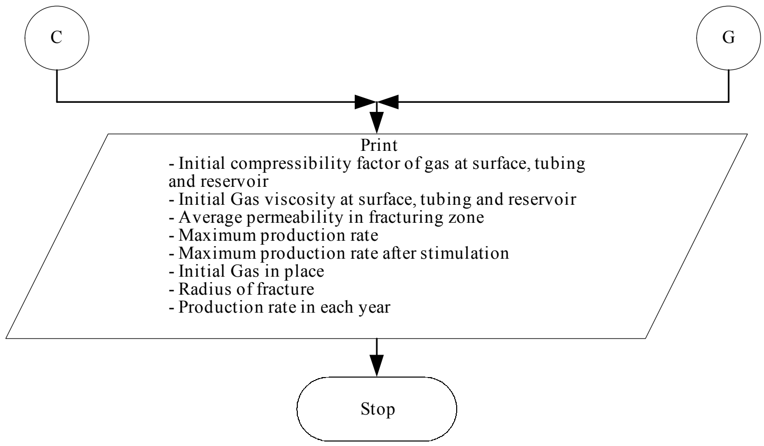


Figure 4.1 Flowchart of Tank model. (continued)

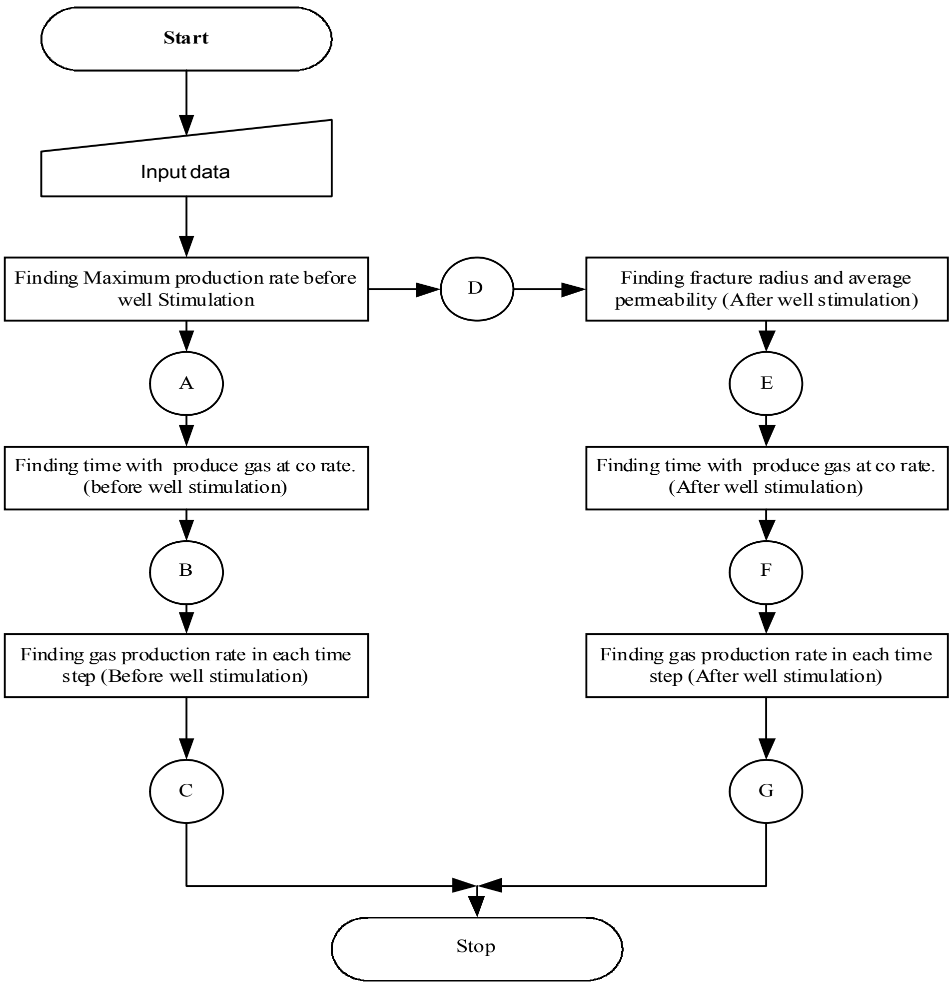


Figure 4.2 Step summary of Tank model.

Volume metric equation

- Initial gas in place

Gas flow equation

Linear Flow of compressible fluid, steady state

$$q = \frac{0.003164 T_{sc} A_c K \ (P_1^2 - P_2^2)}{P_{sc} T L Z \mu} \qquad (4.1)$$

Permeability of fracture

$$k_f = 7.7(10)^{12} W^{12} \qquad (4.2)$$

Linear flow of compressible fluid, steady state

$$q = \frac{0.003164 T_{sc} A_c K_f (P_1^2 - P_2^2)}{P_{sc} T L Z \mu} \qquad (4.3)$$

Radial flow of compressible fluid, steady state

$$q = \frac{0.01988 T_{sc} K h (P_1^2 - P_2^2)}{P_{sc} T (Z\mu) \ln(r_2 / r_1)} \qquad (4.4)$$

Permeability Variation in fracturing zone

$$K_{fz} = \frac{0.006328 W_f K_f \ln(r_f / r_w)}{0.01988 (r_f - r_w)} + K \qquad (4.5)$$

Permeability Variation in radial flow

$$K_{avg} = \frac{K_a K_e \ln(r_e / r_w)}{K_a \ln(r_e / r_a) + K_e \ln(r_a / r_w)} \qquad (4.6)$$

Permeability Variation parallel flow with the same bed width

$$K_{avg} = \frac{\sum K_i h_i}{\sum h_i} \qquad (4.7)$$

Single – phase flow of a compressible, Newtonian fluid

For vertical flow

$$P_2^{\,2} = \frac{e^{s}P_1^{\,2} + (2.685\times10^{-3})f(ZTq)^2(e^{s}-1)}{\mathrm{Sin}\theta D^{5}}, \tag{4.8}$$

$$S = \frac{-0.0375\gamma_g \mathrm{Sin}\theta L}{ZL}. \tag{4.9}$$

For horizontal flow

$$p_1^{\,2} - P_2^{\,5} = (4.195\times10^{-6})\frac{\gamma_g ZTq^2}{D^4}\left(\frac{24fL}{D} + \ln\frac{P_1}{P_2}\right). \tag{4.10}$$

Friction factor equation

$$\frac{1}{\sqrt{f}} = -4\log\left\{\frac{\in}{3.7065} - \frac{5.0452}{N_{Re}}\log\left[\frac{\in^{1.1098}}{2.8257} + \left(\frac{7.149}{N_{Re}}\right)^{0.8981}\right]\right\}. \tag{4.11}$$

Reynolds number

$$N_{Re} = 20.09\frac{\gamma_g q}{D\mu}. \tag{4.12}$$

Gas Material balance equation

$$\frac{P}{Z} = -\frac{P_i}{Z_i G}G_p + \frac{P_i}{Z_i}. \tag{4.13}$$

Gas properties

Compressibility factor of gas

$$P_{pc} = 702.5 - 50\gamma_g, \tag{4.14}$$

$$T_{pc} = 167 + 316.67\gamma_g, \tag{4.15}$$

$$\rho_{pr} = 0.27\frac{P_{pr}}{ZT_{pr}}, \tag{4.16}$$

$$P_{pr} = \frac{P}{P_{pc}}\ , \tag{4.17}$$

$$T_{pr} = \frac{T}{T_{pc}}, \tag{4.18}$$

$$Z = 1 + \left(A_1 + \frac{A_2}{T_{pr}} + \frac{A_3}{T_{pr}^{\ 3}}\right)\rho_{pr} + \left(A_4 + \frac{A_5}{T_{pr}}\right)\rho_{pr}^{\ 2} + \left(\frac{A_5 A_6 \rho_{pr}^{\ 5}}{T_{pr}}\right)$$

$$+ \left(\frac{A_7 \rho_{pr} 2}{T_{pr}^{\ 3}}\right)\left(1 + A_8 \rho_{pr}^{\ 2}\right)\exp\left(-A_8 \rho_{pr}^{\ 2}\right). \tag{4.19}$$

Where A_1 = 0.31506237, A_2 = -1.0467099, A_3 = -0.57832729, A_4 = 0.53530771, A_5 = -0.61232032, A_6 = -0.10488813, A_7 = 0.68157001, A_8 = 0.68446549.

Gas formation volume factor

$$B_g = 0.2828\frac{ZT}{P}. \tag{4.20}$$

Gas viscosity

$$\mu = 10^{-4} K \exp\left(x \rho_1^{\ y}\right). \tag{4.21}$$

Where

$$K = \frac{(9.4 + 0.62M)T^{1.5}}{209 + 19M + T}, \tag{4.22}$$

$$X = 3.5 + \frac{986}{T} + 0.01M\ , \tag{4.23}$$

$$Y = 2.4 - 0.2X\ , \tag{4.24}$$

$$M = 28.964\gamma_g, \tag{4.25}$$

$$\rho_1 = \left(1.4926 \times 10^{-3}\right)\frac{PM}{ZT}. \tag{4.26}$$

Initial gas in place

$$G_i = \frac{43{,}560 A \phi (1 - S_w) h}{B_g}. \tag{4.27}$$

4.3 Benefits of Tank model

1) All data are compiled pertinent to a reservoir into one compact database.
2) Tank model predicts reservoir production rate and reservoir pressure in the future.
3) It can be utilized as the management tool for selecting development plan and operational changes.

4.4 Data preparation of the Tank model

The groups of data generally required in making Tank model run are as following:

a. Reservoir data
   - Temperature
   - Pressure

b. Fluid data
   - Specific gravity of gas
   - Water saturation

c. Rock data
   - Porosity
   - Permeability

d. Pipe data
   - Pipe diameter
   - Pipe length
   - Pipe relative roughness

e. Tubing data

- Tubing diameter
- Tubing length
- Pipe relative roughness
- Angle

f. Other data

- Pressure at separator
- Surface temperature
- Net perforated thickness
- Well boor radius
- Reservoir radius
- Maximum production rate limit after well stimulation
- Net thickness of fracture

g. Performance

- Initial production rate
- Initial production rate limit after well stimulation

4.5 Input data for this Tank model

a. Reservoir data

- Reservoir temperature	640	°R
- Reservoir thickness	250	feet
- Initial reservoir pressure	4,000	Psia

b. Fluid data

- Specific gravity	0.6	
- Initial water saturated	0.2	
c. Rock data		
- Porosity	0.04	
- Permeability	0.2	md
d. Pipe data		
- Pipe diameter	4	inch
- Pipe length	200	feet
- Relative pipe roughness	0.001	
e. Tubing data		
- Tubing diameter	4	inch
- Tubing length	7000	feet
- Pipe relative roughness	0.001	
- Angle	90°	
f. Other data		
- Pressure at separator	400	Psia
- Surface temperature	520	°R
- Net perforated thickness	250	feet
- Well bore radius	0.3	feet
- Reservoir radius	2500	feet
- Maximum production rate limit after stimulation	25	MMSCF/D
- Net thickness of fracture	200	feet
g. Performance		

- Initial production rate after stimulation is set at 12,000 MSCF/D

4.6 Tank model

Tank model was designed for 50 BCF/Well gas in place and 1,200 feet thicken. It covers area about 640 Acres. The top structure of model is at 6,000 feet depth. The output data from prospect Tank model running results are following:

Initial compressibility factor of gas at Surface	0.9350	
Initial Gas viscosity at surface	1.1353E-02	Cp
Initial average Compressibility factor of gas in tubing	0.9370	
Initial Gas viscosity in tubing	1.5954E-02	Cp
Initial Compressibility factor of gas in reservoir is	0.9440	
Initial Gas viscosity in reservoir	0.0216 Cp	
Average permeability in fracturing zone	19	md
Maximum production rate	4800	MSCF/D
Maximum production rate after stimulation	25	MMSCF/D
Initial Gas in place	52195.4814	MMSCF
Radius of fracture	540	feet

Tank model reservoir in three dimensions is shown in Figure 4.3 The production rate of each well is shown in Tables 4.1 and 4.2. Figures 4.4 through 4.6 show the prospect Tank model running results. Source codes of Tank model are shown in Appendix B.

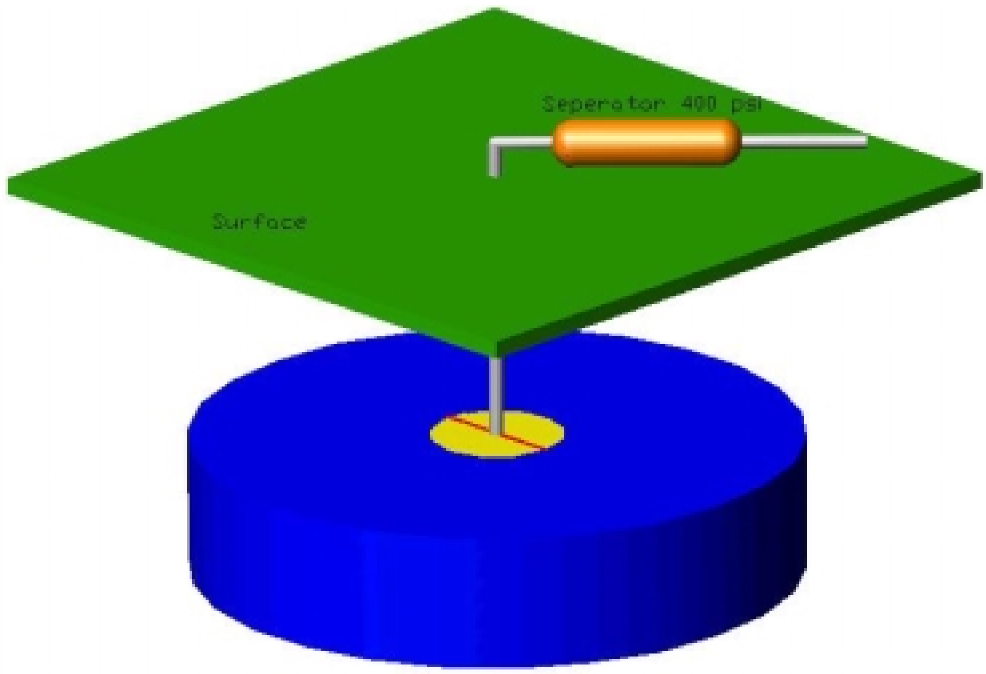


Figure 4.3 Tank model shape of reservoir in three dimensions.

Table 4.1 Gas production rate of each well is started at the 1st year and ended at the 24th year of production. (Without well stimulation)

Year	Production Rate (MSCF/D)	Pressure (Psia)
1	3500	3877.60
2	3500	3755.70
3	3500	3636.92
4	3500	3521.08
5	3484	3417.31
6	3270	3310.22
7	3080	3211.61
8	2908	3120.38
9	2752	3035.59
10	2608	2956.49
11	2478	2882.46
12	2358	2812.94
13	2248	2747.49
14	2146	2685.69
15	2052	2627.23
16	1964	2571.78
17	1882	2519.09
18	1806	2468.95
19	1734	2421.12
20	1668	2375.46
21	1604	2331.78
22	1544	2289.94
23	1488	2249.83

Table 4.2 Gas production rate of each well is started at the 1st year and ended at the 18th year of production. (After well stimulation)

Year	Production rate (MSCF/D)	Pressure (Psia)
1	12000	3586.93
2	12000	3204.66
3	12000	2849.06
4	9826	2563.52
5	8226	2319.17
6	6952	2119.03
7	5932	1951.92
8	5104	1810.21
9	4426	1688.51
10	3866	1582.87
11	3400	1490.36
12	3006	1408.74
13	2674	1336.23
14	2388	1271.46
15	2144	1213.32
16	1932	1160.89
17	1746	1113.44
18	1584	1070.34

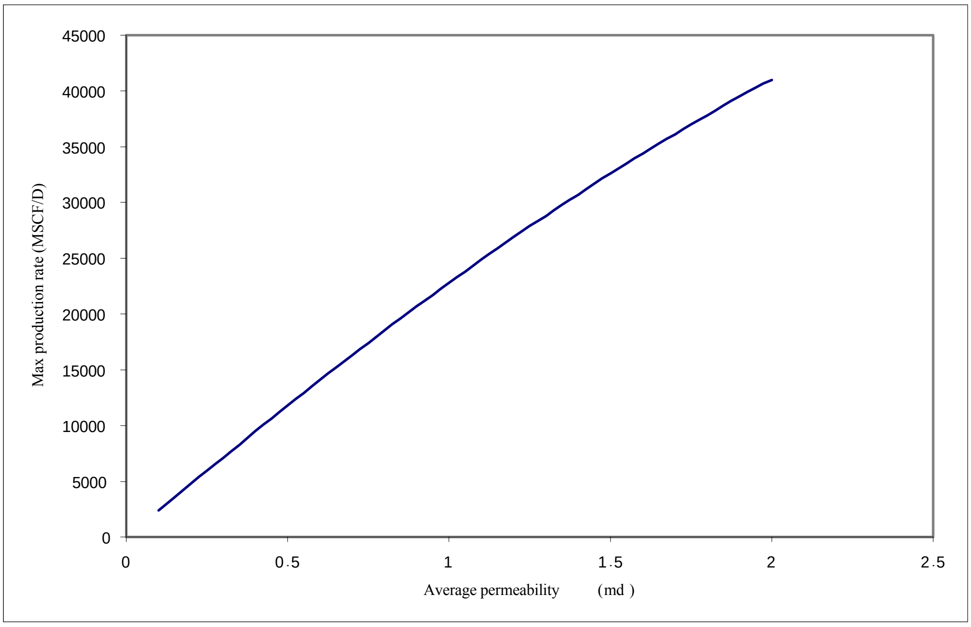


Figure 4.4 The relationship between average permeability and max production rate per well. (From prospect Tank model running result)

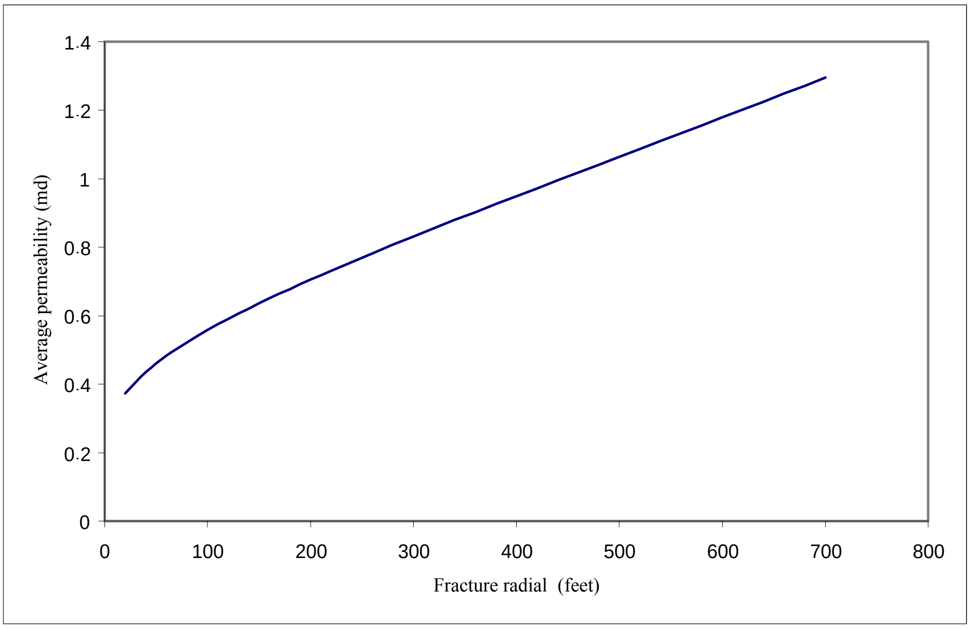


Figure 4.5 The relationship between fracture radial and average permeability. (From prospect Tank model running result)

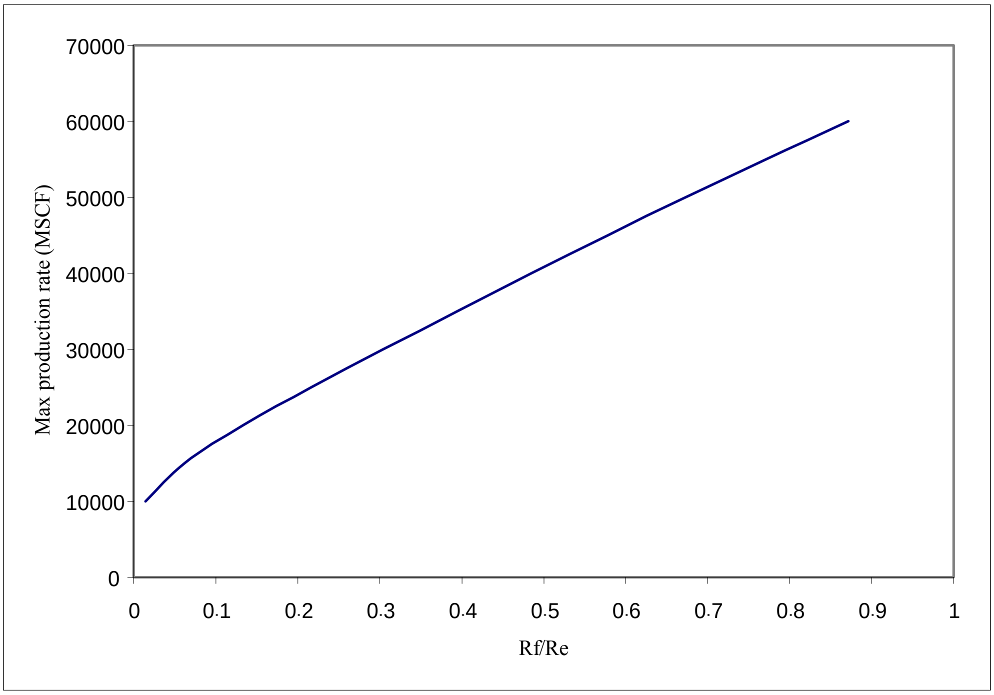


Figure 4.6 The relationship between ratio of fracture radial with reservoir radial and max production rate per well**.** (From prospect Tank model running result)

4.7 Conclusions

The Tank model is useful for determination of the petroleum production and estimate of the production rate. The top reservoir is at 6,000 feet depth. Before well stimulation the production rate is started at 3500 MSCF/D. The model produces gas with constant rate for four years. After that, the production rate declines about 4.4% in each year that are calculated from mean of rate decline in each year until the production limit at 1,500 MSCF/D is in 23rd year. After 4,440 barrel acid fracturing, the total production rate is started at 12,000 MSCF/D, and kept constant rate four years. After that, the production rate declines at about 12.6% in each year that are calculated from mean of rate decline in each year until the production rate limit at 1,500 MSCF/D is in 18thyear. The total cumulative gas production is 36.2 BCF with Gas in place is 50 BCF with the recovery factor of 73%.

CHAPTER 5

WELL STIMULATION PROCESS

5.1 Theory

Well stimulation process is the method creating to increase productivity. It can increase production rate by enlarging old channels or creating new ones of sand or limestone formation. Stimulation may be divided into three main class as matrix acidizing ,hydraulic fracturing and fracture acidizing. Matrix acidizing involves the acid injection into the formation. Hydraulic fracturing involves the injection of a fracturing fluid and propping agent into the formation under sufficient pressure to open existing fractures or create new ones. An acid-soluble pay is dissolving action to enlarge existing voids, and thereby increases the permeability of the zone. Fracture acidizing involves the high hydraulic pressure injection and the acid is forced into the formation to cause a fracture.

5.2 Fundamental of well stimulation

a) Matrix acidizing

Matrix acidizing is designed to remove formation damage, there are improving the permeability of the near-wellbore formation. Sandstone reservoirs are normally treated with hydrofluoric acid and limestone reservoirs are practiced with hydrochloric acid. The acid is pumped slowly through the matrix of the reservoir, taking care not to exert enough pressure to fracture the reservoir. The acid commonly used is 15 percent of hydrochloric by weight reacts with limestone or other carbonate according to the following equation:

$$2HCl + CaCo_3 \rightarrow CaCl_2 + H_2O + CO_2$$

b) Hydraulic fracturing

Hydraulic fracturing is the most effective stimulation treatment for the sandstone typically encountered in older, more consolidated continental sediments. Unconsolidated sandstone typical of coastal sediments normally have very high permeability and do not need stimulation.

Several thousand pounds of surface pressure are usually needed to break down the formation. The fracturing fluid is typically gelled water, using polymers to limit leak-off in to the surrounding formation. This keeps sand-face pressures high enough to extend the fracture hundreds of feet. The gel also makes the water slippery, which reduces friction loss, lowering horsepower requirements.

Once the fracture is extended enough, a propping agent-often large rounded sand grains-which is in traduced in to the gelled fluid is begin to pump. The gel transports the proppant in suspension as it is pumped out into the fracture. Pumping is then stopped. As pressure dissipates, The fracture starts to heal but is held open by the proppant (Figure 5.1). When the well is brought back on production, the fluids move laterally from the formation into the fracture, then flow freely through the matrix of proppant to the wellbore.

c) Fracture acidizing

Fracture acidizing is used to stimulation production in limestone and dolomite reservoirs. These rocks are composed largely of calcium carbonate ($CaCo_3$), which dissolves in hydrochloric acid (HCl).

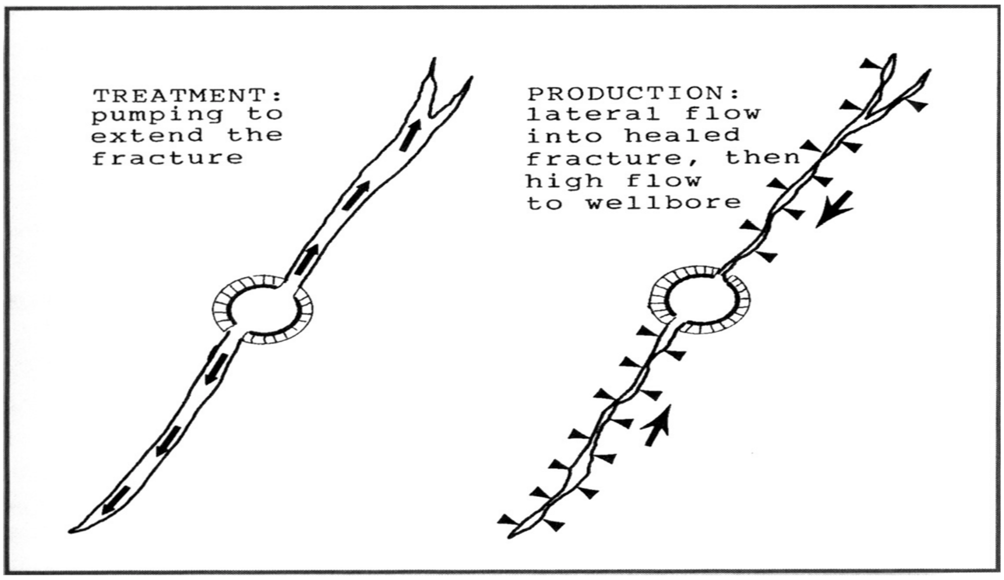


Figure 5.1 Hydraulic fracturing (After Conaway, 1999)

The treatment consists of injecting HCL at high hydraulic pressure into the formation to cause a fracture. The orientation of the fracture is roughly vertical (when the formation is > 3,000 feet depth), but may deviate from the vertical to follow pre existing fractures. As the pressure of the pumped acid extends the fractures, it chemically etches an irregular surface on the sides of the fracture. When the pump are shutdown, the fracture close black up but does not completely heal. The material removed by etching leaves a high-volume flow channel to the wellbore. The fracture changes the flow pattern around the wellbore from the radial flow to many higher volume lateral-flow patterns (Figure 5.2)

The reservoir model is created to study fracture acidizing in carbonate reservoir, it can be solved by following equations

Equation of fracture acidizing design

Fracture area

$$A_f = 2 \times R_f \times H \,. \tag{5.1}$$

The total volume injection

$$W' = W + 0.787 \frac{V_{sp}}{A_{fc}}, \tag{5.2}$$

$$X = 2C \sqrt{\frac{\pi t_s}{W'/12}} \,. \tag{5.3}$$

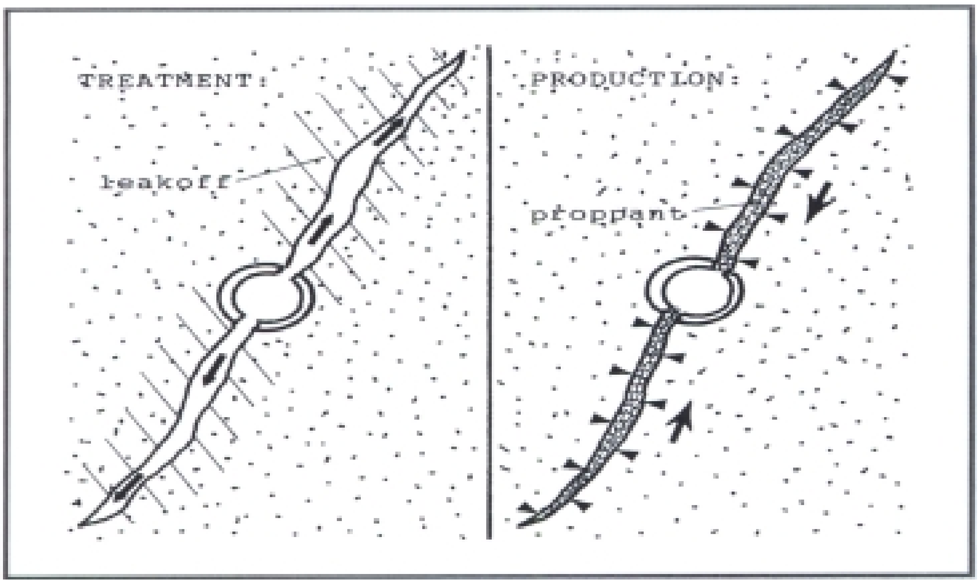


Figure 5.2 Fracture Acidizing. (After Conaway, 1999)

Figure 5.3 the fracture efficiency (EFF) show

$$V_i = \frac{7.84 \times A_f \times W'/12}{EFF/100}. \qquad (5.4)$$

The injection rate

$$q = \frac{V_i}{t}. \qquad (5.5)$$

The hydrostatic pressure

$$\Delta P_s = 0.433 \times \rho_{Acid} \times Depth. \qquad (5.6)$$

The friction pressure drop

$$v = \frac{17.16 \times q}{D^2}, \qquad (5.7)$$

$$\rho = 8.34 \times \rho_{Acid}, \qquad (5.8)$$

$$Nre = \frac{928 \times D \times v \times \rho}{\mu_{Acid}}, \qquad (5.9)$$

$$\frac{1}{\sqrt{f}} = -4 \log\left\{ \frac{\in}{3.7065} - \frac{5.0452}{N_{Re}} \log\left[\frac{\in^{1.1098}}{2.8257} + \left(\frac{7.149}{N_{Re}} \right)^{0.8981} \right] \right\}, \qquad (5.10)$$

$$\Delta P_f = \frac{f \times Depth \times \rho \times v^2}{25.8 \times D}. \qquad (5.11)$$

The surface of injection pressure

$$P_t = G_f \times Depth, \qquad (5.12)$$

$$P_s = P_t + \Delta P_f + \Delta P_s. \qquad (5.13)$$

The hydraulic horsepower required

$$Hh = 0.0245 \times P_s \times q. \qquad (5.14)$$

Source code of Fracture Acidizing design are shown in Appendix C

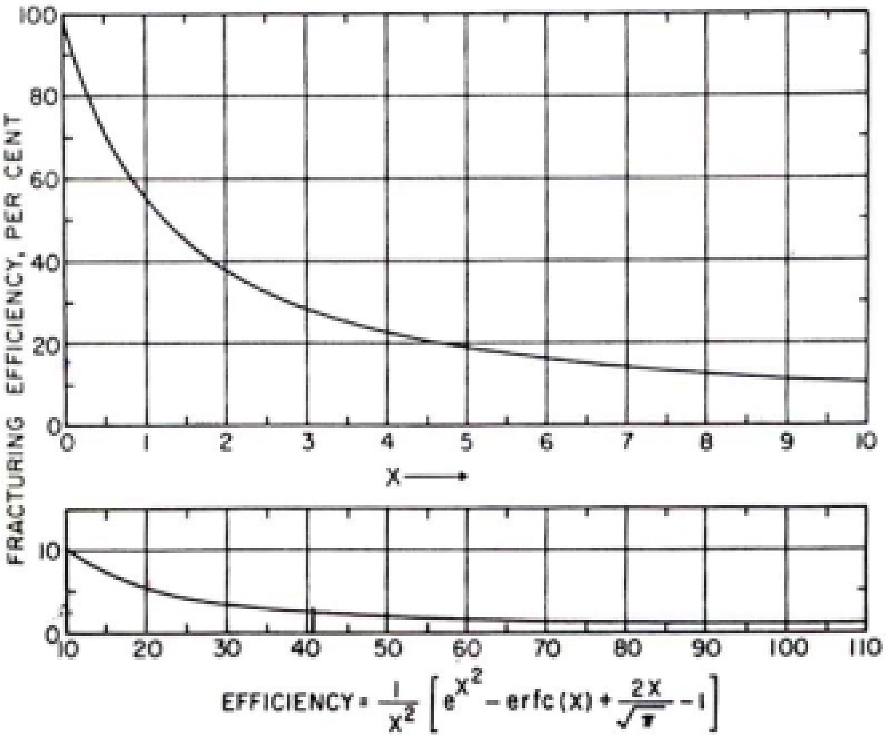


Figure 5.3 Plot of fracturing efficiency against its function. (After Craft, and Holden, 1962)

5.3 Fracture Acidizing design data preparation.

The general required data in fracture acidizing design are as following:

a) Reservoir data

- Formation thickness	1,200	feet
- Shut in bottom-hole pressure	4,000	Psia
- Well spacing	640	Acers
- Depth	6,000	feet

b) Fracture acidizing design data

- Fracture fluid coefficient	0.0005	$\text{feet}/\sqrt{\text{min}}$
- Sport loss	2	cu cm
- Area of filter press	22.8	sq/cu cm
- Acid density	1.10	gm/cu cm
- Acid viscosity	70	cp
- Spending time	180	min
- Fracture gradient	1	Psi/feet
- Fracture width	0.01	in
- Fracture radiant (From Tank model)	540	feet

- Estimate vertical extent has two local

  The first at 6,100-6,550 feet Depth

  The second at 6,650-7,100 feet Depth

c) Tubing data

- Tubing diameter	4	in
- Tubing length	6,600	feet
- Relative pipe roughness	0.001	

The flowchart of Fracture Acidizing design is shown in Figures 5.4.

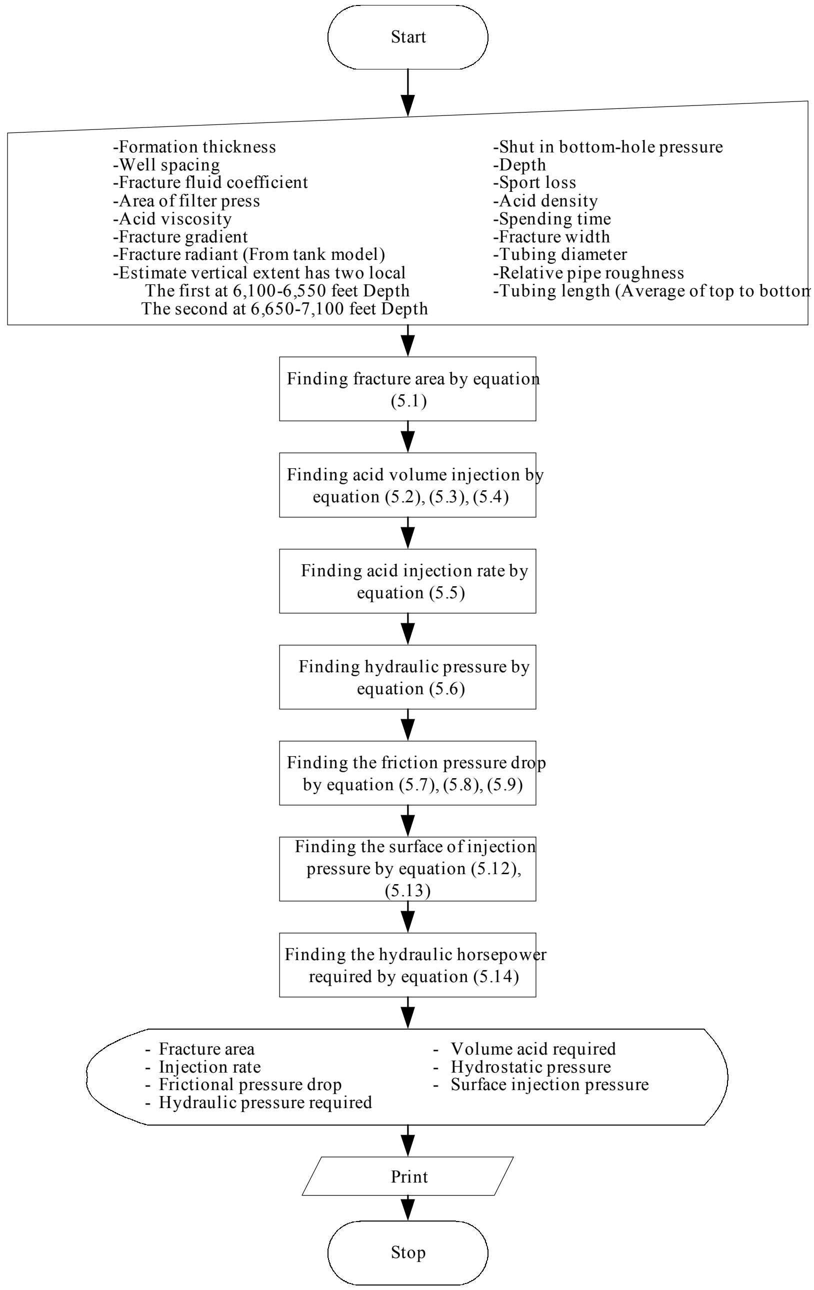


Figure 5.4 Flowchart of Fracture Acidizing design

5.4 Result of fracture Acidizing design

Fracture at 6,100-6,550 feet Depth

- Fracture area	486,000	$feet^2$
- Volume acid required	2,220.44	bbl
- Injection rate	12.34	bbl/min
- Hydrostatic pressure	3,012.49	Psia
- Frictional pressure drop	886.89	Psia
- Surface injection pressure	4,199.29	Psia
- Hydraulic pressure required	1,269.14	Hp

The relationship between fracture radiant and hydraulic pressure required at 6,100-6,550 feet depth are shown in Figure 5.5.

Fracture at 6,650-7,100 feet Depth

- Fracture area	486,000	$feet^2$
- Volume acid required	2,220.44	bbl
- Injection rate	12.34	bbl/min
- Hydrostatic pressure	3,274.56	Psia
- Frictional pressure drop	964.00	Psia
- Surface injection pressure	4,564.44	Psia
- Hydraulic pressure required	1,379.50	Hp

The relationship between fracture radiant and hydraulic pressure required at and 6,6500-7,100 feet depth are shown in 5.6. Figure 5.7 shows the relationship volume acid injection per well and max production rate per well. Figure 5.8 shows Fracture Acidizing design on Tank model.

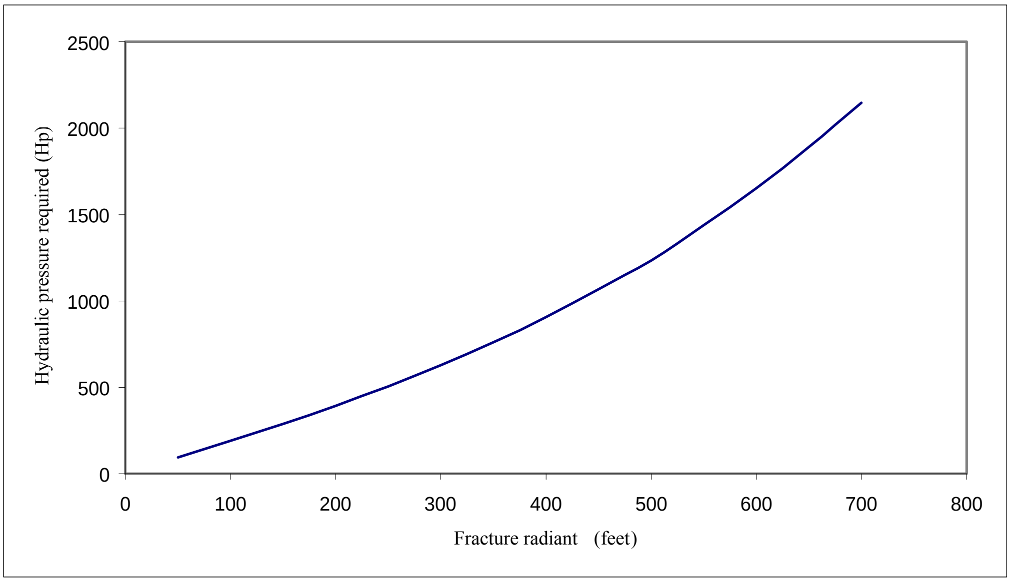


Figure 5.5 The relationship between fracture radiant and hydraulic pressure required at 6,100-6,550 feet depth. (From prospect Fracture Acidizing design running result)

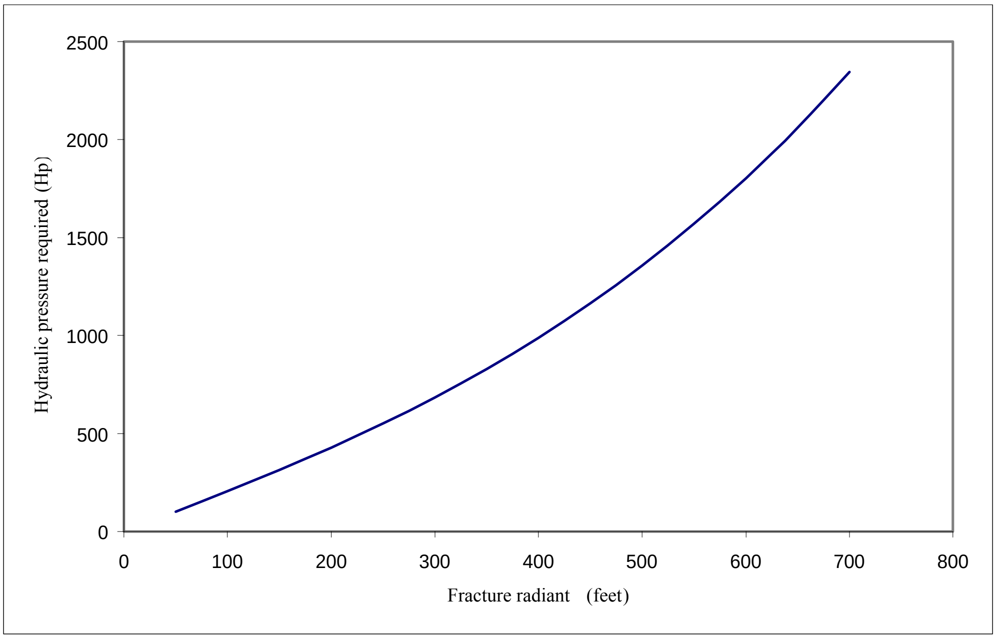


Figure 5.6 The relationship between fracture radiant and hydraulic pressure required at 6,650-7,100 feet depth. (From prospect Fracture Acidizing design running result)

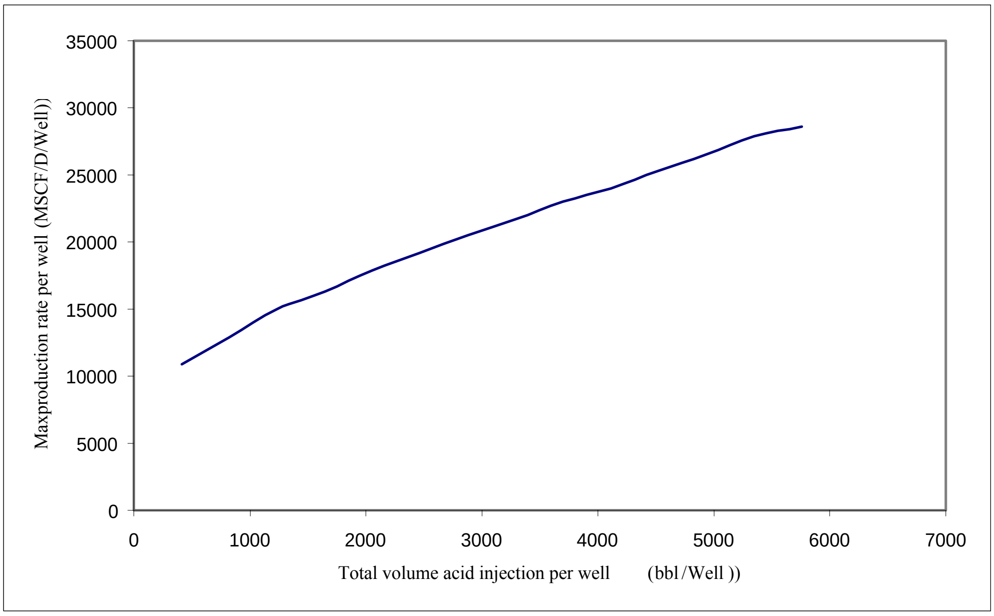


Figure 5.7 The relationship volume acid injection per well and max production rate per well. (From prospect Fracture Acidizing design running result)

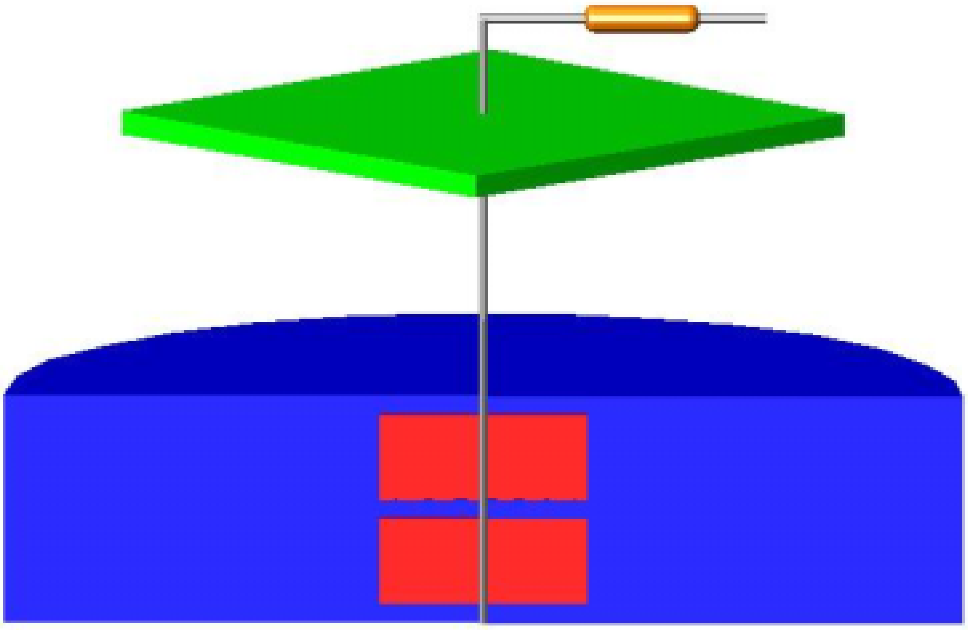


Figure 5.8 Fracture Acidizing design on Tank model**.**

5.5 Conclusions

The fracture acidizing design is the method for increasing permeability of near wellbore and production rate of carbonate reservoirs. The importance factors of this method are acid and pump horse power. The fracture acidizing process is designed in 1,200 feet of formation thickness, 4,000 Psia of shut in bottom-hole pressure, 640 Ar0ces of well spacing, 6,000 of depth to top reservoir, 180 min of acid spending time and two vertical fractures at 6,100-6,550 feet and 6,650-7,100 feet of depth, 0.01 in. of each fractures width, created fracture with radius of 540 feet. It required 4,440 bbl/well of acid and 1,200-1,400 Hp with the pumping hydraulic pressure of 4,200-4600 Psia.

CHAPTER 6

RESERVOIR SIMULATION

6.1 Theory

Reservoir simulation applies the concepts and techniques of mathematical modeling to the analysis of the behavior of petroleum reservoir systems. The simulation is a collection of computer program that implement the mathematical model on a particular computing, machine and refer only to the dynamics of flow within the reservoir.

Numerical reservoir simulators are used widely, primarily because they can solve problems that cannot be solved in any other way. Simulation is the only way to describe quantitatively the flow of multiple phases in a heterogeneous reservoir having a production schedule determined not only by the properties of the reservoir, but also by market demand, investment strategy, and government regulations. However, the usefulness of numerical models extends beyond solving difficult problems; even on simple problems, simulation is often the best solution method because it may be faster, cheaper, or more reliable than other methods.

6.1.1 Classification of reservoir simulation

Reservoir simulator is divided to:

a. Single phase reservoir simulator (liquid or gas)

b. Multiphase reservoir simulator is divided to black-oil reservoir simulator and compositional simulator

6.1.2 Black oil simulation application overview

The Petroleum WorkBench Black Oil reservoir simulator solves problems in which one, two, or three fluid phases are flowing in one, two, or three dimensions.

The black oil simulator is used the FORTRAN for writing the data details input the simulator. Black-oil simulator was the first type developed and still the most frequently used. The simulator can model the flow of water, oil, and gas. Simulator can account for pressure-dependent solubility of gas in oil, but it cannot model changes in oil or gas composition. When modern black - oil simulator is used properly, the user can be confident that the calculations will give realistic answers if the input data are complete and reasonably accurate.

6.1.3 Fundamental of reservoir simulation

a. Single-phase flow

Combining the following develops the equation governing the single-phase flow of a fluid through a porous medium:

1) Conservation of mass

2) Rate equation

3) Equation of state

Conservation of mass

Considered an element of a reservoir is through which a single phase is flowing in the x-direction. Than at any instant:

Mass rate in – mass rate out = mass rate of accumulation

$$\left(\upsilon_x \rho_x \Delta y \Delta z\right) - \left(\upsilon_{x+\Delta x} \rho_{x+\Delta x} \Delta y \Delta z\right) = \left(\Delta x \Delta y \Delta z\right) \phi \frac{\left(\rho_{t+\Delta t} - \rho_t\right)}{\Delta t} . \qquad (6.1)$$

Dividing Equation (6.1) by $\Delta x \Delta y \Delta z$:

$$-\frac{(\tilde{o}_{x+\ddot{A}x}\tilde{n}_{x+\ddot{A}x})-(\tilde{o}_x\tilde{n}_x)}{\ddot{A}x}=\frac{\ddot{o}(\tilde{n}_{t+\ddot{A}t}-\tilde{n}_t)}{\ddot{A}t}. \quad (6.2)$$

Take the limit as $\left\{\ddot{A}x\ \ddot{A}t\right\}$ go to zero simultaneously:

$$\frac{\partial(\tilde{o}\tilde{n})}{\partial x}=-\ddot{o}\frac{\partial\tilde{n}}{\partial t}. \quad (6.3)$$

This is the continuity equation in linear system. Similar:

$$\frac{\partial(\tilde{o}\tilde{n})}{\partial y}=-\ddot{o}\frac{\partial\tilde{n}}{\partial t}, \quad (6.4)$$

$$\frac{\partial(\tilde{o}\tilde{n})}{\partial z}=-\ddot{o}\frac{\partial\tilde{n}}{\partial t}. \quad (6.5)$$

Then for three-dimensional flow:

$$\frac{\partial(\tilde{o}\tilde{n})}{\partial x}+\frac{\partial(\tilde{o}\tilde{n})}{\partial y}+\frac{\partial(\tilde{o}\tilde{n})}{\partial z}=-\ddot{o}\frac{\partial\tilde{n}}{\partial t}. \quad (6.6)$$

Rate Equation

Darcy's law relates the velocity to the pressure gradient:

$$\tilde{o}=-\frac{k}{\grave{\imath}}\frac{\partial p}{\partial x}. \quad (6.7)$$

Then, substituting Equation (6.6) into Equation (6.7):

$$\frac{\partial\left(-\frac{k}{\grave{\imath}}\frac{\partial P}{\partial x}\tilde{n}\right)}{\partial x}=-\ddot{o}\frac{\partial\tilde{n}}{\partial t}. \quad (6.8)$$

Equation of state

The equation of state is needed to express the density in terms of pressure. Most of oil field liquid systems are considered to be slightly compressible. In this case, the equation of state is:

$$\tilde{n}=\tilde{n}_o e^{C(P-P_o)}. \quad (6.9)$$

Where ρ = density at pressure P, ρ_o = density at pressure P_0 and C = isothermal, compressibility factor C $= -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$.

b. Multiphase Flow

The fluid flow in the multiphase is using the derivation of multiphase flow equations. The flow for each phase is developed identically to that scheme outlined for a single-phase fluid. The fluid phase is divided to 3 types that are oil, gas and water. Gas is used in this study. A mass balance on the gas phase must include all possible sources of gas. For a linear system we can write:

Mass rate in - mass rate out = mass rate of accumulation.

Each of the sources of gas as indicated in Figure 6.1 is incorporated in the mass rate term. Thus:

$$\left[-A\left(\frac{k_g}{\mu_g B_g}+\frac{R_{so}k_o}{\mu_o B_o}+\frac{R_{sw}k_w}{\mu_w B_w}\right)\frac{\partial P}{\partial x}\right]_x - \left[-A\left(\frac{k_g}{\mu_g B_g}+\frac{R_{so}k_o}{\mu_o B_o}+\frac{R_{sw}k_w}{\mu_w B_w}\right)\frac{\partial P}{\partial x}\right]_{x+\Delta x}$$

$$= V\left[\frac{\phi\left(\frac{S_g}{B_g}+\frac{R_{so}S_o}{B_o}+\frac{R_{sw}S_w}{B_w}\right)^{n+1}-\left(\frac{S_g}{B_g}+\frac{R_{so}S_o}{B_o}+\frac{R_{sw}S_w}{B_w}\right)^{n}}{\Delta t}\right]. \qquad (6.10)$$

Which becomes in the limit:

$$\frac{\partial}{\partial x}\left[\left(\frac{k_g}{\mu_g B_g}+\frac{R_{so}k_o}{\mu_o B_o}+\frac{R_{sw}k_w}{\mu_w B_w}\right)\frac{\partial P}{\partial x}\right]=\frac{\partial}{\partial t}\left[\phi\left(\frac{S_g}{B_g}+\frac{R_{so}S_o}{B_o}+\frac{R_{sw}S_w}{B_w}\right)\right]. \qquad (6.11)$$

For a radial system the following equation is obtained:

$$\frac{1}{r}\frac{\partial}{\partial r}\left[r\left(\frac{k_g}{\mu_g B_g}+\frac{R_{so}k_o}{\mu_o B_o}+\frac{R_{sw}k_w}{\mu_w B_w}\right)\frac{\partial P}{\partial r}\right]=\frac{\partial}{\partial t}\left[\phi\left(\frac{S_g}{B_g}+\frac{R_{so}S_o}{B_o}+\frac{R_{sw}k_w}{B_w}\right)\right]. \qquad (6.12)$$

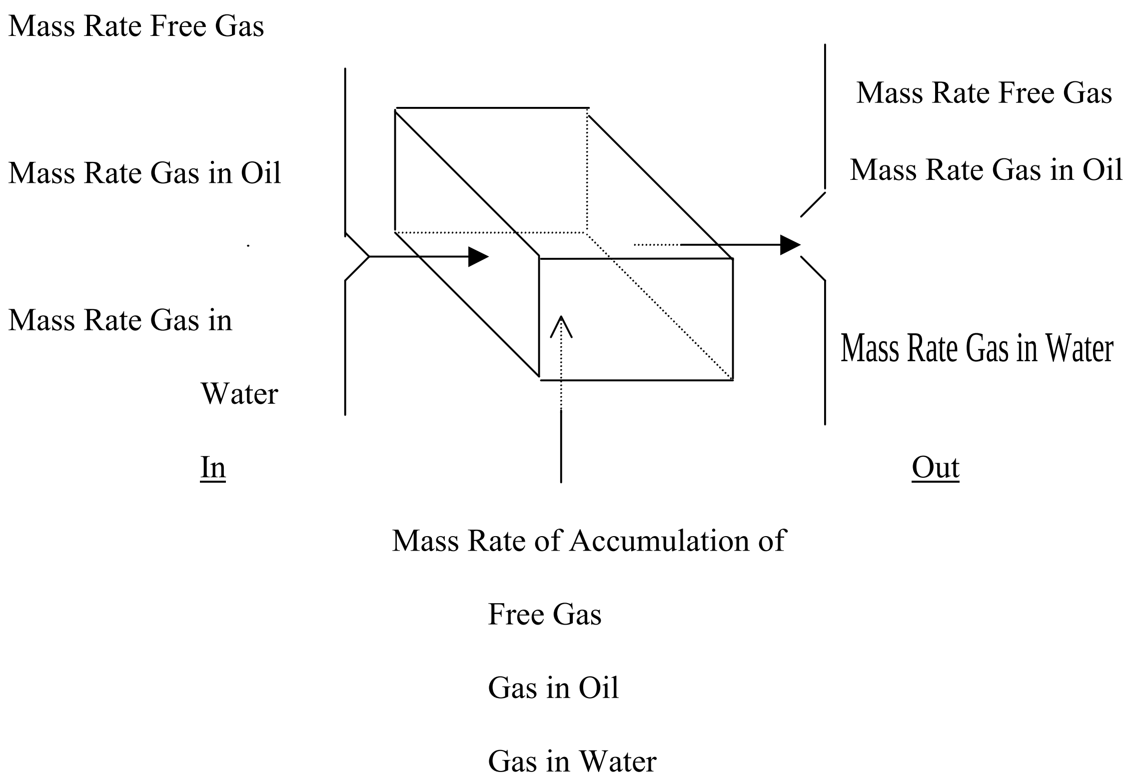


Figure 6.1 A mass balance on the gas phase is shown the detail about mass in, mass out and mass accumulation.

The generalized multiphase flow equation for the unsteady-state flow of oil, gas and water in porous medium is developing by combining the three single-phase flow equations into one basic equation. To do this several other observations are made. First, for all phase the following is true:

$$S_o + S_g + S_w = 1. \tag{6.13}$$

Thus:

$$\frac{\partial}{\partial t}\left[S_o + S_g + S_w\right] = 0. \tag{6.14}$$

Pressure gradients are assumed small and the square of this term is neglected:

$$\left(\frac{\partial P}{\partial t}\right)^2 \approx 0. \tag{6.15}$$

The gas equation (6.12) is multiplied by B_g and expanded as above:

$$\frac{B_g}{r}\left\{r\left(\frac{R_{so}k_o}{\mu_o B_o} + \frac{R_{sw}k_w}{\mu_w B_w} + \frac{k_g}{\mu_g B_g}\right)\frac{\partial^2 P}{\partial r^2} + r\frac{\partial P}{\partial r}\left[\frac{k_0}{\mu_0}\left(\frac{1}{B_0}\frac{\partial R_{so}}{\partial P}\frac{\partial P}{\partial r} - \frac{R_{so}}{{B_0}^2}\frac{\partial B_0}{\partial P}\frac{\partial P}{\partial r}\right)\right.\right.$$

$$\left.\left. + \frac{k_w}{B_w}\left(\frac{1}{B_w}\frac{\partial R_{sw}}{\partial P}\frac{\partial P}{\partial r} - \frac{R_{sw}}{{B_w}^2}\frac{\partial B_w}{\partial P}\frac{\partial P}{\partial r}\right) - \frac{k}{\mu_g}\left(\frac{1}{{B_g}^2}\frac{\partial B_g}{\partial P}\frac{\partial P}{\partial r}\right)\right]\right.$$

$$= +\frac{R_{so}}{B_o}\frac{\partial S_o}{\partial t} - \frac{R_{so}S_o}{{B_o}^2}\frac{\partial P}{\partial t} + \frac{S_w}{B_w}\frac{\partial R_{sw}}{\partial P}\frac{\partial P}{\partial t} + \frac{R_{sw}}{B_w}\frac{\partial S_w}{\partial t}$$

$$\left. - \frac{R_{sw}S_w}{{B_w}^2}\frac{\partial B_w}{\partial P}\frac{\partial P}{\partial t} + \frac{1}{B_g}\frac{\partial S_g}{\partial t} - \frac{S_g}{{B_g}^2}\frac{\partial B_g}{\partial P}\frac{\partial P}{\partial t}\right). \tag{6.16}$$

Collecting terms:

$$\left(\frac{k_o}{\mu_o}\frac{R_{so}B_g}{B_o}+\frac{k_w}{\mu_w}\frac{R_{sw}B_g}{B_w}+\frac{k_g}{\mu_g}\right)\frac{\partial^2 P}{\partial r^2}+\frac{k_o}{\mu_o}\frac{B_g}{B_o}\frac{\partial R_{so}}{\partial P}\left(\frac{\partial P}{\partial r}\right)^2+\frac{k_w}{\mu_w}\frac{B_g}{B_w}\frac{\partial R_{sw}}{\partial P}\left(\frac{\partial P}{\partial r}\right)^2$$

$$-\frac{k_o}{\mu_o}\frac{R_{so}}{B_o^{\,2}}\frac{\partial B_o}{\partial P}\left(\frac{\partial P}{\partial r}\right)^2-\frac{k_w}{\mu_w}\frac{B_g}{B_w^{\,2}}\frac{\partial B_w}{\partial P}\left(\frac{\partial P}{\partial r}\right)^2-\frac{k_g}{\mu_g}\frac{1}{B_g}\frac{\partial B_g}{\partial P}\left(\frac{\partial P}{\partial r}\right)^2$$

$$+\left(\frac{k_o}{\mu_o}\frac{R_{so}B_g}{B_o}+\frac{k_w}{\mu_w}\frac{R_{sw}B_g}{B_w}+\frac{k_g}{\mu_g}\right)\frac{1}{r}\frac{\partial P}{\partial r}$$

$$=\phi\left(\frac{S_oB_g}{B_o}\frac{\partial R_{so}}{\partial P}-\frac{R_{so}S_oB_g}{B_o^{\,2}}\frac{\partial B_o}{\partial P}+\frac{S_wB_g}{B_w}\frac{\partial R_{sw}}{\partial P}-\frac{R_{sw}S_wB_g}{B_w^{\,2}}\frac{\partial B_w}{\partial P}-\frac{S_g}{B_g}\frac{\partial B_g}{\partial P}\right)\frac{\partial P}{\partial t}$$

$$+\phi\left(\frac{B_gR_{so}}{B_o}\frac{\partial S_o}{\partial t}+\frac{R_{sw}B_g}{B_w}\frac{\partial S_w}{\partial t}+\frac{\partial S_g}{\partial t}\right). \qquad (6.17)$$

Neglecting $\left(\frac{\partial P}{\partial r}\right)^2$ terms in the above equation:

$$\left(\frac{k_o}{\mu_o}\frac{R_{so}B_g}{B_o}+\frac{k_w}{\mu_w}\frac{R_{sw}B_g}{B_w}+\frac{k_g}{\mu_g}\right)\left(\frac{\partial^2 P}{\partial r^2}+\frac{1}{r}\frac{\partial P}{\partial r}\right)$$

$$=\phi\left(\frac{S_oB_g}{B_o}\frac{\partial R_s}{\partial P}-\frac{R_{so}S_oB_g}{B_o^{\,2}}\frac{\partial B_o}{\partial P}+\frac{S_wB_g}{B_w}\frac{\partial R_{sw}}{\partial P}-\frac{R_{sw}S_wB_g}{B_w^{\,2}}\frac{\partial B_w}{\partial P}-\frac{S_g}{B_g}\frac{\partial B_g}{\partial P}\right)\frac{\partial P}{\partial t}$$

$$+\phi\left(\frac{R_{so}B_g}{B_o}\frac{\partial S_o}{\partial t}+\frac{R_{sw}B_g}{B_w}\frac{\partial S_w}{\partial t}+\frac{\partial S_g}{\partial t}\right). \qquad (6.18)$$

6.1.4 IMPES method

The Implicit Pressure – Explicit Saturation method (IMPES method) is the one of the solution of the simulation equation. It combines the single- phase equations into a single multiphase equation based on pressure, and then solves the pressure equation implicitly for the pressure distribution. The saturation distribution is explicit calculated for each point. The IMPES process is formulated as follows,

a. An each single- phase equation in a single dimension

$$A_x \frac{\partial}{\partial x}\left(\frac{k_o}{\mu_o B_o}\frac{\partial \Phi_o}{\partial x}\right) + q_o = V_R \frac{\partial}{\partial t}\left(\frac{\phi S_o}{B_o}\right) \qquad \text{Oil} \qquad (6.19)$$

$$A_x \frac{\partial}{\partial x}\left(\frac{k_w}{\mu_w B_w}\frac{\partial \Phi_w}{\partial x}\right) + q_w = V_R \frac{\partial}{\partial t}\left(\frac{\phi S_w}{B_w}\right) \qquad \text{Water} \qquad (6.20)$$

$$A_x \frac{\partial}{\partial x}\left(\frac{k_g}{\mu_g B_g}\frac{\partial \Phi_g}{\partial x} + \frac{R_{so} k_o}{\mu_o B_o}\frac{\partial \Phi_o}{\partial x} + \frac{R_{sw} k_w}{\mu_w B_w}\frac{\partial \Phi_w}{\partial x}\right) + q_g$$

$$= V_R \frac{\partial}{\partial t}\left[\phi\left(\frac{S_g}{B_g} + \frac{R_{so}}{B_o} + \frac{R_{sw} S_w}{B_w}\right)\right] \text{Gas} \qquad (6..21)$$

Equations (6.19), (6.20), and (6.21) are combined to yield a single equation relating the behavior of all phases in the reservoir. In order to make this transformation, the following additional definitions are required:

The potential terms are defined as:

Oil $\Phi_o = P_o + \rho_o g h$ (6.22)

Gas $\Phi_g = P_g + \rho_g g h$ (6.23)

Water $\Phi_w = P_w + \rho_w g h$ (6.24)

The capillary pressure terms are:

$$P_{cw} = P_o - P_w \qquad (6.25)$$

$$P_{cg} = P_g - P_o \qquad (6.26)$$

Equations (6.22) through (6.26) can be combined using in addition, the saturation equation (6.14) to obtain:

$$A_x \frac{\partial}{\partial x}\left(\lambda_T \frac{\partial P_o}{\partial x}\right) + A_x \frac{\partial}{\partial x}\left(\lambda_g \frac{\partial P_{cg}}{\partial x} - \lambda_w \frac{\partial P_{cw}}{\partial x}\right) + A_x \frac{\partial}{\partial x}\left[\lambda_g \frac{\partial(\rho_g gh)}{\partial x}\right.$$

$$\left. + \lambda_o \frac{\partial(\rho_o gh)}{\partial x} + \lambda_w \frac{\partial(\rho_w gh)}{\partial x}\right] = B_1 \frac{\partial P_o}{\partial t} + B_2, \qquad (6.27)$$

$$A_x \frac{\partial}{\partial x}\left(\lambda_T{}^n \frac{\partial P_o{}^{n+1}}{\partial x}\right) + A_x \frac{\partial}{\partial x}\left(\lambda_g \frac{\partial P_{cg}}{\partial x} - \lambda_w \frac{\partial P_{cw}}{\partial x}\right)^n + A_x \frac{\partial}{\partial x}\left[\lambda_g{}^n \frac{\partial(\rho_g gh)}{\partial x}\right.$$

$$\left. + \lambda_o{}^n \frac{\partial(\rho_o gh)}{\partial x} + \lambda_w{}^n \frac{\partial(\rho_w gh)}{\partial x}\right] = B_1{}^n \frac{\partial P_o{}^{n+1}}{\partial t} + B_2{}^{n+1}, \qquad (6.28)$$

where the λ-variables are mobility terms, β1-variables are functions of PVT (pressure-volume-temperature) terms, and β2-variables are production terms. For two-dimensional flow, equation (6.28) is expanded to include the y-coordinate terms. The summarize IMPES processes are shown in Figures 6.2 through 6.5.

6.1.5 Benefits of reservoir simulation

All data are compiled pertinent to a reservoir into one compact database. Opportunity provides to produce the reservoir before commencing actual production. The reservoir can produce several times to examine alternatives. The management tool can be utilized for selecting development plan and operational changes. It can be basic data for company and regulatory agencies, which concern with petroleum resource.

6.2 Data preparation of reservoir simulation

The groups of data generally required in making a simulation run is as follows:

a. Fluid Data

Start Time Step:

TIME = T **STEP 1**

Old Pressure Distribution Old Saturation Distribution

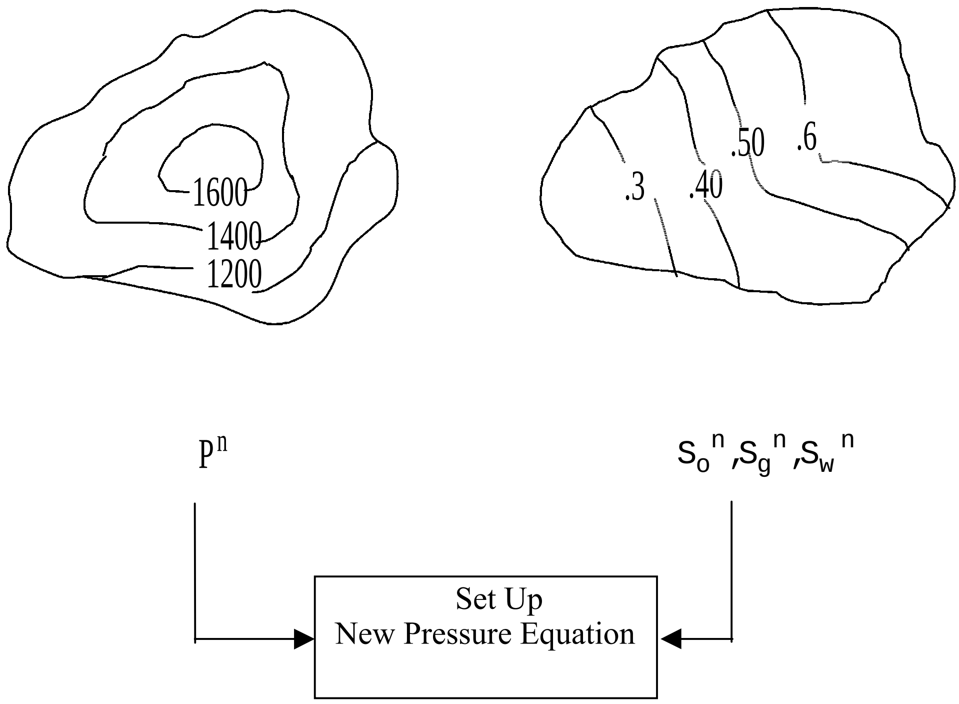
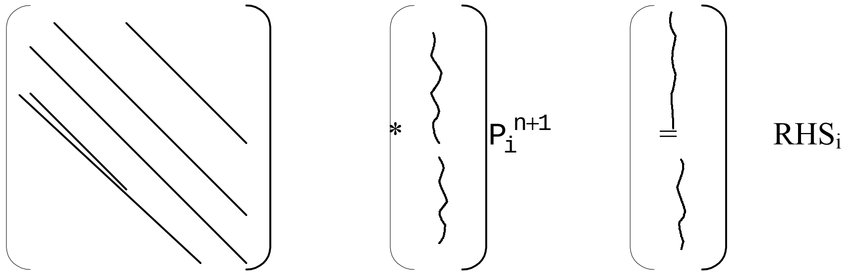


Figure 6.2 Setting up pressure equations at the time step1.

Time = t

Step 2:



Solve For New Pressure : P^{n+1}

Time = t+Δt

Step 3: Calculate New Saturations Using The New Pressure Gradients

$$\rightarrow S_o^{n+1}, S_g^{n+1}, S_w^{n+1}$$

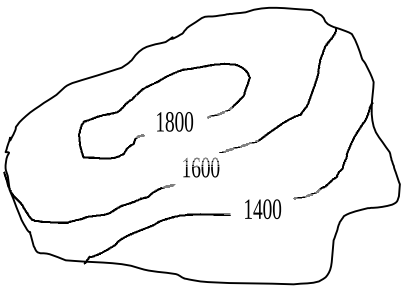
Figure 6.3 At the time step 2 is used the matrix for solving new pressure (implicit pressure).

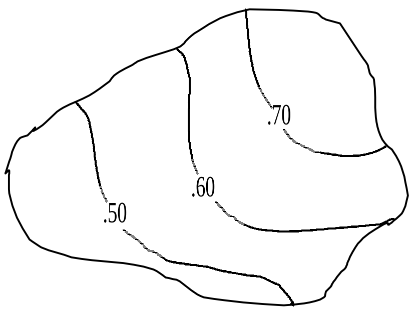
Time = t+Δt

End Results

New Pressure Distribution

New Saturation Distribution





End of Time Step: P^{n+1}

$S_o^{n+1}, S_g^{n+1}, S_w^{n+1}$

Figure 6.4 Results at end of time step are the saturation that solve by substitute new pressure in the equation (explicit saturation).

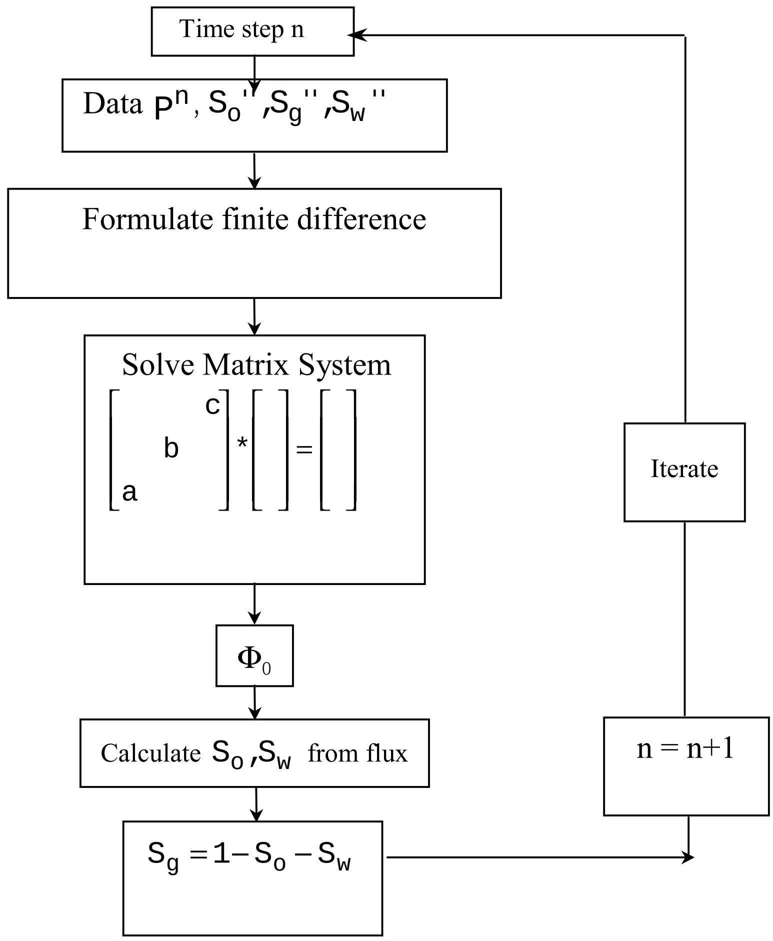


Figure 6.5 IMPES Summary.

The reservoir fluids have properties that must be evaluated many times during the simulation of a reservoir under depletion or under some secondary or tertiary mechanism.

The pressure-dependent fluid properties are;

1) Formation volume factors
2) Fluid viscosity
3) Solution gas-oil ratio.

These properties are generally obtained from laboratory studies of samples of the reservoir fluid. Regardless of the data entry methods you use, you must use the oil data (for black oil system only), gas data and Water options on the basic menu to entry:

1) The under-saturated oil compressibility (black oil system only).
2) The under-saturated oil viscosity slope (black oil system only).
3) Bubble point pressure (black oil system only).
4) Gravity (black oil and gas-water system).
5) Water viscosity (black oil and gas-water system).
6) Water Formation volume factor (black oil and gas-water system).

b. Rock Data

The various parameters needed to determine the physical extent of the reservoir end to evaluate the transmissibility during the simulation run must input some form. The required data are:

1) Permeability. The data can be obtained from several sources;
   - Pressure build up data (drill stem test)
   - Pressure fall off data

- Interference tests
- Initial potential test
- Regression analysis (case history approach)
- Laboratory measurements

2) Porosity. The porosity is usually obtained from one of the following sources;

- Logging data in the form of sonic/acoustic logs
- Laboratory measurements
- Published correlation

3) Formation Thickness are obtained from;

- Gross isopach map (must simulations usually use)
- Net isopach map

4) Formation elevations, source, log data, drilling records

5) Compressibility, sources; laboratory analyses, Published correlations

6) Relative Permeability, can be obtained from one of five means;

- Laboratory measurements using steady-state displacement process
- Laboratory measurements using unsteady-state displacement process
- Calculation from capillary pressure data
- Calculation from field data
- Calculation from published correlation

7) Formation fluid saturations. In a reservoir there are two possible planes of interest that can be used to evaluate saturations of reservoir fluids; the gas/oil contact and water/oil contact. The saturations are generally computed from the locations of the contact within a cell. Connate water can be evaluated from

- Core data
- Electric logs
- Capillary pressure data

8) Capillary pressure, is usually determined from laboratory data

c. Production Data

Production data are required to operate the simulator in history mode. The information required is obtained from well production records. The following is required for each well:

1) Oil production vs. time.
2) Water production vs. time.
3) Gas production vs. time.
4) Any measured pressure vs. time.

d. Flow rate Data

Flow rate data are required by the simulator to compute producing capacity of a well within the system. These data are generally based on the following:

1) Productivity index.
2) Injectivity Index.
3) Optimum flow rates.
4) Maximum allowable drawdown.

Flowing wells and gas lift well generally show some rate sensitivity to gas-oil ratio (GOR), bottom hole pressure (BHP), and flow rate. A surface fit of following bottom hole pressure versus flow rate and GOR is necessary to determine the flow parameters in the well bore during simulation

6.3 Input data for this simulation model

The simulation model was designed for 296 BCF gas in place according to the FASPU program running in the northeast Thailand. The exploration risk was evaluated at 10% risk of the field to be discovered. It was recommended that three wells be one discovery for 10 exploration wells. The field with six wells has been producing for several years. Input data consists of general data, rock and fluid data, well data, grid data and production data. Available reservoir and production data are given below:

a. Field data

- Production area	27.26	square kilometers.
- Depth to top of structure	-6,000	feet.
- Initial pressure	4,000	psia.
- Initial temperature	640	°R
- Base date for simulation	01-01-03 (DD-MM-YY).	
- Starting gas production	01-02-03 (DD-MM-YY)	

- Input unit: English - SPE Standard.
- Output unit: English - SPE Standard.

b. Rock properties data

- Gross thickness	150	feet/Layer.
- Net thickness	24	feet/Layer.
- Irreducible water saturation	0.1	fraction.
- Critical gas saturation	0.05	fraction.
- Relative permeability to gas @ irreducible water saturation	1.0	fraction
- Pore size distribution Index	0.8	

	- Capillary entry pressure - G/W	1.0	psia.
	- Constant compressibility for matrix rock	5 E-6	1/psi
c.	Fluid data		
	1) Gas property		
	- Gas gravity	0.6	
	2) Water property		
	- Density @ standard conditions	62.4	lb/cu.ft.
	- Water compressibility	0.3 E-5	1/psi.
	- Viscosity	0.5	cp.
	- Formation volume factor		
	@ initial reservoir pressure	1.001	RB/STB
	- Standard pressure	14.65	psia.
	- Standard temperature	60	°F
	- Maximum pressure current	4,000	psia.
d.	Grid		
	- Number of layers to model	10	layers.
	- X-origin on map	0	
	- Y-origin on map	0	
	- Grid angle (X-axis)	0	
	- Number of X-increments	15	cells.
	- Size of X-increments	1,000	feet.
	- Number of Y-increments	21	cells.
	- Size of Y-increments	1,000	feet.
e.	Equilibrium		

-	Reference elevation	-7,500	feet.
-	Pressure @ reference elevation	4,000	psia.
-	Elevation of G-W contact	-7,500	feet.
-	G-W capillary pressure @ constant elevation	0	psia

f. Wells

Production rate input value for each well. The production rate of each well is shown in Tables 6.1 and 6.2.

6.4 Simulation Model Types

Reservoir Modeling is separated three types following this:

1. Physical Models

The Models are constructed to duplicate pressures that are physically similar to the original scaled-down reproductions of the original.

Analog Models

The Models are use similarities between the phenomenon of fluid flows through porous media and physical phenomena to simulate reservoir performance.

2. Mathematical Models

The Models use mathematical equations or set of equations describing the physical behavior of the process under investigation. The reservoir model is a representation of fluid flow through porous media. A model can be abstract mathematical description of a process or a laboratory scale experiment. A reservoir

Table 6.1 Gas production rate V.S Time. (Without well stimulation)

Date	Gas production rate (MSCF/D)					
	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
1-Feb-03	4,000	4,000	4,000	-	-	-
1-Feb-04	4,000	4,000	4,000	4,000	4,000	4,000
31-Jan-05	4,000	4,000	4,000	4,000	4,000	4,000
31-Jan-06	4,000	4,000	4,000	4,000	4,000	4,000
31-Jan-07	4,000	4,000	4,000	4,000	4,000	4,000
31-Jan-08	4,000	4,000	4,000	4,000	4,000	4,000
30-Jan-09	4,000	4,000	4,000	3,948	4,000	3,760
30-Jan-10	4,000	4,000	3,839	3,740	3,987	3,760
30-Jan-11	4,000	4,000	3,668	3,558	3,790	3,575
30-Jan-12	3,791	3,826	3,511	3,390	3,617	3,404
29-Jan-13	3,606	3,663	3,365	3,233	3,455	3,243
29-Jan-14	3,436	3,513	3,227	3,084	3,302	3,091
29-Jan-15	3,278	3,373	3,096	2,944	3,156	2,949
29-Jan-16	3,130	3,240	2,973	2,812	3,018	2,813
28-Jan-17	2,990	3,113	2,855	2,686	2,886	2,684
28-Jan-18	2,856	2,993	2,742	2,566	2,759	2,562
28-Jan-19	2,730	2,877	2,634	2,453	2,638	2,445
28-Jan-20	2,610	2,766	2,531	2,345	2,522	2,334
27-Jan-21	2,496	2,660	2,433	2,242	2,410	2,228
27-Jan-22	2,388	2,558	2,339	2,145	2,304	2,128
27-Jan-23	2,287	2,460	2,247	2,054	2,203	2,033
27-Jan-24	2,191	2,366	2,159	1,967	2,108	1,943

Note: The gas production rate is started the 1st year and ended at the 20th year of production.

Table 6.2 Gas production rate V.S Time. (With well stimulation)

Date	Gas production rate (MSCF/D)					
	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
1-Feb-03	12,000	12,000	11,500	-	-	-
1-Feb-04	12,000	12,000	11,500	11,500	13,000	13,000
31-Jan-05	12,000	12,000	11,500	11,500	13,000	13,000
31-Jan-06	12,000	12,000	11,500	11,500	13,000	13,000
31-Jan-07	12,000	12,000	11,224	11,500	13,000	13,000
31-Jan-08	11,499	11,258	8,626	9,448	10,380	9,076
30-Jan-09	8,676	8,991	7,144	7,496	8,455	7,358
30-Jan-10	6,983	7,585	6,050	6,113	7,028	6,046
30-Jan-11	5,717	6,516	5,193	5,006	5,902	5,016
30-Jan-12	4,738	5,669	4,502	4,224	4,993	4,191
29-Jan-13	3,969	7,977	3,930	3,565	4,250	3,528
29-Jan-14	3,355	4,400	3,449	3,037	3,637	2,989
29-Jan-15	2,857	3,912	3,041	2,608	3,126	2,548
29-Jan-16	2,451	3,494	2,691	2,255	2,699	2,183
28-Jan-17	2,116	3,132	2,389	1,964	2,340	1,880
28-Jan-18	1,838	2,817	2,180	1,721	2,036	1,628
28-Jan-19	1,607	2,542	1,903	1,517	1,779	1,417
28-Jan-20	1,413	2,300	1,706	1,345	1,562	1,240

Note: The gas production rate is started the 1st year and ended at the 18th year of production. The starting production in each well after well stimulation ware designed by pressure and thick perforating in each well.

model is use to analyze characteristics and behavior of a reservoir process that cannot be conveniently observed. A reservoir model is base on geological, petrophysical and production data. Almost all models use to simulate reservoir behavior are mathematical in nature. Laboratory scale physical models are primarily used to study specific oil and gas reservoir recovery process. The results from physical models are then incorporated into reservoir scale mathematical models for engineering design process. The simulation model in this study has approximate size $4.26 \times 6.4 \times 0.457$ cubic-kilometers. It covers area about 27 square kilometers. It composes of 10 layers. Each cell of a layer is called one grid block (Fanchi, 1997) which $304.80 \times 304.80 \times 47.72$ cubic-meters. The details of each layer are shown in Tables 6.3 and 6.4. The reservoir area of each layer is divided into number of grid blocks follows the Table 6.5. The total grid block of model is accounted to 1,668 grid blocks. The model has six vertical wells. Each well is located at the middle of the assigned grid block. The gross thickness of five wells in each layer is 150 feet and the net thickness varies in the interval of 24 feet. The top structure of model is started at the depth of 6,000 feet and the end of bottom structure at the depth of 7,500 feet (below MSL). Simulation model shape of reservoir with three dimensions is shown in Figure 6.6. The permeability and porosity distributions are shown in Figures 6.7, 6.8 and 6.9.

Table 6.3 Details of each layer are composed of layer number, well number, coordinate (x,y), structure top, gross thickness, net thickness, porosity, water saturation and permeability.

Layer	Well	X	Y	HTOP (ft)	GTh (ft)	NTh (ft)	Phi	Sw	K(md)
1	1	9,500	10,500	-6,000	150	24	0.0435	0.2	0.212
1	2	6,500	15,500	-6,000	150	24	0.0435	0.2	0.212
1	3	10,500	16,500	-6,000	150	24	0.0435	0.2	0.212
2	1	9,500	10,500	-6,150	150	24	0.043	0.2	0.212
2	2	6,500	15,500	-6,150	150	24	0.043	0.2	0.212
2	3	10,500	16,500	-6,150	150	24	0.043	0.2	0.212
3	1	9,500	10,500	-6,300	150	24	0.0425	0.2	0.207
3	2	6,500	15,500	-6,300	150	24	0.0425	0.2	0.207
3	3	10,500	16,500	-6,300	150	24	0.0425	0.2	0.207
3	4	3,500	9,500	-6,300	150	24	0.0425	0.2	0.207
3	5	10,500	5,500	-6,300	150	24	0.0425	0.2	0.207
3	6	4,500	4,500	-6,300	150	24	0.0425	0.2	0.207
4	1	9,500	10,500	-6,450	150	24	0.042	0.2	0.207
4	2	6,500	15,500	-6,450	150	24	0.042	0.2	0.207
4	3	10,500	16,500	-6,450	150	24	0.042	0.2	0.207
4	4	3,500	9,500	-6,450	150	24	0.042	0.2	0.207
4	5	10,500	5,500	-6,450	150	24	0.042	0.2	0.207
4	6	4,500	4,500	-6,450	150	24	0.042	0.2	0.207
5	1	9,500	10,500	-6,600	150	24	0.0415	0.2	0.202
5	2	6,500	15,500	-6,600	150	24	0.0415	0.2	0.202
5	3	10,500	16,500	-6,600	150	24	0.0415	0.2	0.202
5	4	3,500	9,500	-6,600	150	24	0.0415	0.2	0.202
5	5	10,500	5,500	-6,600	150	24	0.0415	0.2	0.202
5	6	4,500	4,500	-6,600	150	24	0.0415	0.2	0.202
6	1	9,500	10,500	-6,750	150	24	0.041	0.2	0.202
6	2	6,500	15,500	-7,750	150	24	0.041	0.2	0.202
6	3	10,500	16,500	-7,750	150	24	0.041	0.2	0.202
6	4	3,500	9,500	-7,750	150	24	0.041	0.2	0.202
6	5	10,500	5,500	-7,750	150	24	0.041	0.2	0.202
6	6	4,500	4,500	-7,750	150	24	0.041	0.2	0.202
7	1	9,500	10,500	-6,900	150	24	0.0405	0.2	0.197
7	2	6,500	15,500	-6,900	150	24	0.0405	0.2	0.197
7	3	10,500	16,500	-6,900	150	24	0.0405	0.2	0.197
7	4	3,500	9,500	-6,900	150	24	0.0405	0.2	0.197
7	5	10,500	5,500	-6,900	150	24	0.0405	0.2	0.197
7	6	4,500	4,500	-6,900	150	24	0.0405	0.2	0.197
8	1	9,500	10,500	-7,050	150	24	0.04	0.2	0.197
8	2	6,500	15,500	-7,050	150	24	0.04	0.2	0.197
8	3	10,500	16,500	-7,050	150	24	0.04	0.2	0.197
8	4	3,500	9,500	-7,050	150	24	0.04	0.2	0.197
8	5	10,500	5,500	-7,050	150	24	0.04	0.2	0.197
8	6	4,500	4,500	-7,050	150	24	0.04	0.2	0.197
9	4	3,500	9,500	-7,200	150	24	0.0395	0.2	0.192
9	5	10,500	5,500	-7,200	150	24	0.0395	0.2	0.192
9	6	4,500	4,500	-7,200	150	24	0.0395	0.2	0.192
10	4	3,500	9,500	-7,350	150	24	0.039	0.2	0.192
10	5	10,500	5,500	-7,350	150	24	0.039	0.2	0.192
10	6	4,500	4,500	-7,350	150	24	0.039	0.2	0.192

Table 6.4 The reservoir area is related with amount of grid blocks in each layer from the 1st layer to 10th layer.

Layer number	Amount of grid block
1	60
2	84
3	126
4	135
5	176
6	198
7	234
8	247
9	207
10	201

Figure 6.6 Simulation model shape of reservoir with three dimensions.

0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.212
0.21	0.212	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.212	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21

(a) Layer 1

0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.212
0.21	0.21	0.212	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.212	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21

(b) Layer 2

0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.207	0.205
0.205	0.205	0.205	0.207	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.207	0.205	0.205
0.207	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.207	0.205
0.205	0.207	0.205	0.205	0.205	0.205	0.205	0.205	0.205

(c) Layer 3

Figure 6.7 The permeability distribution in each grid block from the 1st layer until the 10th (without well stimulation).

0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.207	0.205
0.205	0.205	0.205	0.207	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.207	0.205	0.205
0.207	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.207	0.205
0.205	0.207	0.205	0.205	0.205	0.205	0.205	0.205	0.205

(d) Layer 4

0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.202	0.2	0.2
0.2	0.2	0.2	0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.202	0.2	0.2	0.2
0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.202	0.2	0.2
0.2	0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

(e) Layer 5

Figure 6.7 The permeability distribution in each grid block from the 1st layer until the 10th (without well stimulation - Continued)

0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.202	0.2	0.2
0.2	0.2	0.2	0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.202	0.2	0.2	0.2
0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.202	0.2	0.2
0.2	0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

(f) Layer 6

0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195	0.195
0.195	0.195	0.197	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195
0.195	0.195	0.195	0.197	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195

(g) Layer 7

Figure 6.7 The permeability distribution in each grid block from the 1st layer until the 10th (without well stimulation - Continued)

0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195	0.195
0.195	0.195	0.197	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.197	0.195	0.195	0.195
0.195	0.195	0.195	0.197	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195

(h) Layer 8

0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.192	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.192	0.19	0.19	0.19
0.19	0.19	0.19	0.192	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19

(i) Layer 9

Figure 6.7 The permeability distribution in each grid block from the 1st layer until the 10th (without well stimulation - Continued)

0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.192								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.192	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.192	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19

(j) Layer 10

Figure 6.7 The permeability distribution in each grid block from the 1st layer until the 10th (without well stimulation - Continued)

0.21	0.21	0.21	0.21	0.21	19.05
0.21	19.05	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	19.05	0.21
0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21

(a) Layer 1

0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	19.05
0.21	0.21	19.05	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	19.05	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21
0.21	0.21	0.21	0.21	0.21	0.21	0.21

(b) Layer 2

0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	19.05	0.205
0.205	0.205	0.205	19.05	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	19.05	0.205	0.205
19.05	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	19.05	0.205
0.205	19.05	0.205	0.205	0.205	0.205	0.205	0.205	0.205

(c) Layer 3

Figure 6.8 The permeability distribution in each grid block from the 1st layer until the 10th after well stimulation.

0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	19	0.205
0.205	0.205	0.205	19	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	19	0.205	0.205
19	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
0.205	0.205	0.205	0.205	0.205	0.205	0.205	19	0.205
0.205	19	0.205	0.205	0.205	0.205	0.205	0.205	0.205

(d) Layer 4

0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	19	0.2	0.2
0.2	0.2	0.2	0.2	19	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	19	0.2	0.2	0.2
0.2	19	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	19	0.2	0.2
0.2	0.2	19	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

(e) layer 5

Figure 6.8 The permeability distribution in each grid block from the 1st layer until the 10th after well stimulation. (Continued)

0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	19	0.2	0.2
0.2	0.2	0.2	0.2	19	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	19	0.2	0.2	0.2
0.2	19	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	19	0.2	0.2
0.2	0.2	19	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

(f) Layer 6

0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	19	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	19	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	19	0.195	0.195	0.195	0.195
0.195	0.195	19	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	19	0.195	0.195	0.195
0.195	0.195	0.195	19	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195

(g) Layer 7

Figure 6.8 The permeability distribution in each grid block from the 1st layer until the 10th after well stimulation. (Continued)

0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	18.95	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	18.95	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	18.95	0.195	0.195	0.195	0.195
0.195	0.195	18.95	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	18.95	0.195	0.195	0.195
0.195	0.195	0.195	18.95	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195

(h) Layer 8

0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	18.95	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19							0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	18.95	0.19	0.19	0.19
0.19	0.19	0.19	18.95	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19

(i) layer 9

Figure 6.8 The permeability distribution in each grid block from the 1st layer until the 10th after well stimulation. (Continued)

0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	18.95								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19								0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	18.95	0.19	0.19	0.19
0.19	0.19	0.19	0.19	18.95	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19

(j) Layer 10

Figure 6.8 The permeability distribution in each grid block from the 1st layer until the 10th after well stimulation. (Continued)

0.042	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.044
0.043	0.044	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.044	0.043
0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043

(a) Layer 1

0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043
0.043	0.043	0.043	0.043	0.043	0.043	0.043

(b) Layer 2

0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.043	0.042
0.042	0.042	0.042	0.043	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.043	0.042	0.042
0.043	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.043	0.042
0.042	0.043	0.042	0.042	0.042	0.042	0.042	0.042	0.042

(c) Layer 3

Figure 6.9 The porosity distribution in each grid block from the 1^{st} layer until the 10^{th}.

0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042

(d) layer 4

0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.042	0.041	0.041
0.041	0.041	0.041	0.041	0.042	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.042	0.041	0.041	0.041
0.041	0.042	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.042	0.041	0.041
0.041	0.041	0.042	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041

(e) Layer 5

Figure 6.9 The porosity distribution in each grid block from the 1st layer until the 10th.

(Continued)

0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041

(f) Layer 6

0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.041	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.041	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.041	0.04	0.04	0.04	0.04
0.04	0.04	0.041	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.041	0.04	0.04	0.04
0.04	0.04	0.04	0.041	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

(g) layer 7

Figure 6.9 The porosity distribution in each grid block from the 1st layer until the 10th.

(Continued)

0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

(h) Layer 8

0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.04	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039							0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.04	0.039	0.039	0.039
0.039	0.039	0.039	0.04	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039

(i) Layer 9

Figure 6.9 The porosity distribution in each grid block from the 1st layer until the 10th.

(Continued)

0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039								0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039

(j) Layer 10

Figure 6.9 The porosity distribution in each grid block from the 1st layer until the 10th. (Continued)

6.5. Simulator procedure

Menus drive the simulator as follows:

a. Edit menu

It is the first menu displayed when the simulation is started. It creates or opens projects and cases through file menu, and specifies the fluid system, reference, and input and output units through system menu. The step of edit menu follows this.

1) Create a new or open project

File →Project →New

2) Set system

System data → Fluid type (oil-gas-water)

Reference (table)

Base date (table)

Input units (English-SPE)

3) Output units (English-SPE)

b. Jump → Fluids menu

Fluids menu uses to enter laboratory or simulator generated fluid property data. The step of fluid menu follows this.

1) Input basic data

Basic data → Oil data (table)

Gas data (table)

Default all (used for correlation)

Equation to Use (used for correlation)

2) Input oil properties by keying in table

Edit → Edit data → Key in (table)

Plots → Oil plots (oil PVT display)

3) Input gas properties by keying in table

Plots → Gas plots

Edit →Edit data →Key in (table)

Plots → Gas plots (gas PVT display)

Edit → Validate (fluid data)

4) Optionally oil & gas properties by importing tables

c. Jump →Rocks

To enter laboratory or simulator generated water-oil and gas-oil relative permeability and capillary pressure data. The step of rocks menu follows this.

1) Input basic data

Basic data → Compressibility (table)

Default all (optional for correlation)

2) Input oil/water relative permeability

Edit → Edit data → Key in (table)

Plots → Water oil K_r (display)

Plots → Gas liquid K_r

Edit → Edit data → Key in (table)

Edit → Validate (rock date)

d. Jump → Mapping

To handle map information, girding system, well location, property data, i.e., structure, thickness, porosity and permeability. The step of mapping menu follows this.

1) Define simulation grid

   Grid → Create grid → Regular grid → Grid by form (table)

   View →Zoom → Scale to grid

2) Enter reservoir data

   Edit maps → Constant by layer (table)

3) Add a well

   Edit maps → Wells → Add wells

   Select well symbol

   Enter well name

   Pick well location

4) Build Arrays

   Grid →Build arrays → Full build

   Answer "Yes"

5) View → Display items (simulation grid)

6) Verify the arrays for thickness, porosity, permeability, etc. by selecting each property for each layer

   View → Layer up

   Layer down

   Select layer - Layer1

   - Layer2

   \- - - - - -

View → Property → Select property → Structure tops

Vertical gross thickness

Porosity

X (R) permeability

Y (T) permeability

Z permeability

e. Jump Wells

To enter well definition, completion, production/injection, production control data, and time points.

1) Enter well Information

Define → Completions → Define completion

Add completion locations: Yes

Calculate Kh: Yes

Well history → Rates (rate table)

Plots (display)

2) Enter well controls

Controls → Minimum rate

Maximum water cut

Maximum GOR

BHP limites

THP limlts

- - -

All Wells

f. Jump → Equilibrium

The following steps of equilibrium show how to enter equilibrium data. The equilibrium data that input into the equilibrium menu are the reference elevation, the elevation of gas- water contact, the pressure value at the reference elevation and the gas- water capillary pressure. The steps of equilibrium menu are followed this.

Enter equilibrium data

Equilibrium (table)

g. Jump → Run

1) Initialize and build deck

Initialize → Build deck

Run

Initial in-place water, oil, solution gas, free gas, average pressures are shown.

2) Create time points

Time points → Define points (table)

3) Set history Matching Option

Simulate → Options → History matching (yes)

4) Simulate

Simulate → Build deck

Simulate → Sumbit

5) Monitor progress of the simulation

Simulate → Monitor

h. Jump →Results

To display results in tables x, y plots and maps.

1) Load results

File → Simulation result → Load results

Clear prior results (yes)

Delete interface file (yes)

2) View results

Plots → Wells → Plots

Plots → Wells → Copy history

Plots → Wells → Plots

Plots → Wells → Observed pressures

Enter pressure into the screen

i. Jump → Run

Rebuild the simulation deck and then submit the run

j. Look at results: Jump → Results

Load results and view the well plot

k. Prediction run:

1) Jump → Run

Time points → edit time points

Enter end date and desired increment

2) Jump → Well

Control → field minimum

3) Jump → Run

Build the simulation deck and submit the run

4) Jump → Results

Load results and view the well plots.

The other menu

Jump menu

To change edit, fluids, rocks, mapping, wells, aquifer, equilibrium, run and result menus.

Tools menu.

To check completeness of the input data, specify display, mapping, and hard copy options, display an on-screen calculator, change colors used for display, system of units used for input and output data, and specify the type of model to be used to create a mathematical model of input data.

Help menu

To display software version, and turn on the help system.

View menu

To view specific types of data in each main menu. Some sub menus and options are repeated from main menu to main menu. All main menus, for example, have a file menu, a Jump menu, a tools menu, and a help menu, and most have a view menu. The options associated with the sub menus may differ slightly from main menu to main menu, but the menu options themselves have the same general functions.

6.6 Results

a. Total field.

- Initial Gas In Place (BCF)	296
- Initial Water In Place (MMSTB)	60.9
- Initial Average Pressure (Psia)	3991

- Field Matrix Pore Volume (MMRB) 287

b. Total field at the end of time step. (Well stimulation)

- Fluid In Place

Total Gas (BCF)	49.3
Water (MMSTB)	60.8

- Cumulative Production

Gas (BCF)	247
Water (MSTB)	70

c. Each well.

The production rate of six wells summary is shown in Figures 6.10 and 6.11.

d. Time step summary

The time steps summary has shown the production rates of total field that decline when the time is elapse. Time step summary is shown in Tables 6.7 and 6.8.

The relationships between reservoir pressure and time (without well stimulation and after well stimulation) are shown in Figures 6.12 and 6.13.

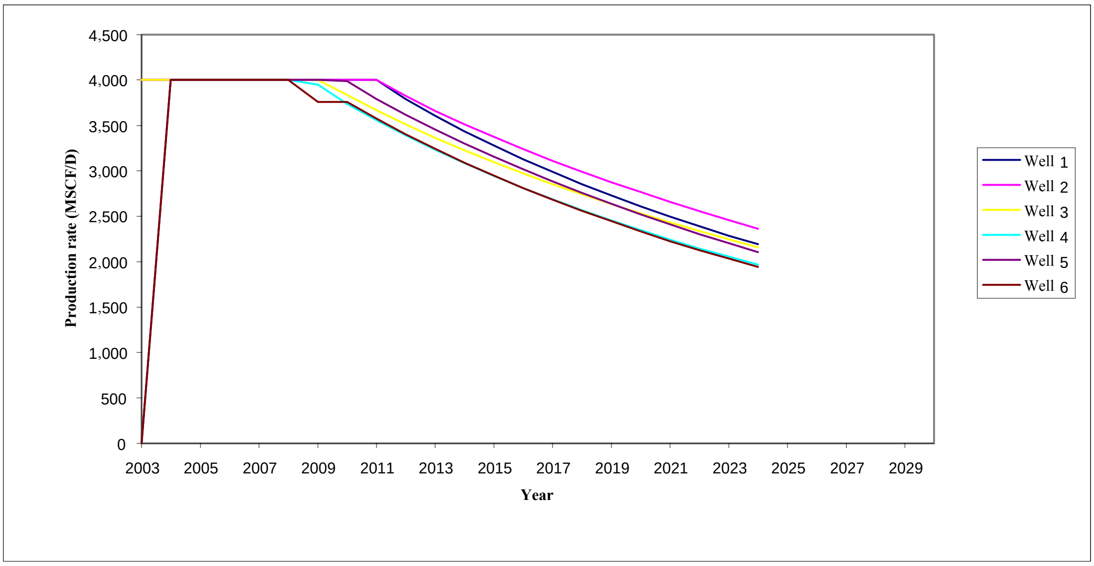


Figure 6.10 The production rate of six wells summary. (Without well stimulation)

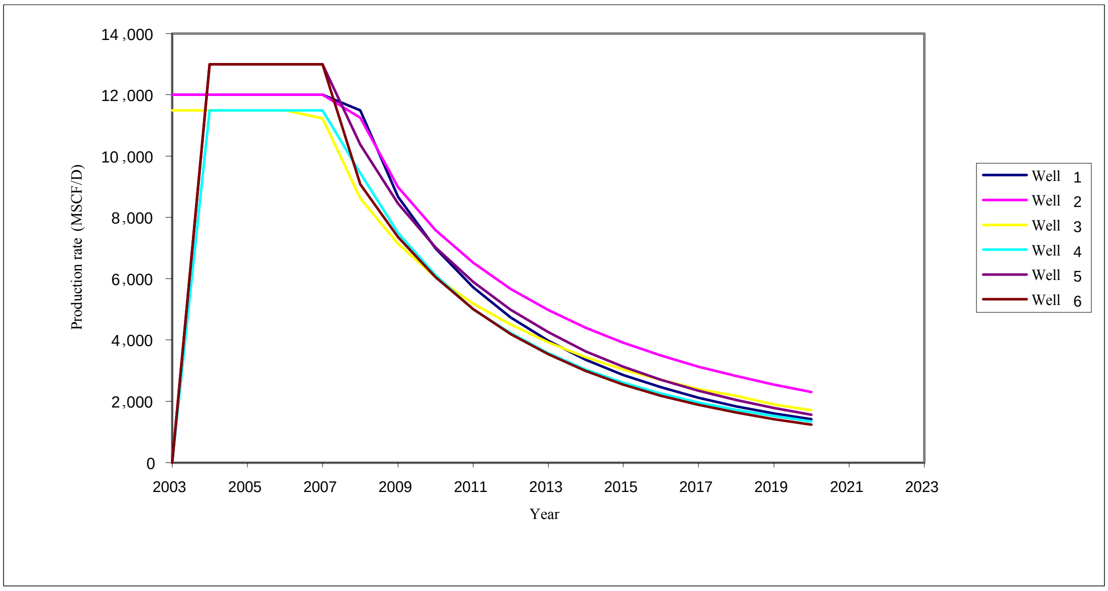


Figure 6.11 The production rate of six wells summary. (After well stimulation)

Table 6.5 The production rate declining with time. (Before well stimulation).

Time		Production		Max
Step	Day	Gas	Water (STB/D)	Pressure (Psia)
1	2	0	0	3991
2	6	0	0	3991
3	14	0	0	3991
4	31	0	0	3991
5	65	12000	0	3988
6	133	12000	0	3983
7	269	12000	0	3972
8	396	12000	0	3961
9	578.5	24000	0	3931
10	761	24000	0	3900
11	943.5	24000	0	3869
12	1126	24000	0	3838
13	1309	24000	0	3806
14	1491	24000	0	3774
15	1674	24000	0	3742
16	1856	24000	0	3709
17	2039	24000	0	3676
18	2221	24000	0	3643
19	2404	24000	0	3609
20	2586	23924	0	3575
21	2769	23637	0	3541
22	2951	23325	0	3507
23	3134	22946	0	3473
24	3316	22591	0	3440
25	3499	22059	0	3407
26	3681	21540	0	3374
27	3864	21043	0	3342
28	4046	20565	0	3310
29	4229	20102	0	3278
30	4411	19653	0	3247
31	4594	19219	0	3217
32	4776	18796	0	3186
33	4959	18385	0	3156
34	5141	17985	0	3127
35	5324	17595	0	3098
36	5506	17214	0	3069
37	5689	16842	0	3040
38	5871	16479	0	3012
39	6054	16123	0	2984
40	6236	15776	0	2957
41	6419	15437	0	2930
42	6601	15107	0	2903
43	6784	14784	0	2876
44	6966	14468	0	2850
45	7149	14161	0	2825
46	7331	13861	0	2799
47	7514	13569	0	2774
48	7696	13283	0	2749
49	7879	13005	0	2725
50	8061	12733	0	2701
51	8244	12468	0	2677
52	8426	12208	0	2653
53	8609	11955	0	2630
54	8791	11707	0	2607
55	8974	11465	0	2584

Table 6.6 The production rate declining with time. (After well stimulation).

Time		Production		Max
Step	Day	Gas(MSCF/D)	Wate(STB/D)	Pressure (Psia)
1	2	0	0	3991
2	6	0	0	3991
3	14	0	0	3991
4	31	0	0	3991
5	65	35500	0	3983
6	107.8	35500	0	3973
7	179.3	35500	0	3956
8	301.5	35500	0	3926
9	396	35500	0	3904
10	487.2	73000	0	3857
11	543.3	73000	0	3828
12	629.2	73000	0	3784
13	761	73000	0	3714
14	943.5	73000	0	3614
15	1126	73000	1	3511
16	1309	73000	2	3405
17	1491	73000	5	3295
18	1674	73000	11	3180
19	1856	71486	22	3063
20	2039	66785	28	2948
21	2221	60239	27	2840
22	2404	53381	24	2740
23	2586	48119	22	2647
24	2769	43667	20	2559
25	2951	39803	18	2475
26	3134	36410	17	2397
27	3316	33400	16	2322
28	3499	30716	15	2252
29	3681	28316	14	2185
30	3864	26161	13	2121
31	4046	24218	12	2061
32	4229	22461	11	2003
33	4411	20867	11	1948
34	4594	19416	10	1896
35	4776	18092	10	1846
36	4959	16881	9	1799
37	5141	15772	9	1753
38	5324	14756	8	1710
39	5506	13821	8	1668
40	5689	12961	7	1628
41	5871	12168	7	1590
42	6054	11435	7	1554
43	6236	10765	6	1519
44	6419	10143	6	1486
45	6601	9567	6	1454
46	6784	9032	6	1423
47	6966	8536	5	1394
48	7149	8074	5	1366
49	7331	7643	5	1338
50	7514	7242	5	1312

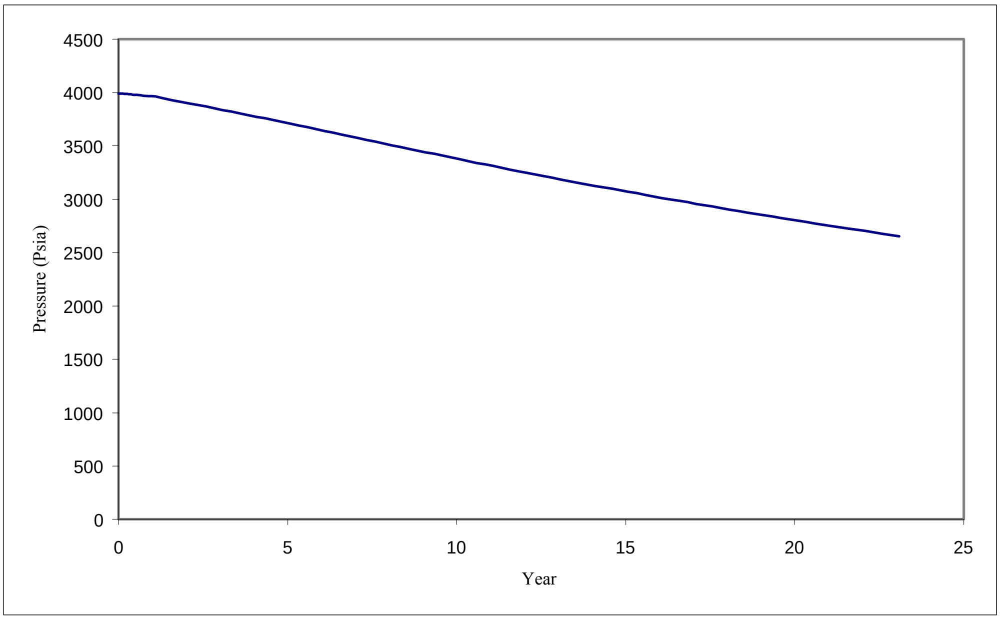


Figure 6.12 The relationship between reservoir pressure and time.

(Without well stimulation)

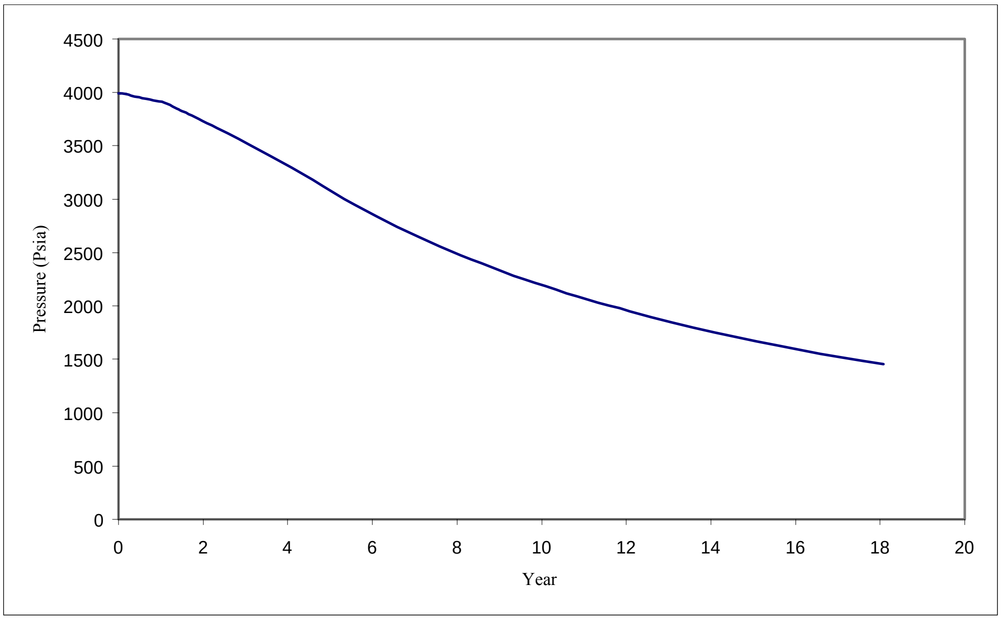


Figure 6.13 The relationship between reservoir pressure and time.

(After well stimulation)

6.7 Discussions

In this thesis, the reservoir simulation is useful for determination of the energy production and estimating the production rate. The model size is 4.26 x 6.4 x 0.457 cubic-kilometers. It is started at 6000 feet of depth. The reservoir is divided in to 10 layers with 150 feet (45.72 meters) of gross thickness in each layer. The production rate is started at 35.5 MMSCF/D , and after that the production rate are increased to 72 MMSCF/D by increasing development wells stimulation. It is constant for 3 year and declined 14% per year until 21^{th}year (18^{th} year production) that is the last year of gas production. The final production rate at 21^{th}year is 9.57 MMSCF/D. If permeability value in each grid block is changed, the pressure values will rapidly decline when permeability increases. Vice versa if permeability values decrease then the pressure values decline slowly.

The input data

a. Reserve inplace

The reserve is resulted from FASPU program running. It is 300 BCF. The model is created based on the inplace value. It has six vertical wells with ten layers. Each layer is modeled as an limestone. The model has equally top structure in each layer. The model lay out is set as one contour of one layer and contour interval of structural contour map is 150 feet. The top layer has the smallest reservoir area. The underneath layers have increased area according to depth until the bottom layer, that is the biggest reservoir area. (Witch is assumed as an anticline contor)

b. Permeability

The permeability values that put in simulation model are the assumed values with guidance from literature review. The result from the simulation is the result for the prospect reservoir not the actual reservoir. The permeability of the original rock may not be good enough to produce gas. It is good effective value for producing gas after the well stimulation process is performed.

c. Porosity

The porosity values are measured from specimens by using the porosimeter at the SUT laboratory. The porosity values are shown in the Table 3.3.

d. Other data

The other input data such as field data, rock property data, fluid data etc. are assumed and estimated from limestone review, are shown in the data preparation of simulation.

The output data

The output data of prospect reservoir from simulation running result are following this:

a. Reserve that is calculated from the simulation run is 240 BCF. Gas in place is 300 BCF.

b. The prospect reservoir area covers around 27 square kilometers (6,749 acres).

c. The gross thickness is 150 feet and net thickness is 24 feet in each layer.

d. The prospect reservoir has average permeability about 0.2 mD and average porosity about 0.04.

e. The total production rate before the well stimulation process is performed are 12.00 MMSCF/D, at 1st of year production the rate increase to 24.00 MMSCF/D at 2nd because development wells are increased. It is constant for 6 year and declined 4%per year, average of rate decline value from the first year of decline rate to the end of production, until the production rate than 10 MMSCF/D at the 25th year (22th year production)

f. After the well stimulation process, 540 feet of fracture radiant required, 4,440 bbl of acid and 1,200-1,400 of hydraulic pressure required, the total production rate is performed are 35.5 MMSCF/D, at 1st of year production the rate increase to 73 MMSCF/D at 2nd because development wells are increased. It is constant for 3 year and declined 14% per year, average of rate decline value from the first year of decline rate to the end of production, until until the production rate than 10 MMSCF/D at the 21thyear (18th year production)

g. The production efficiency is calculated by using gas cumulative divided by gas in place (240 BCF/300 BCF) equal to 80%.

6.8 Conclusions

The reservoir simulation is created with the approximate size of 4.26x6.4x0.457 cubic-kilometers. The prospect reservoir area covers around 27 square-kilometers (6,749 acres). The gross thickness is 150 feet and net thickness is 24 feet in each layer. The total gross thickness is 1,500 feet and total net thickness is 240 feet. The total grid block of reservoir area model is accounted to 1,668 grid blocks. The model consists of one exploration well, three appraisal wells and three development wells. The three appraisal wells will later be changed into development wells. So the model has seven wells but exposes only six wells. The average permeability of the prospect reservoir is approximately 0.2 mD and average porosity about 0.04 (4%). Before well stimulation, the total production rate is 12 MMSCF/D in the first year of gas production and there are three production wells. The gas production rate in the 2nd to

6th year is 22 MMSCF/D because there are three more production wells, and the production rate will be constant for six years. After that, the production rate declines about 4.12% in each year and ended in the 22nd year of production. The total cumulative gas production is 133 BCF but original gas in place is 300 BCF. The efficiency is 44% of initial gas in place. After 4,440 barrel of acid fracturing, the production rate is started at 35.5 MMSCF/D in the fist year of gas production. The gas production rate in the 2nd to 4th year is 73 MMSCF/D. After that, the production rate declined about 15% per year and ended in the 18th year of production. The total cumulative gas production is 240 BCF when original gas in place is 300 BCF. The efficiency is 80% of initial gas in place. And the end of production is set by economic limit shown in chapter 7 .

CHAPTER 7

PROSPECT ECONOMIC EVALUATION

7.1 Objective

The objective is to determine the pay back period, net present value, profit investment ratio and internal rate of return for analyzing and estimating the change of investment.

7.2 Exploration and production regulation

The exploration period and production region under the Petroleum Acts "Thailand III" statute are divided in to six years of exploration period and 20 years of production period that can be continued for another 10 years (start produce at the end of exploration period). This study will be early production on the 4th year of investment.

7.3 The exploration and production work plan

The total exploration and production period is 22 years that are divided in this study into four years for exploration and 18 years for production. The work plan will be this following schedule.

1st year @ 2000 : 2-D seismic investigation of 300 kilometers

: Geological survey

2nd year @ 2001 : 3-D seismic investigation of 30 square kilometers

: Drill one exploration wells

3rd year @ 2002 : First phase gas pipeline (four kilometers) layout

: Drill three appraisal wells

4th year @ 2003 : Drill three development wells

: Second phase gas pipeline (three kilometers)

: Installing processing facilities

: Starting economic production for three wells.

5th year @ 2003 : Increasing development well for three wells.

The total production wells are six. In the first year of production three wells will be produced. Six wells will be produced in the second year. The total gas production rate from Tank model (Chapter 4) is listed in Table 7.1. The gas production rate in the 1st year is 10.5 MMCF/D, and gas production rate in the 2nd to 4th year are 21 MMSCF/D. The production rate declines each year after that and ends in the 22nd year. The production rate decline is shown in Figure 7.1. The gas production rate from the simulation process (Chapter 6) is listed in Table 7.2. The gas production rate in the 1st. year is 12 MMCF/D, and the gas production rates in the 2nd to 6th year are 22 MMSCF/D. The production rate declines each year after that and ends in the 24th year. If well stimulation process has been done, the gas production rate in the 1st. year will be 35.5 MMCF/D, and gas production rates in the 2nd to 4th year will be 73 MMSCF/D. After that, the production rate declines each year and ends at the 18th year. The production rate decline is shown in Figure 7.2. When wells are stimulated process, the gas production rate in the 1st year will be 36 MMCF/D, and the gas production rate in the 2nd to 3rd year will be 72 MMSCF/D, the production rate will then decline each year and end in the 18th year

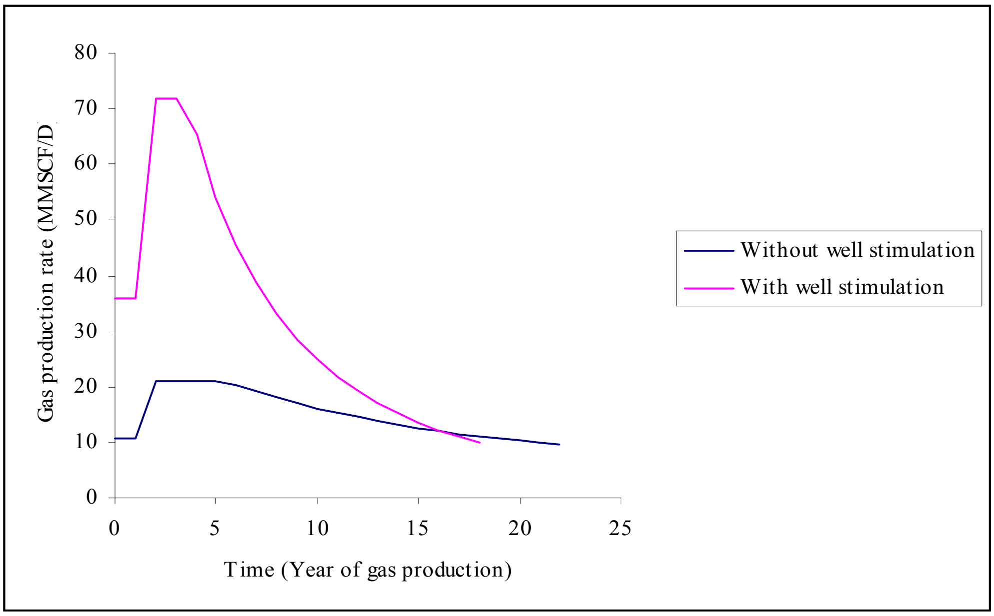


Figure 7.1 The relationship between production rates and time.

(From Tank model).

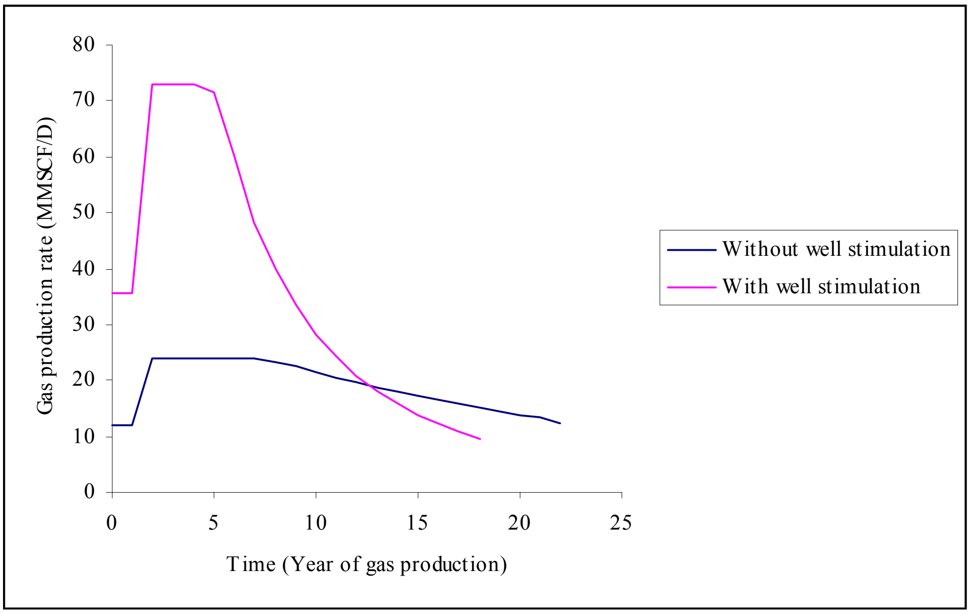


Figure 7.2 The relationship between production rates and time.

(From Simulation model).

Table 7.1 Production rates of six wells (for both before and after well stimulation) from Tank model in the chapter 4.

Year	Total production rate (MMSCF/D) (Without well stimulation)	Total production rate (MMSCF/D) (With well stimulation)
1	10.500	36.000
2	21.000	72.000
3	21.000	72.000
4	21.000	65.478
5	20.952	54.156
6	20.262	45.534
7	19.050	38.652
8	17.964	33.108
9	16.980	28.590
10	16.080	24.876
11	15.258	21.798
12	14.508	19.218
13	13.818	17.040
14	13.182	15.186
15	12.594	13.596
16	12.048	12.228
17	11.538	11.034
18	11.064	9.90
19	10.620	-
20	10.206	-
21	98.16	-
22	9.444	-

Table 7.2 Production rates of six wells (for both before and after well stimulation) simulation model in the chapter 6.

Year	Total production rate (MMSCF/D) (Without well stimulation)	Total production rate (MMSCF/D) (With well stimulation)
1	12	35.50
2	24	73.00
3	24	73.00
4	24	73.00
5	24	71.47
6	24	60.24
7	23.924	48.12
8	23.325	39.80
9	22.591	33.40
10	21.539	28.32
11	20.565	24.22
12	19.653	20.87
13	18.796	18.09
14	17.985	15.77
15	17.214	13.82
16	16.478	12.17
17	15.776	10.76
18	15.106	9.566
19	14.468	-
20	13.861	-
21	13.283	-
22	12.208	-

The recoverable reserve of this study is 240 BCF (from simulation model) and 215 BCF (from Thank model) that derived from complying FASPU program (Fast Appraisal System for Petroleum Universal) program. The FASPU program is an evaluated program of potential oil and gas reservoir that will be discovered. This program is used the principle of lognormal distribution by assigning the calculation of reservoir size distribution. This program calculates mean values and variance of oil and gas accumulative size. The FASPU program estimation is divided into groups under the same condition such as same geological characteristic and play attributes. The geological attributes consist of play attributes, prospect attributes and hydrocarbon volume. The play and prospect attributes characteristic is used for analyzing the geological characteristic. Hydrocarbon volume analyzes the hydrocarbon accumulation. The play attributes consist of 1) hydrocarbon source 2) timing period during trapping and sealing occurred that include the properly duration of hydrocarbon migration and 3) the hydrocarbon migration is considered along the volume of hydrocarbon that migrates till deposit at least 1 accumulation in specific case. Lastly, potential reservoir facies mean the characteristics of reservoir include porosity and permeability that control the potential of reservoir. The prospect attributes consist of trapping mechanism, effective porosity and hydrocarbon accumulation. The hydrocarbon volume consists of closure area, reservoir thickness, reservoir depth, hydrocarbon saturation, percent trap fill and number of drillable prospects. The probability distribution of each attribute is calculated by using the cumulative distribution function at seventh fractile (100^{th}, 75^{th}, 50^{th}, 25^{th}, 5^{th}, 0^{th}). The play analysis uses seventh fractile for calculating the hydrocarbon volume attributes.

7.4 Assumptions of economic study

The petroleum economic studies under the concession system and petroleum economics evaluation of Thailand III (Department of Mineral Resource, 1999) has assumptions and details that into basic assumptions add other assumptions cost.

7.4.1 Basic assumptions

a.	Number of exploration well	1
	Number of appraisal well	3
	Number of development well	3
b.	Sale gas reserve from simulation model(BCF)	300
c.	Gas heating value (BTU/SC)	1,000
d.	Exchange rate (Baht to US$)	40
e.	Income tax (%)	50
f.	Escalation factor (%)	2
g.	Discount rate (%)	7.25
h.	Tangible cost (%)	20
i.	Intangible cost (%)	80
j.	Depreciation of tangible cost (%)	20
k.	Sliding Scale royalty (%)	5 & 6.25

Monthly sale volume (BCF)	Rate (%)
0 – 600	5.00
600 – 1,500	6.25
1,500 – 3,000	10.00
3,000 – 6,000	12.50
> 6,000	15.00

Monthly sale volume levels are calculated from production rate level of oil that relate with block by block basic:

Production Level (BPD)	Rate (%)
0-2,000	5.00
2,000-5,000	6.25
5,000-10,000	10.00
10,000-20,000	12.50
> 20,000	15.00

The gas production levels are calculated by using condition of gas and oil heating value. One standard cubic foot of gas has heating value equal to 1000 BTU and a generous conversion factor of 10 million BTU gas to one barrel oil is provide, for example 2000BPD→(2000B/D) x (30D/M) x (10x10^6BTU/1B) x (1 SCF/1000BTU) = 600MMSCF/M.

7.4.2 Other assumptions

a. The gas price is constant over the contract.

b. Increasing rate of capital expenditure comes from the price increasing of machinery and equipment used in oil industries, and given to two percent per year.

c. Discount rate of money is 7.25 percent (Siam Commercial Bank, April 2002)

d. Operating cost is escalated 2 percent each year forward.

e. The first production is conduct in the five years of work plan.

f. The expenses used in cash flow analysis are estimated as follow:

1) Capital cost

- 2- D seismic investigation (US$ / line km) 1,000
- 3-D seismic investigation (US$ / line sq.km) 5,000
- Well drilling & completion exploration well (MMUS$ / well) 8
- Well drilling, completion appraisal well and well stimulation (MMUS$ / well) 9
- Well drilling, completion development well and well stimulation (MMUS$ / well) 9
- Pipeline (MMUS$ / km) 0.5
- Processing production facilities (MMUS$) 70
- Geological survey (MMUS$) 0.1
- Special bonus (MMUS$) 2

2) Operating cost (US$ / MMSCF) 400

3) The gas production will be stopped at economic limit which will be set
   - Net income < 0.5 of total operation cost
   - Discounted cash flow < 1 MMUS$
   - Fix cost + variable cost =2.5 MM US$

4) Petroleum price
   - Gas price (US$ / MMBTU) 2.52

7.5 Cash flow table explanations

a. The cash flow table is shown in the Tables 7.3 to 7.6. The cash flow table detail of each block is explained as follow this:

Table 7.3 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(Before well stimulation and the data of Tank model)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
YEAR					GROSS REV.	ROYALTY	2%	INVESTMENT COST						
	GAS			GAS	SALE	SLIDING	ESCAL	SEISMIC	SEISMIC	DRILLING		PIPELINE	PROCESSING	OPER.
	PRODUCTION			PRICE	INCOME	SCALE	FACTOR	2D	3D	INTANG	TANG		FACILITY	COST
	MMCF/D	MMCF/M	MMCF/Y	US$/MMBTU	MM US$	MM US$		MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2000	0.00	0.00	0.00	2.52	0.00	0.00	1.0000	2.40						0.00
2001	0.00	0.00	0.00	2.52	0.00	0.00	1.0200		0.15	6.40	1.60			0.00
2002	0.00	0.00	0.00	2.52	0.00	0.00	1.0404			19.20	4.80	2.00	40.00	0.00
2003	10.50	126.00	3832.50	2.52	9.66	0.48	1.0612			19.20	4.80	1.50	30.00	1.53
2004	21.00	252.00	7665.00	2.52	19.32	1.21	1.0824							3.07
2005	21.00	252.00	7665.00	2.52	19.32	1.21	1.1041							3.13
2006	21.00	252.00	7665.00	2.52	19.32	1.21	1.1262							3.19
2007	20.95	251.42	7647.48	2.52	19.27	1.20	1.1487							3.25
2008	20.26	243.14	7395.63	2.52	18.64	0.93	1.1717							3.20
2009	19.05	228.60	6953.25	2.52	17.52	0.88	1.1951							3.07
2010	17.96	215.57	6556.86	2.52	16.52	0.83	1.2190							2.95
2011	16.98	203.76	6197.70	2.52	15.62	0.78	1.2434							2.85
2012	16.08	192.96	5869.20	2.52	14.79	0.74	1.2682							2.75
2013	15.26	183.10	5569.17	2.52	14.03	0.70	1.2936							2.66
2014	14.51	174.10	5295.42	2.52	13.34	0.67	1.3195							2.58
2015	13.82	165.82	5043.57	2.52	12.71	0.64	1.3459							2.51
2016	13.18	158.18	4811.43	2.52	12.12	0.61	1.3728							2.44
2017	12.59	151.13	4596.81	2.52	11.58	0.58	1.4002							2.38
2018	12.05	144.58	4397.52	2.52	11.08	0.55	1.4282							2.32
2019	11.54	138.46	4211.37	2.52	10.61	0.53	1.4568							2.27
2020	11.06	132.77	4038.36	2.52	10.18	0.51	1.4859							2.22
2021	10.62	127.44	3876.30	2.52	9.77	0.49	1.5157							2.17
2022	10.21	122.47	3725.19	2.52	9.39	0.47	1.5460							2.13
2023	9.82	117.79	3582.84	2.52	9.03	0.45	1.5769							2.09
2024	9.44	113.33	3447.06	2.52	8.69	0.43	1.6084							2.05
Total	288.80		105411.27		265.64	14.25								48.37

Table 7.3 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(Before well stimulation and the data of Tank model - Continued)

P	Q										R	S	T	U
	DEPRECIATION(20%)													CUMULATIVE
TOTAL	TANGIBLE EXPENSE										WRITE	TOT.ALLOW	TAXABLE	TAXABLE
COST	1999	2000	2001	2002	2003	2004	2005	2006	2007	TOTAL	OFF	EXPENSE	INCOME	INCOME
MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2.40	0.00									0.00	2.40	2.40	-2.40	-2.40
8.15		0.32								0.32	6.55	6.87	-6.87	-9.27
66.00			9.68							9.68	19.20	28.88	-28.88	-38.15
57.03				16.94						16.94	21.22	38.16	-28.50	-66.65
3.07					16.94					16.94	4.27	21.21	-1.90	-68.55
3.13						16.94				16.94	4.33	21.27	-1.96	-70.50
3.19							16.62			16.62	4.40	21.02	-1.70	-72.21
3.25								7.26		7.26	4.45	11.71	7.56	-64.64
3.20									0.00	0.00	4.13	4.13	14.50	-50.14
3.07										0.00	3.95	3.95	13.58	-36.57
2.95										0.00	3.78	3.78	12.74	-23.82
2.85										0.00	3.63	3.63	11.99	-11.83
2.75										0.00	3.49	3.49	11.30	-0.53
2.66										0.00	3.36	3.36	10.67	10.14
2.58										0.00	3.25	3.25	10.10	20.23
2.51										0.00	3.14	3.14	9.57	29.80
2.44										0.00	3.05	3.05	9.08	38.88
2.38										0.00	2.96	2.96	8.63	47.50
2.32										0.00	2.88	2.88	8.21	55.71
2.27										0.00	2.80	2.80	7.81	63.52
2.22										0.00	2.73	2.73	7.45	70.97
2.17										0.00	2.66	2.66	7.11	78.08
2.13										0.00	2.60	2.60	6.79	84.87
2.09										0.00	2.54	2.54	6.49	91.36
2.05										0.00	2.48	2.48	6.20	97.57
180.42										84.70	109.96	194.66	70.97	

Table 7.3 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(Before well stimulation and the data of Tank model - Continued)

V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
	YEAR				CASH FLOW SUMMARY						DISCOUNTED	7.25%
INCOME		GAS		GAS	GROSS	CAPEX	OPEX	GOVERNMENT TAKE		ANNUAL	CASH FLOW	DISC
TAX(50%)		PRODUCTION		PRICE	REVERNUE			ROYALTY	INC.TAX	CASH FLOW	(NPV@7.25%)	FACTOR
MM US$		MMCF/D	MMCF/Y	US$/MMBTU	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	
0.00	2000	0.00	0.00	2.52	0.00	2.40	0.00	0.00	0.00	-2.40	-2.40	1.0000
0.00	2001	0.00	0.00	2.52	0.00	8.31	0.00	0.00	0.00	-8.31	-7.75	0.9324
0.00	2002	0.00	0.00	2.52	0.00	68.67	0.00	0.00	0.00	-68.67	-59.70	0.8694
0.00	2003	10.50	3832.50	2.52	9.66	58.90	1.53	0.60	0.00	-51.38	-41.65	0.8106
0.00	2004	21.00	7665.00	2.52	19.32	0.00	3.07	1.21	0.00	15.04	11.37	0.7558
0.00	2005	21.00	7665.00	2.52	19.32	0.00	3.13	1.21	0.00	14.98	10.56	0.7047
0.00	2006	21.00	7665.00	2.52	19.32	0.00	3.19	1.21	0.00	14.92	9.80	0.6571
0.00	2007	20.95	7647.48	2.52	19.27	0.00	3.25	1.20	0.00	14.82	9.08	0.6127
0.00	2008	20.26	7395.63	2.52	18.64	0.00	3.20	1.16	0.00	14.27	8.15	0.5712
0.00	2009	19.05	6953.25	2.52	17.52	0.00	3.07	0.88	0.00	13.58	7.23	0.5326
0.00	2010	17.96	6556.86	2.52	16.52	0.00	2.95	0.83	0.00	12.74	6.33	0.4966
0.00	2011	16.98	6197.70	2.52	15.62	0.00	2.85	0.78	0.00	11.99	5.55	0.4631
0.00	2012	16.08	5869.20	2.52	14.79	0.00	2.75	0.74	0.00	11.30	4.88	0.4318
5.34	2013	15.26	5569.17	2.52	14.03	0.00	2.66	0.70	5.34	5.34	2.15	0.4026
5.05	2014	14.51	5295.42	2.52	13.34	0.00	2.58	0.67	5.05	5.05	1.89	0.3754
4.78	2015	13.82	5043.57	2.52	12.71	0.00	2.51	0.64	4.78	4.78	1.67	0.3500
4.54	2016	13.18	4811.43	2.52	12.12	0.00	2.44	0.61	4.54	4.54	1.48	0.3263
4.31	2017	12.59	4596.81	2.52	11.58	0.00	2.38	0.58	4.31	4.31	1.31	0.3043
4.10	2018	12.05	4397.52	2.52	11.08	0.00	2.32	0.55	4.10	4.10	1.16	0.2837
3.91	2019	11.54	4211.37	2.52	10.61	0.00	2.27	0.53	3.91	3.91	1.03	0.2645
3.73	2020	11.06	4038.36	2.52	10.18	0.00	2.22	0.51	3.73	3.73	0.92	0.2466
3.55	2021	10.62	3876.30	2.52	9.77	0.00	2.17	0.49	3.55	3.55	0.82	0.2300
3.39	2022	10.21	3725.19	2.52	9.39	0.00	2.13	0.47	3.39	3.39	0.73	0.2144
3.24	2023	9.82	3582.84	2.52	9.03	0.00	2.09	0.45	3.24	3.24	0.65	0.1999
3.10	2024	9.44	3447.06	2.52	8.69	0.00	2.05	0.43	3.10	3.10	0.58	0.1864
35.75	Total	288.80	105411.27		265.64	138.28	48.37	14.60	35.75	28.64	-26.92	
									PIR=	0.21	IRR=	2.82%

Table 7.4 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(Before well stimulation and the data of reservoir simulation)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
YEAR					GROSS REV.	ROYALTY	2%	INVESTMENT COST						
	GAS			GAS	SALE	SLIDING	ESCAL	SEISMIC	SEISMIC	DRILLING		PIPELINE	PROCESSING	OPER.
	PRODUCTION			PRICE	INCOME	SCALE	FACTOR	2D	3D	INTANG	TANG		FACILITY	COST
	MMCF/D	MMCF/M	MMCF/Y	US$/MMBTU	MM US$	MM US$		MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2000	0.00	0.00	0.00	2.52	0.00	0.00	1.0000	2.40						0.00
2001	0.00	0.00	0.00	2.52	0.00	0.00	1.0200		0.15	6.40	1.60			0.00
2002	0.00	0.00	0.00	2.52	0.00	0.00	1.0404			19.20	4.80	2.00	40.00	0.00
2003	12.00	144.00	4380.00	2.52	11.04	0.55	1.0612			19.20	4.80	1.50	30.00	1.75
2004	24.00	288.00	8760.00	2.52	22.08	1.38	1.0824							3.50
2005	24.00	288.00	8760.00	2.52	22.08	1.38	1.1041							3.57
2006	24.00	288.00	8760.00	2.52	22.08	1.38	1.1262							3.65
2007	24.00	288.00	8760.00	2.52	22.08	1.38	1.1487							3.72
2008	24.00	288.00	8760.00	2.52	22.08	1.10	1.1717							3.79
2009	23.92	287.09	8732.26	2.52	22.01	1.10	1.1951							3.86
2010	23.33	279.90	8513.63	2.52	21.45	1.07	1.2190							3.84
2011	22.59	271.09	8245.72	2.52	20.78	1.04	1.2434							3.79
2012	21.59	259.12	7881.45	2.52	19.86	0.99	1.2682							3.69
2013	20.57	246.78	7506.23	2.52	18.92	0.95	1.2936							3.59
2014	19.65	235.84	7173.35	2.52	18.08	0.90	1.3195							3.50
2015	18.80	225.55	6860.54	2.52	17.29	0.86	1.3459							3.41
2016	17.99	215.82	6564.53	2.52	16.54	0.83	1.3728							3.33
2017	17.21	206.57	6283.11	2.52	15.83	0.79	1.4002							3.25
2018	16.48	197.74	6014.47	2.52	15.16	0.76	1.4282							3.17
2019	15.78	189.31	5758.24	2.52	14.51	0.73	1.4568							3.10
2020	15.11	181.27	5513.69	2.52	13.89	0.69	1.4859							3.03
2021	14.47	173.62	5280.82	2.52	13.31	0.67	1.5157							2.96
2022	13.86	166.33	5059.27	2.52	12.75	0.64	1.5460							2.89
2023	13.28	159.40	4848.30	2.52	12.22	0.61	1.5769							2.83
2024	12.21	146.50	4455.92	2.52	11.23	0.56	1.6084							2.65
Total	365.01		133227.19		335.73	17.89								61.54

Table 7.4 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(Before well stimulation and the data of reservoir simulation - Continued)

P	Q										R	S	T	U
	DEPRECIATION(20%)													CUMULATIVE
TOTAL	TANGIBLE EXPENSE										WRITE	TOT.ALLOW	TAXABLE	TAXABLE
COST	1999	2000	2001	2002	2003	2004	2005	2006	2007	TOTAL	OFF	EXPENSE	INCOME	INCOME
MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2.40	0.00									0.00	2.40	2.40	-2.40	-2.40
8.15		0.32								0.32	6.55	6.87	-6.87	-9.27
66.00			9.68							9.68	19.20	28.88	-28.88	-38.15
57.25				16.94						16.94	21.50	38.44	-27.41	-65.56
3.50					16.94					16.94	4.88	21.82	0.25	-65.30
3.57						16.94				16.94	4.95	21.89	0.18	-65.12
3.65							16.62			16.62	5.03	21.65	0.43	-64.69
3.72								7.26		7.26	5.10	12.36	9.72	-54.98
3.79									0.00	0.00	4.90	4.90	17.18	-37.80
3.86										0.00	4.96	4.96	17.05	-20.75
3.84										0.00	4.91	4.91	16.55	-4.20
3.79										0.00	4.83	4.83	15.95	11.75
3.69										0.00	4.69	4.69	15.17	26.92
3.59										0.00	4.53	4.53	14.38	41.30
3.50										0.00	4.40	4.40	13.68	54.98
3.41										0.00	4.28	4.28	13.01	67.99
3.33										0.00	4.16	4.16	12.39	80.38
3.25										0.00	4.04	4.04	11.79	92.17
3.17										0.00	3.93	3.93	11.22	103.39
3.10										0.00	3.83	3.83	10.69	114.08
3.03										0.00	3.72	3.72	10.17	124.25
2.96										0.00	3.62	3.62	9.68	133.93
2.89										0.00	3.53	3.53	9.22	143.16
2.83										0.00	3.44	3.44	8.78	151.94
2.65										0.00	3.21	3.21	8.02	159.96
193.59										84.70	126.78	211.48	124.25	

Table 7.4 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(Before well stimulation and the data of reservoir simulation - Continued)

V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
	YEAR				CASH FLOW SUMMARY						DISCOUNTED	7.25%
INCOME		GAS		GAS	GROSS	CAPEX	OPEX	GOVERNMENT TAKE		ANNUAL	CASH FLOW	DISC
TAX(50%)		PRODUCTION		PRICE	REVERNUE			ROYALTY	INC.TAX	CASH FLOW	(NPV@7.25%)	FACTOR
MM US$		MMCF/D	MMCF/Y	US$/MMBTU	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	
0.00	2000	0.00	0.00	2.52	0.00	2.40	0.00	0.00	0.00	-2.40	-2.40	1.0000
0.00	2001	0.00	0.00	2.52	0.00	8.31	0.00	0.00	0.00	-8.31	-7.75	0.9324
0.00	2002	0.00	0.00	2.52	0.00	68.67	0.00	0.00	0.00	-68.67	-59.70	0.8694
0.00	2003	12.00	4380.00	2.52	11.04	58.90	1.75	0.69	0.00	-50.30	-40.77	0.8106
0.00	2004	24.00	8760.00	2.52	22.08	0.00	3.50	1.38	0.00	17.19	12.99	0.7558
0.00	2005	24.00	8760.00	2.52	22.08	0.00	3.57	1.38	0.00	17.12	12.07	0.7047
0.00	2006	24.00	8760.00	2.52	22.08	0.00	3.65	1.38	0.00	17.05	11.20	0.6571
0.00	2007	24.00	8760.00	2.52	22.08	0.00	3.72	1.38	0.00	16.98	10.40	0.6127
0.00	2008	24.00	8760.00	2.52	22.08	0.00	3.79	1.38	0.00	16.90	9.66	0.5712
0.00	2009	23.92	8732.26	2.52	22.01	0.00	3.86	1.10	0.00	17.05	9.08	0.5326
0.00	2010	23.33	8513.63	2.52	21.45	0.00	3.84	1.07	0.00	16.55	8.22	0.4966
7.98	2011	22.59	8245.72	2.52	20.78	0.00	3.79	1.04	7.98	7.98	3.69	0.4631
7.59	2012	21.59	7881.45	2.52	19.86	0.00	3.69	0.99	7.59	7.59	3.28	0.4318
7.19	2013	20.57	7506.23	2.52	18.92	0.00	3.59	0.95	7.19	7.19	2.89	0.4026
6.84	2014	19.65	7173.35	2.52	18.08	0.00	3.50	0.90	6.84	6.84	2.57	0.3754
6.51	2015	18.80	6860.54	2.52	17.29	0.00	3.41	0.86	6.51	6.51	2.28	0.3500
6.19	2016	17.99	6564.53	2.52	16.54	0.00	3.33	0.83	6.19	6.19	2.02	0.3263
5.90	2017	17.21	6283.11	2.52	15.83	0.00	3.25	0.79	5.90	5.90	1.79	0.3043
5.61	2018	16.48	6014.47	2.52	15.16	0.00	3.17	0.76	5.61	5.61	1.59	0.2837
5.34	2019	15.78	5758.24	2.52	14.51	0.00	3.10	0.73	5.34	5.34	1.41	0.2645
5.09	2020	15.11	5513.69	2.52	13.89	0.00	3.03	0.69	5.09	5.09	1.25	0.2466
4.84	2021	14.47	5280.82	2.52	13.31	0.00	2.96	0.67	4.84	4.84	1.11	0.2300
4.61	2022	13.86	5059.27	2.52	12.75	0.00	2.89	0.64	4.61	4.61	0.99	0.2144
4.39	2023	13.28	4848.30	2.52	12.22	0.00	2.83	0.61	4.39	4.39	0.88	0.1999
4.01	2024	12.21	4455.92	2.52	11.23	0.00	2.65	0.56	4.01	4.01	0.75	0.1864
64.23	Total	365.01	133227.19		335.73	138.28	61.54	18.30	64.23	53.38	-14.22	
									PIR=	0.39	IRR=	4.99%

Table 7.5 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(After well stimulation and the data of Tank model)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
YEAR					GROSS REV.	ROYALTY	2%	INVESTMENT COST						
	GAS			GAS	SALE	SLIDING	ESCAL	SEISMIC	SEISMIC	DRILLING		PIPELINE	PROCESSING	OPER.
	PRODUCTION			PRICE	INCOME	SCALE	FACTOR	2D	3D	INTANG	TANG		FACILITY	COST
	MMCF/D	MMCF/M	MMCF/Y	US$/MMBTU	MM US$	MM US$		MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2000	0.00	0.00	0.00	2.52	0.00	0.00	1.0000	2.40						0.00
2001	0.00	0.00	0.00	2.52	0.00	0.00	1.0200		0.15	6.40	1.60			0.00
2002	0.00	0.00	0.00	2.52	0.00	0.00	1.0404			21.60	5.40	2.00	40.00	0.00
2003	36.00	432.00	13140.00	2.52	33.11	1.66	1.0612			21.60	5.40	1.50	30.00	5.26
2004	72.00	864.00	26280.00	2.52	66.23	4.14	1.0824							10.51
2005	72.00	864.00	26280.00	2.52	66.23	4.14	1.1041							10.72
2006	65.48	785.76	23900.20	2.52	60.23	3.76	1.1262							9.95
2007	54.16	649.92	19768.40	2.52	49.82	3.11	1.1487							8.39
2008	45.53	546.41	16619.91	2.52	41.88	2.09	1.1717							7.20
2009	38.63	463.56	14099.95	2.52	35.53	1.78	1.1951							6.23
2010	33.11	397.32	12085.15	2.52	30.45	1.52	1.2190							5.44
2011	28.59	343.08	10435.35	2.52	26.30	1.31	1.2434							4.79
2012	24.88	298.56	9081.20	2.52	22.88	1.14	1.2682							4.26
2013	21.80	261.60	7957.00	2.52	20.05	1.00	1.2936							3.80
2014	19.22	230.64	7015.30	2.52	17.68	0.88	1.3195							3.42
2015	17.04	204.48	6219.60	2.52	15.67	0.78	1.3459							3.09
2016	15.19	182.28	5544.35	2.52	13.97	0.70	1.3728							2.81
2017	13.60	163.20	4964.00	2.52	12.51	0.63	1.4002							2.57
2018	12.23	146.76	4463.95	2.52	11.25	0.56	1.4282							2.36
2019	11.03	132.41	4027.41	2.52	10.15	0.51	1.4568							2.17
2020	9.99	119.88	3646.35	2.52	9.19	0.46	1.4859							2.00
Total	590.49		215528.12		543.13	30.19								94.97

Table 7.5 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(After well stimulation and the data of Tank model - Continued)

P	Q										R	S	T	U
	DEPRECIATION(20%)													CUMULATIVE
TOTAL	TANGIBLE EXPENSE										WRITE	TOT.ALLOW	TAXABLE	TAXABLE
COST	1999	2000	2001	2002	2003	2004	2005	2006	2007	TOTAL	OFF	EXPENSE	INCOME	INCOME
MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2.40	0.00									0.00	2.40	2.40	-2.40	-2.40
8.15		0.32								0.32	6.55	6.87	-6.87	-9.27
69.00			9.80							9.80	21.60	31.40	-31.40	-40.67
63.76				17.18						17.18	28.51	45.69	-12.58	-53.25
10.51					17.18					17.18	14.65	31.83	34.39	-18.85
10.72						17.18				17.18	14.86	32.04	34.18	15.33
9.95							16.86			16.86	13.71	30.57	29.66	44.99
8.39								7.38		7.38	11.50	18.88	30.93	75.92
7.20									0.00	0.00	9.29	9.29	32.59	108.51
6.23										0.00	8.00	8.00	27.53	136.04
5.44										0.00	6.97	6.97	23.49	159.53
4.79										0.00	6.11	6.11	20.19	179.72
4.26										0.00	5.40	5.40	17.48	197.20
3.80										0.00	4.81	4.81	15.25	212.44
3.42										0.00	4.30	4.30	13.37	225.82
3.09										0.00	3.88	3.88	11.80	237.62
2.81										0.00	3.51	3.51	10.46	248.08
2.57										0.00	3.19	3.19	9.32	257.39
2.36										0.00	2.92	2.92	8.33	265.72
2.17										0.00	2.68	2.68	7.47	273.20
2.00										0.00	2.46	2.46	6.73	279.92
233.02										85.90	177.31	263.21	279.92	

Table 7.5 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(After well stimulation and the data of Tank model - Continued)

V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
	YEAR				CASH FLOW SUMMARY						DISCOUNTED	7.25%
INCOME		GAS		GAS	GROSS	CAPEX	OPEX	GOVERNMENT TAKE		ANNUAL	CASH FLOW	DISC
TAX(50%)		PRODUCTION		PRICE	REVERNUE			ROYALTY	INC.TAX	CASH FLOW	(NPV@7.25%)	FACTOR
MM US$		MMCF/D	MMCF/Y	US$/MMBTU	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	
0.00	2000	0.00	0.00	2.52	0.00	2.40	0.00	0.00	0.00	-2.40	-2.40	1.0000
0.00	2001	0.00	0.00	2.52	0.00	8.31	0.00	0.00	0.00	-8.31	-7.75	0.9324
0.00	2002	0.00	0.00	2.52	0.00	71.79	0.00	0.00	0.00	-71.79	-62.41	0.8694
0.00	2003	36.00	13140.00	2.52	33.11	62.08	5.26	2.07	0.00	-36.29	-29.42	0.8106
0.00	2004	72.00	26280.00	2.52	66.23	0.00	10.51	4.14	0.00	51.57	38.98	0.7558
7.66	2005	72.00	26280.00	2.52	66.23	0.00	10.72	4.14	7.66	43.70	30.80	0.7047
22.49	2006	65.48	23900.20	2.52	60.23	0.00	9.95	3.76	22.49	24.02	15.79	0.6571
15.47	2007	54.16	19768.40	2.52	49.82	0.00	8.39	3.11	15.47	22.85	14.00	0.6127
16.30	2008	45.53	16619.91	2.52	41.88	0.00	7.20	2.62	16.30	15.77	9.01	0.5712
13.76	2009	38.63	14099.95	2.52	35.53	0.00	6.23	1.78	13.76	13.76	7.33	0.5326
11.74	2010	33.11	12085.15	2.52	30.45	0.00	5.44	1.52	11.74	11.74	5.83	0.4966
10.09	2011	28.59	10435.35	2.52	26.30	0.00	4.79	1.31	10.09	10.09	4.67	0.4631
8.74	2012	24.88	9081.20	2.52	22.88	0.00	4.26	1.14	8.74	8.74	3.77	0.4318
7.62	2013	21.80	7957.00	2.52	20.05	0.00	3.80	1.00	7.62	7.62	3.07	0.4026
6.69	2014	19.22	7015.30	2.52	17.68	0.00	3.42	0.88	6.69	6.69	2.51	0.3754
5.90	2015	17.04	6219.60	2.52	15.67	0.00	3.09	0.78	5.90	5.90	2.06	0.3500
5.23	2016	15.19	5544.35	2.52	13.97	0.00	2.81	0.70	5.23	5.23	1.71	0.3263
4.66	2017	13.60	4964.00	2.52	12.51	0.00	2.57	0.63	4.66	4.66	1.42	0.3043
4.17	2018	12.23	4463.95	2.52	11.25	0.00	2.36	0.56	4.17	4.17	1.18	0.2837
3.74	2019	11.03	4027.41	2.52	10.15	0.00	2.17	0.51	3.74	3.74	0.99	0.2645
3.36	2020	9.99	3646.35	2.52	9.19	0.00	2.00	0.46	3.36	3.36	0.83	0.2466
147.63	Total	590.49	215528.12		543.13	144.58	94.97	31.13	147.63	124.83	41.97	
									PIR=	0.86	IRR=	15.91%

Table 7.6 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(After well stimulation and the data of reservoir simulation)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
YEAR					GROSS REV.	ROYALTY	2%	INVESTMENT COST						
	GAS			GAS	SALE	SLIDING	ESCAL	SEISMIC	SEISMIC	DRILLING		PIPELINE	PROCESSING	OPER.
	PRODUCTION			PRICE	INCOME	SCALE	FACTOR	2D	3D	INTANG	TANG		FACILITY	COST
	MMCF/D	MMCF/M	MMCF/Y	US$/MMBTU	MM US$	MM US$		MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2000	0.00	0.00	0.00	2.52	0.00	0.00	1.0000	2.40						0.00
2001	0.00	0.00	0.00	2.52	0.00	0.00	1.0200		0.15	6.40	1.60			0.00
2002	0.00	0.00	0.00	2.52	0.00	0.00	1.0404			21.60	5.40	2.00	40.00	0.00
2003	35.50	426.00	12957.50	2.52	32.65	1.63	1.0612			21.60	5.40	1.50	30.00	5.18
2004	73.00	876.00	26645.00	2.52	67.15	4.20	1.0824							10.66
2005	73.00	876.00	26645.00	2.52	67.15	4.20	1.1041							10.87
2006	73.00	876.00	26645.00	2.52	67.15	4.20	1.1262							11.09
2007	71.47	857.62	26085.89	2.52	65.74	4.11	1.1487							11.07
2008	60.24	722.86	21987.09	2.52	55.41	3.46	1.1717							9.52
2009	48.12	577.43	17563.40	2.52	44.26	2.21	1.1951							7.76
2010	39.80	477.63	14528.06	2.52	36.61	1.83	1.2190							6.54
2011	33.40	400.80	12191.00	2.52	30.72	1.54	1.2434							5.60
2012	28.32	339.79	10335.34	2.52	26.05	1.30	1.2682							4.84
2013	24.22	290.61	8839.46	2.52	22.28	1.11	1.2936							4.23
2014	20.87	250.40	7616.38	2.52	19.19	0.96	1.3195							3.71
2015	18.09	217.10	6603.40	2.52	16.64	0.83	1.3459							3.28
2016	15.77	189.27	5756.85	2.52	14.51	0.73	1.3728							2.92
2017	13.82	165.86	5044.85	2.52	12.71	0.64	1.4002							2.61
2018	12.17	146.02	4441.32	2.52	11.19	0.56	1.4282							2.34
2019	10.76	129.18	3929.08	2.52	9.90	0.50	1.4568							2.12
2020	9.57	114.79	3491.59	2.52	8.80	0.44	1.4859							1.92
Total	661.11		241306.21		608.09	34.44								106.27

Table 7.6 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(After well stimulation and the data of reservoir simulation - Continued)

P	Q										R	S	T	U
	DEPRECIATION(20%)													CUMULATIVE
TOTAL	TANGIBLE EXPENSE										WRITE	TOT.ALLOW	TAXABLE	TAXABLE
COST	1999	2000	2001	2002	2003	2004	2005	2006	2007	TOTAL	OFF	EXPENSE	INCOME	INCOME
MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$
2.40	0.00									0.00	2.40	2.40	-2.40	-2.40
8.15		0.32								0.32	6.55	6.87	-6.87	-9.27
69.00			9.80							9.80	21.60	31.40	-31.40	-40.67
63.68				17.18						17.18	28.42	45.60	-12.94	-53.61
10.66					17.18					17.18	14.85	32.03	35.11	-18.50
10.87						17.18				17.18	15.07	32.25	34.90	16.40
11.09							16.86			16.86	15.29	32.15	35.00	51.40
11.07								7.38		7.38	15.18	22.56	43.17	94.57
9.52									0.00	0.00	12.98	12.98	42.42	137.00
7.76										0.00	9.97	9.97	34.29	171.29
6.54										0.00	8.37	8.37	28.24	199.52
5.60										0.00	7.14	7.14	23.58	223.11
4.84										0.00	6.15	6.15	19.90	243.00
4.23										0.00	5.34	5.34	16.94	259.94
3.71										0.00	4.67	4.67	14.52	274.46
3.28										0.00	4.12	4.12	12.52	286.98
2.92										0.00	3.65	3.65	10.86	297.85
2.61										0.00	3.25	3.25	9.47	307.31
2.34										0.00	2.90	2.90	8.29	315.60
2.12										0.00	2.61	2.61	7.29	322.89
1.92										0.00	2.36	2.36	6.44	329.33
244.32										85.90	192.86	278.76	329.33	

Table 7.6 The cash flow table that calculates the pay back period, net present value, profit investment ratio and internal rate of return.

(After well stimulation and the data of reservoir simulation - Continued)

V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
	YEAR				CASH FLOW SUMMARY						DISCOUNTED	7.25%
INCOME		GAS		GAS	GROSS	CAPEX	OPEX	GOVERNMENT TAKE		ANNUAL	CASH FLOW	DISC
TAX(50%)		PRODUCTION		PRICE	REVERNUE			ROYALTY	INC.TAX	CASH FLOW	(NPV@7.25%)	FACTOR
MM US$		MMCF/D	MMCF/Y	US$/MMBTU	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	MM US$	
0.00	2000	0.00	0.00	2.52	0.00	2.40	0.00	0.00	0.00	-2.40	-2.40	1.0000
0.00	2001	0.00	0.00	2.52	0.00	8.31	0.00	0.00	0.00	-8.31	-7.75	0.9324
0.00	2002	0.00	0.00	2.52	0.00	71.79	0.00	0.00	0.00	-71.79	-62.41	0.8694
0.00	2003	35.50	12957.50	2.52	32.65	62.08	5.18	2.04	0.00	-36.65	-29.71	0.8106
0.00	2004	73.00	26645.00	2.52	67.15	0.00	10.66	4.20	0.00	52.29	39.52	0.7558
8.20	2005	73.00	26645.00	2.52	67.15	0.00	10.87	4.20	8.20	43.88	30.92	0.7047
25.70	2006	73.00	26645.00	2.52	67.15	0.00	11.09	4.20	25.70	26.16	17.19	0.6571
21.59	2007	71.47	26085.89	2.52	65.74	0.00	11.07	4.11	21.59	28.97	17.75	0.6127
21.21	2008	60.24	21987.09	2.52	55.41	0.00	9.52	3.46	21.21	21.21	12.12	0.5712
17.15	2009	48.12	17563.40	2.52	44.26	0.00	7.76	2.21	17.15	17.15	9.13	0.5326
14.12	2010	39.80	14528.06	2.52	36.61	0.00	6.54	1.83	14.12	14.12	7.01	0.4966
11.79	2011	33.40	12191.00	2.52	30.72	0.00	5.60	1.54	11.79	11.79	5.46	0.4631
9.95	2012	28.32	10335.34	2.52	26.05	0.00	4.84	1.30	9.95	9.95	4.30	0.4318
8.47	2013	24.22	8839.46	2.52	22.28	0.00	4.23	1.11	8.47	8.47	3.41	0.4026
7.26	2014	20.87	7616.38	2.52	19.19	0.00	3.71	0.96	7.26	7.26	2.73	0.3754
6.26	2015	18.09	6603.40	2.52	16.64	0.00	3.28	0.83	6.26	6.26	2.19	0.3500
5.43	2016	15.77	5756.85	2.52	14.51	0.00	2.92	0.73	5.43	5.43	1.77	0.3263
4.73	2017	13.82	5044.85	2.52	12.71	0.00	2.61	0.64	4.73	4.73	1.44	0.3043
4.14	2018	12.17	4441.32	2.52	11.19	0.00	2.34	0.56	4.14	4.14	1.18	0.2837
3.65	2019	10.76	3929.08	2.52	9.90	0.00	2.12	0.50	3.65	3.65	0.96	0.2645
3.22	2020	9.57	3491.59	2.52	8.80	0.00	1.92	0.44	3.22	3.22	0.79	0.2466
172.86	Total	661.11	241306.21		608.09	144.58	106.27	34.84	172.86	149.53	55.60	
									PIR=	1.03	IRR=	18.17%

Column		Detail
A	=	Year
B	=	Gas production per day (MMSCF/D)
C	=	Gas production per month (MMSCF/M)
D	=	Gas production per year (MMSCF/Y)
E	=	Gas price (US$ / MMBTU) constant over the contract
F	=	Gross revenue sale income (MMUS$)
	=	[(1000 * D* E)] / 1,000,000
G	=	Royalty sliding scale 6.25 or 5 percent of gross revenue (MMUS$)
	=	F*0.0625 or 0.05
H	=	2% escalation factor
I	=	(2-D seismic investigation cost * distances of 2-D seismic) + geologic survey + special bonus
J	=	3-D seismic investigation cost * area of 3-D
I,J	=	Investment is intangible cost 100 percent
K	=	Number of well * Intangible cost 80 percent * well cost
L	=	Number of well * Tangible cost 20 percent * well cost
K&L	=	Investment cost is divided to tangible cost 20 percent and intangiblecost 80 percent
M	=	Pipeline cost * pipeline length
N	=	Processing production facilities
M&N	=	Investment cost is tangible cost 100 percent
O	=	Operating cost
	=	[D*400/1,000,000] * escalation factor 2% for each year

P	=	Total cost = I+J+K+L+M+N+O
Q	=	Depreciation rate 20 percent of tangible cost (straight forward 5 years).
	=	(L+M+N)*0.20
R	=	Write off (MMUS$) = G+I+J+K+O
S	=	Total allow expense = (Total Q) + R
T	=	Taxable income (MMUS$) = F-S
	=	Gross revenue - Total allow expense
U	=	Cumulative taxable income (MMUS$)
V	=	Income tax (MMUS$) = U*0.50
W	=	Year
X	=	Gas production per day (MMSCF/D)
Y	=	Gas production per year (MMSCF/Y)
Z	=	Gas price (US$/MMBTU)
AA	=	Gross revenue = F
AB	=	Capital cost (MMUS$)
	=	(I+J+K+L+M+N) * (2% escalation factor)
AC	=	Operation cost (MMUS$) = O
AD	=	Royalty = G
AE	=	Income tax. (MMUS$) = V
	=	U*0.5 (50 percent of taxable income accounted when the project start getting profit
AF	=	Annual cash flow = AA-AB-AC-AD-AE
AG	=	Discounted cash flow (NPV @ 7.25%)

= AE * discounted factor each year

AH = Discounted factor

Note: a. The glossary of evaluation terms show in appendix.

b. Cash inflow and cash outflow analysis is considered the money annual project that specified the cash status of annual economic process.

c. Pay back period analysis consider at the first year of the cumulative taxable income is the positive value.

d. Income tax is calculated from net profit.

e. Net profit after tax is equal to cash flow minus tangible cost.

f. Tangible cost is equal to depreciation-sunk cost including the operating cost.

g. Depreciation sunk cost is 20 percent of depreciation.

h. Net present value, profit investment ratio and interest rate of return are calculated similar to example below.

1) Net present value (NPV)

Assume NPV at 20th year (2023) calculated backward to 1st year (2000) @ i = 7.25%

$$NPV = A (1 + i)^{-n},$$

$$= 1.42 (1+0.0725)^{-19},$$

$$= 0.38 \text{ MMUS\$}.$$

Where A is the annual cash flow, n is the amount of year, and i is the discount rate.

2) Profit Investment Ratio (PIR)

PIR is the ratio of sum of annual cash flow divided by sum of CAPEX

$$PIR = \sum (\text{Annual cash}) / \sum (\text{CAPEX}).$$

Data from Tank model and Well stimulation with

$$PIR = 130.21/144.58,$$

$= \quad 0.90.$

Data from reservoir simulation and Well stimulation with

PIR $= 149.94/144.58 = 1.04.$

3) Internal Rate of return (IRR)

- Using trial & error to find **I** value. **I** value make the lower equation to be zero or nearby when replace **I** in the equation.

$$0 = (-C)+A(1+\mathbf{I})^{-1}+A(1+\mathbf{I})^{-2}+...+A(1+\mathbf{I})^{-n}.$$

Where C is negative annual cash flow value, A is annual cash flow value and **I** is the assume value. Assume **I** = 0.1821, the result when replace **I** in upper equation is NPV that equal to 0.01, **I** = 0.1823, the result when replace **I** in upper equation is NPV that equal to -0.01.

Using interpolate method to find IRR.

$$IRR = [(NPV_{\mathbf{I}=0.1889} / \{NPV_{\mathbf{I}=0.1889} - NPV_{\mathbf{I}=0.1891}\})*(\mathbf{I}_{0.1891} - \mathbf{I}_{0.1889})] + \mathbf{I}_{0.1889},$$

$$= [(0.01 / \{0.01-(-0.01)\}) * (0.1823-0.1821)] + 0.1821,$$

$$= 0.1822 = 18.22\%.$$

7.6 Results of cash flow calculation

From total of cash flow analysis shows the total study worth of 18 years of Tank model which is done well stimulation process. The total worth is divided in to gross sale income 543.13 MMUS$ and total cost 233.02 MMUS$.

The total cost is divided in to three parts.

a. Exploration cost 2.55 MMUS$.

b. Drilling & production facilities cost 135.50 MMUS$.

c. Operating cost 94.97 MMUS$.

Government take is divided in to

a. Royalty cost 30.19 MMUS$.

b. Income tax @ 50% 147.63 MMUS$.

Cumulative annual cash flow = 124.83 MMUS$.

From total of cash flow analysis shows the total study worth of 18 years of reservoir simulation with well stimulation with. The total worth is divided in to gross sale income 608.09 MMUS$ and total cost 244.32 MMUS$.

The total cost is divided in to three parts.

a. Exploration cost 2.55 MMUS$.

b. Drilling & production facilities cost 135.50 MMUS$.

c. Operating cost 106.27 MMUS$.

Government take is divided in to

a. Royalty cost 34.84 MMUS$.

b. Income tax @ 50% 172.46MMUS$.

Cumulative annual cash flow = 149.40 MMUS$.

7.7 Economic analysis

Data from Tank model (With well stimulation)

a. Since 1st year until 4th year of the project (B. C. 2000-2004), cash flow is still in negative because total investment does not return in this time frame. This period contains many expenses including investment, development and exploration.

b. The 4th year (at B. C. 2003) is the first production year that produces 36 MMSCF/D of natural gas. The gross revenue 33.11 MMUS$ and cash flow becomes negative at -29.42 MMUS$. The cumulative tax income still minus value at –53.25 MMUS$.

c. The 5th year (at B. C. 2004), the production are increased by increasing development well for three wells that produces 72 MMSCF/D of natural gas. The gross revenue is 66.23 MMUS$ and cash flow becomes positive at 38.98 MMUS$. The cumulative tax income is still minus value at –18.85 MMUS$.

d. The production has continuously produced along 2 year from 5th year production (2004) to 6th year (2005) which production rate is 72 MMSCF/D. At the 5th year, this project earns 99.34 MMUS$ of total income. The cash flow becomes positive at 30.80 MMUS$ when reaches 6th year.

e. The production rate continues decreasing in 7th- 18th. year. At the last production year, cash flow and cumulative income belong to positive value which indicates the cumulative income are 279.92 MMUS$.

f. The natural gas production has paid back completely at 3nd year of production that is observed from cumulative income recovering to positive range.

g. Total income after project is successful 124.83 MMUS$. The total discount cash flow which calculated backward to 1st year (2000) with i = 7.25% is 41.97 MMUS$.

h. Internal rate of return (IRR) is 15.91%.

i. Profit to investment ratio (PIR) is calculated by using the annual cash flow divided by CAPEX. Profit investment ratio is equal to 0.86.

Data from Reservoir simulation model (With well stimulation)

a. Since 1st year until 4th year of the project (B. C. 2000-2004), cash flow is still in negative because total investment does not return in this time frame. This period contains many expenses including investment, development and exploration.

b. The 4th year (at B. C. 2003) is the first production year that produces 35.5 MMSCF/D of natural gas. The gross revenue 32.65 MMUS$ and cash flow becomes negative at -29.71 MMUS$. The cumulative tax income still minus value at –53.61 MMUS$.

c. The 5th year (at B. C. 2004), the production are increased by increasing development well for three wells that produces 73 MMSCF/D of natural gas. The gross revenue is 67.15 MMUS$ and cash flow becomes positive at 39.52 MMUS$. The cumulative tax income is still minus value at –18.50 MMUS$.

d. The production has continuously produced along 3 year from 5th year production (2004) to 7th year (2006) which production rate is 73 MMSCF/D. At the 5th year, this project earns 99.80 MMUS$ of total income. The cash flow becomes positive at 17.19 MMUS$ when reaches 7th year.

e. The production rate continues decreasing in 8th- 18$^{th.}$ year. At the last production year, cash flow and cumulative income belong to positive value which indicates the cumulative income are 329.33 MMUS$.

f. The natural gas production has paid back completely at 3nd year of production that is observed from cumulative income recovering to positive range.

g. Total income after project is successful 149.53 MMUS$. The total discount cash flow which calculated backward to 1st year (2000) with i = 7.25% is 41.97 MMUS$.

h. Internal rate of return (IRR) is 18.17%.

i. Profit to investment ratio (PIR) is calculated by using the annual cash flow divided by CAPEX. Profit investment ratio is equal to 1.03.

7.8 Conclusions

The data from Tank model with well stimulation is used in the economic aspect. The gas production had started in the 4th year (1st year production) with the rate of 36 MMSCF/D and in the 5th year the rate increased to 72 because development wells were increased. The production was constant for 2 year and then declined 13% per year until ended at the 21thyear (18th year production). The final production rate in 21thyear is 9.99 MMSCF/D. The pay back period is determined by using cash flow calculation. The natural gas production has completely paid back at the 3rd year of the production. The internal rate of return is 15.91% and the profit to investment ratio is equal to 0.86. Without well stimulation the reservoir will not be economically produced because the initial rate of return is 2.82% which is less than discount rate of 7.25%.

The data from reservoir simulation model with well stimulation is used in the economic aspect. The gas production had started in the 4th year (the 1st year production) with the rate of 35.5 MMSCF/D, at the 5th year the rate increased to 73 because development wells were increased. The rate was constant for 3 year and declined 14% per year until and ended at the 21st year (the 18th year production) that is the last year of gas production. The final production rate in the 21th year is 9.57 MMSCF/D. The pay back period is determined by using cash flow calculation. The natural gas production has completely paid back in the 3rd year of the production. The internal rate of return is 18.17% and the profit investment ratio is 1.03. Without well stimulation the reservoir will not be economically produced because the initial rate of return is 4.99% which is less than discount rate of 7.25%.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The estimation of petroleum production efficiency in carbonate reservoir of northeastern Thailand is not accurate and sufficient enough. The study of porosity and permeability distribution is necessary. In this thesis, the carbonate rock samples are collected from Saraburi, Phetchabun, Lopburi and Loei provinces. These samples have moderated properties for gas reservoir. Porosity and permeability values were measured in the laboratory. The specimens had average porosity about 4%. The permeabilities of specimen were determined by using the overburden poro-perm cell. The average permeability value is 0.000296 mD, but it does not represent to use in the reservoir model simulation because the permeability value in the outcrops and in the actual reservoir are different. The permeability in outcrops were cemented and the core with natural fractures in the reservoir condition could not be collected and tested. The permeability values used in simulator come from the assumptions, well test data, collection data in reference papers and simulation history match. The average permeability is 0.2 mD. Simulation model gives the reasonable results. The original rock permeability may not be good enough to produce gas but after well stimulation process, the permeability becomes good effective value. The average values of permeability in fracturing zone is approximetely 19 md.

In the part of Tank model, the Tank model is useful for determination of the petroleum production and estimate of the production rate. The top of the model is set at 6,000 feet of depth. Before stimulation the production rate is started at 3500 MSCF/D/well. The model produces gas with constant rate for four years. After that, the production rate declines each year and ends at the 24^{th} year. If well stimulation process has been done, the production rate is started at 12,000 MSCF/D/Well, and kept at constant rate for four years. After that the rate declines each year and ends at the 18^{th} year. The total gas production is 36.2 BCF with gas in place of 52 BCF.

In the part of well stimulation, in this study, reservoir model is carbonate limestone reservoir with fracture acidizing to increase production rate. This design is the method for increasing permeability of near wellbore and production rate of carbonate reservoirs. The importance factors of this method are acid and pump. The fracture acidizing process is designed 1,200 feet of formation thickness, 4,000 Psia of shut in bottom-hole pressure, 640 acres of well spacing, 6,000 of depth to top reservoir, 180 min of acid spending time and two vertical fractures at 6,100-6,550 feet and 6,650-7,100 feet of depth, 0.01 in of each fractures width, 540 feet of fracture radiant. It required 4,440 bbl/well of acid and 1,200-1,400 Hp of with the hydraulic pump pressure of 4,200-4600 psia.

In the part of reservoir simulation, the model is created with the approximate size of 4.26x6.4x0.457 cubic-kilometers. The prospect reservoir area covers around 27 square-kilometers (6,749 acres). The gross thickness is 150 feet and net thickness is 24 feet in each layer. The total gross thickness is 1,500 feet and total net thickness is 240 feet. The total grid block of reservoir area model is accounted to 1,668 grid blocks. The model has one exploration well, three appraisal wells and three development wells. Three of six development wells are changed from appraisal wells to development well. So that the model has seven wells but exposes only six wells. The prospect reservoir has average permeability about 0.2 mD and average porosity about 0.04 (4%). The simulation gives reserve of 240 BCF and original gas in place of 300 BCF (according to FASPU program). The cumulative gas production efficiency is 80% of initial in place.

The data from Tank model with well stimulation are used in the economic aspect. The gas production had started at the 4th year (1st year production) with the rate of 36 MMSCF/D, at the 5th year the rate increased to 72 MMSCF/D because of the producing wells were increased. The production was constant for 2 year and then declined 13% per year until ended at the 21thyear (18th year production). The final production rate at 21thyear is 9.99 MMSCF/D. The pay back period is determined by using cash flow calculation. The natural gas production has completely paid back at the 3rd year of the production. The internal rate of return is 15.91% and the profit to investment ratio is equal to 0.86. Without well stimulation the reservoir will not be economically produced because the initial rate of return is 2.82% which it is less than discount rate of 7.25%

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8.2 The recommendations of Tank model with well stimulation

1) The researcher should study and learn to understand the gas flow and acid fracturing equation.

2) The researcher should know about basic of visual basic program because the visual basic program is used for creating Tank model and acid fracturing design.

3) The limitation action of the Tank model is that it can predict the petroleum production rate on one well.

4) In this thesis, visual basic is interested because it is easy and convenient to use for writing Tank model and acid fracturing program.

5) The fracture acidizing for well stimulation is used in carbonate reservoir because it gives maximum production efficiency and increases the production rate in carbonate reservoir.

8.3 The recommendations of simulation

1) The researcher should study and learn to understand the black oil simulation manual before working with simulation program.

2) The researcher should know about basic FORTRAN because the FORTRAN is used in the simulator.

3) The contour intervals are difficult to draw by hand. Setting the coordinate x, y of the contour on the white paper that is the property map of the Work Bench program. Contours are identified in each layer of the model.

4) Simulation results are case study data which can be used for decision making in the investment of petroleum exploration and production in the nearby petroleum potential area.

5) Reliability of simulation result depends on the accuracy of the input data and the simulation model.

6) The digitized calculation by computer will provide more accurate values and less time of calculation than using the manual calculation. The repeating calculation manually often gives error.

7) Simulation results are useful in the prediction of the future petroleum business in northeastern Thailand.

8.4 The recommendations of simulation of gas reservoir in the northeast.

Most of the gas reservoirs in northeastern Thailand are carbonate reservoir. The prediction about petroleum production is very difficult and complex because the carbonate reservoir has fractures and caverns, and carbonate rock are massive to fine-grained. The suggestions for gas reservoir simulation in northeastern Thailand are as follows:

1) Study of the interested area used in the simulation process in order to know the problems, data details, history etc.

2) Porosity values in northeastern Thailand rocks are uncertain because of the fraction in the reservoirs. Porosity determination is important. High porosity is in the fractured zone. If only high porosity is input in the simulation model, the results are not correct. The researcher should use the average porosity to input in the simulation process.

3) The completed data of gas reservoir in northeastern Thailand should be collected and used in simulation so that the results are proximity of the actual performance.

8.5 The recommendations of simulation results used in the petroleum exploration and production

1) Simulation results are advantage valuable data to use for decision-making in the investment of petroleum exploration and production in the other petroleum prospects in northeastern Thailand.

2) Simulation results are useful in the prediction of the future petroleum business in the northeast.

3) The simulation is the method of compiling program to create the model that is similar to the actual by input the data in the simulation program. After history match, the modified input become more accurate and the production forecast is reliable. The simulation can reduce the time and money from real performance in other new fields. Then simulation is a considered method, which is useful for the estimation of petroleum production. The simulation accuracy depends on the quantity and quality of input data.

REFERENCES

Assavapatchara, S., Charusiri, P. and Khantaprab, C. (1997). The Permian carbonate rocks in Thailand. In **The International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific** (p. 139). Bangkok.

Assavarittiiprom, V., Chaisilboon, B. and Polachan, S. (1995). Review on petroleum exploration in Northeastern Thailand. In **Proceedings of the International Conference on Geology, Geotechnology and Mineral Resources of Indochina (Geo-Indo'95)** (pp. 541-550). Khon Kaen.

Barnum, R.S. and Moore, K.S. (1985). **Results of Nam Phong 1A Production Tests, Korat Plateau, Thailand.** Exxon Production Research Company. (Unpublished menuscript).

Bill Johnson. (2002). **Well Stimulation Advances** [On-line]. Available:http://www. pttc.org/ solutions/208.pdf.

Booth, J. E. (1998). The Khorat Plateau of NE Thailand-Exploration History and Hydrocarbon Potential. In **Proceedings of the SEAPEX Exploration Conference** (pp. 169-203). Singapore.

Calvin, C. M. and Robert L. D. (1989). **Reservoir Simulation**. U.S.: Society of Petroleum Engineer.

Chierici, G. L. (1995). **Principles of Petroleum Reservoir Engineering**. Germany.

Chinoroje, O. and Cole, M. R. (1995). Permian carbonates in the Dao Ruang-1 exploration well Implications for petroleum potential, Northeast Thailand. In **Proceedings of the International Conference on Geology, Geotechnology and Mineral Resources of Indochina (Geo-Indo'95)** (pp. 563-576). Khon Kaen.

Chonglakmani, C., Charoentitira , T. and Liengjarern, M. (1995). Permian carbonates of Loei area, Northeastern Thailand. In **Proceedings of the International Conference on Geology, Geotechnology and Mineral Resources of Indochina (Geo-Indo'95)** (pp. 577-587). Khonkean.

Conaway, C. F. (1999). **The Petroleum Industry Anontechnical Guide**. Oklahoma: PennWell Publishing Company.

Craft, B. C. and Holden, W. R. (1962). **Well Design.** New Jersey: Prentice-Hall, Inc.

Craft, B.C. and Hawkins, M. F. (1990). **Applied Petroleum Reservoir Engineering**. New Jersey: Prentice-Hall, Inc

Doscher, T.M. (1993). Petroleum reservoir model. In S.P. Parker (ed.) **McGraw-Hill Encyclopedia of Engineering** (pp. 893-895). U.S.: McGraw-Hill.

Economides, M.J. and Daniel, H.A. (1994). **Petroleum Production System.** New Jersey: Prentice-Hall, Inc.

Hall, S. J., Spengler, R. M., Sumpter, L. T., Kuhn, G. R., Zhang, G. and Murrey, M. (2002) **Nam Phong Field: Successful Directional Drilling in Naturally Fractured Carbonate Reservoir**. Bangkok: Department of Miniral Resources

Harris, R. and McKay, I. (2002). **Arcasolve™ Stimulation of Natural Fracture Networks in Austin Chalk.** Presented at Cleansorb Limited, The Surrey

Technology Centre (Adapted from Arcasolve Technical Document ATD-CH3). United Kingdom: Cleansorb Ltd.

Henry, B. C. (1997). **Modern Reservoir Engineering-A Simulation Approach**. New Jersey: Englewood Cliffs.

http://www.dme.wa.gov.au/Petroleum/PDF/Woodada%20Gasfield.pdf.

John, R. F. (1997). **Principles of Applied Reservoir Simulation**. Texas: Houston.

Kozar, M. G., Crandall, G. F. and Hall, S. E. (1992). Integrated Structural and Stratigraphic Study of the Korat Basin, Rat Buri Limestone (Permian),Thailand. In **Geologic Resource of Thailand : Potential for Future Development** (pp. 692-736). Bangkok.

Kriangkri, T. (1987). **The Reserve, Energy Production and Production Natural Gas Rate Determination.** Institute of Engineering, Suranaree University of Technology. (Unpublished menuscript).

Kritzler, T. (2002). **A Systematic Approach to improve the Performance of Acid-Fracturing Treatments in Low –Pressure, Low-Temperature Wells** [On-line]. Available: http://speonline.spe.org/events/urls/2002fd/ SPE73746.pdf.

McCray, A. W. (1975). **Petroleum Evaluations and Economic Decisions.** New Jersey: Prentice-Hall, Inc.

Mineral Fuels Division, Department of Mineral Resources Ministry of Industry. (1999). **Petroleum Act and Petroleum Income Tax Act B.E. 1999 Thailand III**. Bangkok.

Owad-Jones, D.L. and Ellis, G.K. **Woodada gasfield**. Available:

Piyasin, S. (1995). The hydrocarbon potential of Khorat plateau. In **Proceedings of**

the International Conference on Geology, Geotechnology and Mineral Resources of Indochina (Geo-Indo'95) (pp. 551-562). Khon Kaen.

Prapidtan, S. (1995). Petroleum exploration in Northeastern Thailand: The revealed results and its potential. In **Proceedings of the International Conference on Geology, Geotechnology and Mineral Resources of Indochina (Geo-Indo'95)** (pp. 589-599). Khon Kaen.

Rahim, Z., Bartko, K. and Mohammed, Y. (2002). **Hydraulic Fracturing Case Histories in the Carbonate and Sandstone Reservoirs of Khuff and PreKhuff Formations.** In Bybee, K. (Ed.) Assistant Technology contains highlights of paper SPE 77677, Ghawar Field, Saudi Arabia, presented at the 2002 SPE Annual Technical Conference and Exhibition, San Antonio, Texas, 29 September-2 October.

Sattayarak, N. (1992). Petroleum Exploration Opportunities in Thailand. In **the National Conference on Geologic Resources of Thailand: Potential for Future Development** (pp. 668-675). Bangkok.

Shannon, P. (1988). **Fundamentals of Core Analysis and Special Core Analysis**. Bangkok. Thailand: PTTEP Short Course.

Smith, R. V. (1990). **Practical Natural Gas Engineering.** Oklahoma: PennWell Publishing Company. Sattayarak, N., Pradidtan, S. and Chonglakmani, C. (1997). Stratigraphy and depositional environment of the upper Palaeozoic and Mesozoic sediments in the central and northeastern parts of Thailand. In **the International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific and the Associated Meeting of IGCP 359, IGCP 383 (Geo-Indo'97)** (pp. 7-14). Bangkok.

APPENDIX A

PHOTOGRAPH SHOW AREAS STUDY

Figure A.1 Stop 1 outcrop from Kaeng Khoi, Saraburi province.

Figure A.2 Stop 2 outcrop from Stop 2 Khao Kho, Saraburi province.

Figure A.3 Stop 3 from Kaeng Khoi, Saraburi province.

Figure A.4 Stop 4 from Khao Kho, Saraburi province.

Figure A.5 Stop 5 from Khao Kho, Saraburi province.

Figure A.6 Stop 6 from Kaeng Khoi, Saraburi province.

Figure A.7 Stop 7 from Muaklek, saraburi province.

Figure A.8 Stop 8 from Pak Chong, Nakhon Ratchasima province.

Figure A.9 Stop 9 from Pak Chong, Nakhon Ratchasima province.

Figure A.10 Stop 10 from Kaeng Khoi, Saraburi province.

Figure A.11 Stop 11 from Muang, Loei province.

Figure A.12 Stop 12 from Arawan, Loei province.

Figure A.13 Stop 13 from 78 km Chompae-Loamsak, Phetchabun province.

Figure A.14 Stop 14 from 39 km Chompae-Loamsak, Phetchabun province.

Figure A.15 Stop 15 from Khao Somposhn, Chaibadal, Lopburi.

Figure A.16 Stop 16 Muaklek, saraburi province.

Figure A.17 Stop 17 from Muaklek, saraburi province.

APPENDIX B

FORM AND SOURCE CODE OF TANK MODEL

Figure B.1 Tank model input form

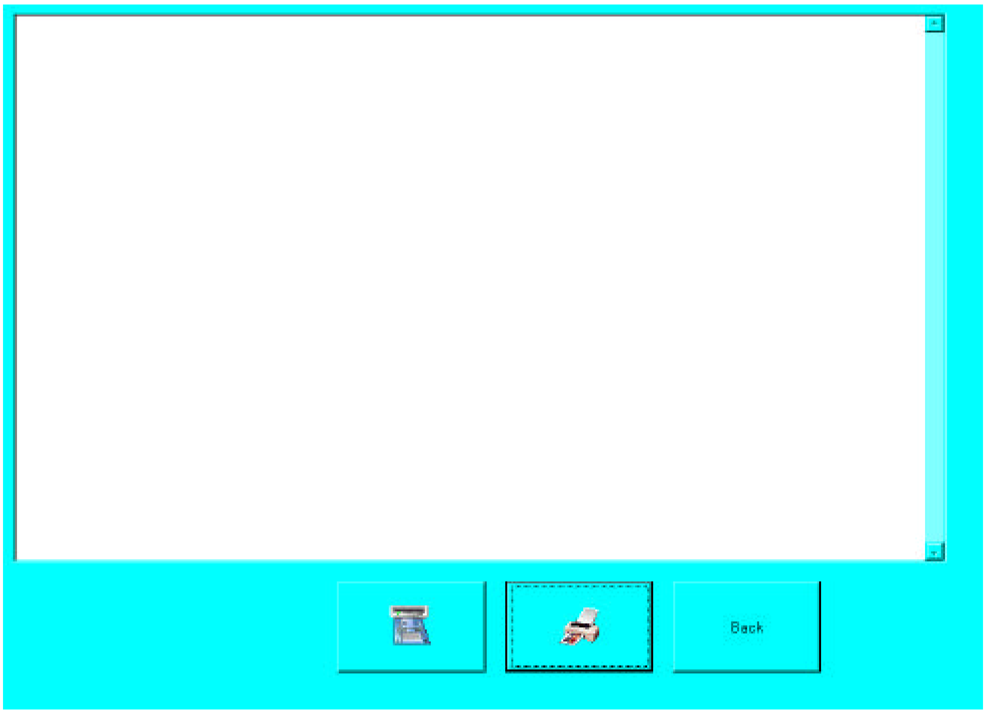

Figure B.2 Tank model output form

Source code of tank form

```
Private Sub Qmax_Click()

Dim M, Q, Pi, AAA, Ppc, Tpc, Dpr, Z, Zt As Double

Pi = 3.14159265358979

If MsgBox("Please wait one minute", vbYesNo + vbQuestion, "Message") = vbYes Then

Else

Exit Sub

End If

ZZ = 0.2

ZZZ = 0.2

A1 = 0.31506237

A2 = (-1.0467099)

A3 = (-0.57832729)

A4 = 0.53530771

A5 = (-0.61232032)

A6 = (-0.10488813)

A7 = 0.68157001

A8 = 0.68446549


   'Surface

Do

ZZZ = ZZZ + 0.001

Ppc = (702.5 - (50 * Sg.Text))

Tpc = (167 + (316.67 * Sg.Text))

Ppr = (Ps.Text / Ppc)

Tpr = (Ts.Text / Tpc)

Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))

B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)

B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))

B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)

B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))

If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do

Z1 = ZZZ

Loop

PrintE ("Z at Surface = " & Z1 & vbCrLf)
```

```
XXX = (3.5 + (986 / Ts.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Ts.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Ts.Text))
De1 = ((0.0014926 * Ps.Text * Sg.Text * 28.964) / (Z1 * Ts.Text))
Vis = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
PrintE (" Viscosity at Surface(Cp) = " & Vis & vbCrLf)
    'Tubing
Tt = (((Ts.Text * 1) + (Tr.Text * 1)) / 2)
Pt = (((Ps.Text * 1) + (Pri.Text * 1)) / 2)
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pt / Ppc)
Tpr = (Tt / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
PrintE (" Z averate in tubing = " & Zt & vbCrLf)
Loop
Zt = (ZZZ * 1)
PrintE (" Z averate in tubing = " & Zt & vbCrLf)
XXX = (3.5 + (986 / Tt) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tt ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tt))
De1 = ((0.0014926 * Pt * Sg.Text * 28.964) / (Zt * Tt))
Vit = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
PrintE (" Viscosity in tubing (Cp) = " & Vit & vbCrLf)

  'Reservoir
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
```

```
Tpc = (167 + (316.67 * Sg.Text))

Ppr = (Pri.Text / Ppc)

Tpr = (Tr.Text / Tpc)

Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))

B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)

B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))

B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)

B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))

If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do

Zr = ZZZ

Loop

PrintE (" Z at reservoir is = " & Zr & vbCrLf)

XXX = (3.5 + (986 / Tr.Text) + (0.01 * 28.964 * Sg.Text))

YYY = (2.4 - (0.2 * XXX))

KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tr.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tr.Text))

De1 = ((0.0014926 * Pri.Text * Sg.Text * 28.964) / (Zr * Tr.Text))

Vir = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

PrintE (" Viscosity in reservoir(Cp)= " & Vir & vbCrLf)

Q = 1000

AAA = Pri.Text

Do

Q = Q + 100

    'Surface pipe

Nre = ((20.09 * Sg.Text * Q) / (Dp.Text * Vis))

J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))

O = ((5.0452 / Nre) * (Log(J) / Log(10)))

Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))

F = (1 / Y ^ 2)

M = ((4.195 * (10 ^ -7)) * ((Sg.Text * Z1 * Ts.Text * Q ^ 2) / Dp.Text ^ 4))

n = ((24 * F * Lp.Text) / Dp.Text)

pp = (((M * n) + (Ps.Text) ^ 2) ^ 0.5)


  'Tubing

Nret = ((20.09 * Sg.Text * Q) / (Dt.Text * Vit))

Jt = (((Et.Text ^ 1.1098) / 2.8257) + ((7.149 / Nret) ^ 0.8981))

O = ((5.0452 / Nret) * (Log(Jt) / Log(10)))
```

```
Yt = -4 * (Log((Et.Text / 3.7065) - O) / Log(10))
Ft = (1 / Y ^ 2)
Sy = Sin((ang.Text * Pi) / 180)
S = -((0.0375 * Sg.Text * Sy * Lt.Text) / (Zt * Tt))
a = ((Ft * ((Zt * Tt * Q) ^ 2) * (2.685 * (10 ^ -3))) / ((Sy * (Dt.Text ^ 5))))
B = (a * (1 - (Exp(-S))))
E = (Exp(-S))
C = ((pp ^ 2) * E) - B
Pwf = (C ^ 0.5)
K1 = K.Text
Flow = (Q * 1)
G = ((0.0007078 * K1 * H.Text) / (Tr.Text * Vir * Zr * Log(Re.Text / Rw.Text)))
Flo = (Flow / G)
Pee = (Pwf ^ 2)
Sp = (Flo + Pee)
Pe = Sp ^ 0.5
If Pe >= (AAA * 1) Then Exit Do
Loop
Qmm.Text = (Q * 1)
PrintE (" Maximum production rate(MSCF/D) = " & Q & vbCrLf)
End Sub
Private Sub Report_Click()
frmoutput.Show
Gi.Hide
End Sub
Public Sub PrintE(Str As String)
    frmoutput.txtReport.Text = frmoutput.txtReport.Text & Str
    frmoutput.txtReport.SelStart = Len(frmoutput.txtReport.Text)
End Sub
Public Sub cmdExit_Click()
If MsgBox("Are you sure to exit a program", vbQuestion + vbYesNo) = vbYes Then
End
End If
End Sub
Private Sub Rf_Click()
Dim M, Q, Pi, AAA As Double
```

```
Pi = 3.14159265358979
Q = Qf.Text
AAA = Pri.Text
ZZ = 0.2
ZZZ = 0.2
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
A8 = 0.68446549

  'Surface
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Ps.Text / Ppc)
Tpr = (Ts.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Z1 = ZZZ
Loop
XXX = (3.5 + (986 / Ts.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Ts.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Ts.Text))
De1 = ((0.0014926 * Ps.Text * Sg.Text * 28.964) / (Z1 * Ts.Text))
Vis = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

  'Tubing
```

```
Tt = (((Ts.Text * 1) + (Tr.Text * 1)) / 2)
Pt = (((Ps.Text * 1) + (Pri.Text * 1)) / 2)
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pt / Ppc)
Tpr = (Tt / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Loop
Zt = (ZZZ * 1)
XXX = (3.5 + (986 / Tt) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tt ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tt))
De1 = ((0.0014926 * Pt * Sg.Text * 28.964) / (Zt * Tt))
Vit = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

  'Reservoir
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pri.Text / Ppc)
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Zr = ZZZ
```

```
Loop

XXX = (3.5 + (986 / Tr.Text) + (0.01 * 28.964 * Sg.Text))

YYY = (2.4 - (0.2 * XXX))

KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tr.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tr.Text))

De1 = ((0.0014926 * Pri.Text * Sg.Text * 28.964) / (Zr * Tr.Text))

Vir = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

Rfrac = 100

Do

Rfrac = Rfrac + 10


  'Surface

Nre = ((20.09 * Sg.Text * Qf.Text) / (Dp.Text * Vis))

J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))

O = ((5.0452 / Nre) * (Log(J) / Log(10)))

Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))

F = (1 / Y ^ 2)

M = ((4.195 * (10 ^ -7)) * ((Sg.Text * Z1 * Ts.Text * Q ^ 2) / Dp.Text ^ 4))

n = ((24 * F * Lp.Text) / Dp.Text)

pp = (((M * n) + (Ps.Text) ^ 2) ^ 0.5)

Nret = ((20.09 * Sg.Text * Qf.Text) / (Dt.Text * Vit))

Jt = (((Et.Text ^ 1.1098) / 2.8257) + ((7.149 / Nret) ^ 0.8981))

O = ((5.0452 / Nret) * (Log(Jt) / Log(10)))

Yt = -4 * (Log((Et.Text / 3.7065) - O) / Log(10))

Ft = (1 / Y ^ 2)

Sy = Sin((ang.Text * Pi) / 180)

S = -((0.0375 * Sg.Text * Sy * Lt.Text) / (Zt * Tt))

a = ((Ft * ((Zt * Tt * Qf) ^ 2) * (2.685 * (10 ^ -3))) / ((Sy * (Dt.Text ^ 5))))

B = (a * (1 - (Exp(-S))))

E = (Exp(-S))

C = ((pp ^ 2) * E) - B

Pwf = (C ^ 0.5)

Wf1 = (Wf.Text / 12)

Kf = (7.7 * (10 ^ 12) * (Wf1 ^ 2))

Ktf = (((2 * 0.003164 * Wf1 * Kf * Log(Rfrac / Rw.Text)) / (0.01988 * (Rfrac - Rw.Text))) + K.Text)

Kavf = (((Ktf * Hf.Text) + (K.Text * (H.Text - Hf.Text))) / H.Text)

OO = (((Log(Re.Text / Rfrac)) / K.Text) + ((Log(Rfrac / Rw.Text)) / Kavf))
```

```
K2 = ((Log(Re.Text / Rw.Text)) / OO)
Flow = (Qf.Text * 1)
G = ((0.0007078 * K2 * H.Text) / (Tr.Text * Vir * Zr * Log(Re.Text / Rw.Text)))
Flo = (Flow / G)
Pee = (Pwf ^ 2)
Sp = (Flo + Pee)
Pe = Sp ^ 0.5
If Pe <= AAA Then Exit Do
Loop
MsgBox "Rf (Ft)=" & Str(Rfrac)
Rff.Text = (Rfrac * 1)
PrintE (" Maximum production rate new (MSCF/D)= " & Q & vbCrLf)
PrintE (" Redil of fracture (FT)= " & Rfrac & vbCrLf)
End Sub
Private Sub year_click()
Dim M, Q, Pi, Pa, Gi, Month As Double
Pi = 3.14159265358979
Q = Qp.Text
ZZ = 0.2
ZZZ = 0.2
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
A8 = 0.68446549

'Surface
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Ps.Text / Ppc)
Tpr = (Ts.Text / Tpc)
```

```
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Z1 = ZZZ
Loop
XXX = (3.5 + (986 / Ts.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Ts.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Ts.Text))
De1 = ((0.0014926 * Ps.Text * Sg.Text * 28.964) / (Z1 * Ts.Text))
Vis = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pri.Text / Ppc)
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Zri = ZZZ
Loop
Bg = ((0.02829 * Zri * Tr.Text) / Pri.Text)
Gi = ((640 * 43560 * Poro.Text * (1 - Swi.Text) * H.Text) / (Bg * 1000))
PrintE (" Gas inpress (MMSCF) = " & (Gi / 1000) & vbCrLf)
PrintE ("     Month     " & " Production Rate ( MMSCF/D )" & "         Pressure (Psia)" & vbCrLf)
Month = 0
Do
Month = Month + 1
Gp = (Q * 30.4375 * Month)
MM = -(Pri.Text / (Zri * Gi))
```

```
Pa = ((MM * Gp) + (Pri.Text / Zri))
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
A8 = 0.68446549
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Pa) / (Ppc * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
ZZZ = (B1 + B2 + B3 + B4)
Zr = ZZZ
Pen = (Pa * Zr)
XXX = (3.5 + (986 / Tr.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tr.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tr.Text))
De1 = ((0.0014926 * Pri.Text * Sg.Text * 28.964) / (Zr * Tr.Text))
Vir = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

   'Surface pipe
Nre = ((20.09 * Sg.Text * Q) / (Dp.Text * Vis))
J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))
O = ((5.0452 / Nre) * (Log(J) / Log(10)))
Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))
F = (1 / Y ^ 2)
M = ((4.195 * (10 ^ -7)) * ((Sg.Text * Z1 * Ts.Text * Q ^ 2) / Dp.Text ^ 4))
n = ((24 * F * Lp.Text) / Dp.Text)
pp = (((M * n) + (Ps.Text) ^ 2) ^ 0.5)
```

```
    'Tubing
Tt = (((Ts.Text * 1) + (Tr.Text * 1)) / 2)
Pt = (((Ps.Text * 1) + (Pen * 1)) / 2)
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pt / Ppc)
Tpr = (Tt / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Loop
Zt = (ZZZ * 1)
XXX = (3.5 + (986 / Tt) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tt ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tt))
De1 = ((0.0014926 * Pt * Sg.Text * 28.964) / (Zt * Tt))
Vit = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Nret = ((20.09 * Sg.Text * Q) / (Dt.Text * Vit))
Jt = (((Et.Text ^ 1.1098) / 2.8257) + ((7.149 / Nret) ^ 0.8981))
O = ((5.0452 / Nret) * (Log(Jt) / Log(10)))
Yt = -4 * (Log((Et.Text / 3.7065) - O) / Log(10))
Ft = (1 / Y ^ 2)
Sy = Sin((ang.Text * Pi) / 180)
S = -((0.0375 * Sg.Text * Sy * Lt.Text) / (Zt * Tt))
a = ((Ft * ((Zt * Tt * Q) ^ 2) * (2.685 * (10 ^ -3))) / ((Sy * (Dt.Text ^ 5))))
B = (a * (1 - (Exp(-S))))
E = (Exp(-S))
C = ((pp ^ 2) * E) - B
Pwf = (C ^ 0.5)
K1 = K.Text
Flow = (Q * 1)
```

```
G = ((0.0007078 * K1 * H.Text) / (Tr.Text * Vir * Zr * Log(Re.Text / Rw.Text)))
Flo = (Flow / G)
Pee = (Pwf ^ 2)
Sp = (Flo + Pee)
Pe = Sp ^ 0.5
PrintE ("      " & Month & "               " & Q & "                                  " & Pen & vbCrLf)
If (Pen <= Pe) Then Exit Do
Loop
MsgBox "Time prodution constance(Month)=" & Str(Month)
Time.Text = (Month * 1)
End Sub
Private Sub Qres_Click()
Dim M, Q, Qx, Pi, Pa, Gi, Year As Double, strRnd As String, i As Integer
If MsgBox("Please wait one minute", vbYesNo + vbQuestion, "Message") = vbYes Then
Else
Exit Sub
End If
Pi = 3.14159265358979
Qoil = Qp.Text
ZZ = 0.2
ZZZ = 0.2
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
A8 = 0.68446549

'Surface
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Ps.Text / Ppc)
```

```
Tpr = (Ts.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Z1 = ZZZ
Loop
XXX = (3.5 + (986 / Ts.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Ts.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Ts.Text))
De1 = ((0.0014926 * Ps.Text * Sg.Text * 28.964) / (Z1 * Ts.Text))
Vis = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pri.Text / Ppc)
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Zri = ZZZ
Loop
Bg = ((0.02829 * Zri * Tr.Text) / Pri.Text)
Gi = ((640 * 43560 * Poro.Text * (1 - Swi.Text) * H.Text) / (Bg * 1000))
i = 0
Gp1 = ((Qoil * 30.4375) * Time.Text)
Do
i = i + 1
Qbefor = Q
Gp2 = (Gp1 + (Q * 30.4375))
```

```
MM = -(Pri.Text / (Zri * Gi))

Pa = ((MM * Gp2) + (Pri.Text / Zri))

A1 = 0.31506237

A2 = (-1.0467099)

A3 = (-0.57832729)

A4 = 0.53530771

A5 = (-0.61232032)

A6 = (-0.10488813)

A7 = 0.68157001

A8 = 0.68446549

Ppc = (702.5 - (50 * Sg.Text))

Tpc = (167 + (316.67 * Sg.Text))

Tpr = (Tr.Text / Tpc)

Dpr = ((0.27 * Pa) / (Ppc * Tpr))

B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)

B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))

B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)

B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))

ZZZ = (B1 + B2 + B3 + B4)

Zr = ZZZ

Pen = (Pa * Zr)

XXX = (3.5 + (986 / Tr.Text) + (0.01 * 28.964 * Sg.Text))

YYY = (2.4 - (0.2 * XXX))

KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tr.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tr.Text))

De1 = ((0.0014926 * Pri.Text * Sg.Text * 28.964) / (Zr * Tr.Text))

Vir = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

Q = 950

Do

Q = Q + 2


  'Surface pipe

Nre = ((20.09 * Sg.Text * Q) / (Dp.Text * Vis))

J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))

O = ((5.0452 / Nre) * (Log(J) / Log(10)))

Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))

F = (1 / Y ^ 2)
```

```
M = ((4.195 * (10 ^ -7)) * ((Sg.Text * Z1 * Ts.Text * Q ^ 2) / Dp.Text ^ 4))
n = ((24 * F * Lp.Text) / Dp.Text)
pp = (((M * n) + (Ps.Text) ^ 2) ^ 0.5)

    'Tubing
Tt = (((Ts.Text * 1) + (Tr.Text * 1)) / 2)
Pt = (((Ps.Text * 1) + (Pen * 1)) / 2)
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pt / Ppc)
Tpr = (Tt / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Loop
Zt = (ZZZ * 1)
XXX = (3.5 + (986 / Tt) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tt ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tt))
De1 = ((0.0014926 * Pt * Sg.Text * 28.964) / (Zt * Tt))
Vit = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Nret = ((20.09 * Sg.Text * Q) / (Dt.Text * Vit))
Jt = (((Et.Text ^ 1.1098) / 2.8257) + ((7.149 / Nret) ^ 0.8981))
O = ((5.0452 / Nret) * (Log(Jt) / Log(10)))
Yt = -4 * (Log((Et.Text / 3.7065) - O) / Log(10))
Ft = (1 / Y ^ 2)
Sy = Sin((ang.Text * Pi) / 180)
S = -((0.0375 * Sg.Text * Sy * Lt.Text) / (Zt * Tt))
a = ((Ft * ((Zt * Tt * Q) ^ 2) * (2.685 * (10 ^ -3))) / ((Sy * (Dt.Text ^ 5))))
B = (a * (1 - (Exp(-S))))
E = (Exp(-S))
```

```
C = ((pp ^ 2) * E) - B
Pwf = (C ^ 0.5)
K1 = K.Text
Flow = (Q * 1)
G = ((0.0007078 * K1 * H.Text) / (Tr.Text * Vir * Zr * Log(Re.Text / Rw.Text)))
Flo = (Flow / G)
Pee = (Pwf ^ 2)
Sp = (Flo + Pee)
Pe = Sp ^ 0.5
If (Pe >= Pen) Then Exit Do
Loop
Gp1 = Gp2
Tcon = (1 * Time.Text)
Mont = (i + Tcon)
strRnd = "i at" & CStr(i) & "=" & CStr(Q)
Production_rate.AddItem strRnd
PrintE ("     " & Mont & "              " & Q & "                              " & Pen & vbCrLf)
If (Q <= 1200) Then Exit Do
Loop
PrintE ("---------------------------------------------------------------------------" & vbCrLf)
MsgBox "      OK"
End Sub
Private Sub Yearnew_Click()
Dim M, Q, Pi, Pa, Gi, Year, Month As Double
Pi = 3.14159265358979
Q = Qpf.Text
Rfrac1 = Rff.Text
ZZ = 0.2
ZZZ = 0.2
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
```

```
A8 = 0.68446549
'Surface
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Ps.Text / Ppc)
Tpr = (Ts.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Z1 = ZZZ
Loop
XXX = (3.5 + (986 / Ts.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Ts.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Ts.Text))
De1 = ((0.0014926 * Ps.Text * Sg.Text * 28.964) / (Z1 * Ts.Text))
Vis = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pri.Text / Ppc)
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Zri = ZZZ
Loop
Bg = ((0.02829 * Zri * Tr.Text) / Pri.Text)
```

```
Gi = ((640 * 43560 * Poro.Text * (1 - Swi.Text) * H.Text) / (Bg * 1000))
PrintE ("     Month     " & " Production Rate ( MMSCF/D )" & "         Pressure (Psia)" & vbCrLf)
Month = 0
Do
Month = Month + 1
Gp = (Q * 30.4375 * Month)
MM = -(Pri.Text / (Zri * Gi))
Pa = ((MM * Gp) + (Pri.Text / Zri))
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
A8 = 0.68446549
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Pa) / (Ppc * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
ZZZ = (B1 + B2 + B3 + B4)
Zr = ZZZ
Pen = (Pa * Zr)
XXX = (3.5 + (986 / Tr.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tr.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tr.Text))
De1 = ((0.0014926 * Pri.Text * Sg.Text * 28.964) / (Zr * Tr.Text))
Vir = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))

  'Surface pipe
Nre = ((20.09 * Sg.Text * Q) / (Dp.Text * Vis))
J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))
```

```
O = ((5.0452 / Nre) * (Log(J) / Log(10)))
Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))
F = (1 / Y ^ 2)
M = ((4.195 * (10 ^ -7)) * ((Sg.Text * Z1 * Ts.Text * Q ^ 2) / Dp.Text ^ 4))
n = ((24 * F * Lp.Text) / Dp.Text)
pp = (((M * n) + (Ps.Text) ^ 2) ^ 0.5)

  'Tubing
Tt = (((Ts.Text * 1) + (Tr.Text * 1)) / 2)
Pt = (((Ps.Text * 1) + (Pen * 1)) / 2)
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pt / Ppc)
Tpr = (Tt / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Loop
Zt = (ZZZ * 1)
XXX = (3.5 + (986 / Tt) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tt ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tt))
De1 = ((0.0014926 * Pt * Sg.Text * 28.964) / (Zt * Tt))
Vit = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Nret = ((20.09 * Sg.Text * Q) / (Dt.Text * Vit))
Jt = (((Et.Text ^ 1.1098) / 2.8257) + ((7.149 / Nret) ^ 0.8981))
O = ((5.0452 / Nret) * (Log(Jt) / Log(10)))
Yt = -4 * (Log((Et.Text / 3.7065) - O) / Log(10))
Ft = (1 / Y ^ 2)
Sy = Sin((ang.Text * Pi) / 180)
S = -((0.0375 * Sg.Text * Sy * Lt.Text) / (Zt * Tt))
```

```
a = ((Ft * ((Zt * Tt * Q) ^ 2) * (2.685 * (10 ^ -3))) / ((Sy * (Dt.Text ^ 5))))
B = (a * (1 - (Exp(-S))))
E = (Exp(-S))
C = ((pp ^ 2) * E) - B
Pwf = (C ^ 0.5)

  'Reservoir
Wf1 = (Wf.Text / 12)
Kf = (7.7 * (10 ^ 12) * (Wf1 ^ 2))
Ktf = (((2 * 0.003164 * Wf1 * Kf * Log(Rfrac1 / Rw.Text)) / (0.01988 * (Rfrac1 - Rw.Text))) + K.Text)
Kavf = (((Ktf * Hf.Text) + (K.Text * (H.Text - Hf.Text))) / H.Text)
OO = (((Log(Re.Text / Rfrac1)) / K.Text) + ((Log(Rfrac1 / Rw.Text)) / Kavf))
K2 = ((Log(Re.Text / Rw.Text)) / OO)
Flow = (Qpf.Text * 1)
G = ((0.0007078 * K2 * H.Text) / (Tr.Text * Vir * Zr * Log(Re.Text / Rw.Text)))
Flo = (Flow / G)
Pee = (Pwf ^ 2)
Sp = (Flo + Pee)
Pe = Sp ^ 0.5
PrintE ("      " & Month & "              " & Flow & "                                  " & Pen & vbCrLf)
If (Pen <= Pe) Then Exit Do
Loop
MsgBox "Time (Month)=" & Str(Month)
Timef.Text = (Month * 1)
End Sub
Private Sub Productionfrac_rate_Click()
Dim M, Q, Qx, Pi, Pa, Gi, Year As Double, strRnd As String, i As Integer
If MsgBox("Please wait five minute", vbYesNo + vbQuestion, "Message") = vbYes Then
Else
Exit Sub
End If
Pi = 3.14159265358979
Qoil = Qpf.Text
Rfrac1 = Rff.Text
ZZ = 0.2
ZZZ = 0.2
```

```
A1 = 0.31506237
A2 = (-1.0467099)
A3 = (-0.57832729)
A4 = 0.53530771
A5 = (-0.61232032)
A6 = (-0.10488813)
A7 = 0.68157001
A8 = 0.68446549

'Surface
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Ps.Text / Ppc)
Tpr = (Ts.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Z1 = ZZZ
Loop
XXX = (3.5 + (986 / Ts.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Ts.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Ts.Text))
De1 = ((0.0014926 * Ps.Text * Sg.Text * 28.964) / (Z1 * Ts.Text))
Vis = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pri.Text / Ppc)
Tpr = (Tr.Text / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
```

```
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)

B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))

B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)

B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))

If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do

Zri = ZZZ

Loop

Bg = ((0.02829 * Zri * Tr.Text) / Pri.Text)

Gi = ((640 * 43560 * Poro.Text * (1 - Swi.Text) * H.Text) / (Bg * 1000))

i = 0

Gp1 = ((Qoil * 30.4375) * Timef.Text)

Do

i = i + 1

Qbefor = Q

Gp2 = (Gp1 + (Q * 30.4375))

MM = -(Pri.Text / (Zri * Gi))

Pa = ((MM * Gp2) + (Pri.Text / Zri))

A1 = 0.31506237

A2 = (-1.0467099)

A3 = (-0.57832729)

A4 = 0.53530771

A5 = (-0.61232032)

A6 = (-0.10488813)

A7 = 0.68157001

A8 = 0.68446549

Ppc = (702.5 - (50 * Sg.Text))

Tpc = (167 + (316.67 * Sg.Text))

Tpr = (Tr.Text / Tpc)

Dpr = ((0.27 * Pa) / (Ppc * Tpr))

B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)

B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))

B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)

B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))

ZZZ = (B1 + B2 + B3 + B4)

Zr = ZZZ

Pen = (Pa * Zr)
```

```
XXX = (3.5 + (986 / Tr.Text) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tr.Text ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tr.Text))
De1 = ((0.0014926 * Pri.Text * Sg.Text * 28.964) / (Zr * Tr.Text))
Vir = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Q = 990
Do
Q = Q + 2

  'Surface pipe
Nre = ((20.09 * Sg.Text * Q) / (Dp.Text * Vis))
J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))
O = ((5.0452 / Nre) * (Log(J) / Log(10)))
Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))
F = (1 / Y ^ 2)
M = ((4.195 * (10 ^ -7)) * ((Sg.Text * Z1 * Ts.Text * Q ^ 2) / Dp.Text ^ 4))
n = ((24 * F * Lp.Text) / Dp.Text)
pp = (((M * n) + (Ps.Text) ^ 2) ^ 0.5)

  'Tubing
Tt = (((Ts.Text * 1) + (Tr.Text * 1)) / 2)
Pt = (((Ps.Text * 1) + (Pen * 1)) / 2)

Do
ZZZ = ZZZ + 0.001
Ppc = (702.5 - (50 * Sg.Text))
Tpc = (167 + (316.67 * Sg.Text))
Ppr = (Pt / Ppc)
Tpr = (Tt / Tpc)
Dpr = ((0.27 * Ppr) / (ZZZ * Tpr))
B1 = 1 + ((A1 + (A2 / Tpr) + (A3 / (Tpr ^ 3))) * Dpr)
B2 = ((A4 + (A5 / Tpr)) * (Dpr ^ 2))
B3 = ((A5 * A6 * (Dpr ^ 5)) / Tpr)
B4 = (A7 * ((Dpr ^ 2) / (Tpr ^ 3))) * (1 + (A8 * (Dpr ^ 2))) * Exp(-A8 * (Dpr ^ 2))
If (ZZZ >= (B1 + B2 + B3 + B4)) Then Exit Do
Loop
```

```
Zt = (ZZZ * 1)
XXX = (3.5 + (986 / Tt) + (0.01 * 28.964 * Sg.Text))
YYY = (2.4 - (0.2 * XXX))
KKK = (((9.4 + (0.02 * 28.964 * Sg.Text)) * (Tt ^ 1.5)) / (209 + (19 * 28.964 * Sg.Text) + Tt))
De1 = ((0.0014926 * Pt * Sg.Text * 28.964) / (Zt * Tt))
Vit = (10 ^ (-4)) * KKK * Exp(XXX * (De1 ^ YYY))
Nret = ((20.09 * Sg.Text * Q) / (Dt.Text * Vit))
Jt = (((Et.Text ^ 1.1098) / 2.8257) + ((7.149 / Nret) ^ 0.8981))
O = ((5.0452 / Nret) * (Log(Jt) / Log(10)))
Yt = -4 * (Log((Et.Text / 3.7065) - O) / Log(10))
Ft = (1 / Y ^ 2)
Sy = Sin((ang.Text * Pi) / 180)
S = -((0.0375 * Sg.Text * Sy * Lt.Text) / (Zt * Tt))
a = ((Ft * ((Zt * Tt * Q) ^ 2) * (2.685 * (10 ^ -3))) / ((Sy * (Dt.Text ^ 5))))
B = (a * (1 - (Exp(-S))))
E = (Exp(-S))
C = ((pp ^ 2) * E) - B
Pwf = (C ^ 0.5)
Wf1 = (Wf.Text / 12)
Kf = (7.7 * (10 ^ 12) * (Wf1 ^ 2))
Ktf = (((2 * 0.003164 * Wf1 * Kf * Log(Rfrac1 / Rw.Text)) / (0.01988 * (Rfrac1 - Rw.Text))) + K.Text)
Kavf = (((Ktf * Hf.Text) + (K.Text * (H.Text - Hf.Text))) / H.Text)
OO = (((Log(Re.Text / Rfrac1)) / K.Text) + ((Log(Rfrac1 / Rw.Text)) / Kavf))
K2 = ((Log(Re.Text / Rw.Text)) / OO)
Flow = (Q * 1)
G = ((0.0007078 * K2 * H.Text) / (Tr.Text * Vir * Zr * Log(Re.Text / Rw.Text)))
Flo = (Flow / G)
Pee = (Pwf ^ 2)
Sp = (Flo + Pee)
Pe = Sp ^ 0.5
If (Pe >= Pen) Then Exit Do
Loop
Gp1 = Gp2
Time = (1 * Timef.Text)
Mont = (i + Time)
strRnd = "i at" & CStr(i) & "=" & CStr(Q)
```

```
Pronew_rate.AddItem strRnd
PrintE ("     " & Mont & "              " & Q & "                              " & Pen & vbCrLf)
If (Q < 1300) Then Exit Do
Loop
MsgBox "     OK"
PrintE ("--------------------------------------------------------------------------")
End Sub
```

Source code of output form

```
Private Sub CmdBack_Click()
Dim Qmm As Double

    Gi.Show
    frmoutput.Hide
    txtReport.Text = ""

End Sub
Private Sub cmdPrint_Click()

    On Error GoTo Err3
    cmmPrint.ShowPrinter
    Printer.Print txtReport.Text
    Exit Sub
Err3:
End Sub

Private Sub cmdSave_Click()

    On Error GoTo Err1
    Dim Str As String
    cmmTool.InitDir = App.Path
    cmmTool.Filter = "Text Documents|*.txt|All Files|*.*"
    cmmTool.DialogTitle = "Save"
    cmmTool.ShowSave
    Str = cmmTool.FileName
    Call Check_File(Str)
    Exit Sub
Err1:
End Sub

Public Sub Check_File(Str As String) 'Save text file
    On Error GoTo Err2
    Open Str For Input As #1
```

```
    If MsgBox(Str & " already exists." & vbCrLf & "Do you want to replace it", vbYesNo + vbDefaultButton2 + vbExclamation,
"Save As") = vbYes Then
        Close (1)
        Call Save_File(Str)
    End If
    Close (1)
    Exit Sub
Err2:
    Close (1)
    Call Save_File(Str)
End Sub

Private Sub Save_File(Str As String)
    Open Str For Output As #2
    Print #2, txtReport.Text
    Close (2)
End Sub
```

APPENDIX C

FORM AND SOURCE CODE

OF FRACTURE ACIDIZING DESIGN

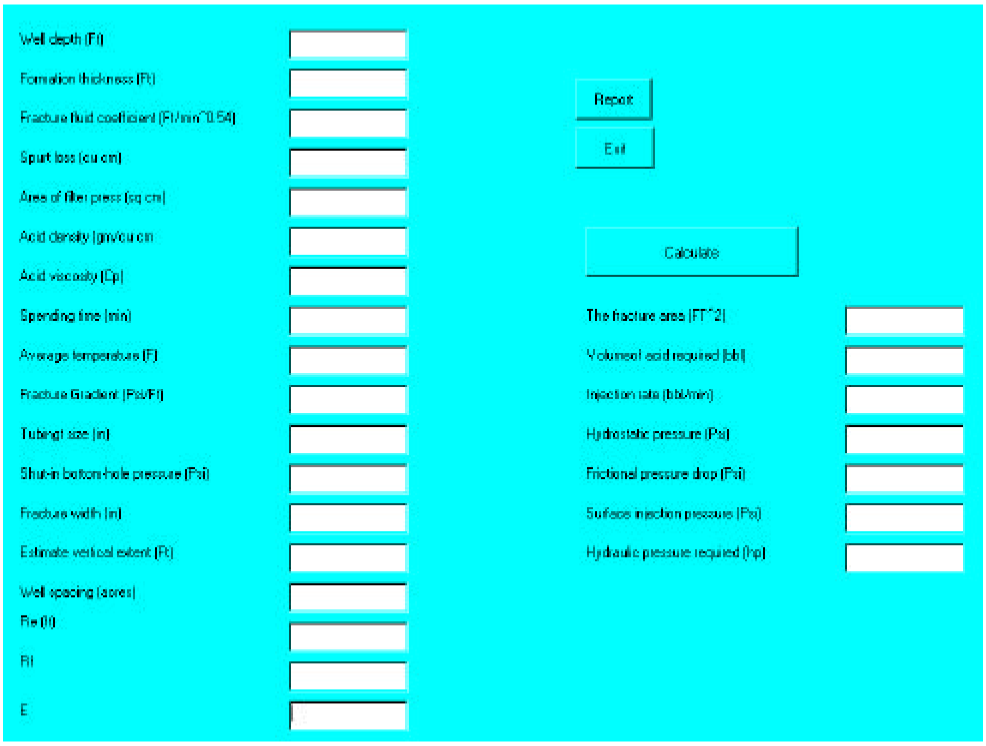

Figure C.1 Fracture acidizing design input form

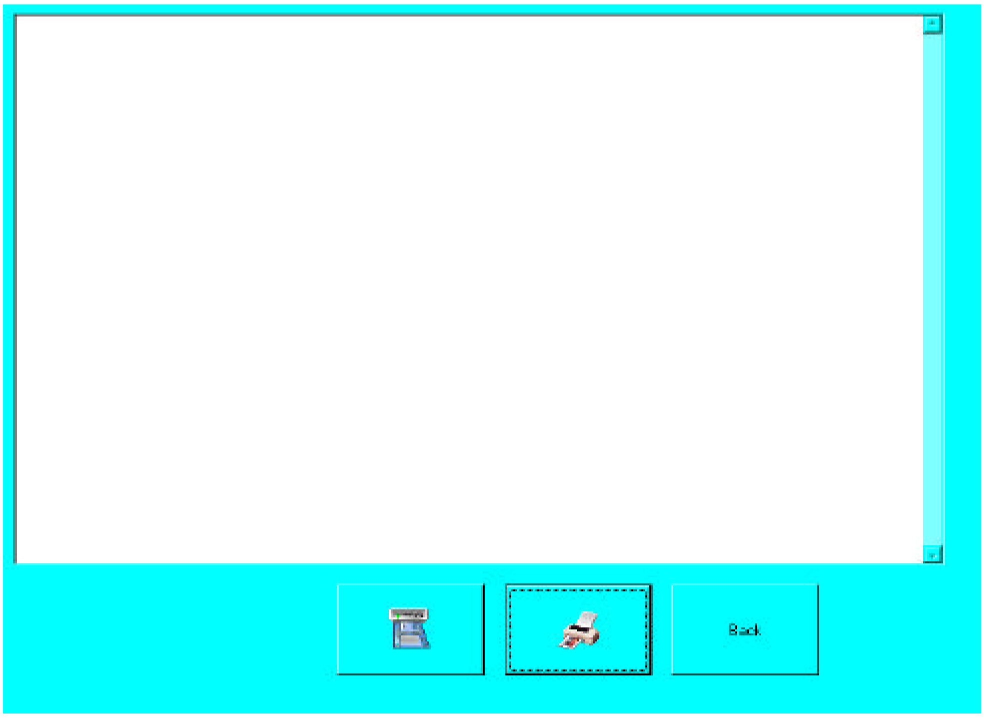

Figure C.2 Fracture acidizing design output form

Source code of fracture acidizing design form

```
Private Sub Calculate_Click()
Dim Ws As Double
A = 2 * Rf.Text * Hf.Text
A.Text = A
PrintE ("Fracture Area (Feet^2)             = " & A & vbCrLf)

Ws = W.Text + (0.787 * (Vsp.Text / Af.Text))
x = ((2 * C.Text * ((3.141592654 * Time.Text) ^ 0.5)) / (Ws / 12))

If x >= 0 And x < 1.5 Then
   erfc = 96.4576473 * Exp(-0.5197838 * x)
   ElseIf x >= 1.5 And x < 3 Then
   erfc = 68.8216182 * Exp(-0.2846821 * x)
   ElseIf x >= 3 And x < 4.5 Then
   erfc = 69.381392 * Exp(-0.2753475 * x)
   ElseIf x >= 4.5 And x < 6 Then
   erfc = 38.8526939 * Exp(-0.1512884 * x)
   ElseIf x >= 6 And x < 10 Then
   erfc = 31.9355403 * Exp(-0.115345 * x)
   ElseIf x >= 10 And x < 20 Then
   erfc = 20.120827 * Exp(-0.0693147 * x)
   ElseIf x >= 20 And x < 30 Then
   erfc = 7.71094933 * Exp(-0.0223143 * x)
   ElseIf x >= 30 And x <= 100 Then
   erfc = 5.0824328 * Exp(-0.00966 * x)
End If

Vi = ((7.48 * A * (Ws / 12)) / (erfc / 100))
Vbbl = (Vi / 42)
V.Text = Vbbl
PrintE ("Voume acid required (bbl)          = " & Vbbl & vbCrLf)

Q = (Vi / (42 * Time.Text))
Q.Text = Q
```

```
PrintE ("Injection rate (bbl/min)                = " & Q & vbCrLf)
Dps = (0.433 * DenA.Text * Depth.Text)
Dps.Text = Dps
PrintE ("Hydraulic pressure (Psi)                = " & Dps & vbCrLf)

Vis = ((17.16 * Q) / (D.Text ^ 2))
Dent = (8.34 * DenA.Text)
Nre = ((928 * D.Text * Vis * Dent) / VisA.Text)

J = (((Ep.Text ^ 1.1098) / 2.8257) + ((7.149 / Nre) ^ 0.8981))
O = ((5.0452 / Nre) * (Log(J) / Log(10)))
Y = -4 * (Log((Ep.Text / 3.7065) - O) / Log(10))
F = (1 / Y ^ 2)

Dpf = ((F * Depth.Text * Dent * (Vis ^ 2)) / (25.8 * D.Text))
Dpf.Text = Dpf
PrintE ("Frictional pressure drop (Psi)        = " & Dpf & vbCrLf)

Pt = (Gf.Text * Depth.Text)
Ps = (Pt + Dpf - Dps)
Ps.Text = Ps
PrintE ("Surface injection pressure (Psi)      = " & Ps & vbCrLf)

Hh = 0.0245 * Ps * Q
Hh.Text = Hh

PrintE ("Hydraulic pressure required (Psi)   = " & Hh & vbCrLf)

MsgBox "         OK"

End Sub
Private Sub Report_Click()
Form1.Show
Acidfracturing.Hide
End Sub
Public Sub cmdExit_Click()
```

```
    If MsgBox("Are you sure to exit a program", vbQuestion + vbYesNo) = vbYes Then
        End
    End If

End Sub
Public Sub PrintE(Str As String)
    Form1.txtReport.Text = Form1.txtReport.Text & Str
    Form1.txtReport.SelStart = Len(Form1.txtReport.Text)
End Sub
```

Source code of output form

```
Private Sub CmdBack_Click()
Dim Qmm As Double
  Acidfracturing.Show
   Form1.Hide
   txtReport.Text = ""
      End Sub
Private Sub cmdPrint_Click()
   On Error GoTo Err3
   cmmPrint.ShowPrinter
   Printer.Print txtReport.Text
   Exit Sub
Err3:
End Sub
Private Sub cmdSave_Click()
   On Error GoTo Err1
   Dim Str As String
   cmmTool.InitDir = App.Path
   cmmTool.Filter = "Text Documents|*.txt|All Files|*.*"
   cmmTool.DialogTitle = "Save"
   cmmTool.ShowSave
   Str = cmmTool.FileName
   Call Check_File(Str)
   Exit Sub
Err1:
End Sub
Public Sub Check_File(Str As String) 'Save text file
   On Error GoTo Err2
   Open Str For Input As #1
   If MsgBox(Str & " already exists." & vbCrLf & "Do you want to replace it", vbYesNo + vbDefaultButton2 + vbExclamation,
"Save As") = vbYes Then
      Close (1)
      Call Save_File(Str)
   End If
   Close (1)
```

```
    Exit Sub
Err2:
    Close (1)
    Call Save_File(Str)
End Sub
Private Sub Save_File(Str As String)
    Open Str For Output As #2
    Print #2, txtReport.Text
    Close (2)
End Sub
```

APPENDIX D

FIGURE OF PRESSURE DISTRIBUTION

3884	3866.4	3877.5	3866.5	3800.9	3667.9
3838.1	3770	3836.8	3843.9	3733	3307.3
3754.7	3424.7	3768.3	3849.9	3822.5	3720
3841.8	3775.8	3849.1	3883.7	3880.6	3858.5
3895.6	3881.6	3895	3902	3898.9	3896.2
3917.2	3911.7	3907.4	3895.1	3877.1	3886.8
3923.9	3917.2	3899.4	3853.9	3774.2	3833.8
3925.5	3916.4	3884.9	3779.5	3425.3	3745
3927.3	3920.9	3901.9	3855	3774.4	3834.1
3928.7	3925.1	3915.6	3897	3875.2	3886.5

1 YEAR

3801.3	3771.5	3776.7	3749.7	3648.1	3476.4
3737	3652.7	3721.8	3721.3	3577.5	3107.5
3639.5	3284.4	3646.7	3736.5	3694.4	3568.8
3750.2	3671	3752.8	3794.8	3787.1	3756.1
3834.9	3812.9	3825.8	3832	3824.6	3819.2
3876.9	3864.3	3850.9	3826.4	3797.6	3806.6
3891.3	3877.1	3842.1	3770.9	3668.6	3730.6
3893.3	3877.9	3825.2	3684.3	3293	3623.4
3895.2	3886.7	3851.4	3777	3672	3733.2
3901.9	3897.1	3876.5	3839.2	3801.2	3810.1

2 YEAR

3568.4	3515.2	3496.5	3444.1	3314.3	3119.5
3496	3386.7	3437.7	3416.8	3246.8	2741
3394.4	3003.3	3366.1	3445.8	3388.7	3249.2
3523	3425	3496.5	3529.2	3512.3	3475.6
3629.2	3594.5	3595.1	3590.3	3574.5	3565.9
3685	3663.9	3637.2	3597.6	3557.3	3563.5
3701.7	3683.7	3635.2	3543.9	3423.7	3484
3698.4	3685.5	3621.2	3456.6	3030.6	3371.2
3696.2	3696.4	3654.4	3560.6	3434.9	3491.6
3705.1	3710.8	3686.4	3632.9	3576.4	3576.6

5 YEAR

3227.7	3158	3124.7	3062.3	2929.1	2736.8
3146.1	3017.4	3058.4	3031.4	2862	2370.9
3031.4	2606.2	2977.9	3056.7	2999.9	2864.9
3160.1	3046.6	3112.4	3141.6	3123.8	3088.6
3265.2	3220.9	3214.1	3204.5	3187.1	3179.7
3317.3	3290	3256.7	3211.6	3168.6	3176.6
3327.2	3305.8	3251.7	3153.8	3026.5	3092
3315.8	3301.8	3233.1	3059	2608.3	2971
3306.1	3307.5	3264.4	3166.6	3034.9	3096.9
3309.1	3317.9	3295	3240.4	3182.8	3184.9

10 YEAR

2949.1	2879.5	2842.7	2783.2	2664.4	2494.2
2870.5	2749.3	2778.9	2751	2600.5	2165.1
2760	2376.8	2700.3	2766.5	2715.9	2597.2
2865	2758.6	2811.7	2834.8	2818.7	2788.3
2950.3	2906.3	2895.8	2885	2869.2	2863.4
2989	2961	2927.9	2886.2	2848	2855.8
2991.2	2969	2918.5	2830.7	2719.6	2777.4
2975.6	2960.6	2898.1	2744.2	2351.2	2669
2962.6	2961.9	2922.6	2836.1	2721.8	2776.8
2962.5	2969.1	2948.2	2900.3	2850.6	2853.8

15 Year

2712.7	2647.7	2611.4	2554.9	2445.8	2292.4
2639.2	2527.8	2550.8	2522.9	2385.6	1993.8
2534.2	2187.4	2474.5	2531.7	2484.3	2377
2621	2523.3	2568.5	2587.5	2571.8	2544
2689.9	2648.8	2637.9	2627.2	2612.4	2606.9
2717.8	2691.5	2661.1	2623.6	2589.5	2596.5
2714.2	2693.5	2648.2	2570.4	2472.1	2523.6
2695.8	2681.8	2626.4	2490.5	2142.9	2424.4
2680.9	2679.8	2645	2569.1	2468.4	2517.9
2678.7	2684.1	2665.8	2624.3	2581.3	2585

20 Year

Figure D.1 Pressure distribution of layer 1. (Without well stimulation)

3920.3	3900	3879.2	3889.9	3879.8	3817.6	3692.8
3905.2	3857.8	3782.7	3848.7	3856.6	3749.4	3334.7
3886.7	3781.1	3437.4	3779.8	3861.9	3836.5	3739.7
3906.9	3861	3788.1	3860.5	3895.2	3892.9	3872.8
3925.6	3909.9	3893.2	3906.3	3913.4	3910.6	3908.8
3935.3	3929.6	3923.1	3918.6	3906.3	3888.8	3899.7
3939.1	3935.6	3928.5	3910.5	3865.2	3786.2	3848.6
3940.4	3937.2	3927.7	3896.1	3790.8	3437.2	3762.1
3941.2	3938.8	3932.2	3913.3	3866.7	3787.1	3849.5
3941.8	3940.3	3936.8	3928.3	3911.5	3892	3903.5
3942.2	3941.6	3940.2	3937.1	3932	3927.4	3929.5
3942.4	3942.1	3941.5	3940.4	3938.7	3937.4	3937.8

1 Year

3867.2	3824.6	3787.8	3792.1	3766.8	3670.8	3510.8
3841.6	3764.8	3668.1	3735.6	3736.5	3598.1	3141.3
3816.3	3674.7	3299.2	3659.3	3749.9	3711.1	3593.4
3847.9	3775.9	3684.9	3764.9	3807.1	3801.1	3773.6
3883.1	3852.8	3825.5	3837.5	3843.9	3837.5	3834.1
3901.8	3890.4	3876	3862.4	3838.1	3810.5	3822.3
3901	3901.8	3888.1	3853.4	3782.6	3682.1	3749.2
3880.9	3899.7	3888.1	3836.3	3696.2	3306.5	3645.1
3853.5	3897	3896.4	3863	3789.8	3686.8	3752.8
3883.5	3907.9	3908.8	3891.2	3857.3	3822.4	3831.6
3903.2	3914.8	3918.2	3911	3894.3	3874.3	3864.5
3900.1	3912.1	3919.5	3916.9	3902.7	3875.4	3841.3

2 Year

3686	3605.7	3539.2	3518.5	3468.4	3346.1	3165.8
3651.9	3536.3	3407.8	3455.9	3436.9	3273.6	2782.4
3621.4	3440.9	3021.7	3381.5	3462.4	3409.8	3280.4
3658.2	3556.9	3441.7	3510.2	3543.6	3529.5	3498.3
3699.7	3651.8	3608.6	3607.8	3603.7	3590	3585.5
3714.5	3699.2	3675.8	3649.1	3610.4	3572.5	3583.7
3692.9	3707.7	3693.4	3646.3	3556.4	3439.3	3507.2
3640	3694.3	3692.8	3631.7	3468.8	3045.7	3397.5
3587.6	3683.5	3702.1	3664.9	3573.7	3451.1	3514.4
3627.2	3697.3	3718.5	3700.4	3651.2	3597.6	3597.9
3656.2	3699.5	3725.7	3721.4	3688.7	3643.7	3615.2
3644.1	3685.3	3718.4	3720.8	3687.1	3624.4	3558.5

5 Year

3384.3	3275.8	3187.6	3151.2	3090.9	2965.2	2788.1
3339.8	3195.9	3042.8	3079.8	3054.2	2891.6	2414.9
3296	3086.2	2627.2	2995.1	3075	3023	2898.9
3322.8	3199.7	3065.1	3127.3	3157.2	3142.6	3114.3
3354.5	3291.6	3236.3	3227.4	3218.6	3203.9	3202
3357.6	3333.4	3302.4	3268.8	3224.8	3185	3199.4
3322.8	3333.6	3315.2	3262.6	3166.5	3043.1	3118.2
3256.9	3311	3308.3	3243.1	3071.1	2624.1	3000.2
3193.6	3291.5	3311.9	3274.2	3179.3	3051.6	3122
3220.8	3297.2	3323.1	3307.4	3258	3203.9	3207.3
3240.6	3290.5	3323.8	3324.5	3293.9	3249.8	3223.3
3223.8	3271.7	3312.6	3321	3290	3227.8	3163.4

10 Year

3107.6	2998.1	2909.7	2869.5	2811.6	2699.2	2543.1
3060.7	2920.4	2775	2800.2	2773.5	2628.9	2206.4
3011.3	2813.5	2397.6	2717.2	2784.3	2738.1	2629.5
3023.7	2904.4	2776.9	2826.3	2850	2837	2813.1
3041.3	2977	2921.4	2908.8	2898.7	2885.7	2885.3
3034.6	3006	2973.2	2939.6	2899	2863.9	2878.2
2995.5	2999	2978.5	2929	2842.9	2735.6	2802.5
2930.2	2973.1	2967.3	2907.7	2755.8	2366.2	2696.6
2868.1	2951.1	2966.7	2932	2848.3	2737.8	2800.9
2887.8	2953	2974.4	2959.9	2917	2871.1	2876.2
2902.9	2945.9	2974.8	2975.8	2950.4	2914	2893.4
2887.7	2929.6	2965.7	2974.1	2948.9	2897	2842.9

15 Year

2861.6	2758.9	2676.3	2636.6	2581.5	2478.3	2337.4
2815.4	2685.9	2552	2570.9	2544	2411.9	2031.9
2764.4	2583.9	2207	2490.5	2548.4	2504.9	2406.7
2767.5	2657.7	2540.5	2582.1	2601.6	2588.7	2566.8
2775.1	2715	2663	2649.9	2639.8	2627.5	2626.9
2762	2733.9	2703	2672	2635.4	2604.1	2616.8
2721.7	2722.1	2702.5	2658	2581.6	2486.8	2546.4
2659.1	2694.6	2688.3	2635.2	2501.2	2156.7	2449.4
2600	2671.5	2684.4	2653.7	2580.2	2483.1	2539.9
2614.2	2670.7	2689	2676.4	2639.3	2600	2605.5
2625.9	2663.2	2688.3	2689.5	2668.3	2637.7	2620.9
2611.8	2648.3	2680.1	2688	2667.1	2623.1	2576.7

20 Year

Figure D.2 Pressure distribution of layer 2. (Without well stimulation)

3945	3934.6	3915.3	3893.8	3904.2	3895.8	3840.8	3738.9	3827.3
3940.2	3920.5	3873.7	3796	3861.6	3871.1	3771.8	3399.5	3750.4
3936	3903.6	3798.7	3450.2	3792	3874.8	3853.3	3772.5	3848.3
3940.8	3921.8	3876.1	3800.5	3872.2	3907.2	3906.3	3891.1	3909.2
3946.8	3938.5	3922.8	3905	3917.8	3925	3922.8	3923.2	3931.6
3950.4	3947.2	3941.4	3934.5	3930	3917.9	3901.2	3915.2	3931
3952.2	3950.5	3947.1	3939.8	3921.9	3876.9	3799.5	3869.7	3914.6
3952.9	3951.7	3948.6	3938.9	3907.5	3802.8	3451.3	3791.1	3895.1
3953.2	3952.4	3950.2	3943.5	3924.9	3878.8	3800.9	3871	3916
3953.5	3953	3951.7	3948.3	3940.1	3924.2	3906	3920.3	3935.8
3953.6	3953.4	3952.8	3951.4	3948.4	3943.5	3939.2	3942.1	3946.6
3953.7	3953.6	3953.3	3952.8	3951.7	3950.3	3949.2	3949.8	3951.1
3953.8	3953.7	3953.6	3953.4	3953.1	3952.7	3952.5	3952.6	3952.9
3953.8	3953.8	3953.7	3953.6	3953.5	3953.4	39053.3	3953.4	3953.4

1 Year

3916	3888.2	3847.5	3808.9	3812.8	3790.9	3706.4	3577.2	3687.5
3905.2	3863.5	3787.1	3685.4	3752	3755.7	3628.3	3219.7	3601.1
3897.4	3839.9	3698.3	3314.5	3673.5	3765.7	3733.1	3636.5	3729.7
3906.3	3867.9	3795.5	3699.2	3777.9	3820.9	3817.7	3798.6	3827.9
3917.4	3898.8	3868.3	3838.5	3849.8	3856.7	3852	3853.7	3872.2
3915.7	3913.6	3903.1	3888	3874.3	3850.6	3825.1	3843.8	3873.8
3880	3906.2	3911.6	3899.1	3865	3795.3	3698	3778.7	3846.8
3749.8	3868.7	3905.1	3898.1	3847.8	3709	3323.4	3684.5	3819.3
3338.3	3801.8	3896.6	3905.6	3874.7	3803.2	3703.6	3782.8	3850.4
3748.5	3870.4	3912.9	3919.3	3903.9	3871.9	3839.2	3853.6	3882.2
3872.4	3904.6	3922.8	3928.4	3922	3905.3	3883.9	3872.6	3886.8
3886.2	3891	3913.1	3926.8	3926.3	3909.5	3869.7	3803.1	3845.6
3824.9	3762	3854.4	3906.7	3918.9	3893.2	3788	3421.8	3751.8
3694.8	3323	3744.8	3880	3914.8	3903.1	3848.2	3752.8	3821.6

2 Year

3785.4	3722.7	3645.2	3574.5	3553.1	3507.6	3400.1	3257.1	3394.3
3764.3	3687	3571.5	3434.7	3481.1	3465.8	3316	2878.8	3301.4
3748	3656.4	3474.6	3042.3	3401	3484.3	3440.2	3337.6	3453.8
3752.4	3686.9	3583.9	3460.3	3526.7	3561.6	3552.7	3534.8	3582.8
3754.4	3720.5	3671.6	3624.2	3622.4	3619.6	3609.9	3615.2	3651.5
3726.6	3726.1	3712.5	3688.6	3662.2	3625.4	3591.9	3615.2	3663.9
3636.2	3690.5	3713.5	3703.2	3658.1	3570.9	3459.7	3547.2	3636.6
3420.5	3609.6	3690.3	3699.4	3642.6	3482.9	3065.9	3447.4	3605.9
2911.4	3506.6	3669.5	3706.6	3675.5	3588	3470.9	3552.4	3636.8
3392.9	3593.3	3690.9	3724.6	3712	3666.1	3615.9	3623.7	3660.6
3565.7	3643.4	3701.1	3732.8	3730.8	3698.3	3651.6	3621.4	3636.3
3576.1	3611.7	3671.7	3716.9	3724.3	3687.5	3607.4	3501.7	3542.1
3457.5	3399.2	3551.2	3659.5	3693	3644.6	3477.5	3028.6	3392.4
3259	2854.9	3384	3604.8	3676.6	3650.5	3543.5	3394.2	3471.2

5 Year

Figure D.3 Pressure distribution of layer 3. (Without well stimulation)

3524	3434.1	3328.7	3233.7	3195.4	3139.5	3028.7	2891	3038.8

3489.4	3385.6	3241.2	3077.1	3111.3	3089.2	2940	2517.5	2942.1
3456.6	3339.9	3127.8	2652.1	3018.4	3100.9	3058	2962.9	3089.3
3444.2	3358.4	3232.6	3087.1	3146.4	3177.9	3169.6	3157.6	3217.7
3428.7	3380	3315.5	3254.2	3243.9	3236.7	3227.2	3238.6	3288.1
3381.9	3372	3348.9	3316.4	3283.1	3241.5	3207.3	3237.9	3301.2
3272.8	3321.5	3340	3325.3	3275.1	3182.1	3066.3	3165.4	3271.5
3044.6	3227	3306.4	3314.4	3254	3085.8	2646.4	3057.6	3236.5
2539.3	3114.2	3276.3	3315.3	3284.3	3193.7	3073.4	3165.9	3265.3
2986.1	3186	3288.5	3327.6	3318.2	3273	3223.6	3237.5	3285.5
3144.1	3226	3290.9	3330	3333.3	3303.5	3258.3	3232	3255
3149.2	3190.5	3257.4	3310.4	3324	3290.1	3211.1	3108.1	3154.7
3032.3	2982.4	3138.1	3252.4	3291.9	3246.6	3080.5	2631.6	3001.6
2841.8	2461.3	2977.2	3199.6	3277	3254.6	3149.2	3001.3	3082.8

10 Year

3253.9	3160	3053.2	2957.7	2915	2860.3	2760.8	2640.4	2776.8
3213	3107.9	2967.1	2810.4	2832.4	2808.4	2675.5	2301.7	2684.8
3171.2	3055.7	2855.4	2422.8	2740.7	2810	2771.9	2690.1	2807.5
3146.8	3059.9	2937.7	2799.2	2845.5	2870.7	2863.5	2855.5	2914.8
3120.3	3067.8	3001.5	2939.6	2925.2	2916.6	2908.7	2921.6	2971.3
3067.4	3050.6	3022.4	2987.5	2953.8	2915.4	2886.1	2916	2977.8
2961.1	2997.2	3007.1	2989	2941.4	2858.3	2758	2847.9	2947.5
2751.1	2906.2	2971	2974.1	2918.5	2770.2	2387.8	2750.6	2913.7
2299.6	2800.2	2939.2	2970.8	2942.1	2862.6	2758.9	2843.4	2937.2
2685.8	2858.3	2946.4	2979.3	2970.6	2931.7	2890.6	2906.5	2954.9
2820.5	2891.2	2947.2	2981.1	2984.5	2960	2923.2	2903.9	2929.8
2824.4	2859.8	2918.4	2965.3	2978.4	2950.9	2884.7	2797.8	2844.4
2724.2	2680.7	2816.9	2918.3	2954.8	2917.8	2775.2	2385	2714.5
2560.1	2226.8	2679.3	2875.1	2945.1	2928.4	2839.5	2714.3	2789.3

15 Year

3001.9	2912	2811.5	2721.9	2679.7	2627.5	2535.9	2426.8	2550.1
2959.7	2860.4	2730	2585.7	2601.5	2576.8	2455.2	2119.2	2463.2
2914.3	2806.4	2623.4	2231	2512.8	2572.5	2536.4	2462.1	2568.2
2883.7	2801.9	2689	2561.6	2600.3	2620.9	2613.2	2605.5	2659
2851.4	2800.6	2738.1	2680.1	2665.3	2656.3	2648.7	2659.9	2704.5
2796.6	2777.9	2749.6	2716.4	2685.2	2650.5	2624.4	2651.1	2706.4
2696.3	2724.7	2730.4	2712.5	2669.5	2595.9	2507.5	2587.5	2676.4
2504.9	2639.2	2693.8	2694.9	2645.3	2514.5	2176.3	2498.5	2644
2099.2	2540.8	2661.9	2688.6	2663.1	2593.4	2502.7	2578.6	2662.9
2437.2	2588.9	2665.5	2693.8	2686.2	2652.8	2617.9	2633.4	2677.7
2554.5	2616.1	2664.8	2694.2	2697.7	2677.2	2646.4	2631.1	2655.8
2557.1	2587.8	2639.1	2680.4	2692.5	2669.7	2613.1	2538.1	2581.5
2468.4	2429.7	2550.3	2640.1	2673.2	2642.2	2518.3	2174.6	2468.1
2323.8	2029	2429.3	2603.1	2665.8	2652.9	2576.6	2467.7	2536

20 Year

Figure D.3 Pressure distribution of layer 3. (Without well stimulation - Continued)

3961	3957.5	3951.1	3944.8	3944.7	3939.2	3921.4	3899.4	3915.4
3957.4	3948.8	3931.6	3911.6	3921.2	3914.8	3868.8	3783.5	3856.6
3952.3	3934	3887.6	3809.1	3874.6	3885.6	3791.8	3431.9	3773
3948.1	3917.5	3812.6	3461.7	3803.9	3887.6	3869	3794.8	3865.7
3952.7	3934.8	3889.2	3812.4	3883.9	3919.2	3919.5	3906.6	3923.1
3958.3	3950.6	3934.9	3916.6	3929.1	3936.5	3935	3936.5	3944.1
3961.8	3958.7	3953	3945.9	3941.3	3929.4	3913.3	3928.8	3943.5
3963.4	3961.9	3958.4	3951	3933.2	3888.5	3812.1	3885.3	3927.9
3964	3963	3959.8	3950.2	3918.8	3814.4	3463.7	3809.3	3909.2
3964.4	3963.6	3961.4	3954.8	3936.2	3890.6	3813.7	3886.8	3929.2
3964.6	3964.1	3962.9	3959.6	3951.6	3936.1	3918.6	3934.1	3948.1
3964.7	3964.5	3963.9	3962.5	3959.7	3954.9	3950.8	3954.1	3958.2
3964.8	3964.7	3964.5	3963.9	3963	3961.6	3960.6	3961.3	3962.4
3964.9	3964.8	3964.7	3964.5	3964.2	3963.9	3963.6	3963.8	3964.1
3964.9	3964.9	3964.8	3964.8	3964.6	3964.5	3964.5	3964.5	3964.6

1 Year

3944.1	3932.4	3914.3	3897.3	3890.1	3874.4	3840.9	3807.5	3829.9
3932.3	3909.8	3873.2	3836.8	3840.2	3822.5	3752.4	3646	3734.6
3920.1	3882.2	3806.5	3703.1	3769.7	3776.3	3657.4	3264.3	3634.6
3912.2	3858.4	3716.6	3328.9	3687.9	3781.9	3754.5	3667.8	3754.7
3920.4	3884.5	3811.8	3713	3791	3834.8	3834.4	3820	3846.7
3930.5	3913.1	3882.3	3851.2	3862.1	3869.6	3866.6	3871.3	3888.1
3928.3	3925.6	3915.2	3899.9	3886.2	3863.2	3839.5	3861.8	3889.6
3893.3	3915.3	3922	3910.3	3876.7	3808	3713.4	3800.2	3864.1
3766.4	3871.5	3912.8	3908.4	3859.4	3721.8	3338.8	3709.4	3838
3359.9	3794.1	3901.3	3915.4	3886.3	3816.1	3719.2	3804.2	3867.5
3765	3872.6	3920.2	3929.6	3915.8	3885	3853.8	3870.8	3897.2
3885.8	3911.7	3931.8	3938.8	3933.1	3916.4	3894.4	3882.5	3900.3
3899.6	3896.8	3920.8	3936.5	3936.6	3918.7	3874.1	3799.4	3858.9
3843.7	3778	3867.8	3918.8	3930.5	3904.6	3799.3	3433.4	3770.1
3724.2	3351.2	3764.5	3894.4	3927.5	3916.3	3863.4	3771.6	3842.3

2 Year

3846.9	3813.6	3767	3721.7	3690.5	3654.2	3604.4	3565.4	3597.5
3813.9	3763.2	3691.8	3623.4	3602	3562.5	3473	3356.7	3464.4
3787.9	3718.8	3604	3464	3510.1	3498.9	3360.3	2939.7	3350.2
3770.4	3685.4	3502.4	3063	3422.2	3508.4	3472.1	3382.9	3490.8
3772.7	3711.7	3607.1	3478.8	3544.4	3581.2	3577.4	3567.8	3611.5
3772.2	3739.9	3689.9	3640	3637.8	3636.6	3631	3642.8	3676
3742.3	3739.6	3725.8	3701.7	3675.9	3641.1	3612.1	3642.7	3687.9
3651.5	3696.2	3721.3	3713.5	3670.5	3586	3480.2	3578.1	3662.1
3438.8	3603.2	3691.4	3706.9	3653.8	3497.3	3085.3	3481.3	3632.8
2934.1	3484.9	3664.9	3712.3	3686.3	3602.2	3490.3	3581.6	3661.4
3411	3584.9	3690.3	3731.3	3723	3679.9	3632.9	3646	3682.5
3581.4	3643.5	3704.9	3740.3	3740.6	3708.8	3661.7	3632.9	3656.6
3594.9	3610.7	3673.4	3722.9	3732.4	3694.2	3607.8	3494.3	3563.9
3489.4	3421.3	3568	3673.8	3706.6	3658.3	3492.3	3046	3425.2
3311.6	2896.5	3413.4	3625.6	3695	3670.8	3569.3	3428.4	3513.4

5 Year

Figure D.4 Pressure distribution of layer 4. (Without well stimulation)

3620	3567.1	3495.5	3425.8	3374.7	3324.9	3269	3231.1	3268.5
3564.7	3491.2	3392.8	3298.8	3259.2	3208.6	3115.8	3004.4	3119.2
3521.2	3428.8	3284.7	3115.6	3148.8	3130.7	2992.4	2585.3	2997.7
3485.6	3377.9	3163.4	2677.8	3044.7	3130.5	3096	3015.3	3132.4
3469.9	3390.1	3261.7	3109.8	3167.6	3201.2	3199.2	3197.3	3252.2
3450.4	3404.4	3337.8	3272.9	3261.9	3256.8	3252.9	3272.9	3318.4
3400.2	3388.5	3364.7	3331.3	3298.6	3259.7	3231.6	3272	3330.8
3289.2	3328.6	3348.7	3336.3	3288.4	3198.8	3090.4	3202.6	3302.6
3062.5	3220.8	3307.2	3321.7	3265.5	3101.4	2668.1	3097.7	3268.7
2560.4	3092	3270.6	3320.2	3294.9	3208.9	3095.4	3200.3	3295
3003.2	3176.4	3286.3	3333.2	3328.8	3287.5	3242.7	3264.2	3311.9
3159.4	3225.2	3293.8	3337	3343.1	3314.6	3270.3	3247.1	3279.5
3168.5	3189.3	3259	3316.5	3332.5	3297.8	3213.3	3103.6	3180.9
3066.1	3005.3	3155.6	3267.6	3306.7	3262.1	3097.5	2651.8	3039.8
2897.8	2504.5	3008.7	3223	3298.4	3278.5	3179.4	3041.3	3133.1

10 Year

3362.6	3304.8	3227.9	3153.6	3098.1	3047.3	2994.6	2960.9	2995.8
3298.5	3221.2	3120.7	3025.3	2980.8	2930.3	2845.8	2748.1	2853.5
3247	3153.5	3012.7	2850.6	2871.1	2850.2	2726.6	2366.3	2737.5
3201.6	3095.3	2892.4	2449.3	2767.5	2839.8	2809.1	2740.3	2848.9
3173.6	3093	2967.8	2822.6	2867.1	2894.3	2893.1	2894.7	2948.4
3143.1	3093.5	3024.8	2958.9	2943.4	2936.8	2934.3	2955.7	3001
3086.5	3068.6	3039.2	3002.8	2969.4	2933.6	2910.3	2949.7	3006.9
2978.1	3006.4	3017.1	3000.5	2954.8	2875.1	2781.8	2884.5	2977.9
2768.9	2903.1	2973.6	2982.1	2930.1	2785.7	2409.1	2789.3	2945.1
2319.4	2782.4	2935.8	2976.4	2952.8	2877.7	2780.7	2877.4	2966.3
2701.8	2851.3	2945.9	2985.5	2981.2	2946.2	2910	2933.5	2981
2835.1	2891.8	2950.9	2988.5	2994.5	2971.5	2936	2920.3	2954.1
2842.6	2860.2	2921.3	2972.1	2987.6	2959.7	2889.2	2797.1	2870.3
2755	2701.9	2833.5	2932.9	2969.2	2933	2792.1	2404.9	2750.9
2611.1	2266.1	2708.6	2897.6	2965.9	2951.6	2868.6	2752.3	2837.3

15 Year

3109.6	3053.8	2979.7	2907.6	2852.8	2803.2	2753.1	2721.4	2751.6
3045.4	2971.6	2876.3	2786.1	2741.9	2693.2	2615.2	2526.4	2620.6
2992.5	2904.2	2773.5	2624.1	2638.2	2616.2	2502.9	2178.7	2511.6
2943.6	2844.3	2658.5	2256.3	2538.4	2600.5	2571	2508.4	2606
2909.6	2833.5	2717.6	2583.8	2620.6	2642.9	2640.5	2641.4	2689.6
2873.4	2825.4	2760.2	2698.3	2682.3	2675	2672.1	2690.9	2731.5
2815.1	2795.6	2765.8	2730.9	2699.7	2667.2	2646.5	2681.7	2732.8
2712.5	2734.2	2740.4	2723.4	2682	2611.4	2529.2	2620.8	2704
2521.7	2637.7	2697.1	2702.7	2656.2	2528.8	2196	2533.8	2672.5
2117.6	2526.1	2659.7	2694.2	2673.1	2607.4	2522.7	2609.7	2689.3
2452.1	2583.5	2665.7	2699.8	2696.1	2666.2	2635.7	2658.1	2701.5
2568	2617.3	2668.7	2701.3	2706.9	2688	2658.4	2646.6	2678.1
2573.8	2588.8	2642.3	2687.1	2701.3	2678.2	2618	2538.7	2605.3
2496.4	2449	2565.5	2653.6	2686.5	2656.2	2533.9	2193	2501.5
2369.5	2064.6	2455.9	2623.6	2684.9	2674.2	2603.3	2502.7	2579.9

20 Year

Figure D.4 Pressure distribution of layer 4. (Without well stimulation - Continued)

3974.6	3972.8	3969.2	3963.2	3957.1	3957.2	3952.3	3935.9	3916	3934.4	3954.3
3973.6	3969.9	3961.6	3945.2	3925.7	3935.3	3930.2	3888.4	3809.9	3886.5	3937.1
3972.1	3965.3	3946.8	3900.5	3821.8	3887.4	3899.4	3808.7	3453.8	3807.9	3917.4
3971.1	3961.5	3930.4	3825.4	3473.4	3815.9	3900.3	3883.5	3813.1	3890	3938.2
3972.2	3965.5	3947.2	3901.4	3824.2	3895.5	3931.1	3932.2	3921.1	3939.9	3957.3
3973.8	3970.3	3962.5	3946.6	3928.1	3940.6	3948.1	3947	3949.3	3958.1	3966.1
3974.9	3973.3	3970.2	3964.4	3957.2	3952.6	3940.9	3925.2	3941.6	3957.4	3967
3975.5	3974.7	3973.1	3969.7	3962.3	3944.5	3900.1	3824.4	3899.2	3943.8	3963
3975.8	3975.3	3974.2	3971	3961.4	3930.2	3826.1	3475.9	3824.1	3927	3959
3975.9	3975.6	3974.8	3972.6	3966	3947.6	3902.3	3826.1	3900.7	3944.9	3963.8
3976	3975.7	3975.3	3974.1	3970.8	3963	3947.7	3930.7	3946.8	3961.5	3969.5
3976	3975.9	3975.6	3975.1	3973.7	3970.9	3966.3	3962.4	3965.9	3970.2	3973.2
3976	3975.9	3975.8	3975.6	3975.1	3974.2	3972.9	3972	3972.7	3973.9	3974.9
3976.1	3976	3975.9	3975.8	3975.7	3975.4	3975	3974.8	3975	3975.3	3975.6
3976.1	3976	3976	3975.9	3975.9	3975.8	3975.7	3975.6	3975.7	3975.8	3975.9
3976.1	3976.1	3976.1	3976	3976	3976	3976	3976	3976	3976	3976

1 Year

3966.4	3958.4	3946.5	3929.3	3913.1	3906.6	3892.5	3862	3832.7	3860.9	3902.5
3962.5	3949.4	3927.4	3892.4	3857.1	3861	3846.4	3784.1	3688.7	3785.1	3869.9
3957.5	3938	3899.2	3823.5	3719.5	3786.4	3795.4	3682.3	3297.4	3688.7	3840.6
3954.6	3930.6	3875.2	3732.6	3342.7	3702.1	3797.8	3774.3	3694.6	3793.4	3873.1
3956.2	3937.5	3900.1	3826.4	3726.3	3804	3848.8	3850.7	3840.3	3873	3910.4
3957.6	3945.7	3927	3895.6	3863.7	3874.5	3882.5	3881.1	3888.3	3908.8	3931.5
3951.6	3942.8	3938.2	3927.3	3911.7	3898.1	3875.8	3853.6	3878.7	3910.1	3935.4
3927.5	3910.5	3926.9	3933.1	3921.6	3888.4	3820.6	3727.9	3818.8	3887.9	3928.3
3867.9	3795.6	3882.6	3922.7	3919.3	3871	3734.4	3353.1	3729.4	3864.7	3921.9
3774.4	3418.1	3805.2	3910.3	3925.9	3897.9	3828.8	3733.7	3822.6	3890.9	3930.6
3866.4	3794.3	3883.4	3930	3940.4	3927.4	3897.5	3867.5	3886.5	3916.5	3940.7
3922.2	3903.5	3922.6	3942.2	3949.8	3944.5	3928	3905.9	3894.9	3918.1	3941.2
3936.8	3917.5	3908.8	3931.8	3947.6	3947.8	3929.5	3883.6	3808.3	3880.3	3927.8
3924.4	3872.7	3800.5	3884.2	3932	3942.7	3917	3812.7	3449.8	3802.4	3909.7
3903.7	3782.9	3418.5	3797.8	3912.9	3942.4	3932.6	3885.9	3804.4	3878.2	3930.3
3922.6	3871.4	3785.5	3876.2	3931.8	3952	3950.6	3934.2	3914.6	3932.8	3949.8

2 Year

3902.1	3871.8	3836.1	3790.9	3747.5	3718	3684.4	3639.4	3606.2	3649.1	3723
3888.1	3847	3795.5	3726.3	3659.2	3639.2	3604.5	3525.4	3423.5	3544.4	3671.8
3871.6	3821.3	3748.6	3632.9	3491.1	3537.9	3530.6	3400	2989	3431.2	3631.8
3857.8	3803.1	3713	3526.9	3082.8	3443.4	3532.6	3502.7	3424.5	3552	3673.3
3847.4	3802	3735.8	3628.3	3496.8	3562.1	3601	3602	3600.5	3656.8	3729.5
3829.2	3797	3759.9	3707.4	3655.7	3653.3	3653.9	3652.3	3670.5	3713.4	3767.8
3786.5	3763.8	3755.3	3739.7	3715.1	3689.9	3657	3632.1	3669.5	3724.4	3781.1
3701.9	3674.3	3707.8	3731.3	3724.6	3683.2	3601.3	3500	3606.5	3702.1	3775.7
3564.8	3474.9	3611.1	3697.5	3715.9	3665.4	3511.6	3103.6	3510.6	3675.7	3767.3
3412	3002.7	3490.9	3668.5	3720.1	3697.5	3616.5	3508.8	3608.4	3700.1	3772
3537.3	3447.7	3591.9	3695.6	3739.8	3734.3	3693.6	3649.6	3668.5	3716.2	3771.3
3638.8	3606.9	3653.2	3713	3750	3751.7	3720.9	3674.9	3650.4	3689.8	3748.7
3671.8	3626.4	3625	3684.3	3733.9	3744	3705.6	3618.4	3507.8	3605.6	3703.9
3649.8	3545.7	3456.8	3592.1	3692.3	3723.4	3676	3513.1	3074.5	3488.2	3667.1
3619.9	3419.8	2994.3	3467.1	3657.9	3722.2	3702.6	3614.5	3494.3	3595.8	3709.9
3662.3	3564.8	3446.2	3586.9	3702.8	3757.7	3758.1	3721.9	3686.6	3722.2	3767.4

5 Year

Figure D.5 Pressure distribution of layer 5. (Without well stimulation)

3711	3656.6	3598	3527.4	3459.5	3410.2	3363.2	3311.9	3280.1	3330.4	3419.7
3682.3	3614.1	3537.3	3440.4	3347	3308.2	3262.2	3179.7	3082.8	3212.8	3358.4
3646.8	3569.2	3470.3	3324	3151.6	3184.9	3170.6	3040.3	2642.3	3090.8	3309.5
3611.4	3531.1	3415.1	3195.6	2702.5	3071.2	3160.4	3133.2	3064.8	3205.2	3346.5
3577.4	3509.8	3421.9	3288.7	3131.9	3189.1	3225.3	3229.3	3237.6	3308.9	3402.4
3533.1	3483.5	3430	3359.6	3291.7	3280.3	3277.6	3279.1	3308.1	3367	3442.4
3462.5	3427.4	3407.8	3381.1	3346.6	3314.6	3278.4	3256.1	3306	3378.4	3456.8
3350	3315.3	3342	3359.9	3348.3	3302.3	3216	3113.9	3237.8	3353.8	3450.1
3188.8	3099	3229	3313.3	3330.8	3277.7	3117.2	2688.9	3133.5	3322.8	3437.9
3018.2	2626.1	3097.2	3273.4	3327.5	3306.2	3224.2	3116.8	3232.9	3343.9	3437.3
3124.8	3038.7	3182.6	3290.7	3341.1	3340.2	3302.2	3262.2	3292.1	3355	3429.4
3217.2	3185.2	3234.8	3301.6	3346.6	3354.8	3328.1	3286.2	3269.5	3321.7	3398.9
3250	3202	3204.4	3270.5	3328.3	3345.3	3311.1	3226.9	3122.2	3231.8	3348.7
3234.4	3126.6	3043.2	3181.9	3288.7	3326.6	3283.5	3123	2685.9	3114.3	3313.2
3216.2	3013.6	2606.2	3067.8	3261.9	3332.9	3318.7	3234.5	3119.7	3232.3	3366.6
3271	3171.8	3057.1	3199.3	3322	3385.4	3393.4	3363.7	3336.2	3382.9	3439.2

10 Year

3466.1	3403.3	3338.2	3261.8	3188.7	3134.5	3085.8	3037	3008.5	3055.1	3139.2
3429.8	3353.1	3271.3	3171.3	3075.7	3031.4	2984.4	2908.7	2823.5	2942.8	3078.4
3383.6	3299.2	3198	3054.3	2888.6	2908.5	2890.6	2773.5	2421.1	2825.5	3027
3336	3250.4	3134.7	2926.3	2475.2	2794.8	2870	2845.7	2788.1	2918.9	3051.9
3289.1	3216.2	3126.6	2996.1	2845.7	2889.2	2918.6	2923.1	2934.4	3003.8	3094.5
3233.6	3178.5	3120.7	3047.6	2978.3	2962.2	2957.7	2960.5	2990.6	3049	3124.1
3156.4	3115.8	3089.5	3056.7	3018.6	2985.6	2952.3	2934.7	2983.5	3054.1	3131.9
3043.6	3005.3	3021.3	3029.3	3013	2968.8	2892.3	2805.2	2919.3	3028.3	3121.9
2889.3	2804.4	2912.8	2981	2991.6	2942.4	2801.4	2429.6	2824.5	2998	3108
2728.6	2379.6	2789	2939.9	2984.3	2964.2	2893	2802.1	2909.9	3014.5	3105.3
2813.3	2734.9	2858.3	2951.1	2993.7	2992.7	2961	2929.7	2961.6	3023.8	3097.7
2890.3	2859.6	2901.8	2959.2	2998.3	3006.2	2985.2	2952.5	2943.5	2996	3072
2918.3	2874	2875.3	2933	2984.2	3000.7	2973.6	2903.9	2817	2920.1	3031
2906.9	2810.1	2736.8	2858.5	2953.4	2988.8	2954.3	2817.5	2438.3	2821.7	3004.8
2895.4	2715.8	2358.2	2763.4	2935.2	3000	2991.3	2922.1	2826.8	2932	3058.1
2948.1	2860.3	2759.9	2885.8	2995.3	3053.8	3065.2	3044.6	3026.8	3073.8	3128.2

15 Year

3211	3149.5	3086.4	3012.4	2941.2	2887.4	2839.6	2792.7	2765.3	2806.1	2881.6
3173.2	3098.7	3020.3	2925.2	2834.2	2789.7	2744	2673.8	2596	2702.2	2823.6
3124.3	3043.1	2947.3	2813.4	2660.2	2673.6	2654.1	2546.8	2229.2	2591.9	2772.5
3072.7	2990.8	2882.2	2690.9	2281	2564.2	2628.8	2605.1	2552.5	2669.7	2788.9
3021.4	2951	2865.9	2744.6	2605.7	2641.4	2665.5	2668.1	2677.7	2739.8	2821.4
2962.4	2908.1	2851.8	2782	2716.6	2699.7	2694.3	2696.1	2722.6	2774.9	2842.8
2884.4	2843.8	2816	2782.6	2745.7	2714.7	2684.5	2668.9	2712.4	2775.4	2845.6
2776.4	2738.8	2748.8	2752.2	2735.2	2695.1	2627.3	2550.8	2652.5	2749.4	2833.4
2633.4	2555	2647.6	2704.7	2711.9	2667.7	2543.3	2214.9	2565.9	2720.2	2818.6
2484.3	2172.4	2533	2664.2	2701.8	2683.7	2621.5	2542.4	2639.3	2733	2814.6
2554.3	2482.7	2590.6	2671	2707.6	2706.7	2679.8	2653.8	2683.9	2740.4	2807.2
2619.2	2590.8	2626.9	2676.6	2710.4	2717.8	2700.7	2673.8	2668	2716.3	2785
2642.3	2602.4	2602.8	2653.3	2698.3	2713.5	2691.2	2631.9	2557.4	2650.8	2750.3
2632	2546	2480.8	2588.4	2672.4	2704.5	2675.9	2557.3	2223.7	2565.9	2729.8
2622.5	2463.3	2147.4	2505.9	2658	2716.1	2710.4	2652.1	2570.5	2665.8	2779.2
2669.8	2592.6	2504.3	2616	2713	2765.6	2777.7	2762.3	2749.5	2793.6	2843.3

20 Year

Figure D.5 Pressure distribution of layer 5. (Without well stimulation – Continued)

3986.6	3986	3984.8	3983	3981.2	3980.5	3978.5	3973.9	3969.8	3974.3	3979.1
3986	3984.5	3981.4	3976.1	3970.8	3971	3966.9	3953.1	3936.3	3953.9	3969.2
3985	3981.8	3973.9	3957.6	3938.4	3948.1	3943.9	3904.4	3829.2	3907.9	3952.1
3983.6	3977.4	3959.2	3912.6	3833.7	3899.4	3912.1	3823.1	3470.9	3831.3	3933.3
3982.6	3973.8	3942.9	3837.3	3484.7	3827.5	3912.3	3896.7	3828.5	3908.8	3952.6
3983.6	3977.5	3959.4	3913.2	3835.6	3906.9	3942.7	3944.4	3934.4	3954.7	3970.1
3985	3982	3974.2	3958.1	3939.4	3951.8	3959.4	3958.6	3961.6	3971	3978.1
3986.1	3984.7	3981.5	3975.6	3968.4	3963.8	3952.2	3936.8	3953.8	3970.3	3978.8
3986.6	3985.9	3984.4	3980.9	3973.4	3955.7	3911.4	3836.1	3911.9	3957.5	3975.1
3986.8	3986.4	3985.3	3982.1	3972.5	3941.4	3837.4	3487.4	3837.2	3941.5	3971.4
3987	3986.7	3985.9	3983.7	3977.1	3958.8	3913.6	3837.8	3913.3	3958.5	3975.9
3987	3986.9	3986.4	3985.2	3981.9	3974.2	3959.1	3942.3	3958.9	3973.9	3981.2
3987.1	3987	3986.7	3986.2	3984.9	3982.2	3977.7	3974	3977.6	3982	3984.5
3987.1	3987	3986.9	3986.7	3986.2	3985.4	3984.1	3983.3	3984.1	3985.3	3986.1
3987.1	3987.1	3987	3986.9	3986.8	3986.5	3986.2	3986	3986.2	3986.5	3986.8
3987.1	3987.1	3987.1	3987	3987	3986.9	3986.8	3986.8	3986.8	3986.9	3987
3987.2	3987.1	3987.1	3987.1	3987.1	3987.1	3987.1	3987	3987.1	3987.1	3987.1
3987.2	3987.2	3987.2	3987.2	3987.2	3987.2	3987.2	3987.2	3987.2	3987.2	3987.2

1 Year

3982.3	3979.2	3973.9	3966.8	3960	3955.2	3948.1	3937.5	3930.5	3939.8	3951.7
3979	3973	3962.4	3947.3	3933.1	3927.6	3916.1	3890.9	3867.1	3894.8	3925.5
3975	3964.3	3943.4	3908.9	3874.2	3879	3866.6	3809.1	3720.3	3821.2	3891.9
3970.3	3953.6	3915.3	3838.8	3734.3	3801.6	3812.4	3703	3322.9	3725.9	3863.6
3967.6	3946.4	3891.2	3747.1	3355.5	3715.5	3812.5	3791.8	3717.1	3822.9	3893.3
3968.9	3952.5	3915.1	3840.1	3738.9	3816.6	3862	3865.7	3858.5	3895	3927.2
3970	3959.6	3940.6	3908.3	3875.8	3886.5	3895	3894.8	3904.1	3926.9	3946.3
3964.1	3956.3	3950.8	3939.3	3923.4	3909.8	3888	3867	3894.1	3927.8	3949.9
3941	3925.3	3939	3944.4	3932.9	3900	3832.7	3741.4	3835.1	3907.3	3943.4
3884.2	3815.2	3894.8	3933.5	3930.3	3882.4	3746.4	3366.2	3746.4	3885.5	3937.5
3793.7	3444.2	3817.9	3920.8	3936.8	3909.3	3840.9	3747.1	3838.6	3909.8	3945.4
3882.8	3813.9	3895.5	3940.8	3951.5	3939	3909.6	3880.5	3901	3933.1	3954.6
3936	3918.7	3934.6	3953.4	3961.1	3956.1	3939.9	3918.1	3907.9	3933.5	3954.7
3950.3	3933	3921.9	3943.8	3959.2	3959.3	3941	3894.9	3820.3	3896.9	3941.7
3939.2	3893.5	3819.3	3899.5	3945.1	3954.9	3929.3	3825.7	3464.3	3822.7	3924.5
3920.6	3814	3450.1	3820.2	3928.7	3955.9	3946.6	3902.5	3825	3900	3944.8
3940.5	3894.6	3815.5	3897.5	3947.3	3965.3	3964.2	3949.7	3932.2	3949.2	3964.3
3960.5	3943	3923.1	3944.3	3964.2	3973.7	3974.6	3970.1	3965.8	3970.5	3975.7

2 Year

3937.1	3922.4	3900.1	3873.4	3847.1	3825	3803.7	3783.5	3775.4	3794	3818.9
3921.6	3898.6	3865.7	3824.6	3785.4	3759	3730.1	3692.5	3666.9	3709.5	3762.8
3906.3	3874.1	3824.3	3755.8	3689.6	3671.3	3640.8	3568.9	3476.2	3604.5	3707.1
3890.2	3848.7	3776.3	3658.3	3514.9	3562.8	3558.7	3433.7	3028.8	3489.8	3667.4
3876.5	3830	3739.2	3549	3100.9	3462.9	3554.8	3530	3460.5	3600.3	3704.8
3865.6	3826.7	3759.1	3647.8	3513.5	3578.8	3619.6	3624.8	3630.2	3694.7	3756.1
3846.6	3818.7	3779.6	3724.2	3670.6	3668.2	3670.3	3672.2	3696.2	3745.6	3791.3
3804.1	3783.5	3771.5	3753.6	3728.2	3703.5	3672.3	3650.8	3694.1	3755.4	3803.8
3721.6	3694.6	3721.1	3742.5	3736	3695.8	3615.8	3518.1	3631.7	3734.8	3798.9
3589.2	3500.5	3622.5	3706.3	3725.8	3677	3525.3	3120.2	3536	3709.7	3791
3441.1	3035	3501.5	3676	3729.3	3708.8	3630.1	3526	3632.3	3731.7	3794.8
3562.6	3474.2	3603.2	3704.1	3749.6	3745.8	3707	3665.8	3689.8	3744.7	3793
3660.8	3629.9	3666.8	3724	3761.2	3763.9	3734.1	3689.8	3669.4	3717.4	3770.5
3694.6	3653.8	3643.6	3698.8	3747.3	3757.3	3719.2	3632.9	3526.6	3637.2	3727.8
3677	3586.8	3488.5	3615.9	3711.4	3740.9	3694.1	3533.8	3100.1	3529	3693.8
3652.7	3480.6	3045.9	3505.5	3685.4	3745.8	3728.3	3647.1	3536.5	3644.5	3737.5
3701.1	3610.7	3498.9	3625.8	3730.8	3781.5	3783.2	3751.9	3721.9	3756.5	3798.1
3765.8	3719.2	3681.7	3727.4	3785.1	3821.2	3829.8	3820.4	3813.2	3829	3850

5 Year

Figure D.6 Pressure distribution of layer 6. (Without well stimulation)

3772.9	3742.6	3699.1	3648.9	3599.9	3558.4	3523.1	3495.5	3486.5	3509.5	3540.6
3739.7	3697.5	3641.6	3575.2	3511.7	3465.7	3423.4	3379.5	3355	3404.5	3468.2
3707.5	3654	3578.6	3481.4	3388.4	3351.1	3308.9	3233.6	3146.3	3284.4	3400.2
3671.7	3608.4	3508.9	3358.6	3183.3	3216.9	3205.7	3081.5	2689.1	3159.5	3351
3635.9	3568.4	3450.5	3224.6	2724.8	3095.6	3187.6	3166.5	3108.1	3263.2	3383.7
3600.5	3543.2	3452.7	3313.6	3152.4	3209.1	3247.8	3257.2	3274.5	3356.5	3434.6
3554.6	3512	3455.2	3380.2	3309.5	3297.8	3297.3	3303.7	3340.7	3408.5	3471.4
3483.1	3452	3427.8	3397.5	3361.5	3329.9	3296.2	3278.9	3337.1	3418.6	3484.8
3371.8	3338.6	3357.4	3372.2	3360.5	3315.8	3232.4	3135.6	3269.2	3395.6	3478.7
3214.2	3125.8	3241	3322.2	3340.7	3289.8	3132.1	2707.8	3164.7	3365.7	3466.9
3048	2657.7	3107.6	3280.4	3336.3	3317.8	3239	3136.7	3262.3	3383.8	3465.2
3151	3065.2	3193.5	3298.7	3350.6	3352	3316.9	3281.2	3318.5	3391.2	3455.9
3240.8	3209.3	3248.9	3312.7	3358.1	3367.6	3342.8	3303.9	3293.5	3356.7	3425.4
3275.1	3232	3224.6	3286.3	3343	3360.3	3327.1	3245	3146.2	3271	3377.4
3264.8	3171.9	3077.9	3208.3	3310.9	3347.6	3305.8	3148.8	2717.1	3164	3345.1
3253.7	3080.5	2661.4	3111.1	3294.9	3362.8	3351.5	3275.1	3171.4	3292.2	3400.3
3317.7	3224.3	3115.6	3243.9	3355.9	3415.5	3425.2	3401.1	3379.7	3425.9	3478.5
3401.3	3350.3	3312.3	3361.8	3427.7	3473.6	3491.7	3491.2	3493.6	3520.3	3551.1

10 Year

3540.3	3503.9	3452.4	3393.9	3336.8	3288.5	3248.6	3218.6	3208.3	3228.8	3257.9
3498.4	3449.6	3386.5	3313.3	3243.7	3192.1	3147	3104.1	3081.4	3126.8	3186.1
3457.3	3397.3	3316.3	3215	3119.3	3075.7	3031.8	2962.2	2885.1	3011.5	3118.3
3410.4	3341.8	3239.3	3091.2	2922.1	2941.9	2926.4	2814.3	2466.5	2891	3066.5
3362	3290.4	3172.3	2957.2	2498.8	2819.9	2897.6	2878.7	2830.4	2974.7	3087.5
3313.4	3251.9	3159.1	3022.3	2867	2909.9	2941.3	2950.8	2970.7	3050.1	3125.7
3256	3208.9	3147.6	3069.2	2996.6	2979.9	2977.4	2984.9	3022.8	3090.1	3152.5
3177.3	3141.9	3110.9	3073.9	3033.9	3001	2970	2957.4	3014.5	3094	3159.5
3065	3029.4	3037.9	3042.5	3025.5	2982.4	2908.6	2826.8	2950.6	3069.6	3150.1
2913.7	2830.8	2925.9	2990.7	3001.9	2954.5	2816.3	2448.3	2855.5	3040.2	3136.5
2756	2409.2	2800	2947.6	2993.4	2975.7	2907.7	2822	2939.1	3053.9	3132.7
2837.6	2759.7	2869.6	2959.5	3003.3	3004.4	2975.6	2948.7	2988.2	3059.8	3123.8
2912.1	2882.5	2915.6	2970.4	3009.8	3019.1	3000.1	2970.6	2967.9	3030.8	3097.9
2941.4	2902.1	2894.7	2948.5	2998.8	3015.8	2989.9	2922.5	2841.6	2958.8	3058.7
2934.8	2851.9	2769	2883.9	2975.1	3009.6	2976.6	2843.3	2469.1	2869.8	3035.4
2929.9	2776.8	2409	2804.2	2967.1	3029.4	3023.6	2961.8	2876.8	2989.6	3090.5
2991.6	2909.1	2813.9	2927.6	3027.8	3083.2	3096.3	3081	3068.6	3115.3	3166.5
3070.5	3025.4	2992.4	3037.1	3097.4	3141.4	3162.3	3167.9	3176.5	3206.1	3237.8

15 Year

3287.1	3250.2	3198.8	3140.7	3083.6	3034.8	2994.1	2963.5	2951.4	2967.9	2993.2
3243.3	3195.1	3133.5	3062.4	2994.2	2942.4	2897.5	2855.7	2833.1	2872.4	2925.2
3200.1	3141.8	3064	2967.6	2876	2831.8	2788.4	2723.6	2652.8	2764.7	2860.3
3150.1	3084.3	2987.4	2848.9	2692.2	2705.2	2687.8	2584.9	2271.1	2651.6	2808.6
3097.7	3029.4	2918.5	2720.4	2303.3	2588	2654.6	2635.7	2591.4	2720.4	2821.5
3044.8	2985.6	2897.3	2769.4	2626	2660.8	2686.6	2693.6	2710.8	2781.8	2850
2983.9	2937.8	2877.9	2802.8	2733.9	2716.2	2712.4	2718.4	2751.8	2812.3	2868.9
2904.5	2869.2	2836.9	2799.2	2760	2729	2700.8	2689.6	2740.5	2811.7	2871
2796.6	2761.8	2765.1	2765	2746.9	2707.7	2642.3	2570.6	2680.9	2786.9	2859.3
2655.9	2579.8	2660.5	2714.2	2721.7	2679	2557.1	2232.2	2594.2	2758.3	2844.7
2509.6	2199.8	2543.9	2671.8	2710.5	2694.4	2635.1	2560.7	2666	2768.7	2839.7
2576.4	2505.9	2601.5	2679.1	2716.6	2717.5	2693.3	2671.3	2708.2	2773	2831.1
2638.9	2611.8	2639.9	2687.1	2721.1	2729.6	2714.4	2690.5	2690.5	2747.8	2808.8
2663.1	2627.9	2620.7	2667.6	2711.8	2727.3	2706.3	2649.2	2580.1	2686.1	2775.8
2657	2583.6	2510.2	2611.7	2692.2	2723.6	2696.4	2581.1	2252.1	2609.8	2757.7
2653.3	2518.2	2193.2	2542.9	2687.1	2742.8	2739.9	2688.4	2616.2	2718.2	2809
2708.5	2636.3	2552.7	2653.6	2742.5	2792.5	2806.3	2795.7	2787.8	2831.7	2878.7
2778.6	2739.5	2711.2	2751	2805.3	2845.9	2866.9	2874.9	2885.7	2914.8	2944.8

20 Year

Figure D.6 Pressure distribution of layer 6. (Without well stimulation - Continued)

3998.1	3997.8	3997.2	3996.1	3994.5	3992.9	3992.2	3990.4	3986.3	3982.7	3986.9	3991.6	3995
3997.9	3997.3	3996.1	3993.3	3988.5	3983.6	3983.9	3980.6	3968.5	3953.5	3970.6	3984.5	3992.4
3997.6	3996.5	3993.6	3986.1	3969.6	3950.4	3960.3	3956.6	3918.5	3845.7	3928	3970.3	3987.8
3997.3	3995.3	3989.6	3972.1	3924.6	3845.4	3911.2	3924.2	3836.4	3486.5	3855.1	3954.5	3984
3997.1	3994.5	3986.3	3956.5	3849.4	3496.1	3839	3924	3909.3	3843	3927.7	3970.4	3987.8
3997.3	3995.3	3989.6	3972.2	3924.9	3847	3918.2	3954.1	3956.3	3947.2	3969.4	3984.5	3992.3
3997.7	3996.5	3993.6	3986.1	3969.5	3950.6	3963	3970.7	3970.1	3973.6	3984	3990.9	3994.9
3997.9	3997.3	3996	3993	3986.8	3979.5	3974.9	3963.4	3948.3	3965.7	3983.1	3991.5	3995.4
3998.1	3997.8	3997.1	3995.6	3992	3984.5	3966.8	3922.7	3847.7	3924.1	3971.3	3988.5	3994.7
3998.2	3998	3997.6	3996.5	3993.2	3983.6	3952.5	3848.7	3498.8	3849.8	3956.3	3985.4	3994.1
3998.2	3998.1	3997.8	3997.1	3994.8	3988.2	3969.9	3924.9	3849.4	3925.6	3972.2	3989.1	3995
3998.2	3998.1	3998	3997.5	3996.3	3993.1	3985.4	3970.4	3953.8	3970.7	3986.4	3993.4	3996.4
3998.3	3998.2	3998.1	3997.8	3997.3	3996.1	3993.5	3989.3	3985.8	3989.3	3993.6	3996.1	3997.4
3998.3	3998.2	3998.1	3998	3997.8	3997.4	3996.6	3995.4	3994.6	3995.4	3996.6	3997.4	3997.9
3998.3	3998.2	3998.1	3998.1	3998	3997.9	3997.6	3997.3	3997.2	3997.3	3997.6	3997.9	3998.1
3998.3	3998.2	3998.2	3998.1	3998.1	3998.1	3998	3997.9	3997.9	3997.9	3998	3998.1	3998.2
3998.3	3998.2	3998.2	3998.2	3998.2	3998.2	3998.1	3998.1	3998.1	3998.1	3998.2	3998.2	3998.3
3998.3	3998.3	3998.2	3998.2	3998.2	3998.2	3998.2	3998.2	3998.2	3998.2	3998.2	3998.2	3998.3

1 Year

3996	3994.1	3991.1	3986.2	3979.7	3973.6	3969.2	3962.9	3953.4	3947.3	3956.1	3968.2	3979.4
3995	3991.8	3986.5	3977.1	3963.4	3950.7	3946.2	3936.5	3914.9	3894.8	3921.9	3949.9	3971.4
3993.5	3988.4	3978.6	3958.8	3923.9	3889.4	3894.8	3884	3829.7	3745.7	3853.7	3921.6	3959.6
3991.9	3984.5	3968.8	3931.9	3853.2	3747.9	3815.5	3827.4	3720.6	3344.9	3762.6	3897.4	3951.9
3990.8	3982.2	3962.1	3908.7	3761.1	3367.8	3728.1	3826	3807.4	3737.1	3852	3921.5	3959.3
3990.6	3983.1	3967.4	3931	3853.4	3751	3828.6	3874.6	3879.7	3875.2	3916.7	3948.9	3970.6
3989.8	3983.6	3973.4	3954.6	3920.8	3887.6	3898.2	3907.1	3907.8	3918.9	3944.9	3964.4	3978.4
3985.6	3978	3969.5	3963.5	3951.1	3934.9	3921.4	3899.9	3879.7	3908.6	3945.4	3967.4	3980.9
3974.3	3957.3	3939.1	3951	3955.8	3944.2	3911.4	3844.5	3754.1	3850.1	3926.6	3962.2	3979.9
3953.3	3906.6	3831.2	3906.4	3944.6	3941.4	3893.8	3758.1	3378.5	3761.9	3906.3	3957.4	3979
3931.8	3824.5	3462	3829.2	3931.7	3947.8	3920.7	3852.7	3759.8	3853.5	3928.7	3963.9	3981.1
3952.4	3905.3	3829.9	3907	3951.8	3962.7	3950.5	3921.6	3893.1	3914.8	3949.5	3971	3983.6
3971.7	3952.9	3932.9	3946.6	3965	3972.8	3968.1	3952.5	3931.2	3921.3	3948.5	3970.4	3983.4
3979.4	3965.9	3947.4	3934.9	3956	3971	3971.1	3952.9	3907.1	3833.2	3912.1	3958.6	3979.6
3978.3	3956.7	3910.6	3835.2	3913.6	3957.8	3967	3941.4	3838.2	3477.7	3839	3943	3976.1
3975.4	3941	3835.1	3470.2	3837.5	3942.8	3968.7	3959.5	3916.5	3840.7	3916.6	3961.6	3981.6
3980.8	3959.3	3913.2	3835.8	3914.5	3961.3	3978	3976.8	3963.2	3946.7	3963.6	3979.1	3988.4
3986.5	3975.4	3957.3	3938	3958	3976.8	3985.6	3986.4	3982.2	3978.2	3982.8	3988.3	3992.5

2 Year

3965.3	3953.3	3938	3916.9	3891.9	3867.3	3846.6	3826.8	3808.5	3801.4	3819.3	3846	3876.4
3959.4	3942.6	3921.1	3891	3853.3	3817.4	3793.7	3768.4	3736.1	3715.2	3757.2	3807	3855.8
3950.6	3929	3898.6	3850.9	3780.8	3715	3698.2	3670.5	3603.8	3518.2	3658.4	3758.1	3829.8
3940.5	3914.3	3874.4	3803.6	3680.6	3535.3	3583.8	3582	3461.1	3062.2	3546.6	3722.8	3814.4
3929.6	3901.2	3855.9	3766.4	3569.2	3117	3480	3573.9	3553.1	3491.5	3647.6	3752.8	3825.2
3916.4	3889.5	3850.7	3783.4	3665.9	3528.7	3594	3636.2	3644.6	3656.3	3732.1	3795	3846.9
3894.8	3869.6	3840.2	3799.8	3740.1	3684.6	3682	3685.4	3690	3719.3	3777.4	3824.6	3865.6
3856.8	3827.7	3803.1	3788.1	3767.3	3740.9	3716.4	3686.5	3667.7	3716.2	3786.2	3835.8	3875.3
3797.2	3750	3714	3734.5	3754.1	3747.5	3707.9	3629.3	3534.4	3654.2	3767.4	3832.4	3876.7
3722.4	3628.2	3521.9	3633.1	3716.1	3736.3	3688.6	3538.3	3135.3	3558.7	3743.7	3825.7	3874.6
3666.5	3492.5	3057.7	3510.5	3685	3739.4	3720.2	3643.1	3541.7	3653.8	3763.1	3827.7	3872.4
3701.3	3603.4	3496.2	3613.9	3714.1	3760.4	3757.7	3720.2	3681.2	3709.7	3772.7	3823.9	3865.5
3751.6	3693.8	3651.8	3681.4	3736.8	3773.8	3777.1	3748.3	3705.3	3688.4	3743.7	3801.9	3849.9
3781.1	3727.8	3679.3	3662.3	3714.4	3761.6	3771.4	3733.6	3648.5	3545.8	3665.2	3763.1	3829.4
3788.5	3716.5	3620.1	3514.5	3637.2	3729.7	3757.8	3711.2	3552.3	3121.3	3560.8	3733.3	3819.6
3793.5	3699.4	3522.8	3079.4	3534.6	3708.9	3766.9	3750.1	3672	3566.4	3679.3	3774.9	3840.2
3819.2	3746.2	3649	3536.4	3656.7	3755.6	3803.3	3805.3	3776.6	3749.6	3785.6	3831.2	3873.1
3847.4	3798.3	3746.1	3708.2	3751	3805.5	3839.7	3848.1	3839.6	3833.4	3849.6	3873.7	3899.5

5 Year

Figure D.7 Pressure distribution of layer 7. (Without well stimulation)

3824.3	3796	3763.1	3720.8	3672.6	3625.6	3585.7	3552	3525.9	3517.6	3539.6	3573.6	3614.8
3808.2	3772.2	3731	3677.9	3615.1	3555.3	3512.1	3473.5	3434.8	3414.5	3463	3522.6	3585.4
3783.6	3741.6	3689.7	3616.2	3515.5	3422.3	3386.3	3347	3276.8	3197.1	3348.7	3461.4	3548.8
3753.6	3706.8	3644.8	3546.3	3388.3	3209.3	3243.4	3234.4	3114.6	2728.2	3225.8	3416.7	3525
3719.2	3670.8	3604	3486.6	3250.4	2743.7	3116.1	3210.3	3194	3145.2	3319.9	3441.9	3531.7
3678.6	3633.6	3575.5	3484.2	3336.2	3170.4	3226.6	3267.2	3280.9	3306.6	3403.1	3483.5	3553.1
3626	3585.2	3540	3481	3399.3	3325.5	3313.4	3314.6	3325	3369.4	3449.4	3514.6	3573.5
3554.3	3512.7	3476.4	3448.1	3413.1	3375.5	3344	3312.1	3298.9	3364.7	3458.4	3526.7	3584.4
3461.1	3404.6	3361.1	3372.9	3384.7	3372.5	3328.6	3247.1	3154.6	3297	3437.2	3522	3584.9
3356	3256.1	3148.7	3252.4	3332	3351.2	3301.5	3145.8	2724.6	3192.1	3408.6	3511.3	3578.9
3276.9	3101.6	2680.7	3116.5	3288.8	3346	3329.2	3252.7	3154.4	3288.5	3423.6	3507.4	3570.1
3296.8	3194.2	3088.3	3204	3308.2	3361	3364	3330.9	3298.7	3342.8	3426.8	3495.7	3554.6
3342.7	3277.4	3233.1	3264.1	3325.6	3370.9	3381.5	3358.3	3322	3316.9	3390	3465.4	3530.6
3376.5	3313.2	3260.6	3245.3	3303.2	3358.8	3376.2	3343.9	3263.8	3170	3306.1	3421.5	3505.4
3394.6	3310.8	3209.6	3107.1	3232.5	3332.1	3368	3326.9	3171.8	2742.8	3203.1	3393.9	3498.5
3415.4	3308.5	3128.6	2698.3	3144.6	3323.2	3389.1	3379	3306.7	3208.6	3335.9	3447.5	3530.4
3459.7	3372.6	3269.5	3158.7	3280.4	3386.3	3443.1	3453.6	3432.7	3414.9	3463.2	3521.9	3580.4
3504	3441.8	3382.8	3343.7	3390	3452.6	3496.7	3514.7	3515.4	3519.1	3546.8	3582.6	3622.6

10 Year

3601.9	3566.2	3526	3475.5	3418.9	3363.5	3316.4	3277.7	3248.9	3239	3258.3	3290	3329.8
3579.5	3535.3	3486.9	3426.4	3356.3	3289.7	3240.1	3197.8	3158.9	3139.5	3183.3	3238.7	3298.8
3544.9	3495.3	3436.8	3357.1	3251.6	3154.8	3112	3070.3	3005	2934.7	3072.9	3176.8	3259.1
3502.6	3449.1	3381.3	3279.3	3122.6	2949.5	2969.2	2955.5	2847.1	2504.7	2954.1	3128.7	3230.2
3454.5	3400	3328.5	3210.1	2984.3	2518.8	2840.9	2920.6	2906	2866.5	3029	3143.2	3228.8
3399.8	3349.1	3286.4	3192.2	3045.8	2885.5	2927.6	2960.7	2974.2	3002.1	3095.5	3173.3	3241.5
3334	3288.6	3238.7	3174.8	3089	3012.8	2995.5	2994.5	3005.9	3051.2	3130.5	3195.3	3254.2
3252.3	3208	3167.6	3132.6	3090.1	3047.9	3015	2985.7	2977.1	3041.7	3133.4	3201.1	3259.3
3153.4	3097.6	3052.6	3054.5	3055.4	3037.5	2995	2923.1	2845.5	2978	3110.6	3193.1	3255.9
3045.7	2953.4	2853.6	2938.3	3000.9	3012.3	2966.1	2829.8	2464.9	2882.7	3082.3	3180.4	3247.3
2963.1	2805.3	2431.2	2809.7	2956.3	3003.1	2986.9	2921.2	2839.5	2965.1	3093.1	3174.6	3237
2970.6	2877.4	2781.5	2880.4	2969.1	3013.6	3016.2	2989.5	2966.1	3012.3	3095.2	3163.2	3222
3005.3	2945.8	2905	2930.4	2983	3022.3	3032.8	3015.5	2988.8	2991.5	3063.8	3137.2	3201.2
3033.7	2976.4	2928.8	2914.4	2964.9	3014.2	3031.5	3006.8	2941.6	2865.7	2993.3	3101.5	3181.9
3052.2	2976.9	2886.9	2796.5	2907.1	2995.9	3029.8	2997.8	2866.6	2495.1	2908.2	3082.3	3180.6
3075.9	2980.1	2821.2	2443.3	2836	2994.6	3055.2	3050.8	2993	2913.4	3032.1	3136.2	3215.2
3121.1	3042.4	2951.3	2854.1	2962.1	3057	3110.3	3124.3	3111.9	3102.9	3151.8	3209.1	3266.7
3165.6	3108.4	3055.9	3022	3063.9	3121.4	3163.9	3184.9	3191.7	3201.4	3232.2	3269.2	3310.2

15 Year

3350	3313	3272.1	3221.2	3164.7	3109.1	3061.2	3021.6	2991.8	2979.9	2995.2	3022.7	3058.3
3325.2	3280.2	3231.9	3172.4	3103.9	3038.3	2988.3	2945.6	2907.1	2887	2924.6	2973.8	3028.1
3286.9	3237.4	3180.2	3103.6	3002.8	2910	2866.2	2824.7	2763.2	2698.4	2820.8	2913.7	2988.3
3240.1	3187.7	3122.5	3025.9	2879.1	2718.3	2730.9	2714.9	2615.3	2306.1	2708.8	2865.2	2957.3
3187.3	3134.5	3066.1	2954.9	2746.2	2322.4	2607.8	2676	2660.9	2624.5	2769.6	2872.3	2950.3
3128.3	3079.1	3018.8	2929.1	2791.9	2643.4	2677.4	2704.4	2715	2739.4	2823.1	2893.6	2956.2
3059.6	3015.4	2966.7	2904.2	2821.7	2749	2730.6	2728.1	2737.5	2777.6	2849.2	2908.2	2962.5
2977.1	2934.1	2894.2	2858.1	2814.8	2773.2	2741.9	2715.1	2707.6	2765.2	2847.7	2909.3	2962.8
2879.6	2827.3	2784.2	2781.5	2777.4	2758.2	2719.3	2655.7	2587.7	2705.9	2824.2	2898.8	2956.4
2775.7	2692.5	2601.6	2672.9	2724.1	2731.4	2689.6	2569.5	2247.4	2619	2796.6	2885	2946.3
2695.5	2554.5	2220.4	2553.5	2680.3	2719.5	2704.7	2647.4	2576.7	2689.6	2804.4	2878.2	2935.7
2695.8	2612.6	2526.2	2612	2688.2	2726.1	2728.3	2705.9	2687.2	2730.1	2805.3	2867.4	2921.9
2722.1	2669.3	2632.3	2653.6	2698.6	2732.5	2742	2728.4	2707.2	2712.1	2778	2844.9	2904.1
2744.4	2694.3	2652	2638.7	2682.7	2725.8	2741.6	2721.7	2666.8	2602.4	2717.5	2814.9	2888.3
2760.1	2694.3	2615.2	2535.2	2632.9	2711.2	2742	2715.8	2602.7	2276	2644.9	2800.5	2889.6
2781.7	2697.8	2558.1	2224.4	2571.8	2712.1	2766.4	2764.8	2716.9	2649.7	2756.9	2851	2923.3
2822.8	2753.5	2674	2588.9	2684.8	2768.9	2817.3	2832.1	2824.2	2819.4	2865.3	2918.3	2971.6
2863.3	2812.7	2766.9	2737.8	2775.3	2827.2	2866.8	2887.9	2897	2908.9	2938.9	2973.8	3012

20 Year

Figure D.7 Pressure distribution of layer 7. (Without well stimulation - Continued)

4009.1	4008.9	4008.4	4007.5	4006.2	4004.9	4004.4	4002.9	3999.7	3996.8	4000.2	4004.1	4006.4
4009	4008.5	4007.5	4005.2	4001.2	3997.1	3997.5	3994.8	3985	3972.7	3987.5	3998.6	4004.2
4008.7	4007.9	4005.4	3998.8	3981.2	3962	3971.9	3968.5	3931.2	3860.5	3951.7	3987.4	4000.2
4008.4	4006.9	4002.1	3986.7	3936.2	3856.4	3922.3	3935.6	3848.4	3501.1	3890.1	3974.9	3997
4008.3	4006.3	3999.3	3973.3	3861.1	3506.7	3849.9	3935.2	3920.9	3856.4	3951	3987.3	4000.2
4008.4	4006.9	4002.1	3986.8	3936.4	3857.8	3929.1	3965.1	3967.5	3959.4	3985.3	3998.2	4004
4008.7	4007.9	4005.4	3998.6	3980.7	3961.6	3974	3981.7	3981.3	3985.2	3997.3	4003.3	4006.2
4009	4008.5	4007.4	4004.6	3997.9	3990.4	3985.9	3974.4	3959.3	3977.2	3996.6	4003.8	4006.7
4009.1	4008.9	4008.3	4006.9	4003	3995.4	3977.8	3933.6	3858.6	3935.9	3986.8	4001.5	4006.2
4009.2	4009.1	4008.7	4007.7	4004.2	3994.5	3963.4	3859.5	3509.5	3861.8	3974.2	3999.1	4005.7
4009.2	4009.1	4008.9	4008.2	4005.8	3999.2	3980.9	3935.9	3860.4	3937.3	3987.7	4002	4006.5
4009.3	4009.2	4009	4008.6	4007.3	4004.1	3996.4	3981.5	3965.1	3982.2	3999.4	4005.4	4007.6
4009.3	4009.2	4009.1	4008.9	4008.4	4007.4	4005.1	4001.5	3998.5	4001.6	4005.5	4007.5	4008.5
4009.3	4009.2	4009.2	4009.1	4008.9	4008.5	4007.8	4006.8	4006.2	4006.9	4007.9	4008.6	4008.9
4009.3	4009.2	4009.2	4009.2	4009.1	4009	4008.8	4008.5	4008.4	4008.5	4008.8	4009	4009.1
4009.3	4009.3	4009.2	4009.2	4009.2	4009.1	4009.1	4009	4009	4009	4009.1	4009.2	4009.2
4009.3	4009.3	4009.3	4009.2	4009.2	4009.2	4009.2	4009.2	4009.2	4009.2	4009.2	4009.2	4009.3
4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.3
4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4

1 Year

4007.2	4005.8	4003.2	3999.1	3993.9	3988.8	3985.1	3979.9	3972.2	3967.4	3974.5	3984.6	3992.3
4006.3	4004	3999.5	3991.7	3980.4	3969.7	3966	3958.1	3940.6	3924.4	3947.7	3970.4	3985
4004.9	4001.1	3992.8	3975.1	3937.5	3902.9	3908.6	3898.7	3846.4	3766.3	3889.6	3947.3	3974.5
4003.4	3997.9	3984.3	3951.3	3866.4	3759.9	3827.7	3840.3	3735	3363.8	3811.9	3927.7	3967.7
4002.5	3995.9	3978.7	3931	3774.3	3378.9	3739.6	3838.1	3820.7	3754.2	3886.6	3946.5	3974
4002.2	3996.5	3982.8	3950	3866.1	3762.3	3839.9	3886.3	3892.1	3889.9	3940.2	3968.3	3984
4001.3	3996.5	3987.3	3970.1	3932.8	3898.9	3909.4	3918.5	3919.7	3932.3	3963.8	3980.9	3990.9
3997.1	3990.8	3982.4	3976.6	3962.6	3946	3932.5	3911.1	3891.4	3921.8	3964.4	3983.5	3993.3
3986.2	3971	3951.7	3962.4	3966.9	3955.2	3922.4	3855.7	3765.7	3863.9	3948.9	3979.6	3992.6
3965.8	3922.5	3843.6	3915.7	3955.3	3952.3	3904.7	3769.1	3389.7	3776	3931.9	3976	3991.9
3944.7	3842.8	3473.8	3836.2	3942.1	3958.7	3931.7	3863.9	3771.5	3867.1	3950.6	3980.9	3993.7
3964.9	3921.3	3842.3	3916	3962.6	3973.8	3961.9	3933.2	3905.1	3927.8	3967.1	3986.2	3995.7
3983.6	3966.9	3945.6	3958	3976.9	3984.9	3980.9	3966.2	3945.4	3935.1	3963.6	3984.6	3995.2
3991.2	3979.5	3960.7	3947.2	3967.9	3982.7	3983	3965.1	3919.4	3845.8	3926.8	3972.9	3991.4
3990.3	3971.2	3925.3	3848.8	3926.4	3969.9	3978.9	3953.1	3849.6	3488.8	3853.1	3957.6	3987.8
3987.5	3956.7	3851.8	3486.2	3852.4	3955.9	3980.9	3971.7	3929.1	3853.9	3930.6	3975.5	3993.2
3992.9	3974.4	3929.2	3852.7	3929.6	3974.5	3990.3	3989	3975.8	3959.8	3976.7	3992	3999.8
3998.9	3990.3	3974	3956.5	3974.2	3990.6	3998.2	3998.9	3995.3	3991.7	3995.9	4001	4004.1
4003.4	3999.8	3993.9	3989.2	3993.9	3999.8	4003.3	4004	4003.1	4002.3	4003.6	4005.4	4006.6

2 Year

Figure D.8 Pressure distribution of layer 8. (Without well stimulation)

3978.4	3969.3	3955.3	3936.6	3914.8	3893.2	3874.7	3857.3	3841.6	3835.8	3850.5	3873.4	3894.2

3972.6	3960.5	3941.6	3915.2	3882.6	3851.3	3830.2	3808.3	3781.4	3764.5	3800.5	3841.7	3873.9
3964.2	3948.3	3921.5	3877.5	3800.8	3734.8	3718.9	3692.9	3629.3	3549.9	3713.6	3799.5	3849.3
3954.4	3934.8	3899.4	3833.9	3698.8	3551.1	3599.8	3599.2	3480.9	3088.7	3616.4	3769.2	3835.1
3943.9	3922.3	3881.9	3799.5	3586.4	3130	3493.7	3588.8	3570.4	3515.6	3700.4	3792.8	3844.5
3930.7	3910	3874.7	3811.5	3681.7	3541.6	3606.7	3649.8	3660.1	3677.1	3771.5	3827.5	3864.3
3909.1	3889.2	3861.2	3821.9	3754.2	3696.9	3694.1	3698.2	3704.5	3738.1	3810.5	3852.9	3881.8
3871.4	3847.4	3821.5	3804.8	3779.9	3752.6	3728.1	3698.8	3681.6	3734.4	3818.9	3863.1	3891.2
3812.8	3771.5	3730.5	3745.9	3765.1	3758.4	3719.1	3641.2	3548	3672.8	3803.7	3861.1	3892.9
3739.2	3653.3	3536.5	3638.6	3725.7	3746.7	3699.5	3549.8	3147.8	3577.5	3783.5	3855.5	3891
3684.4	3521.5	3070.4	3511.2	3693.7	3749.6	3731.2	3654.8	3554.9	3671.8	3798.2	3855.8	3888.4
3718.8	3629.8	3511.4	3619.2	3724	3771.2	3769.2	3732.4	3694.6	3726.6	3802.2	3849.7	3880.9
3768.4	3718.3	3670.4	3694.4	3750.3	3787.3	3791.2	3763.3	3721	3705.5	3768.7	3826.7	3864.9
3797.9	3753	3701.3	3679	3729.2	3775.6	3785.3	3747.7	3663	3562.9	3690	3789	3844.5
3805.9	3744.9	3646.2	3534.6	3654.6	3745.9	3773.4	3726.4	3567	3136.7	3585	3760.1	3834.7
3811.6	3731.4	3553.9	3104.4	3557.9	3729.2	3785.5	3768.6	3691.7	3588.4	3705.1	3801	3855.1
3837.9	3778.6	3680.9	3567.2	3683.6	3778.4	3823.8	3825.6	3798.3	3773.1	3810.2	3855.8	3888.2
3870.3	3833.1	3783.8	3748.1	3785.5	3833.9	3864.5	3872.6	3865.8	3861	3876.7	3899.2	3917.7
3902.4	3882	3855.4	3840.4	3855.3	3881	3900.8	3909.4	3909.9	3911.1	3920	3932.2	3941.3

5 Year

3841.1	3819	3787.6	3748.1	3704	3660.6	3623.2	3591.8	3568.2	3560.4	3578.4	3607.7	3635.6
3824.6	3798.1	3760.5	3712	3655.6	3601	3560.7	3525.3	3491.5	3474.5	3515.3	3564.7	3605.9
3800.3	3769.1	3722.2	3652.9	3541.5	3447.2	3412	3374.5	3307.4	3234.3	3413	3510	3570.4
3770.6	3735.4	3679.2	3586.3	3410.9	3228.1	3262.1	3254.5	3137.3	2758.1	3304.2	3470.4	3547.6
3736.2	3699.5	3638.8	3528.6	3271.1	2758.3	3131.2	3226.8	3213.3	3173.1	3381.8	3489.1	3552.9
3695.4	3660.9	3607.2	3519.8	3354.7	3184.5	3240.3	3281.9	3298.3	3331	3451.5	3523.3	3572.5
3642.4	3610.6	3567.2	3508.7	3415.3	3338.6	3326.1	3328.2	3341.1	3391.6	3491.5	3550.2	3591.7
3570.7	3536.8	3499.3	3468.6	3426.7	3387.4	3356	3325	3314.2	3386.2	3500.3	3561.5	3602.3
3477.9	3429.3	3380.6	3386.5	3396	3383.3	3339.8	3259.3	3169.2	3318.8	3482.9	3558.2	3603.1
3373.8	3283.6	3165	3258.6	3341.3	3361.1	3312.1	3157.4	2737.8	3213.9	3457.7	3548.6	3597.3
3295.5	3132.2	2694.2	3117	3296.9	3355.7	3339.7	3264.4	3168.4	3309.3	3467.3	3542.4	3587.9
3315	3222.3	3104.4	3208.8	3317.5	3371.3	3375.1	3343.3	3313.1	3362.3	3463.8	3527.8	3571.7
3360.6	3304.4	3253.2	3277.6	3339	3384.3	3395.8	3374.1	3339.2	3337.2	3421	3496	3547.1
3394.8	3342	3285.2	3263.5	3319	3373.8	3391.3	3359.7	3280.8	3190.7	3336.7	3453.1	3521.9
3413.9	3343.8	3239.4	3130.1	3252.6	3351	3386.5	3345.4	3190.3	2762.5	3233.2	3426.6	3514.9
3436	3346.2	3164.6	2726.3	3171.5	3347.5	3412	3402.3	3331.7	3236.6	3368.5	3480	3547.1
3481.9	3412.4	3308.1	3195	3312.6	3414.4	3469.2	3479.8	3460.7	3445.2	3495	3553.8	3598
3534.2	3487.4	3430.7	3393	3433.6	3489.8	3530.5	3548.5	3551.2	3556.8	3584.1	3618.2	3646.5
3588.2	3560.1	3525.8	3507.8	3525.8	3559.5	3589.8	3609	3620	3631.8	3651.6	3673.8	3689.6

10 Year

Figure D.8 Pressure distribution of layer 8. (Without well stimulation - Continued)

3620.5	3592.3	3553.2	3505.3	3452.4	3400.3	3355.3	3318.4	3291.3	3281.4	3296.5	3323.6	3350.4
3597.1	3564.4	3519.5	3463.5	3399.5	3337.5	3290.2	3250.3	3215.1	3197.8	3233.8	3279.4	3318.5
3562.4	3525.6	3472.2	3396.4	3278.9	3180.6	3138.1	3097.8	3035.2	2970.8	3133.6	3222.9	3279.6
3520.2	3480	3418.3	3321.1	3146	2968.8	2988.1	2975.4	2869.3	2533.8	3027.3	3179.4	3251.6
3472	3430.8	3365.3	3253.2	3005.5	2533.5	2856.1	2936.9	2924.9	2893.4	3087.5	3188.2	3248.9
3416.9	3378.1	3319.7	3228.8	3064.5	2899.6	2941.1	2975	2991.1	3025.7	3142.2	3211.8	3260
3350.6	3315.2	3267.3	3203.6	3105.2	3025.7	3007.8	3007.7	3021.5	3072.7	3171.8	3230.1	3271.8
3268.5	3232.7	3191.7	3154.4	3103.8	3059.6	3026.4	2998.1	2992	3062.7	3174.6	3235.4	3276.7
3169.6	3122.2	3073	3069.6	3066.8	3048	3005.7	2934.8	2859.8	2999.3	3155.2	3228.5	3273.4
3062.4	2979.9	2870.6	2946.3	3010.3	3021.9	2976.2	2840.8	2477.7	2904	3129.8	3216.7	3264.9
2980.3	2833.9	2444.7	2812	2964.4	3012.2	2996.9	2932.4	2853.1	2985.4	3135.8	3208.8	3254.1
2987.3	2903.8	2797.3	2886.2	2978.1	3023.4	3026.8	3001.3	2980.1	3031.5	3131.6	3194.8	3238.4
3021.7	2970.8	2923.9	2943.4	2995.7	3035.1	3046.6	3030.9	3005.9	3011.8	3094.3	3167.2	3217
3050.4	3002.9	2951.7	2931.7	2980.1	3028.8	3046.3	3022.4	2958.6	2886.4	3023.2	3132.2	3197.6
3069.9	3007.3	2914.8	2818.4	2926.6	3014.4	3048.2	3016.4	2885.5	2514.9	2937.7	3113.9	3196.3
3094.9	3014.9	2854.7	2469.8	2861.7	3018.1	3077.8	3073.9	3017.9	2941.1	3063.9	3167.8	3231.2
3142	3079.5	2987.5	2888.4	2992.8	3084.3	3135.9	3150.2	3139.6	3132.8	3183.2	3240.5	3283.9
3194.6	3151.9	3101.4	3068.6	3105.6	3157.6	3197.3	3218.4	3227.2	3238.9	3269.5	3305.2	3334.3
3248.5	3222.5	3191.8	3176.2	3193.6	3226	3257.1	3279.8	3296.2	3313.7	3337.9	3363	3380.2

15 Year

3368.6	3339.3	3299.1	3250.4	3197.1	3144.3	3098.2	3059.9	3031.5	3019.4	3030.6	3053.8	3077.4
3342.6	3309.2	3264	3208.3	3145.5	3084.1	3036	2995.3	2959.8	2941.1	2971.2	3011.3	3046.3
3304.1	3267.1	3214.6	3141.4	3029.1	2934.7	2891	2850.5	2791.3	2731.6	2876	2956	3007.2
3257.1	3217.6	3158	3065.8	2901.4	2736.5	2748.5	2733.5	2636	2332.8	2774.7	2911.3	2976.8
3204.1	3164	3101.2	2995.7	2766.2	2336.3	2622	2691.1	2678.4	2649	2822.5	2913.3	2968.7
3144.6	3106.9	3050.7	2964.2	2809.7	2656.6	2689.9	2717.7	2730.5	2760.8	2865.6	2929	2973.1
3075.3	3040.9	2994.3	2932.2	2837.1	2761	2742.1	2740.2	2751.6	2797.3	2886.9	2940.3	2978.6
2992.3	2957.9	2917.6	2879.5	2827.8	2784.1	2752.3	2726.4	2721.1	2784.2	2885.3	2940.8	2978.7
2894.7	2850.6	2803.9	2796.6	2788.3	2768	2729.1	2666.4	2600.8	2725.2	2864.7	2931.3	2972.5
2791.1	2717	2618.1	2681.4	2733	2740.3	2698.9	2579.6	2259.1	2638.5	2839.7	2918.4	2962.5
2711.2	2580.8	2233.6	2556.8	2688	2727.9	2713.9	2657.7	2589.2	2708.2	2843.2	2909.7	2951.4
2711	2636.6	2541	2618	2696.6	2735	2738	2716.8	2700	2747.5	2838.6	2896.6	2937
2736.8	2691.7	2649.7	2665.7	2710.2	2743.8	2754.3	2742.3	2722.8	2730.6	2805.9	2872.5	2918.6
2759.5	2717.9	2672.7	2654.5	2696.5	2738.9	2754.9	2736	2682.5	2621.5	2744.7	2843.1	2902.8
2776.1	2721.3	2640.2	2555.2	2650.7	2728.1	2758.7	2733	2620.3	2294.4	2672	2829.5	2904.1
2798.8	2728.8	2588.1	2248.3	2595.2	2733.5	2787.1	2786.1	2739.8	2675.2	2786.1	2880.1	2938.1
2841.7	2786.8	2706.5	2619.8	2712.5	2793.8	2840.9	2856.1	2849.8	2847	2894.3	2947.4	2987.5
2889.8	2852	2807.8	2779.6	2813.2	2860.5	2897.8	2919.2	2930.1	2943.6	2973.4	3007.1	3034.3
2939.3	2916.4	2889.3	2876.3	2892.9	2923.5	2953.3	2976.2	2993.8	3012.2	3036.2	3060.4	3076.8

20 Year

Figure D.8 Pressure distribution of layer 8. (Without well stimulation - Continued)

4020.4	4020.3	4020.2	4020	4019.7	4019.5	4019.2	4018.9	4018.3	4017.9	4018.3	4019	4019.5
4020.2	4020	4019.7	4019.1	4018.4	4017.6	4017.2	4016.2	4014.3	4012.7	4014.2	4016.6	4018.1
4020.1	4019.7	4019	4017.5	4016.1	4014.4	4014	4012.3	4007.6	4002.7	4005.9	4012.5	4016.2
4019.9	4019.2	4017.5	4013.3							3988	4005	4013.1
4019.6	4018.5	4015.3	4006.5							3965.2	3997.9	4010.9
4019.5	4018.1	4013.6	4000.4							3987.7	4004.9	4013.1
4019.6	4018.5	4015.3	4006.5							4005.2	4012.2	4016
4019.9	4019.2	4017.5	4013.2							4012.5	4015.8	4017.8
4020	4019.7	4018.9	4017							4012.8	4016.3	4018.2
4020.2	4020	4019.6	4018.7							4008.6	4015	4017.8
4020.2	4020.1	4019.9	4019.3							4004	4013.7	4017.5
4020.3	4020.2	4020	4019.6							4009.1	4015.4	4018.1
4020.3	4020.2	4020.1	4019.8							4014.7	4017.5	4019
4020.3	4020.2	4020.2	4020	4019.6	4018.9	4017.6	4015.6	4014.3	4015.7	4017.7	4019	4019.6
4020.3	4020.3	4020.2	4020.1	4019.9	4019.6	4019.1	4018.3	4017.9	4018.4	4019.2	4019.7	4020
4020.3	4020.3	4020.2	4020.2	4020.1	4020	4019.9	4019.7	4019.6	4019.7	4019.9	4020.1	4020.2
4020.3	4020.3	4020.3	4020.2	4020.2	4020.2	4020.1	4020.1	4020.1	4020.1	4020.1	4020.2	4020.2
4020.3	4020.3	4020.3	4020.3	4020.3	4020.2	4020.2	4020.2	4020.2	4020.2	4020.2	4020.3	4020.3
4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3
4020.4	4020.4	4020.4	4020.4	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.4	4020.4

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4019.4	4018.8	4017.9	4016.5	4014.8	4013.1	4011.5	4009.5	4007.3	4006.3	4007.6	4010.2	4012.3
4018.6	4017.5	4015.6	4012.6	4009.2	4005.6	4002.8	3998.9	3993.8	3990.7	3994.3	4001.2	4006.3
4017.7	4015.9	4012.4	4006.9	4002	3996.1	3992.5	3986.8	3977	3969.2	3974.4	3989.1	3999.1
4016.5	4013.6	4007.3	3994.7							3941.2	3972.1	3990.3
4015.3	4011	4001	3979.3							3908.1	3959.5	3984.9
4014.5	4009.4	3997	3968.3							3939.3	3971.3	3989.8
4014.2	4009.6	3999.4	3977.7							3970.5	3987	3997.9
4013.2	4009.1	4001.7	3989.3							3986.7	3996.9	4003.9
4009.1	4003.2	3995.3	3990.9							3988.8	3999.4	4006.2
3998.7	3983.9	3963.5	3973							3981.7	3997.2	4005.8
3979.4	3936.4	3853.2	3920.7							3974.9	3995	4005.3
3959.2	3857.4	3479.6	3833.1							3982.8	3998.1	4006.7
3978.6	3935.2	3851.8	3920.2							3989.7	4001.2	4008.2
3996.4	3980	3957.6	3969	3990.1	3998.2	3995.7	3983.3	3963.6	3949.7	3980	3998.4	4007.3
4003.6	3992.4	3973.9	3959.1	3979.7	3994.4	3994.9	3977.4	3932	3858.4	3943.4	3986.8	4003.5
4002.7	3984.6	3939.2	3860.7	3938.2	3981.6	3990.5	3964.5	3859.3	3496.2	3866.7	3971.1	3999.8
4000.2	3970.9	3867.9	3503.9	3867.4	3968.9	3993.1	3983.7	3941.4	3866.5	3944	3988.4	4005
4005.3	3988.2	3944.4	3869	3944.3	3987.4	4002.4	4001	3988.1	3972.5	3989.4	4004.3	4011.4
4011.2	4003.5	3988.2	3971.7	3988.2	4003.3	4010.2	4010.8	4007.4	4004.1	4008.1	4012.9	4015.6
4015	4011.6	4005.9	4001.5	4005.9	4011.5	4014.7	4015.4	4014.5	4013.8	4015	4016.7	4017.8

2 Year

Figure D.9 Pressure distribution of layer 9. (Without well stimulation)

3999.6	3994.4	3986.2	3975.7	3963.9	3951.7	3940.2	3930.1	3922.4	3920	3924.4	3932.9	3939.8
3993.1	3985.6	3973.7	3958.3	3941.2	3923.7	3907.9	3893.4	3881.1	3876.6	3885.3	3902.2	3916.3
3986.8	3976.7	3960.7	3939.7	3920.4	3897.9	3879.4	3861.3	3843.1	3833.4	3842.5	3871.2	3893.9
3978.8	3965.8	3943.9	3908.9							3786.4	3836.4	3871
3969.7	3953.7	3925.3	3875.8							3739.4	3814.1	3858.4
3959.7	3941.8	3909.8	3851.4							3776.2	3829.6	3866
3946.7	3929.1	3900.1	3851.6							3821.8	3857	3883.5
3925.4	3907.6	3882.8	3849.9							3851.7	3878.6	3899.5
3888.7	3865.5	3839.6	3823							3861.4	3888.4	3908.5
3831.8	3789.9	3744.5	3754.2							3855.4	3888.1	3910.6
3760.7	3672.5	3543.9	3633.5							3845.9	3884.3	3909
3707.5	3541.1	3071	3492.1							3848.2	3882.3	3905.9
3741.1	3649.8	3519.1	3612.3							3840.2	3873.4	3897.7
3789.6	3738.9	3685.7	3705.5	3766.1	3802.6	3807.5	3780.9	3738	3719	3794.8	3848.6	3881.3
3818.7	3774.8	3721	3693.1	3742.6	3788.8	3798.5	3761	3676	3577.1	3715.5	3811	3860.8
3827.1	3768.1	3667.1	3547.8	3667.4	3759.8	3787.6	3739.3	3575.8	3142.3	3604.1	3780.9	3850.7
3833.4	3756.4	3578.5	3126	3577.4	3747	3802.3	3785	3707.6	3604.9	3725.3	3821.3	3871
3859.7	3804	3706.7	3592.2	3706.1	3798.3	3842.3	3843.8	3816.8	3792.4	3830.4	3875.4	3904
3892.3	3858.3	3810.6	3775.5	3810.4	3855.6	3884.4	3892	3885.8	3881.7	3897.1	3918.6	3934
3919.6	3899.2	3873.2	3858.5	3872.6	3897.1	3916.2	3924.4	3925.1	3926.3	3934.9	3946.7	3955

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3883	3867.3	3843.4	3814.3	3782.3	3750.3	3721.2	3697.2	3680.8	3674.8	3679.8	3691.6	3701.4
3862.8	3843.4	3814.7	3779.5	3741.3	3702.7	3668.5	3640.1	3619.4	3612.1	3622.5	3644.4	3663.6
3843.8	3820.8	3787.2	3746	3707.2	3663.2	3625.8	3593.9	3567.7	3555.6	3565.1	3600	3629.1
3819.7	3793.2	3753.2	3695.2							3494.4	3552.4	3594.7
3790.5	3760.7	3713.8	3639.9							3436.5	3520.6	3573.5
3756.5	3725.3	3675	3592.2							3467.9	3531.6	3577
3715.6	3685.5	3639.9	3569.6							3512.7	3558.6	3594.4
3662.5	3633.6	3594.7	3543.9							3544.1	3581.9	3612.2
3591.1	3558.5	3521.5	3491.7							3554.6	3592.9	3622.5
3499.5	3450.4	3397.4	3397.2							3547	3591.6	3623.7
3397.2	3304.6	3174.2	3254.2							3533.1	3583.6	3618.2
3320.4	3153.2	2696.3	3097.5							3528.9	3574.7	3608.1
3339.4	3243.7	3112.8	3200.8							3511.5	3556.7	3590.8
3384.3	3326.9	3269.5	3288.4	3353.9	3398.8	3411.7	3391.8	3356.8	3351.9	3452.6	3522.1	3565.5
3418.6	3366.3	3306.6	3278.2	3332.7	3387.2	3405	3373.8	3294.9	3206.7	3366.8	3479	3540.1
3438.7	3370.4	3263	3145.6	3267.5	3367.1	3403	3360.9	3201.9	2771.9	3256.5	3451.1	3532.7
3462.2	3375.6	3192.5	2750.1	3193.4	3368.2	3431.9	3422.1	3351.3	3257.2	3393.2	3504.5	3565
3509	3443.3	3338.6	3223.8	3339	3438.4	3491.8	3502.3	3484	3469.6	3520.3	3578.4	3616.6
3563.5	3519.7	3463.9	3426.2	3464	3517.1	3556	3573.8	3577.4	3583.8	3610.9	3643.6	3667.1
3610.9	3581.4	3547.2	3529.2	3546.3	3578.9	3608.4	3627.4	3638.5	3650.3	3669.8	3691.5	3706.3

10 Year

Figure D.9 Pressure distribution of layer 9. (Without well stimulation - Continued)

3674.7	3653.2	3620.9	3582	3540	3498.2	3460.3	3429.2	3407.6	3397.8	3400.2	3410.3	3419.4
3645.9	3620.5	3583.9	3539.9	3492.7	3445.1	3402.8	3368	3343.1	3332.8	3340.4	3360.4	3378.5
3618.5	3589.7	3548.8	3500.2	3454.4	3402.2	3357.2	3319.7	3290.3	3276.1	3281.6	3313.6	3341.2
3583.6	3551.8	3505.5	3441							3209.1	3262.9	3302.8
3541.6	3507.1	3454.8	3375.6							3148.4	3226.2	3276
3493.5	3458	3402.9	3316.1							3168.1	3228.3	3271.8
3438	3404	3353.7	3279							3200.9	3245.8	3281
3371.2	3339.2	3296	3240							3223.1	3261.1	3291.6
3288.9	3254.9	3215	3179.3							3227.6	3266.2	3296.3
3190.4	3143.2	3091	3083							3216.9	3261	3293.5
3084.5	3000.4	2881.5	2945.6							3201.1	3250.6	3285.2
3003.3	2854	2448.1	2797.1							3195.1	3240.2	3273.6
3009.6	2923.8	2806.1	2880.7							3178.3	3222.8	3256.9
3043.2	2991.6	2939.5	2953.8	3009.3	3048.6	3061.6	3047.8	3022.9	3026.8	3125.2	3192.6	3234.7
3072.2	3025.2	2971.6	2945.6	2993	3041.6	3059.4	3036	2972.6	2902.5	3052.3	3157.1	3214.8
3092.8	3031.8	2936.8	2833.6	2941.6	3030.3	3064.7	3032.3	2898.4	2525.3	2960.7	3137.7	3213.2
3119.2	3042.2	2880.9	2492.2	2882.9	3038.1	3097.3	3093.4	3037.5	2961.7	3088.1	3191.6	3248.5
3167.6	3108.6	3016.2	2915.8	3018	3107.4	3157.9	3172.3	3162.5	3156.8	3208.1	3264.8	3302.1
3222.6	3182.8	3132.9	3100.1	3134.7	3184.1	3222.3	3243.4	3253.1	3265.7	3296.3	3330.7	3355.1
3270.6	3243.1	3212.1	3196.6	3213	3244.7	3275.2	3297.9	3314.5	3332.1	3356.1	3380.7	3396.9

15 Year

3427.2	3403.9	3369.4	3328.1	3283.5	3239.1	3198.8	3165.4	3141.3	3128.8	3128.2	3135.7	3143.1
3394.9	3368.2	3330.1	3284.7	3236.2	3187.2	3143.4	3106.8	3080.1	3067.3	3071.5	3088	3103.8
3364.2	3334.5	3292.8	3244	3198.3	3145.6	3099.5	3060.7	3030.1	3013.8	3015.3	3042.8	3067.2
3325	3292.8	3246.8	3184.1							2944.4	2992.6	3028.5
3278	3243.8	3192.9	3117.2							2883.6	2954	2999.2
3224.7	3190	3136.9	3054.8							2895.1	2950	2989.7
3164.8	3131.7	3083	3011.7							2919.1	2960.1	2992.4
3094.9	3063.8	3021.8	2967.3							2933.9	2968.8	2996.9
3011.6	2979.1	2940.3	2903.9							2933.7	2969.1	2996.8
2914.3	2870.6	2821.6	2810.5							2920.7	2961	2990.8
2811.5	2736.1	2629.3	2682.5							2904.2	2949.3	2981
2731.9	2599.3	2238.1	2544.9							2897	2938.5	2969.3
2731	2654.9	2549.8	2614							2881.3	2922.5	2954
2756	2710.5	2664	2675.3	2722.2	2755.7	2767.7	2757.3	2738.2	2744.2	2834	2895.9	2934.9
2779	2737.9	2690.7	2667.1	2708.2	2750.4	2766.8	2748.2	2695.3	2636.2	2771.1	2866	2918.8
2796.6	2743.1	2660.1	2569.3	2664.6	2742.8	2773.9	2747.6	2632.8	2304.9	2693.2	2851.4	2920
2820.8	2753	2611.7	2268.8	2614.5	2751.6	2805.1	2804.1	2757.9	2694.3	2808.5	2902.2	2954.2
2865.1	2813	2732.3	2644.6	2735.3	2814.9	2861.3	2876.6	2871.1	2869.3	2917.6	2970	3004.4
2915.6	2880.1	2836.4	2808.1	2839.8	2884.9	2921	2942.5	2954.1	2968.4	2998.2	3030.8	3053.5
2959.6	2935.3	2908	2894.9	2910.9	2940.7	2970.1	2992.9	3010.6	3029.3	3053.1	3076.8	3092.3

20 Year

Figure D.9 Pressure distribution of layer 9. (Without well stimulation - Continued)

4031.4	4031.3	4031.2	4031.1	4031	4030.8	4030.6	4030.4	4030.1	4029.6	4029.3	4029.6	4030.1	4030.5
4031.4	4031.2	4031.1	4030.8	4030.5	4030	4029.5	4029.2	4028.5	4027.3	4026.3	4027	4028.6	4029.6
4031.3	4031.1	4030.9	4030.4	4029.7	4028.9	4028	4027.5	4026.4	4023.9	4021.5	4021.6	4025.5	4028
4031.3	4031	4030.5	4029.6								4011.6	4020.6	4025.7
4031.2	4030.8	4030	4028.5								4001.6	4016.5	4024.2
4031.2	4030.7	4029.8	4027.8								4011.4	4020.5	4025.7
4031.2	4030.8	4030	4028.5								4021.2	4025.3	4027.8
4031.3	4031	4030.5	4029.6								4025.9	4027.9	4029.2
4031.3	4031.1	4030.8	4030.4								4026.4	4028.4	4029.6
4031.4	4031.2	4031	4030.8								4024.4	4027.6	4029.4
4031.4	4031.2	4031.1	4031								4022.5	4026.9	4029.2
4031.4	4031.3	4031.2	4031.1								4024.9	4027.9	4029.6
4031.4	4031.3	4031.2	4031.2								4027.8	4029.3	4030.2
4031.4	4031.3	4031.2	4031.2								4029.6	4030.3	4030.7
4031.4	4031.3	4031.2	4031.2								4030.6	4030.8	4031
4031.4	4031.3	4031.3	4031.2	4031.2	4031.2	4031.1	4031	4030.9	4030.9	4030.9	4031	4031.1	4031.2
4031.4	4031.3	4031.3	4031.2	4031.2	4031.2	4031.2	4031.2	4031.1	4031.1	4031.1	4031.2	4031.2	4031.2
4031.4	4031.3	4031.3	4031.3	4031.2	4031.2	4031.2	4031.2	4031.2	4031.2	4031.2	4031.2	4031.2	4031.3
4031.4	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3
4031.4	4031.4	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3
4031.5	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4

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4030.9	4030.5	4029.9	4029	4027.8	4026.3	4024.7	4023.2	4021.4	4019.5	4018.5	4019.6	4021.9	4023.7
4030.7	4029.9	4029	4027.4	4025.2	4022.7	4020	4017.6	4014.6	4010.8	4008.6	4010.4	4015.4	4019.2
4030.3	4029.2	4027.6	4025	4021.9	4018.3	4014.4	4011.3	4006.9	4000.6	3995.7	3995.6	4005.4	4012.8
4029.9	4028.3	4025.8	4022.1								3973.6	3992.4	4005.2
4029.5	4027.3	4023.8	4018.2								3956.3	3983.9	4001
4029.2	4026.6	4022.6	4015.9								3972.3	3991.7	4004.8
4028.9	4026.3	4022.5	4016.7								3992.6	4003.5	4011.6
4028.2	4025.3	4021.6	4016.7								4004.6	4011.5	4016.7
4026.3	4021.8	4015.7	4008.6								4007.1	4013.9	4018.8
4022.3	4012.7	3996.8	3974.6								4003.5	4012.6	4018.7
4016.2	3995.8	3950.1	3857.9								4000.3	4011.4	4018.4
4011.4	3977.8	3871.2	3465.9								4004.3	4013.4	4019.5
4015.8	3995.1	3949.1	3856.4								4007.4	4015.3	4020.6
4021.3	4010.7	3993.2	3968.8								3999.5	4012.2	4019.6
4024.2	4017	4005.6	3988.8								3969	4001.4	4015.9
4024.7	4016.3	3998	3953.3	3866.3	3946.8	3992.3	4001.9	3974.8	3863.2	3482.2	3880.8	3984.6	4012.1
4024.6	4014.2	3985.1	3885.6	3528.4	3884.1	3982.3	4005.4	3996	3954	3878.9	3958	4001.2	4017
4026.1	4018.7	4001.7	3959.8	3886.8	3959.4	4000.4	4014.6	4013.2	4000.6	3985.4	4002	4016.4	4023
4028	4023.8	4016.2	4001.9	3986.2	4001.8	4015.7	4022.1	4022.6	4019.4	4016.3	4020.1	4024.6	4027
4029.4	4027.2	4024	4019.1	4015.2	4019.1	4023.8	4026.5	4027.1	4026.4	4025.7	4026.8	4028.2	4029.1
4030.3	4029.4	4028.1	4026.4	4025.3	4026.3	4028	4029	4029.4	4029.3	4029.2	4029.5	4030	4030.3

2 Year

Figure D.10 Pressure distribution of layer 10. (Without well stimulation)

4017.1	4012	4006.3	3998.2	3988.2	3976.8	3965.1	3954	3944.1	3936.8	3934.4	3938.3	3946.3	3952.7
4014.6	4007.4	3999.7	3989.1	3975.9	3961.2	3945.9	3931.8	3918.9	3908.5	3904.4	3909.9	3923.2	3934.3
4010.6	4001.5	3991.6	3978.1	3963.1	3946.2	3927.7	3911.2	3895.5	3881.2	3873.5	3873.8	3894.8	3912.4
4005.6	3994.4	3982.1	3967								3831.1	3864.8	3890.9
3999.6	3986.3	3971.2	3952.6								3802.1	3847.2	3879.5
3992.1	3977	3960.2	3939.4								3822.4	3858.3	3885.8
3981.6	3964.6	3947.3	3927.5								3855.7	3880.9	3901.6
3965	3944.4	3925.3	3906.3								3880.5	3900.1	3916.5
3938.9	3909.9	3883	3858.7								3890.4	3909.6	3925.2
3903	3857.1	3807.6	3757.2								3888.3	3910.4	3927.5
3864.2	3791.5	3689.8	3543.2								3882.7	3907.5	3926.2
3840.3	3742.6	3557.2	3045.6								3880.5	3904.2	3922.7
3850.9	3773.6	3667.9	3518.2								3868.3	3893.9	3914.1
3874.9	3818.4	3758.4	3698.5								3828.5	3869.2	3897.6
3894.6	3846	3795.4	3742.5								3754.9	3832	3877.2
3906	3854.7	3789.1	3684.9	3546.8	3671.5	3769.6	3799.9	3748.8	3573.3	3117.1	3620.2	3798.9	3866.6
3916	3861.5	3778.5	3600.5	3151.4	3595.3	3763.4	3818.2	3800.1	3721.2	3617	3742.5	3838.8	3886.5
3932.3	3886.3	3825.8	3728.5	3614.5	3726	3816.4	3859.3	3860.4	3833.4	3809.2	3847.9	3892.4	3919.3
3951.9	3917.2	3879.9	3832.6	3797.9	3831.3	3874.7	3902.2	3909.4	3903.3	3899.4	3914.7	3935.4	3949.4
3969.9	3944.7	3922.1	3897.7	3884	3896.6	3918.7	3936	3943.6	3944.5	3945.8	3953.7	3964.3	3971.7
3983.2	3971.2	3956.5	3942.4	3935.5	3941.1	3952.9	3963.7	3969.9	3972.5	3974.9	3979.7	3985.5	3989.3

5 Year

3916.4	3898.7	3880.6	3856.8	3828	3796.6	3765.1	3736.3	3712.7	3696.5	3690.4	3694.8	3705.9	3715.2
3906.7	3883.9	3862.5	3835.2	3803	3767.6	3731.7	3699.3	3672.4	3653.4	3646	3652.3	3669.8	3684.9
3891.3	3865.3	3840.7	3810.5	3778.2	3741.5	3702.1	3666.9	3637.2	3614.4	3603.2	3601.7	3627.6	3650.3
3870.9	3842.1	3814.9	3785.4								3544.6	3584.7	3617.1
3845.5	3814	3783.9	3750.9								3505.1	3557.6	3596.9
3814.3	3780.8	3749	3714.2								3520.3	3564.2	3599.2
3775.3	3740.2	3708.6	3675.8								3553.2	3586.8	3615
3725.6	3687.6	3655.6	3625.2								3579.8	3607.8	3631.8
3663.2	3617.8	3579.5	3545.8								3590.9	3618.6	3641.9
3590.8	3529.5	3470.5	3413.5								3587.6	3618.5	3643.4
3519.5	3432.4	3323.7	3175.8								3577.6	3611.5	3638.1
3471.8	3359.8	3170.9	2674								3568.3	3601	3627.6
3469.7	3376.5	3263.1	3112.7								3545.9	3581.1	3609.6
3492.6	3418.3	3348.1	3282.9								3493.9	3546.1	3583.9
3519.7	3451.8	3389.4	3329.3								3412.8	3503	3558.2
3545.2	3473	3394.3	3282.5	3146.8	3273.5	3379.4	3418.3	3373.2	3201.8	2749.8	3275.9	3471.7	3550.3
3574.5	3497.8	3401.3	3216.7	2777.8	3213	3386.5	3450	3439.5	3367.4	3272.1	3413.4	3524.7	3582.5
3613.7	3544.1	3469.8	3363.9	3249	3361.6	3459.2	3511.6	3521.9	3503.8	3489.8	3541.4	3598.8	3634.4
3657.9	3598.6	3547.3	3490.9	3453	3489.2	3540.4	3578.2	3595.8	3599.6	3606.3	3633.2	3664.9	3686.3
3699.3	3649.9	3613.9	3580.1	3562.7	3578.1	3608.1	3635.9	3654.4	3665.6	3677.6	3696.3	3716.5	3730
3731	3705.5	3677.2	3653	3641.8	3649.5	3668.8	3690	3707.1	3720.4	3733.2	3748	3762.3	3771.3

10 Year

Figure D.10 Pressure distribution of layer 10. (Without well stimulation - Continued)

3718.4	3692.5	3667.2	3634.6	3596.1	3554.4	3512.9	3475.4	3444.5	3423	3413.1	3414.9	3424.3	3432.8
3703.3	3670.8	3642.1	3606.6	3565.4	3520.7	3475.6	3434.9	3401.3	3377.4	3366.7	3370.1	3385.8	3400
3678.8	3643.5	3611.8	3574.2	3535.4	3490.8	3442.9	3399.8	3363.9	3336.9	3322.7	3317.3	3340.7	3362.1
3646.7	3609.1	3575.4	3540.4								3256.6	3294	3324.5
3607.3	3567.7	3531.9	3494.3								3212.2	3261.4	3298.6
3560.6	3519.9	3483.1	3444.2								3217.8	3259.6	3293.3
3505.8	3464.5	3428.4	3391.7								3240.3	3273.3	3301.2
3440.7	3397.8	3362.1	3328.4								3258.3	3286.6	3311
3364.4	3316.3	3276.4	3241.1								3263.5	3291.7	3315.6
3280.4	3220	3163.6	3109.1								3256.5	3287.5	3313
3199.9	3118.2	3019.3	2885.7								3244.2	3277.9	3304.9
3142.8	3040.2	2871.2	2431								3233.4	3266	3292.8
3129.8	3044.1	2942.3	2807.6								3212	3246.8	3275.3
3143.9	3075	3011.4	2952.7								3165.7	3216	3252.6
3166.8	3103.3	3046.7	2992.9								3096.4	3180.5	3232.3
3192.7	3125.2	3054.2	2955.4	2836.5	2949	3043.9	3081	3046.1	2901.1	2508.8	2980.1	3157.8	3230.2
3224.9	3153.1	3066.4	2903.9	2518.5	2902	3056.1	3115.2	3110.8	3053.7	2977.1	3108.2	3211.4	3265.6
3268.1	3201.4	3134	3040.4	2939.9	3039.8	3127.7	3177.5	3191.8	3182.2	3177	3229	3285.1	3319.9
3316.6	3257.4	3209.6	3159.1	3126.1	3159.3	3206.8	3244.3	3265.3	3275.3	3288.4	3318.9	3352.4	3374.8
3362.4	3310.9	3276	3244.8	3229.6	3244.6	3274.2	3303.4	3325.8	3342.7	3360.5	3383.7	3406.9	3421.9
3397.5	3370.8	3342.2	3318.7	3308.4	3316.9	3337.6	3361.4	3382.8	3401.6	3420.1	3439.7	3457.4	3468.3

15 Year

3474.2	3445.4	3417.8	3382.9	3341.9	3297.6	3253.3	3213.1	3179.9	3156	3143.4	3142.2	3149	3155.9
3456.8	3421	3390.3	3352.9	3310.1	3263.6	3216.6	3174.2	3138.6	3112.7	3099.4	3099.5	3112.1	3124.2
3428.4	3390	3356.7	3318.2	3279.1	3233.7	3184.9	3140.4	3102.9	3074.3	3057.6	3048.6	3068.2	3086.9
3391.1	3351	3316.4	3281.2								2988.2	3021.5	3048.8
3345.6	3304.3	3268.1	3231.1								2942.2	2986.6	3020.3
3292.6	3251	3214.4	3176.7								2941	2979.1	3009.8
3232.1	3190.8	3155.3	3119.6								2955.6	2985.7	3011.3
3163.2	3120.8	3086	3053.3								2966.6	2992.6	3015
3084.6	3038	2999.9	2966								2966.9	2992.8	3014.8
2999.6	2942.6	2890.1	2839.8								2957.3	2985.7	3009.1
2918.2	2843	2754	2634.7								2943.8	2974.7	2999.4
2858.6	2765.8	2615.8	2224.2								2932.5	2962.6	2987.2
2839.9	2762.4	2672.1	2552.1								2912.8	2944.9	2971.3
2847.6	2785.1	2728.8	2676.6								2871.6	2918	2951.8
2865.5	2807.6	2757.3	2710.3								2811.9	2887.9	2935.4
2888	2826.4	2763.6	2677.3	2572.6	2672.1	2755.7	2789.6	2761.1	2636.5	2291.9	2711.7	2870.4	2936.1
2917.8	2852	2775.3	2633	2292.9	2632.3	2768.3	2821.9	2820.5	2773.3	2709.2	2827.5	2921	2970.4
2957.8	2896.7	2836.5	2754.4	2666.9	2755.4	2833.9	2879.8	2895	2889.7	2888.4	2937.4	2989.2	3021.3
3002.6	2948.1	2905.3	2860.7	2832.3	2862.6	2906.5	2941.8	2963.2	2975.2	2989.9	3019.6	3051.3	3072.2
3044.9	2997.4	2966.1	2938.8	2926	2940.6	2968.6	2996.7	3019.3	3037.3	3056.1	3079.3	3101.9	3116.2
3077.6	3053.2	3027.7	3007.1	2998.8	3007.6	3027.7	3051	3072.9	3092.6	3112.1	3132.2	3149.9	3160.6

20 Year

Figure D.10 Pressure distribution of layer 10. (Without well stimulation - Continued)

3771.7	3713	3754.7	3729.5	3543.4	3190
3616.5	3391.8	3616.3	3655.1	3342.6	2736.1
3345.6	2809.7	3388.6	3666.7	3598	3313
3628.5	3408.3	3654.4	3775.4	3772.5	3710
3810.6	3762.9	3809.4	3835.2	3826.8	3820.5
3884.6	3865.8	3851.5	3809.7	3749.8	3783.3
3907	3884.4	3823.3	3669.2	3406.1	3604.7
3912.4	3881.3	3773.9	3420.9	2817.2	3323
3918.2	3896.6	3831.7	3672.3	3405.9	3604.9
3922.9	3910.7	3878.5	3814.8	3741.1	3780

1 Year

3505.3	3411.3	3437.8	3376.8	3112.6	2690.2
3297.9	3026.7	3258.6	3284.6	2903.3	2235.9
2987	2397.7	3015.2	3320.1	3223.7	2890.3
3340.8	3077.9	3352.8	3496.8	3487.3	3407.1
3617.1	3543.9	3587.7	3611.7	3593	3581
3756.8	3714.1	3669.5	3590.1	3498.7	3530
3806.4	3757.5	3640.9	3409.6	3081.4	3285.9
3814.3	3761	3585.8	3124.4	2439.7	2960
3820.8	3790.9	3672.5	3429.6	3089.4	3291.9
3843.8	3826.1	3755.3	3631.3	3505.8	3534.3

2 Year

2735.4	2558.9	2524	2392.4	2026.8	1455.3
2472.9	2074.3	2305.2	2281.9	1757.7	736.1
2075	1214.1	2023.6	2361	2214.8	1769.7
2556	2180.6	2485.1	2625.2	2590.7	2482.4
2926.3	2802.9	2817.6	2812.5	2768.4	2747.6
3116.6	3044.1	2955.9	2823.4	2686	2717.1
3173.1	3109.9	2942.4	2624.1	2182	2430.3
3161.3	3112.8	2883.9	2272.5	1298.9	2017.7
3152	3148.1	3000.3	2670	2201.2	2435.5
3180.2	3194.1	3107	2919	2715.2	2718.8

5 Year

1897.2	1713.2	1640.9	1534.8	1304.3	969.3
1674.8	1330.2	1456.8	1439.4	1139.1	602.1
1338.8	663.8	1225.3	1460.2	1390.4	1150.2
1667.9	1360	1540.6	1629.4	1617.8	1566.9
1918.8	1797.5	1775.6	1756.6	1727.4	1725.1
2037	1959.8	1871.1	1758.6	1655.5	1684.7
2056.3	1992.5	1853.4	1609.9	1288.9	1465.5
2025.4	1978.6	1802	1357.4	649.5	1159.8
1999.7	1990.4	1876.3	1630.7	1290.8	1450.9
2007.1	2015.3	1947.7	1805.4	1652	1652.8

10 Year

1534.8	1386.6	1315.7	1225.4	1053.4	811.4
1358.4	1092.7	1167.6	1142.1	924	558.3
1086.4	599.7	977.4	1129.7	1075.3	909.9
1288.7	1058.9	1171	1225.6	1215.4	1181.3
1439	1341.6	1316.1	1299.1	1279.8	1280.1
1499	1436.7	1369	1291.9	1226.8	1248.9
1493.1	1443.7	1345.9	1187.6	984	1101.9
1456.4	1420.6	1301.3	1016.4	576.2	897.8
1425.8	1416.7	1339.8	1183.8	972.3	1079.9
1422.3	1426.4	1382.1	1291.9	1199.9	1206.7

15 Year

Figure D.11 Pressure distribution of layer 1. (After well stimulation)

3868.2	3799.3	3729.2	3769.1	3744.9	3563.1	3219
3816.3	3656	3406	3628.4	3667.7	3355.5	2746.6
3753.3	3402.3	2818.5	3398.9	3678.4	3611.7	3332.9
3821.8	3666.1	3421.5	3665.5	3786.9	3785.3	3726.7
3886	3832.2	3775.5	3820.7	3846.6	3839	3835.3
3918.9	3899.6	3877.6	3862.7	3821	3762.2	3799.9
3931.6	3920.2	3895.8	3834.4	3680.2	3418.2	3626.8
3935.9	3925.2	3892.7	3784.9	3431	2826	3348.9
3938.4	3930.6	3908.2	3843.5	3685	3420.3	3629.2
3940.1	3935.6	3923.9	3894.7	3837.2	3771.2	3811
3941.4	3939.6	3934.9	3924.6	3907.5	3891.7	3899.2
3942	3941.2	3939.3	3935.6	3930.1	3925.9	3927.7

1 Year

3695.3	3556.1	3437.8	3460.1	3400.6	3142.2	2729.2
3610.7	3361.9	3047	3274.8	3301	2919.5	2246.1
3527.1	3067.4	2405.8	3026.3	3333.4	3240	2914.2
3632	3397.7	3093.9	3364.7	3509.2	3502.5	3429.2
3750.3	3649.9	3558.9	3599.6	3623.8	3607.6	3601.6
3815.5	3776.1	3726.8	3681	3602.1	3513.7	3554.2
3815.1	3815.6	3767.9	3651.8	3421	3095.9	3318.3
3748.9	3809.5	3768.8	3596.1	3134.7	2447.8	2995.8
3656.3	3800.8	3797	3684.6	3444.7	3108.3	3327.8
3758.6	3838.2	3839.1	3778.2	3664.7	3548.3	3577.1
3823.8	3861.4	3870.9	3844.6	3785.7	3712.7	3671.8
3809.1	3849.9	3874.7	3863.9	3809.8	3703	3565.4

2 Year

3099.9	2834.6	2610.6	2566.4	2435.8	2078.3	1519.4
2977.7	2584.1	2110.9	2332.7	2308.9	1783.3	751.1
2859.8	2202.6	1221.3	2037.9	2378.8	2237.3	1803.9
2992.7	2643	2202.1	2499.1	2640.5	2611.9	2516.8
3137.3	2974.6	2821.2	2830.7	2827	2788.8	2780.6
3190.5	3137.1	3056.1	2967.2	2836.8	2706.1	2754.5
3123.2	3166.8	3114.7	2951	2635.3	2199.7	2477.4
2947.8	3122.1	3109.5	2889.7	2280.5	1304.9	2067.2
2756.8	3081.6	3139.4	3006.8	2682.8	2220.6	2480.2
2898.8	3126.6	3190.6	3123.3	2948.5	2752.4	2754.2
2985.7	3124.5	3204.4	3181.5	3060.2	2890.3	2775.4
2930.2	3066.6	3170.7	3168.6	3038.6	2796.3	2528.1

5 Year

2296.8	2014.1	1778.7	1694.3	1586.6	1360.1	1031.6
2168.9	1796.6	1376.7	1491.7	1472	1166.9	613.4
2029	1467.1	671.8	1242.3	1480.3	1414.3	1182.8
2080	1758.2	1384.8	1555.8	1646	1640.7	1604.1
2145.8	1972.3	1817.8	1789.2	1771.7	1749.8	1762.8
2144.8	2064.6	1972.9	1882.1	1772	1677.6	1726.5
2056.2	2059.3	1998.3	1861.1	1620.6	1307.6	1514
1897.9	2001.5	1977	1806.6	1364.3	654.7	1208
1736.2	1951.8	1983.9	1880.9	1641.5	1309.7	1496
1805.3	1966.7	2011.1	1959.1	1829.2	1686	1692.2
1853.5	1956.1	2016.2	2000.5	1914.5	1796.4	1724.7
1821.7	1920.3	1995.1	1995.1	1906.4	1743.9	1573

10 Year

1859.7	1632.2	1441.5	1360.9	1268.3	1097.9	859.5
1748.2	1456.9	1131	1197.1	1169.5	946.7	566.2
1616.6	1187.2	606.2	991.9	1146.8	1094.6	935.1
1616.2	1363	1079.8	1183.9	1239.3	1233.6	1209.9
1629	1485.5	1359.7	1327.9	1311.7	1297.7	1309.5
1600	1525.3	1449.3	1378.8	1303	1244	1280.7
1517	1501.5	1450.6	1353.2	1196.2	998.1	1137.5
1389.4	1445.5	1421.8	1305.9	1022.1	580.1	933
1263.2	1397.2	1414.1	1344.3	1192.1	986.2	1113.1
1294	1397.1	1424.9	1391.1	1309	1223.7	1235.8
1319.9	1386.9	1426.8	1418.7	1365.7	1295.1	1256.8
1299.2	1363.6	1414.8	1417.8	1362.9	1262.6	1159.3

15 Year

Figure D.12 Pressure distribution of layer 2. (After well stimulation)

3925.3	3889.9	3824	3751.1	3789.2	3767.5	3597.3	3290.6	3543.8
3908.9	3841.4	3681.6	3421.2	3642.9	3683.1	3372.8	2760	3299.4
3894	3783.5	3429.8	2827.2	3410.3	3691.7	3629.6	3376.8	3608.1
3910.7	3845.5	3689.3	3434.3	3677.4	3799.3	3800.4	3753.1	3808.1
3931	3903	3849	3788.3	3832.5	3858.7	3852.8	3855.3	3882.3
3943.4	3932.5	3913.1	3889.6	3874.3	3833.1	3776.5	3825.2	3878.8
3949.1	3943.8	3932.4	3907.4	3845.9	3692.1	3433.2	3669.5	3821.6
3951.6	3947.7	3937.1	3904.2	3796.2	3441.3	2834.9	3411	3754.8
3952.7	3950.3	3942.4	3919.9	3855.6	3698	3436.2	3673.4	3825.7
3953	3951.6	3947.4	3936.1	3908.2	3853.3	3791.5	3840.9	3893.8
3953.4	3952.7	3950.8	3946.3	3936.3	3919.7	3904.9	3915.3	3930.5
3953.6	3953.3	3952.5	3950.8	3947.5	3942.6	3939.1	3942.4	3945.9
3953.8	3953.7	3953.4	3952.8	3951.8	3950.6	3950	3950.8	3951.2
3953.9	3953.9	3953.8	3953.5	3953.1	3952.7	3952.5	3952.4	3952.8

1 Year

3831.5	3739.2	3605	3479	3498.2	3442.6	3199.9	2829	3120.5
3795	3656.8	3406.4	3071.2	3297.4	3325	2944.4	2260.1	2848.9
3768.7	3578	3108.7	2413.8	3039.6	3350.4	3263.6	2969.8	3244.4
3800	3671.9	3433.4	3109.7	3378.1	3524	3522.6	3468.2	3552.4
3839.4	3776.6	3674.5	3574.4	3612.8	3637.9	3626.2	3634.8	3691.8
3837.1	3828.7	3792	3740	3693.5	3615.9	3533.2	3596.6	3693.5
3722.7	3806.5	3822.3	3778.4	3663.3	3434.1	3115.6	3384.4	3602.8
3312	3683.1	3801.1	3775.6	3606.8	3145.7	2456.2	3082.4	3512.6
2677.6	3458.8	3772.2	3801.2	3696.5	3460.2	3130.7	3395.7	3613.5
3308.9	3689.6	3828.5	3847.7	3794.3	3686.2	3575.8	3621.7	3716.1
3698.1	3801.5	3861.2	3878.7	3855	3795.2	3716.1	3668.1	3720.7
3734.5	3746.7	3823.6	3871.4	3867.8	3803.1	3646.2	3380.3	3552.9
3514.9	3286.8	3610.8	3797.8	3839.2	3735.4	3323.3	2599.3	3202.4
3089	2517	3231.6	3701.9	3825.2	3776	3560.7	3205.2	3462.5

2 Year

3400.4	3195.5	2938.1	2697.3	2646.8	2520.9	2184.5	1685.9	2111.3
3326.3	3068.5	2669.3	2159.7	2378.1	2355.3	1829.2	780.2	1728.7
3266.7	2950.2	2270.9	1229.3	2059	2406.5	2275.2	1891	2294.6
3283.5	3061.8	2699.8	2224.6	2517.7	2662.5	2644.9	2585.4	2734.2
3294.6	3179.4	3011.3	2841.8	2847.6	2847.1	2819.9	2842.9	2958.1
3207.6	3202.5	3153.2	3069.4	2981	2854.9	2737.1	2828.1	2991.4
2915.3	3088.9	3158.6	3118.5	2960.5	2649.8	2228.1	2579.3	2887.5
2183.6	2817.3	3080.2	3102.5	2894.8	2289.7	1312.3	2193.5	2766.1
1095	2421.9	3002.7	3124.6	3011.4	2696.2	2246.8	2574.6	2866.8
2093.4	2756.5	3075.6	3181.2	3131.5	2966.4	2778.9	2806.9	2933.1
2659.7	2913.2	3100.2	3198.8	3183.5	3061.9	2883.5	2758.6	2818.7
2671	2784	2987.4	3133.6	3148.2	3003.8	2690.3	2235.2	2447.9
2261.4	2007.6	2561.1	2923.6	3024.7	2825.6	2143.7	971.9	1862.5
1598.7	779.2	1950.1	2723.3	2963.3	2854.3	2449.3	1866.1	2189.2

5 Year

Figure D.13 Pressure distribution of layer 3. (After well stimulation)

2655.7	2417.7	2142.6	1888.4	1795.2	1686.9	1470.8	1178.1	1484.2
2550.8	2277.5	1899	1440.5	1551.3	1529.5	1217.2	634.1	1211.4
2444.3	2131.6	1543.6	681.5	1269.9	1513.9	1455.7	1261	1551.2
2394.3	2160.8	1823.5	1412.4	1578.3	1672.4	1679.1	1678.8	1827.6
2342.4	2199.8	2016.9	1842.9	1808.9	1795.2	1786.9	1836	1966.9
2221	2170.4	2089.1	1989.5	1897.4	1792.4	1714.1	1809.1	1976.1
1957.8	2043.6	2061.1	2005	1871.2	1636.2	1339.3	1617.2	1887.1
1410	1816.4	1976.2	1973.6	1811.5	1373.4	661.8	1327.3	1783
648.6	1518.3	1898.5	1973.4	1884.8	1654.2	1337.4	1589.9	1842.8
1266.6	1709.2	1930	2003.5	1965.6	1845.6	1714.6	1753.3	1882.8
1620	1803.5	1940	2013	2003.4	1919	1799.2	1730.8	1802.7
1640.9	1733.2	1874.2	1975.1	1986.1	1889.6	1685.4	1409.3	1559.8
1413.5	1294.1	1629	1856.8	1920.9	1791.5	1363.9	658.4	1195.3
1045.1	623.6	1284.6	1747.8	1896.5	1824.2	1563.8	1199.5	1414.8

10 Year

2155.6	1961.6	1740.2	1533.3	1445.6	1351.3	1185.8	971.4	1193.1
2056.2	1838.7	1542	1184.7	1247.7	1217.7	987.5	580.1	981.9
1947.1	1701	1250.8	614	1015.5	1175.5	1127.9	993.4	1199.8
1874.1	1684.3	1418.8	1104.1	1203.4	1261.6	1264.4	1267.2	1378.8
1801.8	1677.2	1525.6	1383.1	1345.5	1331.5	1327.4	1366.4	1466.2
1686.9	1627.5	1549.8	1465.9	1393.1	1320.2	1272.7	1343.2	1466.6
1482.1	1517.3	1509.5	1459.5	1363.3	1209.2	1021.9	1211.9	1401.8
1087.6	1341.6	1434	1423.1	1311.8	1029.8	585.2	1016.3	1326.8
577.7	1126.3	1365.6	1409.8	1349.2	1202.5	1007	1181.4	1360.1
955.7	1234.6	1375.2	1422.1	1397.6	1322.3	1246	1283	1382.6
1177.8	1290.5	1378.2	1426.7	1422.7	1371.1	1300.2	1267	1328.6
1192.4	1246.4	1336.9	1405.3	1415.8	1356.2	1228.8	1059.2	1172.1
1051.1	974	1188	1338	1384.9	1304.5	1030.9	585	940
819.2	562.4	975.2	1277	1379.3	1337.3	1173.5	942.9	1097.4

15 Year

Figure D.13 Pressure distribution of layer 3. (After well stimulation- Continued)

3952.8	3940.9	3919.2	3897.7	3898.4	3880.8	3820.8	3746.8	3799.9
3940.6	3911.4	3852.2	3784	3818.5	3800.1	3650	3374	3606.9
3923.1	3860.1	3700.7	3435.7	3658	3699.5	3391.2	2772.2	3333.1
3908.4	3802.9	3446.1	2835.8	3421.2	3704.7	3645.8	3400.4	3634.2
3924.3	3862.6	3705.5	3445	3688.8	3811.6	3814.8	3772.6	3826.7
3943.5	3917.3	3862.9	3800.1	3844.1	3870.6	3866	3871.8	3897.4
3955.2	3945	3925.5	3901.2	3885.8	3844.8	3789.8	3843.5	3894.1
3960.5	3955.6	3944.2	3918.9	3857.2	3703.5	3445.7	3693.9	3839.6
3962.8	3959.2	3948.6	3915.5	3807.3	3451.6	2843.7	3438.3	3775.1
3963.8	3961.6	3953.8	3931.3	3867.2	3710.1	3450	3698.4	3843.6
3964.1	3962.9	3958.8	3947.7	3920.3	3866.7	3806.8	3860.4	3908.6
3964.5	3963.9	3962.1	3957.6	3947.9	3931.7	3917.7	3929.4	3943.1
3964.7	3964.5	3963.7	3962.1	3959	3954.4	3951.3	3954.9	3957.6
3964.9	3964.8	3964.5	3964	3963	3961.8	3961.2	3961.9	3962.4
3965	3965	3964.8	3964.6	3964.2	3963.9	3963.7	3963.5	3964

1 Year

3899.2	3860.2	3799.9	3743.3	3721	3671.6	3563.7	3454.9	3525.6
3859.6	3784.7	3663.2	3543.2	3558.2	3508.2	3292.9	2956.8	3229.7
3818.4	3691.7	3441.1	3096.5	3323.4	3353.1	2973.5	2273.3	2903.3
3791.7	3611.5	3134.5	2421.9	3053.3	3368.2	3286.6	3003.2	3287.6
3820.6	3700.1	3457.7	3123.4	3391.3	3539.2	3542.7	3498.8	3583.7
3856.8	3797.6	3693.7	3588.8	3625.8	3652.1	3644.7	3662	3717
3852.4	3842.4	3806	3752.8	3706	3629.7	3551.9	3627.4	3719.3
3737.7	3809.3	3830.3	3788.9	3674.8	3446.9	3133	3424	3633.3
3327	3662.1	3799.3	3783.2	3617.3	3156.4	2464.6	3124.3	3546.3
2687.2	3402.2	3759.7	3806.8	3707.8	3474.2	3149	3435.5	3643.4
3323.5	3666.5	3825.5	3855.8	3807.3	3702.3	3595.7	3650.1	3740
3712.4	3796.2	3863.7	3886.9	3865.6	3805.2	3722.3	3672	3739.7
3750.2	3733.7	3819.8	3876.4	3875.5	3805.5	3628.8	3334.1	3570.9
3543.9	3298.1	3622.7	3809.9	3851	3746.7	3332.6	2607.6	3234.7
3136.3	2527.9	3253.5	3719.8	3840.8	3793.9	3585.8	3238.8	3507.5

2 Year

3577.7	3468.7	3314.4	3163.9	3064.9	2947.3	2775.9	2628.7	2742.8
3468.8	3301.7	3063.6	2828.7	2772.6	2654.6	2352.5	1902.3	2299.6
3378.6	3145	2742.6	2214	2434.5	2413.9	1886.4	808	1826.4
3314.6	3016.2	2317.8	1237.7	2083.3	2438.6	2315.6	1948	2371.2
3324.7	3114.9	2741.3	2244.7	2537.7	2687.3	2680.8	2643.3	2794
3327	3215.8	3041.3	2861.6	2865.5	2869.3	2853.7	2897.6	3009.5
3231.7	3219	3168.3	3082.8	2995.5	2874.4	2769.3	2886.6	3043.1
2933.1	3077.9	3155.1	3123	2970.2	2664.9	2254.6	2646.3	2945
2194.1	2760.4	3052.7	3097.1	2899.8	2299	1319.9	2257.8	2827.1
1101.1	2306.9	2953.6	3112.6	3015.3	2708.4	2269.7	2635.9	2922.3
2100.8	2690.9	3041.1	3172.7	3136.8	2979.6	2800.8	2848.8	2979.9
2673.5	2877.1	3079.5	3192.7	3185.4	3065.2	2883.6	2762.4	2860.6
2695.4	2735.7	2954.7	3119.7	3143	2992.3	2651.7	2161.3	2493.2
2319.2	2018.4	2570.8	2936.2	3039.3	2841.2	2156.2	979.8	1937.1
1696.1	795.5	1981.8	2754	2994.7	2895.1	2508.4	1945.9	2315.3

5 Year

Figure D.14 Pressure distribution of layer 4. (After well stimulation)

2908.9	2765.2	2572.6	2383.4	2248.6	2127.6	1996.2	1904.7	1999.7
2752.2	2557.4	2298.3	2045.8	1946.3	1838	1638.1	1367.2	1650.6
2622.5	2376.8	1993.3	1512.5	1626	1603.1	1282.2	655.7	1301.4
2507.9	2214.8	1603.3	692.1	1303.1	1554.8	1502.8	1320.6	1627.8
2448.9	2228.8	1876.6	1439.3	1604.2	1703.9	1722.9	1745.4	1893.2
2386.3	2249.6	2057.1	1868.9	1831.3	1822.8	1829	1901.8	2027.1
2254.2	2200	2113.4	2007.6	1914.9	1816.1	1754.2	1878.3	2037.5
1981.5	2048.1	2066.9	2013.3	1882.6	1653.9	1371.7	1691.7	1952.9
1422.8	1784	1961	1972	1817.2	1383.3	669.5	1395.6	1851.3
652.9	1443	1865.3	1965.4	1888.8	1666.9	1364.1	1657.2	1905.5
1270.8	1663.4	1905.2	1997.3	1970.7	1859.7	1741.5	1805.3	1937.1
1630.8	1779.2	1926.7	2010.1	2007.5	1926.6	1809.9	1753.2	1852
1661.4	1705.2	1856.5	1970	1987.8	1889.3	1671.1	1379.1	1611.2
1458.4	1303.9	1639.3	1870.5	1937.4	1810.4	1381.3	666.4	1267.7
1119.4	634.1	1312.7	1779.5	1930.9	1867.9	1623.3	1277.1	1535.3

10 Year

2382.3	2261.1	2098.4	1937.3	1816.2	1709	1599.8	1523.2	1588.5
2241.2	2081.5	1872.1	1665.1	1570.9	1475.3	1319	1115.3	1319.6
2118.5	1923.5	1623.1	1245.8	1311.1	1279.2	1039.6	595	1048.8
2001.4	1771.9	1302.5	622.6	1044	1210.3	1166	1038.4	1257.2
1921.6	1743.4	1465.5	1128.3	1225.9	1288.4	1299.9	1318.9	1428.8
1841.3	1722.8	1562.5	1407.5	1366	1355.2	1361.6	1417.9	1512
1718.1	1658	1574.6	1484.2	1409.7	1340.5	1304.7	1396.4	1512.5
1505.6	1529.2	1520.5	1470.1	1375.1	1224.1	1046.4	1266.9	1450.6
1101.7	1327.2	1429.6	1426.2	1318.8	1038.5	590.7	1065.5	1377.1
581.5	1081.1	1347.6	1407.8	1354.9	1213.5	1027.5	1231	1407
961.2	1208.5	1361.8	1420.8	1404	1334.9	1268	1323.7	1423.9
1187.7	1278.2	1372.3	1427.7	1428.5	1379.9	1311.7	1288.1	1366.7
1208.8	1232.3	1328.9	1405.7	1421.1	1360.6	1224.3	1044.9	1211.2
1083.9	982.7	1197.4	1350.4	1399.5	1320.9	1045.6	590.9	993
871.9	569.3	996.7	1302.8	1407.7	1372.4	1218.5	999.9	1185.4

15 Year

Figure D.14 Pressure distribution of layer 4. (After well stimulation- Continued)

3971.8	3965.9	3954.1	3933.4	3912.9	3913.9	3897.7	3841.6	3772.9	3835.8	3903.2
3968.5	3956.2	3928	3871	3804.3	3838.4	3822.3	3680.4	3414.4	3673	3843.2
3963.4	3940.2	3876.3	3716.5	3449.2	3672.4	3715	3407.4	2783.3	3405.9	3774.5
3959.9	3926.9	3819.3	3459.7	2844.2	3431.8	3717.8	3660.9	3420	3683.5	3846.8
3963.5	3940.8	3877.7	3719.3	3456.2	3700.4	3823.9	3828.7	3790.4	3854.9	3913.4
3968.8	3957.5	3930.6	3875.7	3812	3855.8	3882.6	3879.1	3887.3	3917.2	3943.8
3972.5	3967.6	3957.1	3937.4	3912.9	3897.4	3856.8	3802.8	3859.6	3914.4	3946.6
3974.4	3972.2	3967.2	3955.7	3930.3	3868.7	3715.1	3458	3712.7	3866.3	3932.5
3975.2	3974.1	3970.6	3960	3926.9	3818.7	3462.4	2852.3	3457.6	3808.1	3918.4
3975.5	3974.9	3972.8	3965.1	3942.7	3878.8	3722	3462.6	3717.3	3869.9	3934.9
3975.8	3975.3	3974.1	3970.1	3959.1	3932.1	3879.1	3820.4	3876.4	3927.3	3954.7
3975.9	3975.7	3975	3973.3	3968.9	3959.4	3943.7	3930.2	3942.6	3957.3	3966.9
3976	3975.9	3975.6	3974.9	3973.3	3970.3	3966	3963.1	3966.8	3969.7	3972.7
3976.1	3976	3975.9	3975.6	3975.1	3974.2	3973.1	3972.5	3973	3973.8	3974.8
3976.1	3976.1	3976.1	3975.9	3975.7	3975.4	3975.1	3974.9	3974.8	3975.3	3975.7
3976.1	3976.1	3976.1	3976	3976	3975.9	3975.8	3975.7	3975.7	3975.8	3975.9

1 Year

3946.8	3920.8	3880.9	3823.3	3769.6	3749	3703.3	3603	3504.1	3597.6	3732.1
3933.7	3890.3	3816.8	3699.5	3581.8	3597.2	3551.7	3348.9	3025.2	3349.8	3621.2
3917.2	3851.8	3721.4	3468.3	3117.8	3346.9	3378.6	2998.9	2285.4	3018.9	3519.2
3907.6	3826.8	3639.5	3154.2	2429.6	3067	3385.8	3308.4	3034.4	3373.5	3631.6
3914.2	3851.1	3724.8	3477.2	3136.1	3404.6	3554.5	3562.4	3528.4	3638.2	3759.6
3920.8	3881.2	3817.4	3710.7	3602.5	3638.9	3666.5	3662.9	3688.2	3757.3	3831.7
3902.7	3873.5	3857.5	3819.8	3765.5	3718.6	3643.5	3569.8	3654.7	3760.5	3844.8
3820.1	3763.3	3819.7	3840.4	3800	3686.6	3459.6	3148.6	3455.4	3685.2	3819.9
3611	3368.4	3664.7	3804.4	3792.5	3628.3	3167	2472.5	3154.6	3607.4	3798.1
3290.7	2699.3	3392.8	3759.9	3814.9	3719.3	3487.3	3164.8	3466.4	3694.3	3827.5
3606.8	3364.7	3667.8	3829.7	3865.2	3819.6	3716.7	3612.8	3674.6	3778.3	3861.7
3803	3739.1	3802.8	3870.8	3896.8	3877.2	3817	3733.3	3685.3	3774.1	3860.2
3850.7	3780	3740.4	3826.8	3886	3886	3814.2	3631.3	3333.9	3618.9	3804.5
3797.6	3604.1	3316.3	3640.4	3825	3864.9	3760.9	3347.2	2616.6	3315.6	3731
3713.8	3266.4	2542.7	3305.8	3749.9	3863.1	3823	3637.3	3321.7	3610.2	3812.4
3784.2	3582.2	3241.6	3596.5	3818.1	3897.5	3891.6	3826.5	3748.2	3821.3	3887.7

2 Year

3733.3	3634.3	3516.7	3367	3221.7	3127.5	3016.8	2857.1	2725.1	2881.2	3122.5
3686.2	3551.7	3380.8	3147.1	2913.8	2859.5	2747.2	2459.4	2022.9	2510	2937.1
3629.9	3462.9	3214.5	2803.3	2259.8	2486.2	2468.6	1936.9	833.2	2026.7	2775.3
3582.5	3397.3	3076.9	2356.1	1245.2	2107.6	2471.3	2355.9	2006.6	2525.7	2939.6
3549	3395.9	3165.5	2776.5	2263.5	2558	2712.9	2717.3	2703.2	2906.1	3143.8
3490.7	3382.5	3253.5	3068.9	2881	2883.9	2892.3	2888.2	2953.8	3101.4	3277.7
3351	3274.2	3242	3184.9	3097	3010.8	2894.6	2801.7	2943.4	3135.3	3322.4
3069.5	2972.5	3084.1	3158.4	3129.8	2981.1	2680.4	2279.7	2705.7	3050.8	3299.5
2596	2247	2746	3040.8	3096.3	2906.2	2308.6	1326.8	2311.5	2944.1	3263.1
2025.4	1114.8	2273.3	2930.5	3107.3	3020.8	2720.6	2291.1	2690.8	3025.5	3272.6
2482.9	2151.1	2670.6	3024.4	3169.5	3143.1	2992.6	2823	2893.3	3067.2	3257.9
2820.6	2713.9	2869.8	3071.3	3192.4	3191.2	3073.8	2894.7	2789.4	2948.1	3161.5
2912.1	2757.4	2734.4	2949.2	3121.1	3148.9	2997.3	2650.2	2168.2	2610.8	2982.9
2808.4	2447.5	2049.5	2594.1	2958.4	3062.9	2868.5	2185.5	992.9	2120.3	2832
2677.2	1951.3	826.8	2070.3	2817.2	3053.8	2975.9	2637.5	2140.7	2584.2	3004
2821.5	2451.8	1933.4	2521.9	2967.9	3174.1	3176.2	3040.2	2901.7	3048.2	3216

5 Year

Figure D.15 Pressure distribution of layer 5. (After well stimulation)

3147	2994.3	2833.1	2641.9	2456.4	2324.9	2208.2	2083.4	2001	2131.3	2339.6
3061.9	2872.7	2665.8	2406.8	2152.2	2052.2	1945.8	1750.7	1481.5	1838	2176.3
2953.8	2739.5	2471.9	2075.4	1574.2	1694.6	1672.4	1341.5	676.5	1475.7	2027.7
2843.9	2619.4	2296.3	1655.7	701.7	1336.3	1596.9	1550.6	1384.6	1774.6	2114.9
2740	2546.1	2297.5	1924.4	1464.8	1630.6	1736.8	1768.3	1815.7	2012.5	2244.6
2614.9	2464.4	2303	2095.6	1894.5	1854.4	1851.7	1872.3	1969.8	2135.7	2332.1
2428.1	2314.9	2236.5	2139.2	2026.9	1933.4	1840.8	1795	1947.6	2148.2	2356
2143.6	2031.5	2066.4	2078.1	2023.7	1895.3	1672.2	1403.1	1762.9	2073.5	2327
1734.1	1471.1	1781.7	1957.1	1973.9	1824.2	1393.6	676.6	1458.3	1979.2	2282.9
1269.8	662.7	1421.9	1850.2	1962.3	1894.3	1680	1390.2	1722.5	2021	2269.5
1520.2	1305.4	1649.4	1893.4	1995.4	1977.3	1874.3	1769.5	1861.2	2037.4	2239.2
1737.9	1662.6	1775.8	1922.4	2011.9	2015.3	1939	1829.8	1794.2	1948.6	2156.1
1820	1711.2	1708.8	1857	1975.8	1998.4	1901.7	1682.7	1402.5	1726.8	2029
1792.8	1554.3	1329.1	1661.5	1894.7	1964.9	1843.3	1415.6	679	1428.9	1947.5
1761.6	1304.1	653.3	1385.6	1844.5	1997.8	1954.5	1747.8	1450.4	1775.4	2107
1895.8	1655.5	1334.2	1703.3	1992.8	2138.7	2154.6	2082.8	2019.7	2155.1	2300.4

10 Year

2592.8	2458.3	2320.6	2158	1998.2	1879.4	1774.3	1668.9	1598.1	1687.5	1838.6
2508.5	2346.7	2175.5	1964.5	1754.7	1659.4	1563.5	1409.3	1203	1460.3	1706.8
2398.7	2220.1	2005.2	1694.1	1299.4	1369.7	1337.2	1087.1	609.6	1176.8	1579
2282.5	2096.9	1842.7	1348.9	630.5	1072.5	1246	1204.7	1086.6	1367.6	1617.4
2168.5	2005.2	1804.2	1508.3	1151.5	1249.3	1316.4	1336.7	1373.7	1519.2	1690.7
2041.2	1911.1	1771.7	1598.2	1431.8	1387.2	1380.1	1396.9	1470.9	1593.3	1738.6
1878.4	1774.6	1694	1600.4	1503.2	1427	1361.8	1337.3	1449.5	1594.3	1745.7
1652	1552.3	1551	1535.1	1482.3	1387.8	1239.9	1070.7	1320.3	1538.6	1719.1
1343.7	1143.8	1333.1	1432.8	1431.8	1326.9	1047.7	595.9	1111.7	1470.2	1683.3
999	588.6	1071.2	1341.6	1409.2	1361.7	1224.9	1047.8	1280	1492	1668.9
1139.6	988.2	1203.2	1357.3	1422.7	1411.5	1348.3	1291.2	1367.4	1499.1	1646
1271.7	1213.2	1279.8	1372.8	1432.2	1437.1	1392.3	1329.7	1321.7	1440.2	1592.3
1325.6	1246.2	1238.7	1333.1	1413.7	1432.6	1373.7	1236.8	1065.4	1296.8	1515.6
1316.5	1152.4	1001.8	1215.7	1371.8	1423.6	1348.7	1073.2	599.5	1108.3	1474.9
1310.5	1001.4	581.1	1050.7	1355.4	1462.5	1441.1	1312.6	1125.1	1360.3	1599
1412.8	1249	1032.9	1278	1474.1	1575.3	1594.5	1558.7	1530.9	1635.4	1742.8

15 Year

Figure D.15 Pressure distribution of layer 5. (After well stimulation- Continued)

3985.5	3983.7	3979.9	3973.8	3968	3965.9	3959	3942.9	3928.4	3944.2	3960.8
3983.6	3979	3968.7	3950.5	3932.3	3933.6	3920	3871.7	3812.4	3873.8	3926.8
3980.3	3969.9	3942.6	3886.3	3820.1	3854.4	3839.9	3702.1	3440.1	3713.1	3866.6
3975.6	3954.8	3891.5	3730.1	3461	3685.1	3728.4	3420.2	2793.6	3444.4	3800
3972.4	3942.1	3834.9	3471.7	2852.7	3442.2	3729.8	3674.2	3436.5	3715.7	3868.2
3975.7	3955.1	3892.2	3731.8	3466.6	3711.4	3835.6	3841.6	3806.1	3876.7	3929.9
3980.6	3970.4	3943.6	3887.8	3823.3	3867	3894.1	3891.4	3901.4	3934	3957.8
3983.9	3979.6	3969.1	3949	3924.2	3908.6	3868.2	3814.9	3873.7	3931	3960.3
3985.6	3983.7	3978.7	3967	3941.5	3879.9	3726.2	3469.1	3727.8	3885.9	3947.1
3986.3	3985.3	3981.8	3971.2	3938	3829.7	3472.5	2860.8	3472.4	3830.3	3933.9
3986.5	3985.9	3984	3976.3	3953.9	3890	3733.2	3473.9	3732.4	3889.2	3949.3
3986.8	3986.4	3985.2	3981.2	3970.4	3943.5	3890.8	3832.7	3890.2	3942.7	3967.6
3987	3986.8	3986.2	3984.5	3980.2	3971	3955.6	3942.7	3955.4	3970.3	3978.8
3987.1	3987	3986.7	3986	3984.6	3981.7	3977.6	3974.8	3978.4	3981.5	3984
3987.1	3987.1	3987	3986.7	3986.2	3985.4	3984.3	3983.7	3984.1	3985.1	3986
3987.1	3987.1	3987.1	3987	3986.8	3986.6	3986.3	3986.1	3985.9	3986.4	3986.8
3987.2	3987.1	3987.1	3987.1	3987.1	3987	3986.9	3986.8	3986.8	3986.9	3987
3987.2	3987.2	3987.2	3987.2	3987.2	3987.1	3987.1	3987.1	3987.1	3987.1	3987.2

1 Year

3973	3963.4	3946	3922.7	3900.5	3884.7	3860.8	3823.8	3798.8	3830.7	3871.3
3962.7	3943.1	3907.9	3857.2	3809.8	3792.4	3753.7	3668.1	3585.2	3679.6	3782.3
3949.4	3914	3843.4	3727.5	3610.8	3627.6	3586.1	3391	3074.1	3428.1	3666.2
3933.9	3877.4	3747.9	3490.4	3135.1	3366.4	3400	3019.6	2296.5	3085.4	3565.6
3924.9	3853.3	3665.5	3171.1	2437.3	3079.4	3401.5	3327.5	3060.5	3432.3	3670.6
3930.7	3875	3747.9	3494.2	3147.5	3416.8	3568.6	3580.3	3554.6	3680.1	3788.7
3936.2	3901.2	3836.2	3726.1	3615.2	3651.2	3679.9	3679.4	3711.4	3789.8	3855
3918.1	3891.4	3872.8	3833	3777.7	3730.7	3656.4	3585.7	3677.9	3792.6	3867.1
3838.3	3782.4	3831.8	3851.3	3811.1	3697.9	3471.3	3162.3	3480.3	3722.7	3844.4
3635.7	3389.9	3672.9	3812.5	3802.4	3638.9	3177	2480.4	3177.8	3648.8	3824.2
3318.9	2710	3396.1	3765.8	3824.3	3730.4	3499.3	3178.5	3490.7	3730.7	3851.3
3631.5	3386	3675.2	3837.5	3875.5	3831.6	3730	3628.2	3695.6	3807.3	3882.1
3822	3758.7	3813.1	3880.5	3907.9	3889.6	3830.2	3746.8	3701.3	3799.4	3879.2
3868.5	3801.5	3752.1	3837.4	3897.3	3897.9	3825.6	3640.9	3344.2	3647.5	3825.2
3819	3637.5	3332.5	3656.1	3839.5	3878.6	3774.8	3360.7	2625.6	3351.9	3754.4
3741	3317.4	2555.3	3333.4	3771.5	3881.1	3843.5	3666.2	3359.1	3657.3	3835.3
3819	3633	3311.3	3642	3843.8	3916	3911.3	3853.3	3782.8	3851.4	3910.9
3896.1	3824.8	3741.9	3828.8	3909.3	3946.1	3949.3	3931.9	3914.4	3932.5	3952.4

2 Year

3823.5	3775	3701.2	3612.5	3524.7	3451.1	3377.4	3303.1	3267.6	3332.4	3417.1
3772.2	3696.7	3588.1	3451.7	3319.8	3234.1	3136.4	2998.9	2889.7	3047	3227.1
3721	3614.6	3448.1	3214.5	2982.5	2932.2	2826.3	2548.6	2119.9	2654.9	3024.4
3666	3526.6	3277.2	2854.4	2297.4	2530.1	2515.8	1979.5	854.7	2143.4	2861.4
3619	3459.8	3133.8	2389.6	1252.4	2129	2500.6	2391.7	2058.4	2635.1	3014.2
3583.6	3451.2	3213.9	2808.2	2280.2	2576.4	2736.3	2750.7	2757.5	2994.5	3203.6
3522.5	3427.7	3290.9	3094.5	2898.6	2900.9	2913.6	2919.8	3004.8	3176.4	3328.7
3382.9	3311.1	3267.1	3201.9	3110.7	3025.1	2913.3	2830.9	2993.6	3208.8	3371.4
3106.3	3004.9	3096.7	3165.6	3137.9	2991.7	2694.7	2301.9	2755.9	3130.7	3351.2
2643.5	2276.1	2745.5	3038	3098.9	2913.3	2317.7	1333.3	2355.5	3028.2	3317
2079.1	1125.5	2264.2	2921.4	3107	3027.3	2732.1	2310.3	2737.7	3103.1	3323.8
2534.5	2180.3	2666.5	3018.7	3170.8	3150.9	3005.8	2844.7	2934.8	3135.4	3305.8
2865.2	2749.1	2875.8	3072.4	3197.3	3200.5	3086.4	2912	2822.1	3013.6	3210.1
2959.1	2807.1	2749	2956.3	3130.1	3160.8	3010.2	2663.2	2191.8	2685	3038.3
2867.8	2526.5	2079.9	2618.2	2982.2	3088	2896.6	2213.2	1005.9	2208.6	2895.5
2752.9	2059.8	851.3	2123	2866.3	3101.2	3033.6	2714.4	2234.1	2715.6	3072.3
2929.9	2577.3	2080.9	2624.4	3035	3228.7	3236.8	3119.3	2999.6	3142.4	3298.7
3161.4	2977.6	2817.1	3005.7	3231.6	3371.9	3407.1	3373	3345.4	3408.5	3487.9

5 Year

Figure D.16 Pressure distribution of layer 6. (After well stimulation)

3307.5	3220.1	3096.4	2954.2	2814.9	2698.4	2600.5	2523.2	2493.8	2550.7	2628.1
3209.9	3091.4	2936.3	2754.5	2580.1	2454.9	2345.5	2233.7	2163.3	2291.2	2443.7
3114.4	2965.7	2760.5	2498.2	2241.5	2144	2039.8	1848.5	1577.5	1972.3	2259.8
3005.6	2830	2558.8	2146.3	1626.6	1753.4	1732.6	1393.4	695.2	1581.3	2108.6
2894.8	2705.4	2373.4	1702.8	710.6	1366	1635	1594.1	1440.8	1881.5	2188.7
2787.3	2622.7	2363.8	1968	1487.9	1654.8	1767	1810.2	1879.8	2108.3	2308.7
2657.6	2528.4	2355.7	2131.9	1918.2	1875.6	1878.1	1912.1	2032.2	2224.1	2390.7
2467.5	2366.5	2274.6	2164.8	2045.3	1950.5	1863.4	1832.3	2009.6	2236.8	2413.9
2183.2	2073.5	2089.8	2092	2034.9	1907.5	1689.2	1431.5	1825.3	2167.2	2387.3
1778	1501.5	1789.5	1959.6	1978.3	1831.8	1403.4	683.4	1511.3	2074.3	2344.5
1315	670.6	1418.2	1845.3	1963	1900.8	1692.6	1414.1	1780	2110.7	2328.3
1564.4	1329.4	1648.1	1890	1997.2	1985.1	1889.1	1796.9	1913.1	2117.5	2294
1777.7	1693.6	1783.1	1925.3	2018	2026.2	1954.6	1853.9	1837.9	2022.7	2209.9
1862.3	1754.5	1724.4	1866.6	1987.6	2014.1	1920	1703.9	1435	1804.5	2086.7
1845.5	1619.2	1355.6	1685.5	1921.3	1995	1877.5	1448.7	691.3	1512.4	2009.8
1829.3	1391.5	669.4	1432.7	1896.2	2052.4	2018.6	1827.6	1539.5	1899.1	2176.5
1993.9	1760.9	1448.8	1790.6	2059.6	2199.8	2222.2	2165.5	2116.7	2250.7	2389.1
2198.9	2064.1	1954.2	2080.3	2243.2	2355.7	2401.8	2404.8	2418.8	2498.9	2584.9

10 Year

2746.3	2665.9	2552.2	2422.4	2293.9	2182.3	2087.2	2011.9	1976.6	2008.6	2060.6
2651.6	2546.3	2411.4	2254.7	2101.5	1985.7	1885.2	1787.2	1723.4	1809.5	1917.7
2555.8	2428.8	2258.3	2042.8	1830.4	1735.8	1640.9	1487.2	1277.6	1561.6	1769.3
2444.2	2298.7	2080.4	1755.6	1345	1419.9	1387.8	1128.5	622.7	1255.9	1638.8
2326.6	2171.3	1909.2	1390.9	637.9	1098	1278.4	1239.5	1129.5	1447.9	1672.3
2209.7	2071.6	1862.5	1547.8	1172.7	1270.7	1342.3	1370.8	1423.3	1591	1738.6
2078.5	1967.4	1819.7	1631.8	1454.1	1406.6	1402.9	1429.2	1519	1659.5	1782.3
1912.2	1821.7	1730.8	1625.5	1521	1443.2	1381.5	1367.3	1497.2	1660	1788.6
1684.9	1590.8	1575.8	1551.1	1494.6	1399.9	1254.6	1092.9	1367.4	1606.9	1763.2
1378.1	1170.9	1345.3	1439.9	1438.8	1335.1	1056.4	600.9	1151.3	1538.9	1728.1
1031.7	594.5	1072.3	1342.2	1413	1369	1236	1066.6	1323.5	1557.2	1711.8
1171.5	1007	1205.7	1358.3	1426.9	1419.8	1361.7	1313.7	1407.8	1558.2	1686.4
1300.7	1237.3	1288.1	1378.1	1439.4	1447.6	1406.7	1350.4	1356.5	1496	1632.1
1356.4	1278.5	1252.5	1343.3	1425.7	1447.3	1390.7	1255.4	1091.1	1355	1557.7
1354.2	1198.9	1021.7	1235.5	1394.8	1449.4	1377.7	1099.6	607.9	1169.7	1520.6
1358.8	1063.1	591.4	1086.6	1397.1	1506.2	1491.9	1373.9	1191.4	1451.5	1650.2
1483.7	1324.5	1113.1	1342.1	1524.4	1622.5	1646.5	1620.9	1602.5	1706.5	1809.2
1632	1540.3	1465.6	1549.9	1661.2	1742.3	1782.9	1797.9	1821.8	1888.4	1954.2

15 Year

Figure D.16 Pressure distribution of layer 6. (After well stimulation- Continued)

3997.7	3996.9	3995.2	3991.7	3986.2	3980.9	3979.1	3972.9	3958.6	3945.6	3960.4	3976.8	3988
3997.3	3995.5	3991.5	3982.3	3965.8	3949.2	3950.9	3939.3	3896.3	3842.9	3903.2	3952.1	3979.2
3996.4	3992.8	3983.2	3957.4	3900.3	3834.1	3868.7	3855.3	3720.1	3461.8	3751.6	3901.5	3963
3995.3	3988.9	3969.5	3908.7	3743.6	3472.5	3697.3	3741.2	3432.9	2803.2	3488.4	3844.3	3949.3
3994.6	3986.3	3957.9	3854.3	3484.4	2860.9	3452.9	3741.7	3687.3	3452.8	3750.4	3901.7	3963
3995.3	3989	3969.6	3909	3744.7	3477.3	3722.7	3847.4	3854.1	3821.3	3899.2	3952	3979
3996.4	3992.9	3983.3	3957.5	3899.9	3834.7	3878.4	3905.7	3903.5	3915	3950.9	3974.5	3987.6
3997.3	3995.6	3991.5	3981.4	3960.6	3935.5	3919.9	3879.6	3826.8	3887.2	3947.8	3976.5	3989.4
3997.8	3997	3995.1	3990.3	3978.3	3952.7	3891.1	3737.4	3480.2	3742.2	3906	3965.8	3986.9
3998	3997.5	3996.5	3993.2	3982.3	3949.2	3840.8	3483	2869.2	3486.4	3853.7	3954.8	3984.6
3998.1	3997.6	3996.9	3995.2	3987.4	3965	3901.2	3744.5	3485.1	3746.7	3909	3967.6	3987.9
3998.2	3997.9	3997.4	3996.4	3992.4	3981.6	3955	3902.7	3845	3903.6	3958.3	3982.5	3992.4
3998.2	3998.1	3997.8	3997.3	3995.7	3991.7	3982.9	3968.4	3956.2	3968.7	3983.4	3991.5	3995.5
3998.3	3998.1	3998	3997.8	3997.2	3995.8	3993.2	3989.4	3986.8	3990.2	3993.3	3995.7	3997.1
3998.3	3998.2	3998.1	3998	3997.8	3997.4	3996.6	3995.6	3995	3995.1	3996.3	3997.3	3997.8
3998.3	3998.2	3998.1	3998.1	3998	3997.9	3997.7	3997.4	3997.2	3997	3997.5	3997.9	3998.1
3998.3	3998.2	3998.2	3998.2	3998.1	3998.1	3998.1	3998	3997.9	3997.9	3998	3998.1	3998.2
3998.3	3998.3	3998.2	3998.2	3998.2	3998.2	3998.2	3998.2	3998.1	3998.1	3998.2	3998.2	3998.3

1 Year

3992.1	3986.4	3977	3961.2	3940.1	3919.8	3905.6	3884	3850.8	3828.6	3859.1	3900.9	3939
3989.2	3979.3	3961.9	3930.7	3885	3842.4	3827.8	3794.5	3719.3	3646.6	3741.2	3837.7	3911
3984.4	3968.1	3935.6	3868.7	3750.7	3634.1	3652.3	3613.8	3424	3113.4	3500.8	3738	3869.2
3979.3	3955.2	3902	3776.8	3510.5	3150.1	3383.2	3418.2	3037.1	2306.4	3158.3	3649.9	3841.1
3976.3	3947.6	3879.5	3696.9	3187.8	2444.6	3091	3415.9	3344.6	3085.3	3494.7	3737.6	3868.3
3976.6	3951.9	3898.6	3774.8	3511	3158.7	3428.6	3582	3596.7	3578.9	3723.5	3834.7	3908.9
3975.4	3955.4	3920.9	3857	3741.2	3627.5	3663.2	3692.8	3694.9	3732.9	3822.6	3889.2	3936.2
3963.1	3938	3908.8	3888.9	3846.3	3789.7	3742.5	3668.8	3600.4	3699	3824.8	3899.6	3945
3925.8	3866	3800	3844.5	3862.8	3822.4	3709.3	3482.8	3174.9	3502.5	3760.8	3881.6	3941.4
3851.6	3682.8	3407.9	3681.8	3822.2	3813	3649.8	3186.9	2487.9	3198.6	3691.4	3865	3938
3773.2	3387.9	2719.5	3401.3	3774.2	3834.7	3741.7	3511	3191.2	3512.4	3767.5	3887.1	3945.5
3849.3	3679.1	3403.9	3683.5	3847.2	3886.6	3843.9	3743.5	3643.3	3715.3	3836	3911.3	3954.4
3918.2	3851.4	3776.6	3824.8	3892.3	3920.6	3903.8	3846	3763.7	3719.4	3823.5	3906.5	3953.2
3943.1	3893.9	3820.5	3765.3	3849.7	3909.9	3911	3839.2	3654.4	3358.2	3671.7	3857.3	3938.2
3934.9	3851.1	3661.6	3347.1	3670.7	3853.6	3892.3	3788.8	3373.8	2634	3376.2	3792.9	3923.3
3920.3	3782.8	3346.8	2566.2	3352.5	3789.2	3896.9	3860.3	3686.2	3381.1	3686.1	3867	3944.3
3940.8	3856.6	3665.9	3344.5	3669.9	3863.8	3932.2	3927.7	3872.8	3805.4	3873.7	3934.7	3968.8
3962.2	3920.5	3846.7	3765.5	3849	3925.2	3959.9	3962.9	3946.5	3930	3947.8	3968.6	3982.8

2 Year

3891.6	3851.8	3801.1	3731.2	3648.2	3565.9	3496.5	3427.8	3359.5	3327.6	3389.8	3481.2	3582.3
3871.9	3816.4	3745.4	3645.5	3519.5	3398.5	3320.5	3232.3	3110.2	3014.4	3171.6	3346.1	3509.5
3842.3	3770.5	3669.5	3509.1	3269.1	3036.7	2990	2889.7	2619.5	2199.1	2789.4	3165.1	3414
3808.1	3720.5	3585.6	3340.7	2898	2327.7	2564.9	2553.3	2014	872.1	2270	3018.5	3354.1
3771.8	3675.7	3519.4	3196.8	2421	1258.2	2146.9	2524.9	2422	2106.6	2750.3	3145.8	3398.3
3728.2	3637.6	3504.6	3267.3	2838.2	2295.2	2592.6	2756.4	2779.4	2807	3085.1	3305.1	3480
3657.1	3572.8	3472.3	3331.3	3118.8	2914.8	2916.2	2932.2	2947.1	3050.1	3252.3	3412.5	3548
3531.7	3435	3348.4	3294.5	3219.1	3124.1	3038.6	2929.9	2856.1	3037.9	3283.2	3451.6	3582.5
3332.3	3172.5	3037.8	3111.1	3175.2	3147.3	3002.4	2707.9	2321.2	2800.7	3211.7	3437.3	3586.4
3073.1	2743.1	2304.1	2747.1	3040.3	3104.5	2921.5	2326.7	1338.9	2395.2	3114.6	3408.3	3575.7
2864.5	2215.8	1134.5	2258.6	2919.8	3110.9	3035.4	2743.5	2327.8	2779.7	3181.8	3409.6	3563
2985.8	2642.1	2210	2666.1	3019.9	3176.4	3160.7	3019.5	2865.4	2972.9	3203.2	3385.8	3531.1
3147.8	2948	2786.9	2887.9	3080.8	3207.4	3213.9	3103	2932.9	2855.3	3075.2	3293.1	3466.1
3230.7	3042.4	2855.2	2769.5	2969.6	3143.8	3176.5	3027.4	2681.8	2218.5	2748.7	3136.1	3382.7
3235.5	2972.3	2590	2107.2	2640.4	3005.5	3112.7	2923.1	2237.6	1016.8	2272.3	3008.8	3340
3238.2	2882.3	2134.1	869.4	2160.2	2906.3	3140.8	3077.9	2766.1	2289.8	2800.2	3176.8	3419.2
3331.1	3059.7	2670	2156.8	2691.8	3088.7	3275.8	3286.4	3177.2	3066.6	3215.5	3389.3	3542.3
3435.2	3251	3044.7	2881.6	3060.5	3275.9	3410	3444.8	3414.1	3390	3454.6	3545.1	3639.6

5 Year

Figure D.17 Pressure distribution of layer 7. (After well stimulation)

3438.5	3354.6	3258.8	3137.7	3000.7	2866.3	2752.9	2658.3	2584.2	2555.6	2609.6	2694.3	2796.3
3389.3	3283.9	3166.7	3018.3	2844.7	2678.6	2559.3	2455.3	2351.2	2286.4	2412.1	2560.8	2715
3313.5	3192.4	3047	2845.3	2572.4	2312	2216.9	2115.6	1926.6	1656.9	2096.8	2391.1	2608.9
3221.1	3087	2913	2642.7	2205.7	1668	1799.3	1779.8	1434.2	710.5	1694.3	2251.3	2532.8
3116.9	2976.6	2786.1	2453.5	1745.6	717.5	1389.6	1665.4	1629.6	1491.7	1991.3	2315.2	2544.3
2997.2	2864.4	2695.8	2433	2007.9	1507.6	1674.5	1791.7	1844.9	1936	2204.5	2416	2596.2
2848.3	2727.4	2590.6	2410.4	2165.1	1938.5	1893.4	1900	1945.1	2086.9	2311.8	2487.3	2643.8
2654.8	2533.8	2417.8	2314.4	2188.7	2061.7	1965.3	1882.4	1863.3	2064.1	2324.7	2509.6	2665.6
2406.4	2253.6	2116	2115	2106.6	2045.9	1918.7	1703.8	1455.5	1879.8	2260.7	2488	2658.7
2122.4	1866.2	1531.8	1799.2	1965.3	1984.3	1839.5	1412.2	688.9	1559.1	2171.3	2448.9	2633.1
1887.9	1425.1	677.1	1416.9	1845.6	1966.6	1908	1704.3	1434.9	1831.2	2200.7	2427.2	2599.4
1913.5	1654.7	1356	1649.9	1891.7	2002.2	1994.2	1903.4	1821.6	1959.1	2196.4	2385.8	2548.5
2014	1851.2	1728.2	1795.2	1933.4	2028.1	2040	1972.5	1879.1	1879.2	2092.8	2300.6	2477.7
2093.8	1937	1798.3	1744.3	1880.5	2002.8	2032.3	1940.6	1727.4	1467	1872.5	2186.3	2409.5
2142.8	1936.5	1675.1	1380.5	1708.7	1947.3	2024.7	1909.5	1477.2	701	1576.1	2118.9	2396.9
2204.7	1940.2	1455.8	681.6	1468.2	1939.2	2098.9	2070	1884.5	1597.3	1983.4	2281.3	2497.2
2326.7	2111.5	1844.8	1513.7	1853.7	2116.2	2253.8	2279.6	2230.4	2188.8	2329.6	2487.6	2642.8
2445.4	2286.3	2129.9	2014.8	2135.1	2291	2400.4	2447.3	2453.7	2470.9	2553.6	2653.5	2762.4

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2871.6	2790.8	2701.3	2588.8	2462.1	2336.7	2227.1	2133.8	2060.1	2024.4	2053.8	2111	2185.3
2818	2720.3	2614.4	2483.2	2331.6	2183.7	2070.7	1972.9	1879.6	1818.4	1901.1	2004.6	2116.2
2735.3	2626.6	2500.6	2331.8	2106.6	1890.2	1796.4	1702.5	1549.3	1339.3	1654.9	1866.4	2022.8
2633.5	2515.9	2370.6	2152.4	1806.9	1381.2	1458.8	1427.1	1161.4	633.7	1340	1743.7	1947.9
2517.5	2397.4	2240.8	1976.8	1428.2	643.9	1118.1	1304.1	1268	1168.1	1529.6	1765.9	1933.5
2389.8	2276.2	2134.9	1921.9	1583.7	1190.6	1288	1363.2	1398.7	1466.5	1662.6	1818.4	1950.3
2243.8	2139.4	2021.4	1868.3	1662	1472.9	1422.5	1421.4	1455.6	1560.6	1724.9	1854	1967.8
2069.2	1968.3	1867.5	1768.1	1648.5	1536.5	1456.7	1397.6	1392	1538	1724.9	1858.9	1971.1
1862.7	1742.4	1628.5	1601.4	1566.6	1505.8	1410.4	1267	1111.6	1408.3	1674.8	1836.3	1957.8
1632.1	1445	1197.4	1358.4	1448.2	1445.9	1342.8	1064.1	605.1	1186.6	1608.4	1803.4	1934
1436	1109.9	599.2	1074.8	1345.5	1417.9	1376.2	1246	1083	1362	1622.2	1783.6	1907
1419.8	1235.7	1027.1	1209.8	1362.2	1432.6	1428.3	1374.1	1333.6	1443.3	1616	1753.7	1872
1471.1	1353.9	1263.5	1299.1	1386.4	1448.8	1459.6	1422.1	1371.4	1389	1547.7	1698.8	1828.1
1520.9	1410.5	1310.8	1268.7	1356	1439.2	1463	1408.4	1274.9	1115.8	1405.7	1630.2	1791.3
1561.1	1419.2	1238.8	1040.1	1254.5	1416.9	1474.1	1404.2	1122.4	614.5	1216.6	1599.7	1798.1
1617.3	1437.2	1108.8	599.2	1113.9	1431.3	1542.7	1532	1418	1234.4	1514.2	1727.5	1883.4
1714.6	1566.7	1385.2	1160	1389.2	1567.2	1664.3	1690.9	1670.3	1656.5	1765.8	1882.9	1995.9
1805.9	1695	1588	1509.8	1590.2	1697.3	1776.6	1818	1835.4	1861.4	1929.6	2005.9	2088.9

15 Year

Figure D.17 Pressure distribution of layer 7. (After well stimulation- Continued)

4008.8	4008.2	4006.8	4003.9	3999.6	3995.4	3993.8	3989	3977.6	3967.4	3979.2	3992.4	4000.4
4008.4	4007.1	4003.8	3996.3	3982.6	3968.8	3970.3	3961	3925.8	3881.8	3933.9	3973.6	3992.6
4007.6	4004.9	3996.8	3974.3	3913.3	3846.7	3881.4	3868.8	3735.4	3481.5	3805.3	3933.2	3978.9
4006.7	4001.8	3985.5	3932.2	3756.4	3482.9	3708.2	3752.5	3443.7	2812.5	3575.3	3887.2	3967.3
4006.1	3999.6	3975.9	3885.3	3497.1	2869.3	3462.7	3752.5	3698.8	3468.5	3802.8	3932.8	3978.8
4006.7	4001.8	3985.5	3932.3	3757.1	3487.3	3733.1	3858.2	3865.6	3835.4	3926.9	3972.4	3992.3
4007.7	4004.9	3996.8	3973.9	3911.7	3845.5	3889.2	3916.6	3914.8	3927.7	3969.8	3990.2	3999.8
4008.4	4007.1	4003.6	3994.5	3971.9	3946.4	3930.8	3890.4	3837.8	3899.9	3967.4	3991.9	4001.4
4008.9	4008.2	4006.6	4002.2	3989.5	3963.7	3901.8	3747.8	3490.3	3755.5	3932.8	3983.7	3999.4
4009	4008.7	4007.7	4004.8	3993.3	3960.1	3851.4	3492.7	2877.6	3499.9	3888.8	3975.2	3997.6
4009.1	4008.7	4007.9	4006.5	3998.4	3976	3912.1	3755	3495.4	3760	3935.3	3985.2	4000.3
4009.2	4009	4008.5	4007.6	4003.4	3992.6	3966.2	3914.1	3856.8	3916.4	3976.2	3996.8	4004.1
4009.2	4009.1	4008.9	4008.4	4007	4003.5	3995.9	3983.4	3973	3984	3997.1	4003.9	4006.8
4009.3	4009.2	4009.1	4008.8	4008.3	4007.1	4004.8	4001.6	3999.4	4002.2	4005.1	4007.2	4008.3
4009.3	4009.2	4009.2	4009	4008.9	4008.5	4007.9	4007	4006.3	4006.2	4007.4	4008.4	4008.9
4009.3	4009.2	4009.2	4009.1	4009.1	4009	4008.8	4008.6	4008.3	4008	4008.6	4009	4009.1
4009.3	4009.3	4009.2	4009.2	4009.2	4009.2	4009.1	4009.1	4009	4008.9	4009.1	4009.2	4009.2
4009.3	4009.3	4009.3	4009.3	4009.3	4009.3	4009.2	4009.2	4009.2	4009.2	4009.2	4009.3	4009.3
4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.4	4009.3	4009.3	4009.3	4009.4	4009.4	4009.4

1 Year

4003.8	3999.6	3991.6	3978.5	3961.4	3944.9	3932.9	3915.1	3888.2	3870.4	3895	3929.9	3956.4
4001.1	3994	3979.5	3953.6	3915.8	3880.2	3868	3840.5	3778.8	3718.8	3800.7	3880.3	3930.8
3996.8	3984.6	3956.9	3897.2	3770	3652.7	3671.6	3635.2	3449.3	3146.5	3591.8	3797.6	3893.2
3992.2	3974	3928.3	3816.1	3528	3162.3	3396.3	3432.1	3050.4	2315.5	3286.9	3724.4	3868.6
3989.5	3967.6	3909.2	3746.1	3204.2	2451.9	3100.8	3427.7	3358.4	3108	3581.9	3795.1	3892
3989.6	3970.6	3924.4	3812.8	3526.8	3168.8	3439.1	3593.5	3610.2	3599.6	3775.4	3873.7	3927.9
3988.1	3972.3	3941.4	3882.8	3755.2	3638.6	3673.9	3704.2	3707.9	3750.9	3859.6	3918.5	3952.6
3975.9	3954.7	3925.7	3906.6	3858.7	3800.8	3753.4	3679.9	3612.9	3716.9	3862.6	3927.9	3960.8
3939.8	3885.7	3815.1	3856	3873.8	3833.2	3719.9	3493.1	3185.9	3521.6	3810	3914.3	3958.1
3867.6	3709.3	3420.5	3685	3831.6	3823.4	3660	3196.1	2495.4	3217.4	3751.8	3901.5	3955.4
3790.5	3418.3	2728.2	3397.2	3782.4	3844.9	3752.4	3521.6	3202.3	3531.2	3815.2	3918.7	3961.9
3865.4	3705.7	3416.3	3685.6	3856.8	3897.8	3855.9	3756.1	3656.9	3732.5	3869.5	3936.5	3969.2
3932.4	3871.8	3791.7	3835.7	3905.7	3935.2	3920.7	3866.2	3785.2	3738.8	3848.4	3928.5	3967.1
3956.7	3912.9	3837.4	3777.8	3862.1	3922.8	3924.8	3853.9	3669.2	3372.8	3695.3	3880.3	3952.1
3948.8	3872.5	3680.3	3358.5	3683.1	3866.8	3905.6	3802	3385.4	2642.2	3395.4	3816.5	3937.2
3934.8	3807.7	3367.3	2576.4	3368.2	3804.9	3911.5	3875.3	3702.5	3397.7	3707	3888.1	3957.6
3955.2	3881	3690.9	3367.9	3692	3881.4	3947.2	3942.7	3889.4	3823.6	3892	3952.3	3981.4
3977.9	3944.9	3878	3803.9	3878.8	3945.9	3976.1	3978.8	3964.4	3949.8	3966.1	3984.9	3995.8
3993.2	3980.5	3957.3	3938.1	3957.4	3980.5	3993.1	3995.6	3992.1	3988.8	3993.2	3999.3	4003

2 Year

3909.8	3879.5	3833.2	3771	3698.5	3626	3563.7	3502.7	3444.1	3417.1	3467.8	3546.5	3616.3
3890.4	3850.1	3787.6	3699.6	3590.7	3484.7	3414.8	3337.2	3233.1	3152.9	3287.1	3433.9	3544.1
3862.1	3809	3719.5	3571.4	3309.4	3075.1	3030.8	2934.4	2670.4	2263.3	2945.9	3275.1	3453.6
3829.2	3763.3	3643.2	3416.7	2931.1	2348.2	2587.5	2577.6	2037.2	885.8	2476.8	3148	3398.1
3793.8	3720.6	3580.9	3284.1	2448.4	1263.4	2159.1	2541.3	2442.8	2147.8	2900.2	3251.6	3436.9
3750.3	3680.3	3559	3336.8	2863.6	2306.9	2604.5	2770.8	2799.6	2845.2	3187.8	3386	3512
3679.2	3612.6	3516.4	3379.3	3139.1	2927.6	2928	2945.9	2966.3	3084.2	3335	3479.4	3576.1
3555.1	3474.3	3383.6	3323.8	3233.9	3135.3	3049.5	2942.5	2874.1	3071.4	3365.9	3516.1	3609.7
3358.8	3216.9	3065.4	3121.8	3184.4	3156.2	3011.9	2718.3	2335.5	2835.9	3308.2	3507.1	3614.7
3104.1	2798.1	2322.9	2736.6	3044.1	3111.3	2929.6	2334.3	1344	2428.7	3224.7	3483	3604.9
2898.3	2274.3	1141.9	2234.7	2920.6	3116.9	3043.6	2753.1	2341.1	2813.3	3275.3	3478.5	3591
3018.8	2701.4	2229.6	2652.5	3023.4	3184	3170.7	3031.8	2881.8	3002.6	3277.3	3447.5	3557.3
3178.7	3002.4	2818.8	2898.9	3093.5	3221.3	3230.9	3123.1	2955.1	2882.9	3133.2	3352	3491.3
3261.8	3098.9	2896.2	2789	2983.9	3158.5	3193	3045.3	2700.7	2243.2	2804.9	3198.8	3408.3
3268.5	3037.9	2637.8	2128	2657.8	3025.4	3134.8	2946	2257.6	1026.9	2319	3074	3365.7
3273.7	2958.7	2186.9	885	2190.4	2940	3174.4	3113.6	2805.2	2329.8	2858.8	3240.2	3444.6
3369.8	3142.6	2744.4	2217.4	2748.9	3137.1	3319.2	3330.6	3226	3120.7	3274.2	3448.8	3568.5
3490	3348.7	3153.2	2999.6	3157.6	3350.3	3471.6	3505.3	3481.1	3462.9	3524.6	3609.5	3677.1
3608.6	3530.1	3425.2	3362.5	3424.2	3526.5	3605.6	3640.7	3644.6	3649.9	3684	3730.2	3763.8

5 Year

Figure D.18 Pressure distribution of layer 8. (After well stimulation)

3467.4	3401.6	3309.3	3195.2	3068.6	2943.1	2835.3	2745.4	2676.5	2648.6	2691.1	2763.9	2833.6
3416.6	3338.7	3230.2	3093.6	2936.2	2782.7	2669.8	2571.7	2476.7	2417.8	2521.8	2646.9	2749.2
3341.3	3251	3118.6	2927.3	2625.3	2360.9	2267.1	2168.1	1981.8	1720	2231.7	2490.9	2645.4
3249.7	3148.7	2990	2733.6	2248.5	1694.8	1828	1809.2	1460.3	722.5	1860.8	2363.8	2572
3145.8	3039.1	2864.7	2552	1780.5	723	1404.4	1684.4	1652.5	1532.7	2123.4	2413.2	2580.1
3025.5	2923.4	2766.1	2514.6	2039.8	1521.4	1687.5	1807.6	1867.3	1977.2	2307.4	2498.6	2627.9
2875.7	2780.9	2649.8	2471.2	2190.5	1952.7	1905.4	1914.4	1966.5	2126.5	2403.4	2562.3	2673.4
2681.6	2583.8	2465.7	2356.4	2207.3	2073.6	1975.8	1895.1	1883.8	2103.9	2417.9	2584.3	2694.8
2433.8	2302.6	2153.6	2138.4	2118.4	2054.7	1927.2	1713.9	1471.9	1920.9	2364.5	2567	2688.9
2151.5	1917.5	1555.2	1801.4	1970.7	1990.2	1846	1418.9	693.5	1598.3	2285	2531.1	2664
1917.4	1473.9	681.2	1403.1	1847	1971.1	1914.5	1713.1	1449.8	1870.2	2300.1	2503.8	2628.9
1942.9	1706.4	1374.8	1642.2	1894.8	2008.1	2002.5	1914.8	1839.4	1993.3	2278	2454.6	2576
2042.9	1900.5	1758	1806.3	1944.4	2040.7	2056	1992	1902.8	1912.7	2156.6	2364	2503.4
2123.3	1988.4	1836	1762.9	1894.8	2018.1	2050.2	1960	1748.8	1494.3	1929.6	2249.9	2434.4
2174.1	1995.4	1718.8	1400.3	1728.4	1970.6	2051.7	1937.3	1500.5	708.2	1622.9	2183.3	2421.6
2239.1	2008.7	1503.1	691	1497.6	1975.7	2138.7	2112.4	1928.4	1639.9	2043.9	2346.6	2522.9
2367	2191.5	1915.7	1569.6	1910.1	2169.2	2304.7	2332.5	2287.5	2250.3	2395.8	2555.1	2672.3
2508.7	2387.6	2236.6	2125.4	2231.5	2373.1	2475.8	2524.1	2536.6	2558.7	2639.5	2734.4	2811.3
2653.8	2577.2	2481.4	2426.5	2472.1	2560.3	2640.6	2693.9	2727.9	2766.1	2826.7	2891.9	2937.1

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2900.4	2836	2747.8	2640.2	2520.3	2400.5	2294.3	2203.9	2132.9	2096.6	2116.9	2165.2	2214.6
2844	2770.8	2671.8	2548.8	2408.7	2269.6	2160.2	2064.9	1976.9	1918.9	1983.2	2069.1	2142.7
2760.5	2679.5	2563.3	2401.7	2152.1	1931.4	1838	1745	1593.5	1388.1	1753.8	1939.6	2050
2658.9	2570.1	2436.1	2228.4	1843.7	1404.4	1482.8	1451.3	1182.3	642.4	1460.9	1825.9	1976.2
2542.8	2451	2306.6	2057.1	1458.1	648.8	1130.8	1320	1286.3	1199.1	1625.6	1837.8	1959.4
2414.1	2326.7	2194.8	1989.3	1611.4	1203	1299.2	1376.5	1416.4	1497.9	1738.2	1879.1	1973.2
2266.8	2185.6	2072.4	1920.8	1684.7	1485.8	1432.9	1433.3	1472.6	1590.3	1792	1908.6	1989.2
2091.3	2010	1909.4	1806.8	1665.8	1547.3	1465.9	1408.1	1408	1567.6	1792.5	1912.8	1992.3
1884.3	1782.6	1661.8	1625.9	1578.4	1513.9	1417.8	1275.4	1124.3	1438.6	1748.9	1892.8	1979.4
1653.9	1484.6	1218.1	1366.8	1454.8	1451.8	1348.6	1069.7	608.7	1214.8	1688.6	1862	1956
1457.2	1145.4	602.2	1069.1	1348.6	1422.5	1382	1253.2	1094.5	1391	1693.2	1838.7	1928.2
1440.7	1272.7	1041.4	1207.7	1366	1438	1435.3	1383.6	1347.7	1469.3	1675.1	1803.8	1891.8
1491.2	1389.7	1285.9	1308.9	1395.9	1459.1	1472.4	1437.7	1390.3	1414.8	1593.9	1745.1	1846.9
1541.3	1447.7	1338.4	1283.4	1368.2	1452.2	1477.7	1424.6	1292	1136.4	1447.4	1676.5	1809.8
1583.2	1461.3	1270.2	1054.9	1270.9	1436.6	1496.2	1427.1	1140.9	619	1250.8	1646.4	1816.6
1641.9	1486	1142.7	604.9	1136.4	1460.3	1573.7	1564.9	1452	1266.7	1559.2	1776	1902.7
1744	1623.8	1436.5	1200.4	1431.3	1607.3	1703.7	1731.8	1714.2	1703.1	1815.9	1933.5	2018.6
1853.1	1769.1	1665.5	1589.4	1661.2	1759.2	1834.4	1876.7	1898.2	1927.3	1994.3	2068.3	2127.3
1961.5	1908.7	1842.9	1804.6	1836.2	1898.3	1958.1	2003.8	2040.5	2081.3	2135.7	2189.6	2225.7

15 Year

Figure D.18 Pressure distribution of layer 8. (After well stimulation- Continued)

4020.3	4020.1	4019.8	4019.2	4018.4	4017.7	4017	4015.8	4013.9	4012.5	4013.8	4016.1	4017.7
4020	4019.5	4018.6	4016.7	4014.3	4011.9	4010.6	4007.3	4000.6	3994.9	4000.2	4008.5	4013.6
4019.6	4018.7	4016.3	4011.6	4006.9	4001.1	4000	3994	3977.7	3960.2	3971.1	3994.3	4007
4019	4017	4011.4	3997.5							3906.9	3967.9	3996.5
4018.2	4014.8	4003.9	3974.1							3821.7	3941.8	3988.3
4017.8	4013.3	3998.2	3952.9							3905.8	3967.5	3996.3
4018.2	4014.8	4003.9	3974.1							3969.2	3993.4	4006.6
4019	4017	4011.4	3997.1							3994.8	4006	4012.5
4019.6	4018.6	4016.1	4010.1							3995.8	4007.8	4014
4019.9	4019.5	4018.3	4015.5							3981.1	4003	4012.6
4020.1	4019.8	4019	4017.5							3965	3998.4	4011.4
4020.1	4019.7	4018.9	4018.5							3982.9	4004.2	4013.4
4020.2	4020	4019.6	4019.2							4001.8	4011.6	4016.2
4020.3	4020.2	4020	4019.6	4018.7	4016.4	4012	4005.3	4000.5	4005.6	4012.1	4016.3	4018.3
4020.3	4020.2	4020.1	4019.9	4019.4	4018.5	4016.7	4014.3	4012.8	4014.7	4017.1	4018.7	4019.4
4020.3	4020.2	4020.2	4020.1	4019.9	4019.7	4019.2	4018.5	4017.8	4017.2	4018.6	4019.6	4019.9
4020.3	4020.2	4020.1	4020	4020.1	4020	4019.9	4019.7	4019.5	4019.1	4019.7	4020	4020.1
4020.3	4020.3	4020.2	4020.2	4020.2	4020.2	4020.2	4020.1	4020	4020	4020.1	4020.2	4020.2
4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.2	4020.2	4020.2	4020.2	4020.3	4020.3
4020.4	4020.4	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.3	4020.4

1 Year

4018	4016.6	4013.8	4009.7	4004.8	3999.7	3994.7	3988.4	3981.2	3977.3	3981.6	3990.5	3997.1
4016	4012.8	4006.8	3997.6	3986.7	3975.5	3966.3	3953.3	3935.3	3923.8	3936.2	3960.1	3977.7
4013.4	4007.9	3996.7	3978.8	3962.8	3943.5	3931.8	3912	3877.3	3848.5	3865.8	3917.8	3952.9
4009.8	4000.4	3979.6	3937.5							3745.2	3856.5	3921.3
4005.9	3991.9	3958.5	3884.5							3618.8	3809.3	3901.8
4003.6	3987	3945.4	3846.9							3739.2	3853.8	3919.9
4003.5	3988.7	3954.6	3880.6							3853.1	3911.4	3949.5
4001.6	3988.6	3964.1	3922.1							3911.4	3946.6	3970.6
3990.1	3970.6	3943.5	3929.2							3919.4	3955.6	3978.2
3956.3	3903.4	3829.5	3865.5							3895	3947.6	3976.7
3888.2	3730.9	3429.7	3673.8							3871.4	3940.2	3975
3814.3	3441.9	2735.8	3360.5							3898.4	3951	3979.9
3886.2	3727.4	3425.2	3671.3							3920.8	3961.6	3985.3
3949.5	3890.3	3806.7	3846.1	3924.1	3954.2	3944.9	3898.1	3820	3760.5	3879.2	3949.8	3982.3
3972.2	3930.6	3856	3790.5	3875.1	3936.1	3939.1	3869.8	3685.9	3389.4	3728.5	3902.6	3967.5
3964.8	3891.6	3699.1	3365.6	3693.4	3879.5	3919.2	3815.4	3395.7	2649.7	3417.8	3837.4	3952.3
3951.7	3828.8	3388.7	2586.1	3386.6	3821.8	3926.7	3890.8	3719.9	3416.5	3728.1	3906.6	3971.7
3971.2	3901.2	3714.4	3390.9	3714	3898.9	3962.1	3957.5	3905.9	3841.6	3909.5	3967.9	3994.3
3993	3963.4	3900.6	3829.3	3900.6	3963	3990.5	3992.8	3979.4	3965.8	3981.3	3998.7	4008.2
4005.9	3993.9	3972.2	3954	3972.2	3993.7	4005.4	4007.7	4004.4	4001.3	4005.5	4011.2	4014.6

2 Year

Figure D.19 Pressure distribution of layer 9. (After well stimulation)

3955.1	3938.3	3911	3875.9	3836.2	3795	3755.7	3719.7	3691.5	3680.8	3694.7	3723.7	3747.1
3933.2	3908.4	3869.1	3817.9	3760.8	3701.8	3648.4	3597.3	3551.5	3531	3559.7	3617.7	3665.6
3912.1	3878.8	3825.5	3755.5	3690.9	3615.3	3552.7	3488.8	3419.4	3375.1	3404.9	3506.9	3585.7
3885.5	3841.9	3768.5	3651.1							3186	3375.9	3501.3
3854.9	3800.7	3704.2	3534.9							2977.8	3284.7	3452.6
3821.2	3760.6	3650.2	3445.5							3150.6	3352.3	3483.9
3778.4	3718.8	3619	3451							3333.7	3458.7	3550.5
3708.5	3648.4	3563.4	3449.4							3446.9	3538.9	3609.7
3587.7	3509.4	3419.3	3360.3							3482.8	3574.5	3642.1
3398.1	3254.6	3090.1	3124.1							3459.6	3572.2	3648.4
3152.6	2841.3	2335.4	2691.7							3419.8	3554.9	3640.1
2954.1	2318.8	1147.6	2138.5							3423.2	3542.6	3624.5
3071.6	2747.5	2241.8	2597.9							3383.3	3502.7	3588.7
3226.3	3047.8	2847.4	2907.3	3115	3241.6	3255.6	3152.5	2982.1	2896.1	3197.9	3401.8	3521.7
3308.2	3146.5	2936.1	2806.1	2998.3	3173.4	3209.4	3063	2718.7	2266.4	2871	3249.8	3439.2
3316.7	3089.4	2677.9	2138	2666.4	3041.1	3154.6	2965.8	2273.8	1036.2	2364.1	3121.6	3395.9
3324.4	3016.1	2233.4	900.6	2221	2971	3204.7	3144.9	2839.3	2366.7	2905.9	3285.7	3473.6
3420.7	3203.4	2804	2268.6	2797.6	3178.6	3356.9	3368.2	3266.3	3164.3	3320	3491.7	3597.2
3542.3	3411.9	3221.1	3069.8	3218.8	3400.9	3515.2	3547.7	3526	3510.2	3570.7	3651.3	3708
3643.8	3564.8	3462.1	3401	3459.5	3557.4	3633.2	3667.2	3671.5	3677	3710.1	3754.3	3785.4

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3574	3526.1	3453.9	3365.6	3269.1	3172.8	3084.7	3011.4	2959.3	2936.3	2945.5	2974.7	3000
3511.4	3453.2	3367.9	3264.3	3152.9	3040	2939.5	2855.4	2792.8	2765.9	2788.3	2843	2891.4
3452.5	3384.4	3286	3168.1	3057.2	2930.7	2822.8	2730.9	2654.3	2612.2	2629.3	2718.1	2791.6
3377.8	3299.8	3185.2	3023.5							2422.2	2578.8	2689.6
3287.7	3200.8	3066.5	2860.4							2231.7	2475.8	2620.5
3184.7	3092.8	2947	2712.5							2327	2502	2624
3064.5	2974.8	2839.2	2636							2446	2570.8	2666.7
2914.5	2828.1	2709.9	2554.5							2523.1	2627.4	2709.3
2720.8	2627.6	2513.5	2408.8							2543.8	2649.7	2730.6
2475.8	2344.7	2188.8	2160.1							2515.3	2637.8	2725.9
2198.1	1958.7	1574.1	1782.4							2466.9	2606.6	2702
1966.8	1511.2	681.6	1337.9							2445.2	2572.4	2665.4
1990.8	1747.4	1386.9	1604							2388.1	2514.4	2610
2089.2	1941.9	1784.3	1814	1960.8	2057.7	2077.5	2017.8	1928	1931.4	2222.4	2415.8	2535
2169.4	2032.4	1870.8	1777.9	1907.6	2032.1	2066.1	1976.8	1766.3	1515.9	1988.3	2299.4	2464.7
2222.1	2043.2	1754.8	1412.2	1742.9	1991.1	2076.8	1961.7	1519.3	711.1	1663.1	2229.1	2450.9
2290.2	2062.2	1541.8	696.8	1524.1	2007.6	2173.1	2148.1	1964.2	1675.6	2090.8	2393.2	2553.1
2421.9	2252.2	1970.7	1614.3	1955.8	2213.1	2347.6	2376.3	2333.6	2298.8	2446.6	2603.9	2705.1
2570.6	2454.8	2304.2	2192.5	2292.9	2428.4	2528.1	2576.8	2591.8	2615.9	2695.8	2786.8	2851.2
2698.6	2617.4	2521	2465.9	2509.6	2595.2	2673.7	2726.6	2761.3	2800.1	2859.8	2923.2	2965.8

10 Year

Figure D.19 Pressure distribution of layer 9. (After well stimulation- Continued)

3018.2	2966.1	2889.2	2796.9	2697.2	2595.4	2500.5	2419.9	2359.7	2325.8	2320.5	2335.1	2350.6

2946.6	2887.4	2803	2702.6	2593.3	2481.2	2379.3	2292.3	2225.5	2189.2	2193.7	2227.7	2260.9
2879.4	2813.8	2722.1	2613.5	2509.6	2389.6	2283.2	2191.3	2114.3	2066.5	2063.7	2123.3	2175.9
2794.6	2723.5	2621.3	2482.5							1891.9	2003.5	2083.3
2693.4	2616.1	2500.3	2331.2							1728.4	1907.1	2011.5
2577.5	2497.1	2374.2	2184.7							1773	1902.5	1991.2
2447.9	2370.3	2255.3	2087.5							1839.3	1931.6	2001.5
2299.6	2225.8	2123.4	1990.6							1879.1	1955.8	2015.9
2123.9	2046.7	1950.5	1855							1882.8	1959.8	2018.7
1917.2	1817	1693.3	1651.5							1855.3	1943.1	2006.3
1688.5	1516.6	1235.7	1362.9							1815.6	1915.2	1983.3
1492.5	1172.4	602.3	1032.2							1795.8	1887.7	1954.4
1474.4	1301.9	1050.9	1186.2							1754.4	1847.2	1916.5
1523	1419.5	1305.6	1315.7	1407.9	1471.5	1488	1456.8	1409	1429.5	1641	1782.9	1870.2
1573.3	1479	1363.8	1295	1378.6	1463.3	1490.2	1438	1305.5	1152.4	1489.3	1712.6	1832.4
1617	1495.1	1296	1064.5	1284	1454.4	1516.8	1447.5	1156.1	620.1	1279.8	1680.2	1838.9
1678.6	1523.9	1170.2	607.8	1156.4	1485.4	1600.5	1592.7	1479.8	1293.5	1594.2	1811.1	1925.7
1784.4	1667.9	1476.7	1232.2	1465.4	1640.8	1736.8	1765.8	1749.8	1740.4	1854.9	1970.4	2044.3
1899.2	1819	1715.3	1638.2	1706.8	1801.2	1874.4	1917	1940.2	1970.6	2037.6	2109.4	2159.2
1995.8	1939.2	1872.6	1834.2	1864.3	1924.7	1983.5	2029.5	2066.9	2108.1	2162	2214.8	2249

15 Year

Figure D.19 Pressure distribution of layer 9. (After well stimulation- Continued)

4031.4	4031.3	4031.1	4030.8	4030.3	4029.8	4029.1	4028.6	4027.6	4026	4025	4025.9	4027.7	4029
4031.3	4031.1	4030.7	4030	4028.9	4027.5	4026	4024.9	4022.7	4018.5	4015.1	4017.4	4022.7	4026.1
4031.2	4030.8	4030.1	4028.6	4026.5	4023.9	4021	4019.6	4015.7	4007	3998.3	3998.8	4012.4	4020.9
4031.1	4030.4	4029	4026.2								3963.3	3995	4013.1
4031	4029.9	4027.5	4022.5								3926.2	3980.1	4007.5
4030.9	4029.6	4026.6	4020								3962.8	3994.8	4013
4031	4029.9	4027.5	4022.5								3997.6	4011.7	4020.5
4031.1	4030.4	4029	4026.2								4014	4020.7	4025.1
4031.2	4030.8	4030.1	4028.8								4015.8	4022.3	4026.3
4031.3	4031	4030.6	4030								4008.9	4019.6	4025.5
4031.3	4031.1	4030.8	4030.3								4002.1	4017.2	4024.8
4031.3	4031.1	4030.7	4029.9								4010.2	4020.5	4026.1
4031.4	4031.2	4031	4030.6								4020.1	4025.2	4028.2
4031.4	4031.3	4031.2	4031								4026.1	4028.4	4029.7
4031.4	4031.3	4031.2	4031.1								4029.1	4030	4030.6
4031.4	4031.3	4031.2	4031.1	4031	4031	4030.9	4030.7	4030.3	4029.5	4028.2	4029.8	4030.7	4031
4031.4	4031.3	4031.2	4031.1	4031	4031.1	4031.1	4031	4030.8	4030.6	4030.1	4030.7	4031	4031.1
4031.4	4031.3	4031.2	4031.2	4031.1	4031.2	4031.2	4031.2	4031.1	4031	4031	4031.1	4031.2	4031.2
4031.4	4031.3	4031.3	4031.3	4031.2	4031.2	4031.3	4031.2	4031.2	4031.2	4031.2	4031.2	4031.3	4031.3
4031.4	4031.4	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3	4031.3
4031.5	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4	4031.4

1 Year

4030.4	4029.3	4027.9	4025.3	4021.7	4017.4	4012.8	4008.2	4002.5	3996.1	3992.7	3996.1	4003.8	4009.8
4029.8	4028	4025.2	4020.5	4013.8	4006	3997.8	3990.4	3980.3	3967.3	3959	3965.1	3982.3	3995.2
4029	4025.9	4021.2	4013	4003.1	3991.9	3979.4	3969.6	3954.7	3932.2	3914	3912.8	3947.5	3973.3
4027.8	4023.1	4015.4	4003.3								3832.6	3900.8	3946.8
4026.6	4020.1	4009.1	3990.7								3767.1	3869	3931.4
4025.9	4018.3	4005.3	3983.2								3828.4	3898.4	3945.4
4025.5	4018.1	4006.1	3987								3903.2	3941.8	3969.9
4024.3	4016.2	4004.6	3988.8								3946.5	3970.2	3987.9
4019.6	4006.2	3986.6	3962.5								3955.7	3978.6	3994.8
4008.3	3977.4	3922	3842.6								3943.2	3974	3994.1
3989	3919	3754.9	3429.2								3931.9	3969.7	3993.1
3972.9	3854.2	3472.2	2742.5								3945.7	3976.8	3996.9
3988.3	3917.3	3751.8	3424.6								3956.2	3983.2	4001
4006	3971.8	3910.1	3821.3								3924	3971.5	3997.7
4014.2	3991.3	3949.9	3883.7								3800.3	3928.3	3983.8
4014	3984.8	3911.9	3721.5	3347.2	3691.8	3888.8	3932.1	3825.4	3391.2	2656.1	3451.9	3860.3	3968.7
4012.2	3973.5	3851.8	3419.4	2597.1	3413.8	3841.8	3943.3	3908.1	3741	3444.2	3754.1	3925.8	3986.6
4016.9	3990.5	3921.8	3741.9	3422.5	3740.6	3918	3977.6	3973.1	3923.8	3862	3928	3983.3	4007.7
4022.9	4009.2	3980.7	3921.9	3853.7	3921.6	3979.4	4004.6	4006.5	3994.1	3981.4	3995.9	4012.1	4020.5
4027.1	4020.5	4009.6	3991.1	3975.4	3991	4009.2	4019	4020.9	4018	4015.4	4019	4023.8	4026.6
4029.3	4027.1	4023.1	4017.3	4013.3	4017.2	4022.8	4026.3	4027.3	4026.8	4026.2	4027.2	4028.6	4029.5

2 Year

Figure D.20 Pressure distribution of layer 10. (After well stimulation)

3987.4	3971	3952.3	3925.7	3892	3853.9	3814.3	3776.2	3741.5	3714.5	3704.1	3716.3	3743.2	3765
3979.1	3955.6	3930.3	3895.1	3851.2	3802	3750.6	3702.6	3657.3	3618.6	3601	3617.9	3663.3	3700.9
3966.4	3936.3	3903.2	3858.2	3808.2	3751.7	3689.8	3633.7	3578.3	3524.6	3491.4	3488.1	3561.8	3622.9
3950.1	3912.6	3871	3820.5								3324.6	3450.3	3544.3
3930.4	3885.2	3834.2	3771.1								3203.6	3380.7	3501
3906	3854.2	3797	3725.9								3294.1	3427.6	3526.8
3871.6	3813.6	3754.6	3686.9								3425.8	3514.9	3586.6
3817.1	3747.4	3682.9	3618.2								3518.8	3585.9	3641.6
3732	3634.7	3544.6	3461.1								3555.5	3620.3	3672.9
3614.4	3461	3294.3	3117.1								3546.8	3622.2	3680.2
3484.7	3239.5	2891.1	2341.5								3522.8	3609	3672.9
3399.9	3063.1	2384.7	1156.3								3509.9	3592.5	3656.6
3430.9	3166.5	2800.9	2247.1								3456.9	3548.3	3619.9
3502.6	3305.7	3096.1	2877.2								3298.3	3449.7	3553.3
3556.8	3381.9	3196.3	2993.8								3006.7	3302.6	3472
3583.9	3392.8	3140.5	2721.1	2100.9	2647.3	3044.7	3170.1	2977.3	2268.6	1047.6	2434	3167	3427.7
3611.1	3403.5	3072.8	2299.5	929.9	2271	3005	3235.5	3176.2	2876.4	2421.7	2955.7	3325.5	3503.4
3667.8	3493.3	3258.2	2863.8	2337.5	2850.1	3218.6	3392	3402.8	3303.8	3205.9	3360	3526.8	3625.3
3739.8	3607.9	3464.6	3277.4	3129.3	3270.9	3444.1	3552.8	3584	3563.4	3548.7	3607.8	3684.8	3736.2
3807	3710.2	3623.1	3527.2	3471.5	3522.8	3610.4	3678.8	3710.3	3715.3	3721.1	3751.4	3791	3818.3
3856.9	3810.9	3753.7	3698.1	3670.6	3693.1	3740.6	3783.6	3809	3820	3829.6	3847.8	3869.6	3884.3

5 Year

3656.4	3600.7	3544.9	3472.5	3385.5	3290.4	3195.3	3108.3	3035.8	2984.3	2961.3	2968.9	2996.3	3020
3626.2	3554.6	3489.7	3408	3312.1	3207.9	3102.3	3006.3	2925.8	2866.8	2839.8	2851.1	2894.7	2933.1
3577.7	3497.1	3423	3333.6	3240	3133.9	3019.5	2916.6	2829.1	2760.5	2722.1	2709.1	2774	2831.8
3514.2	3425.2	3343.4	3257.1								2539.9	2647.6	2732.3
3436.2	3338.5	3248.4	3152.9								2411.4	2559.9	2667.1
3342	3237.9	3143	3040.8								2451.7	2572.8	2667.3
3228	3119.7	3024.1	2925.8								2538.2	2630.1	2705.9
3088.3	2971.9	2875.3	2783.2								2604.2	2681.4	2746.3
2916.7	2783	2673.6	2573.9								2627.2	2703.9	2767.4
2719.6	2549.4	2392	2233.9								2610	2695.6	2763.9
2520.5	2289.2	2011.2	1598								2573.1	2667.5	2741
2372.4	2075.1	1571.5	679.1								2537.6	2629.6	2703.4
2342.3	2090.3	1800.5	1398.7								2468.3	2566.9	2646.5
2385.1	2177.9	1991.3	1816.6								2324.2	2467.4	2570.6
2447.1	2253.9	2084.1	1922.3								2107.1	2351.5	2499.3
2512.7	2308.5	2096.3	1795.5	1397.8	1743.3	2010.6	2107.1	1988.4	1527.9	708.2	1722.9	2273.5	2483.8
2594.6	2379.6	2120.6	1594.8	698.8	1563.5	2043.6	2209	2184.8	2003.2	1724.8	2140.3	2435.1	2586.1
2704.7	2509.2	2311.8	2027.5	1670.5	2004.9	2256.5	2388.7	2417.6	2377	2345.3	2492.3	2645.7	2738.9
2827.8	2657.8	2517.8	2365.2	2253.6	2349.1	2479.2	2576.1	2624.5	2640.5	2665.5	2743.7	2831.5	2890
2945.2	2798.7	2696.8	2601.6	2548.6	2587.1	2665.4	2738.8	2790.6	2826.3	2865.3	2922.1	2981	3019.5
3036.7	2960.7	2876.9	2804.4	2768.1	2787.2	2840.2	2899.3	2949.5	2990.7	3031.5	3077.5	3120.7	3147.6

10 Year

Figure D.20 Pressure distribution of layer 10. (After well stimulation- Continued)

3114	3047.6	2985.4	2907.4	2815.8	2716.9	2616.1	2521.5	2441.3	2381.5	2347.5	2340.9	2354.1	2368.4
3076.3	2994.2	2925.1	2842	2746.9	2643	2535.4	2436.1	2351.5	2286.9	2250.2	2245.7	2271	2296.3
3015.3	2926.7	2852.1	2766.6	2679.5	2576.9	2464.9	2361.9	2272.9	2201.4	2155.2	2128.1	2169.6	2210
2935.6	2842.8	2764.8	2686.4								1982	2057.8	2118.8
2839.4	2743	2660.4	2575.8								1865	1972.2	2049.1
2728.7	2628.8	2542.7	2454.4								1869.2	1957.7	2026.1
2602	2499.7	2414.9	2330.2								1911	1978	2033.6
2456.9	2352.3	2268.3	2188.9								1942	1998.2	2046.6
2293.5	2179.5	2087.8	2004.9								1946.8	2002.2	2049.4
2114.1	1978.7	1858.5	1736.6								1926.9	1987.9	2037.7
1936.3	1761.7	1560.4	1259.9								1895.3	1962.3	2014.8
1793.9	1576.2	1217.4	600.4								1866.5	1932.4	1984.9
1737.1	1550.9	1342.8	1061								1817.1	1888.9	1946.1
1745.8	1591.5	1458.8	1333.1								1719.7	1824.4	1899.2
1784.3	1639.4	1519.2	1404.9								1578.7	1754	1861
1838	1685.2	1536.4	1327.8	1058	1290.4	1476.4	1546.2	1474.8	1167.4	617.2	1324.5	1716	1866.5
1909.6	1749.6	1569.4	1208.5	607.9	1186.1	1515.7	1631.4	1624.3	1512.7	1331.4	1633.9	1846	1953.4
2002.1	1855.4	1716.2	1521.5	1274.5	1505.1	1677	1771.7	1801	1786.4	1779.1	1893.2	2005.3	2073.8
2105.2	1971.3	1871.3	1765.1	1687.6	1753	1844	1915	1957.2	1981	2012.2	2078.8	2148.4	2193.4
2202.6	2082.6	2006.4	1939.6	1902.6	1928.7	1983.7	2039.8	2085.6	2123.8	2165.1	2216.7	2266.1	2297.2
2278.9	2218.2	2153.9	2099.3	2072.2	2085.4	2125	2172.6	2217.6	2259.2	2301.2	2345.2	2384.1	2407.4

15 Year

Figure D.20 Pressure distribution of layer 10. (After well stimulation- Continued)

APPENDIX E

GLOSSARY TERMS OF EVALUATION

Amortization - An accounting term referring to the process of writing off the cost or value of an asset over its expected service life. Intangible assets such as acquisition cost for non-producing properties, lease bonuses, title-clearing expenditures, geological and geophysical cost are "written off" or "amortized" in amortization accounts. Tangible assets such as physical equipment or in-place reserves are written off through depreciation or depletion accounts.

Capital Expenditure (CAPEX) - An accounting term is applied to expenditure on fixed assets, i.e. items that have a life beyond the current year. The value of such items is usually depreciated over its life. Other items with short life, and expenses such as operating costs, are treated as revenue items and are deducted in full immediately.

Depreciation - An accounting and tax term for allocating a portion of tangible asset cost to a time period. Property, plant and equipment are depreciated, as well as all the costs of developing producing wells and related facilities. Commonly used depreciation methods include straight-line and accelerated depreciation methods such as declining balance or sum-of-the-year's digits.

Development Well - A development well is one drilled on property that is considered proved. Consequently, the designation is arbitrary to the same degree as the property classification.

Discount Cash Flow (DCF) - Cash flows are estimates of future payments and receipts - usually on an annual basis. These are generally calculated in the money of the day terms. The DCF method then takes account of the fact that we would prefer to have a "real" sum of money in our hands now rather than later, because if we did, it could be re-invested to make more money. Thus it "costs" us something to receive it later (opportunity cost). The converse is true of capital costs (they cost less tomorrow than today because - inflation apart - the money can be kept in use in our financial system earning money). The purpose of DCF is to measure this time effect on value and cost, and it is a separate process from looking at inflation effects. Discounting is the exact mathematical inverse of compounding.

Discount Rate - The rate used to discount fund flows in the discount cash flow method and evaluation (e.g., for a discount rate of 5%, year n fund flow is divided by 1.05 to the (n-1) power). It should be chosen to represents the real rate of return the business can expect to make and as such represents the rate that can be expected by investing in other (or opportunity) projects. The following points need to be taken into account when choosing the discount rate:

a. Historic company earnings rates are a guide, but future opportunities may differ.
b. If most of a company's capital is borrowed, the rate should at least exceed the loan rate! Where a company's capital is from several sources sometimes an average cost of capital may be used to derive a minimum discount rate.
c. The relative risk of one business to another.
d. Future investment opportunities - limited, anticipated rate of return.

Expense or Expensed - A disbursement of outlay is subtracted from current revenue. In book or taxable income computations, this may be either OPEX (e.g., salaries and wages) or expensed investments. The entire amount receives tax relief in the year the cost is incurred.

Income Tax - A monetary assessment levied by a government, based upon taxable income.

Intangible Assets - Intangible assets are the class of assets that includes all types of minerals. No value may be established by direct inspection and the asset does not necessarily depreciate with time. It loses value only when produced and furthermore cannot be replaced. The exact differentiation between a tangible (capital) asset and an intangible asset is somewhat arbitrary. From a practical standpoint, such differentiation depends on the current applicable tax provisions governing a specific type of property. Evaluations should not rely solely on past evaluations since the laws regarding intangible assets change.

Internal Rate of Return (IRR) - The discount rate that sets the Present Value of a cash flow stream equal to zero.

Investment - An expenditure of funds to acquire physical of financial assets from which benefits are expected to occur for more than one year.

Net Present Value (NPV) - The value of a discrete or continuous cash flow stream discounted at some discount rate.

Operating Expense (OPEX) - Generally, a cost of conducting business activities or, specifically, cost directly involved with production or services.

Play - An area of localized exploration activity based on a geological hypothesis regarding existence of conditions favorable for mineral occurrence.

Profit - An imprecise term generally perceived to reflect the financial return from an investment. Profit is commonly defined as the excess of revenues over all costs and is also considered to be equivalent to income.

Revenue - The amount is received for the sale of production of manufactured products. Generally, the mathematical product of unit is price and volume. The chief source of cash inflow is most investment evaluations.

Royalty - Royalty is the interest of a party owning minerals in the ground where another party (the working interest) has gained the right to capture such minerals under a lease agreement. Such royalty interest is normally free of all costs of capture except for special treating costs that might be specified in the lease or assignment. This term is often used as an abbreviation for the term landowner's royalty. There are many specific forms of royalty.

Sliding Scale Royalty - A royalty varying in accordance with the amount of production, e.g., a 1/8 royalty if the production is 100 barrels per day or less, and 3/16 royalty if the production is greater than 100 barrels per day. Difficult problems of interpretation of the sliding scale royalty clause arise when government regulations on a unitization agreement limit production on the amount of oil allocated to a particular tract.

Tangible - Refers to an asset having material substance, as for example, equipment. A property value can be determined by objective appraisal.

Taxable Income - The computation of income in accordance with tax codes so as to serve as the basis for computing income taxes. Generally differs from book income (as reported in financial statement) because of different depreciation and depletion accounting procedures.

Write Off - An accounting term for a non-cash or book expense. It is the cost of a long-term asset allocated, period-by-period, over its deemed life. Also called an "Extinguishments". For example: depreciation, depletion and amortization expenses.

BIOGRAPHY

Mr. Parinya Nonrapug was born on the 8th October 1978 in Phichit province. He had graduated with a Bachelor's Degree in Geotechnology from Suranaree University of Technology in 2000. Between 2000 – 2003, he continued with his the Master's Degree in the Petroleum Engineering.