

CHAPTER V

MODEL FORMULATION

As mentioned before, single-layered, two-layered, and three-layered reservoirs will be investigated in this study. This chapter will discuss about reservoir models used for these three cases.

5.1 Models for single-layered reservoir

For the single-layered reservoir, a square reservoir model of area 3300x3300 square feet is used. Because effects of several parameters have to be investigated for this case, there are parameters that are fixed for all runs and some parameters that must be changed to see their effects on the results. Tables 5-1 and 5-2 show fixed-value parameters while Table 5-3 shows variable parameters.

A homogeneous reservoir model is adopted here for simplicity. In addition, a homogeneous system is used in order to avoid obscurity due to heterogeneity that may exist when performing the investigation on the effects of each parameter on the final results.

The reservoir is also assumed to be a volumetric reservoir. The production rate of oil and water are also assumed to be equal to zero. This means that the water saturation in the gas zone is equal to irreducible water saturation and the gas in the

Table 5-1 Fixed-value parameters (rock and fluid properties).

Properties and Conditions	Values
Initial Gas Saturation, S_{gi}	0.8
Initial Water Saturation, S_{wi}	0.2
Initial Oil Saturation, S_{oi}	0.0
Critical Gas Saturation	0.05
Connate Water Saturation	0.20
Residual Gas Saturation	0.1
Irreducible Water Saturation	0.2
Relative Permeability to Gas at S_{wirr}	1.0
Water Compressibility (psi^{-1})	$3 \cdot 10^{-5}$
Rock Compressibility (psi^{-1})	$3.5 \cdot 10^{-6}$
Pore Size Distribution Index	2
Water Viscosity at standard condition (cp)	0.5
Water Formation Volume Factor at P_i (RB/STB)	1.001
Capillary Entry Pressure (psia)	5
Top Structure (top of a reservoir), vertical (ft)	5,000
Reference Elevation (ft)	5,000
Pressure at Reference Elevation (psia)	2,200
Reservoir Size (ft x ft)	3,300 x 3,300
Reservoir Temperature ($^{\circ}\text{F}$)	250
Oil Production Rate	0
Water Production Rate	0

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Table 5-2 Fixed-value parameters (well characteristics).

Properties	Values
Well Radius (ft)	0.29
Tubing Inside Diameter (in.)	2.992
Pipe Roughness (in.)	0.0008

Table 5-3 Variable-value parameters to be studied for single-layered reservoir cases.

Properties and Conditions	Values
Permeability, k (md)	10, 20, 50, 100, 300, 500, 1000
Gas flow rate, q_g (MMscf/d)	1, 5, 10, 15, 20
Porosity, ϕ (fraction)	0.1, 0.2, 0.3
Thickness, h (ft)	15, 20, 30, 60, 90, 120
Gas specific gravity, SG_{gas} (air = 1.0)	0.7, 0.8, 0.9
Impurities: CO ₂ concentration (% mole)	0, 10
N ₂ concentration (% mole)	0, 0.5
Skin factor, s (dimensionless)	0, 5, 20

reservoir is dry with no condensate when produced to the surface. It is also assumed that perforation is done for the whole thickness of the pay zone.

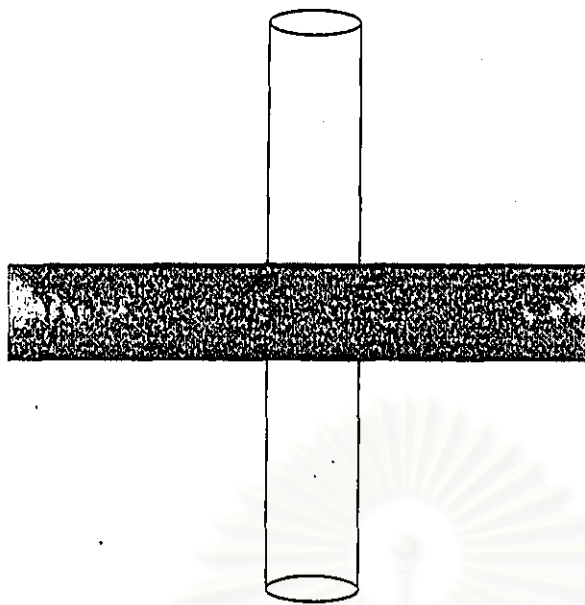
When there is one production well for the single-layered reservoir case, the well is located at the middle of the reservoir as shown in Figure 5-1. For the case of two production wells in the single-layered reservoir, each well will be located at the center of the two triangles divided by one of the diagonal of the square as shown in Figure 5-2.

5.2 Models for two-layered reservoir

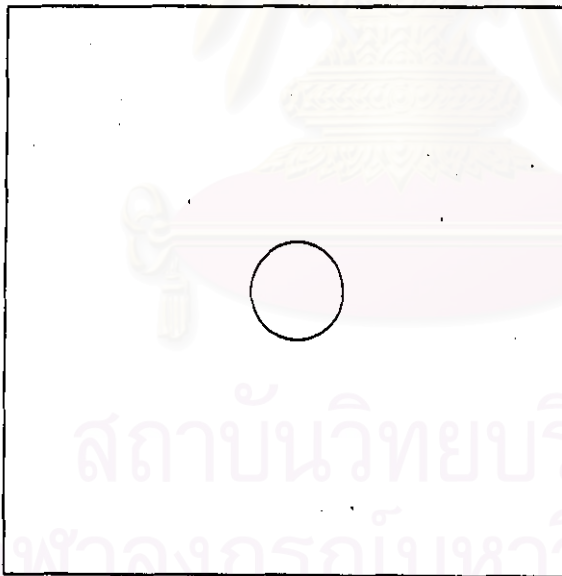
The reservoir model for the two-layered reservoir consists of two porous layers with square shape. The rock and fluid properties and well characteristics which are fixed for the single-layered reservoir (Tables 5-1 and 5-2) are also fixed for this two-layered reservoir case. In addition, there are other parameters that are fixed for this case as shown in Table 5-4.

The parameters which are going to be changes to check their effects on the final results or for other purposes are shown in Table 5-5.

For the two-layered reservoir, cases with one production well and two production wells will be studied. Figure 5-3 shows the schematic drawing of the case with one production well where the well is at the middle of both layers. For the two-layered reservoir with two production wells, two cases will be investigated. For the first case, both wells will be drilled through both layers (Figure 5-4). For the second case, only one production well will be drilled through both layers while the other production well will be drilled only through the upper layer (Figure 5-5). For both



side view



plan view

Figure 5-1 Location of one production well for a single-layered reservoir

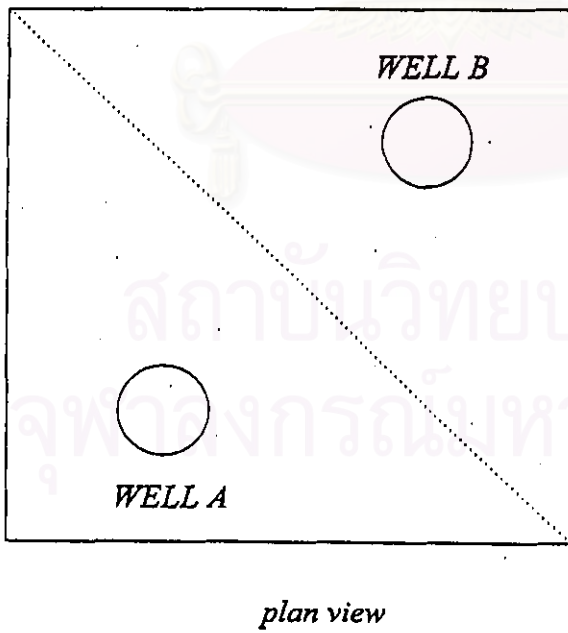
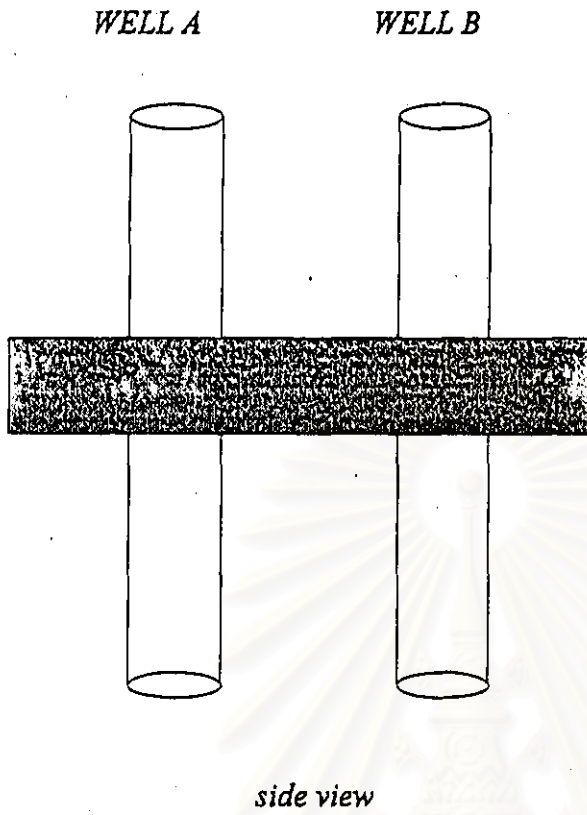


Figure 5-2 Location of two production wells for a single-layered reservoir

Table 5-4 Additional fixed-value parameters for two-layered reservoir cases.

Properties	Values
Top of Layer 1 (ft)	5,000
Top of Layer 2 (ft)	5,500
Gas Specific Gravity	0.8
Impurities: CO ₂ concentration (% mole)	0
N ₂ concentration (% mole)	0
Skin factor, s (dimensionless)	0

Table 5-5 Variable-value parameters to be studied for two-layered reservoir cases.

Properties and Conditions	Values
Permeability, k (md)	10, 20, 50, 100
Gas flow rate, q_g (MMscf/d)	1, 5, 10, 15, 20
Porosity, ϕ (fraction)	0.1, 0.2, 0.3
Thickness, h (ft)	15, 30
Reservoir Size (Area) (ft x ft)	3,300 x 3,300, 2,100 x 2,100

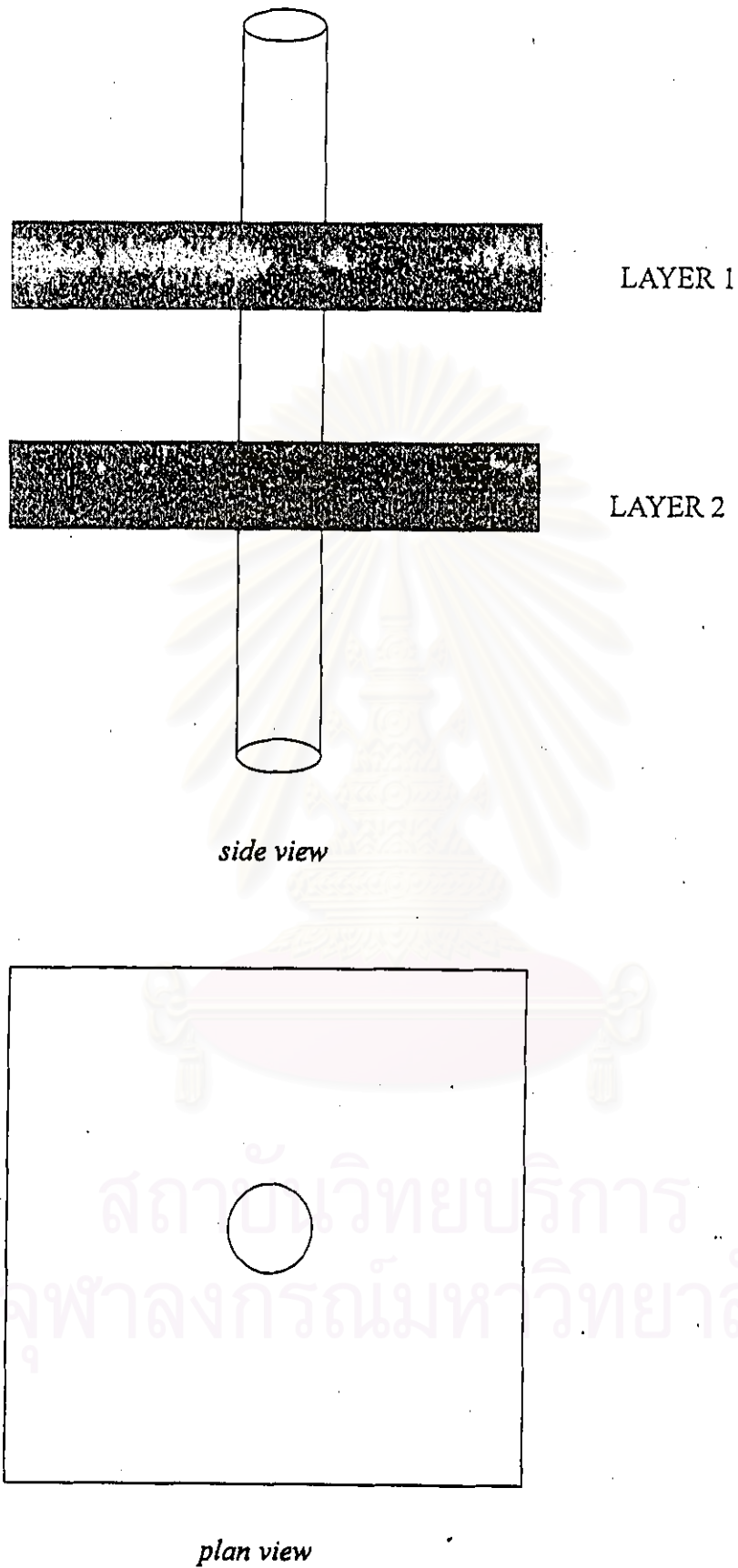


Figure 5-3 Location of one production well for a two-layered reservoir.

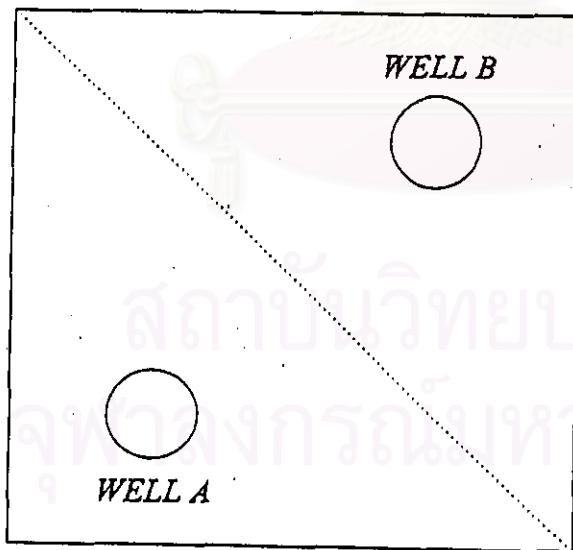
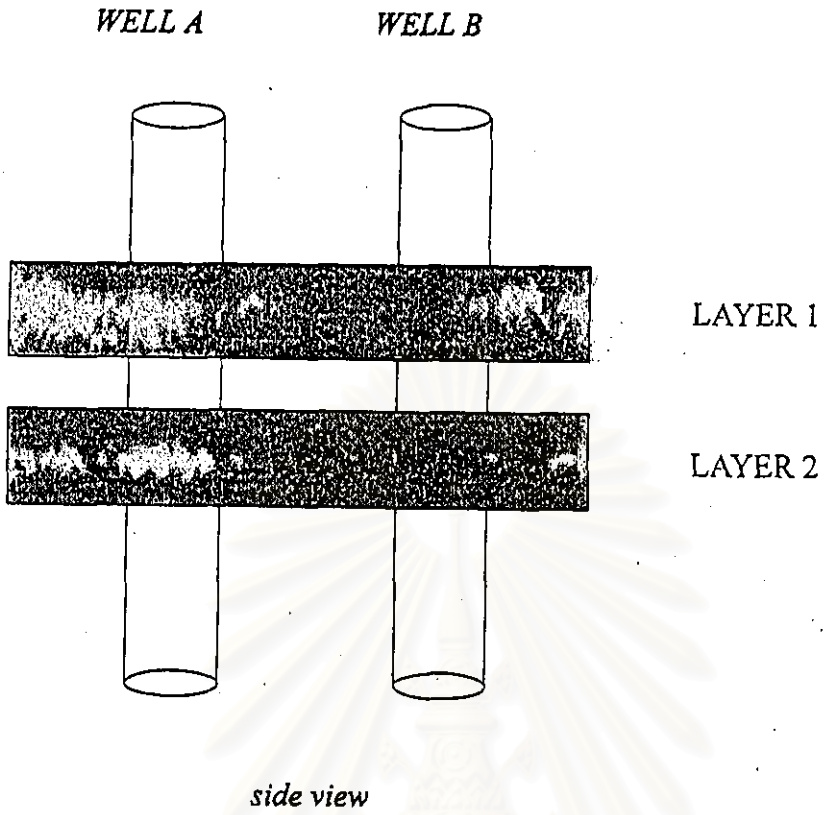
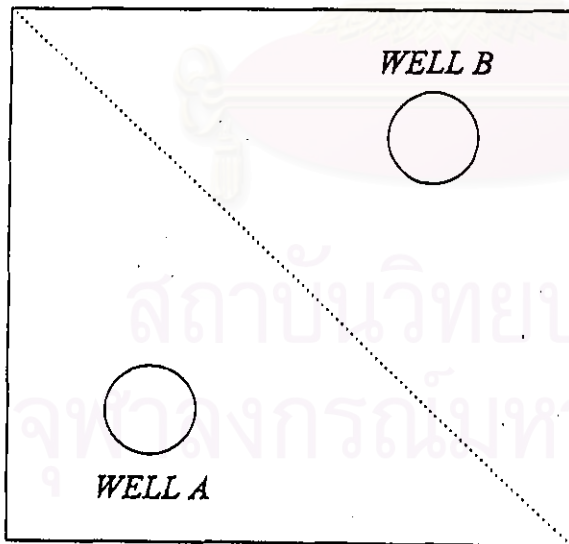
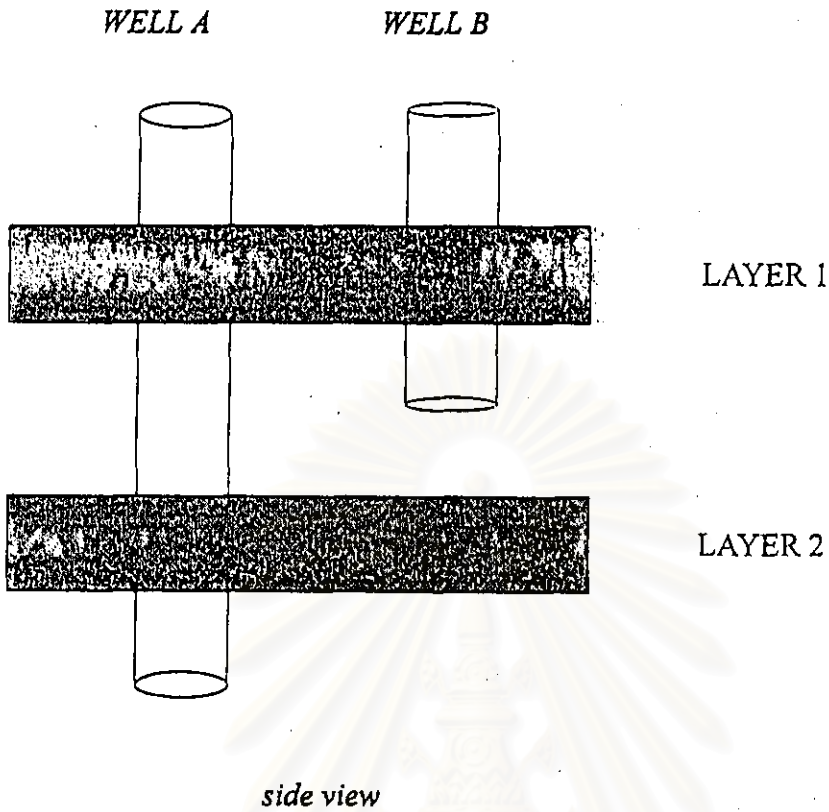


Figure 5-4 Location of two production wells for a two-layered reservoir (both wells penetrate both layers)



plan view

Figure 5-5 Location of two production wells for a two-layered reservoir
(one well penetrates both layers while the other penetrates only one layer)

cases, each well is located in the middle of the triangle constructed by drawing a diagonal across the square.

5.3 Models for three-layered reservoir

For the case of three-layered reservoir, only one run will be carried out. Therefore, all parameters and conditions will be fixed. The fixed parameters and conditions are as shown in Tables 5-1 and 5-2 and those shown in Table 5-6.

The schematic drawing for the three-layered reservoir with one well is shown in Figure 5-6. Here, all three layers are square and the well is at the middle of all the three layers.

Table 5-6 Additional fixed-value parameters for the three-layered reservoir case.

Properties	Values
Top of Layer 3 (ft)	6,000
Permeability, k (md)	20
Gas flow rate, q_g (MMscf/d)	15
Porosity, ϕ (fraction)	0.2
Thickness, h (ft)	30

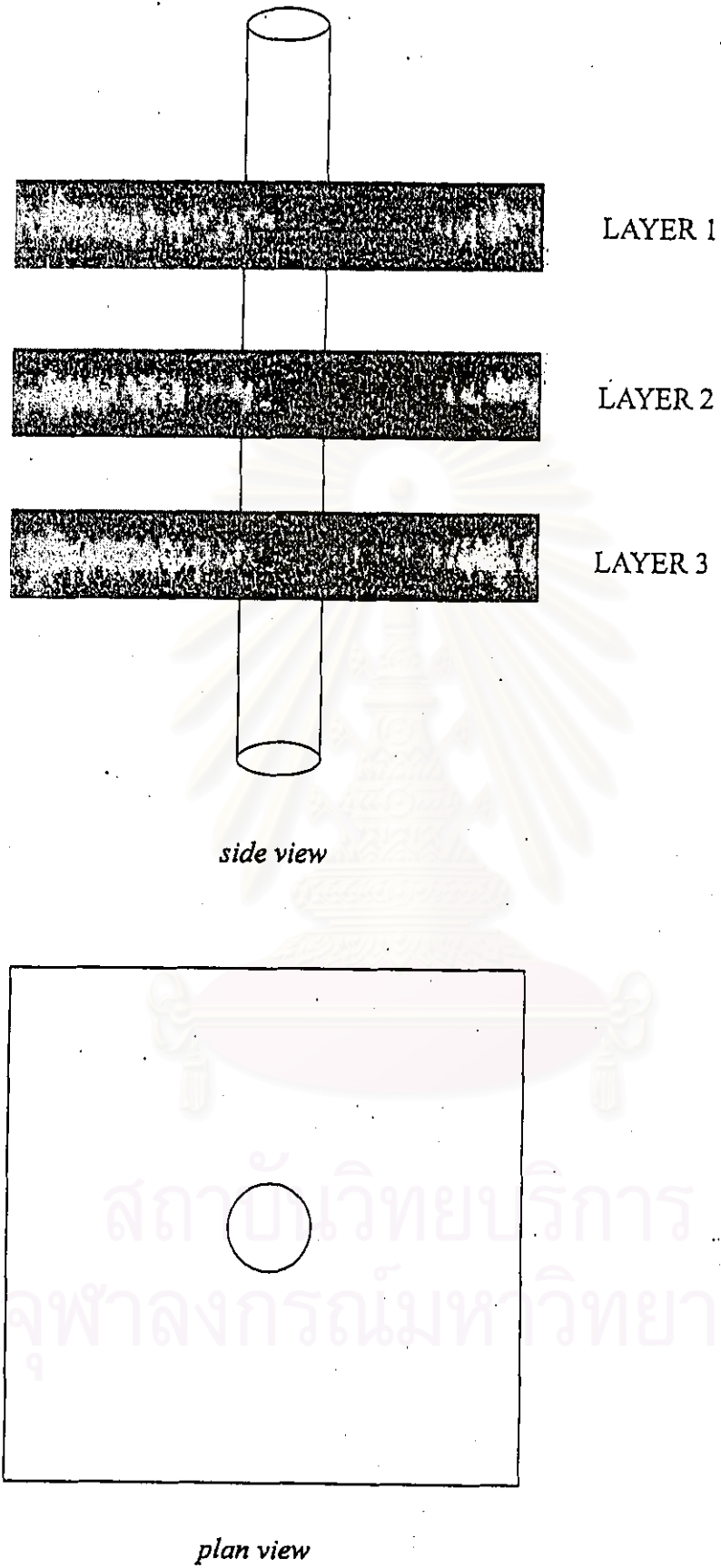


Figure 5-6 Location of one production well for a three-layered reservoir