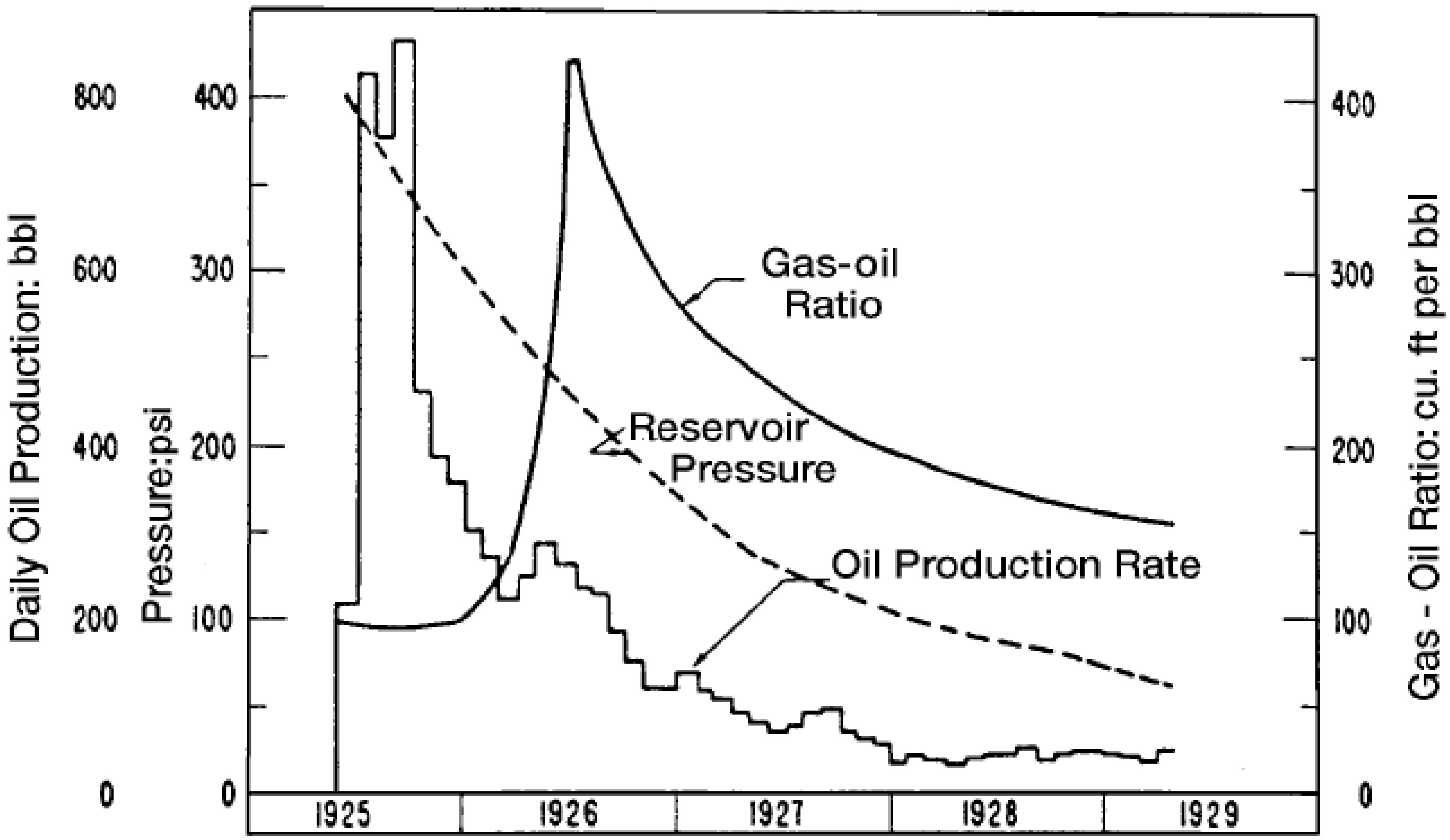
Reservoir Engineering II

Reserve Estimation IV

By

Assist lect. Farah N. Almohammad

The Main Properties Of Drive Mechanisms



The Main Properties Of Drive Mechanisms

1-Rock and Liquid Expansion:

1.Rapid pressure decline.

2.Constant GOR.

3.The least efficient driving force and usually results in the recovery of only a small percentage of total oil in place.

The Main Properties Of Drive Mechanisms

2-The Depletion-Drive Mechanism:

1.Reservoir Pressure: the reservoir pressure declines rapidly and continuously.

2.Water Production: the absence of a water drive means there will be little or no water production.

3.Gas-Oil Ratio: Rapidly increasing gas-oil ratio from all wells. Below the bubble point pressure, gas evolves from solution and begins to flow to the wellbore.

4.Ultimate Oil Recovery: may vary from less than 5 to about 30 percentage.

The Main Properties Of Drive Mechanisms

3-Gas-Cap Drive:

1.Reservoir Pressure: Falls slowly and continuously.

2.Water Production: Absence or neglect water production.

3.Gas-Oil Ratio: Rises continuously in up-structured wells.

4.Ultimate Oil Recovery: The expected oil recovery ranges from 20 to 40 percent.

The Main Properties Of Drive Mechanisms

Four important parameters that effect on the ultimate oil recovery in gas-cap drive:

1.Size of the Original Gas-Cap: the ultimate oil recovery increases with increasing the size of the gas cap.

2.Vertical Permeability: good vertical permeability will permit the oil to move downward with less bypassing of gas.

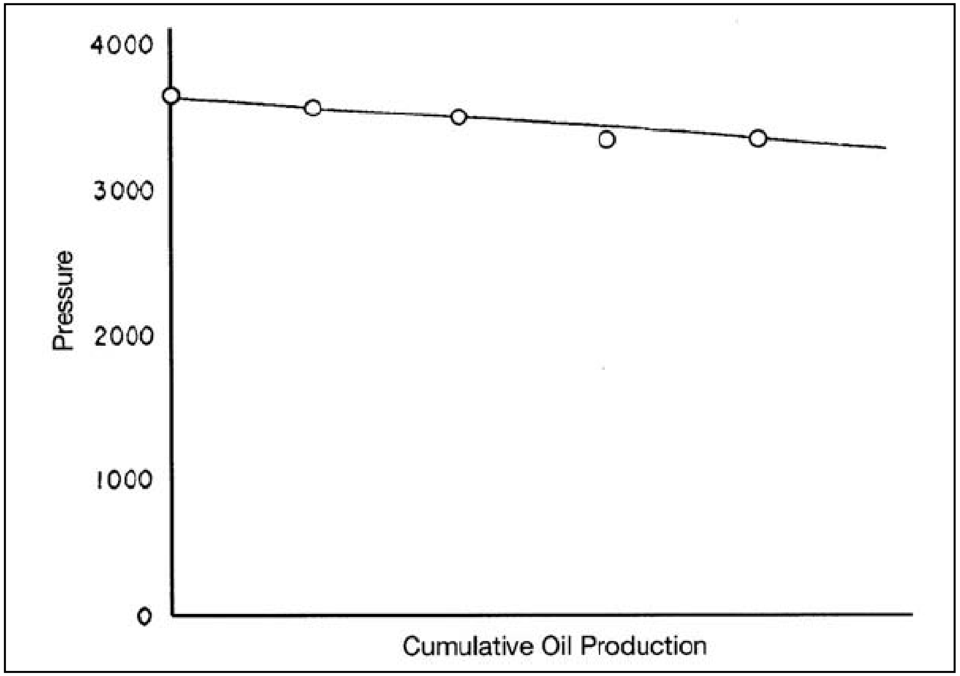
3.Oil Viscosity: As the oil viscosity increase, the amount of gas bypassing will also increase, which leads to a lower oil recovery.

4.Degree of Conservation of the gas: in order to conserve gas, it is necessary to shut in the wells that produce excessive gas.

The Main Properties Of Drive Mechanisms

4-The Water-Drive Mechanism:

1.Reservoir Pressure: declines usually very gradual.



The Main Properties Of Drive Mechanisms

4-The Water-Drive Mechanism:

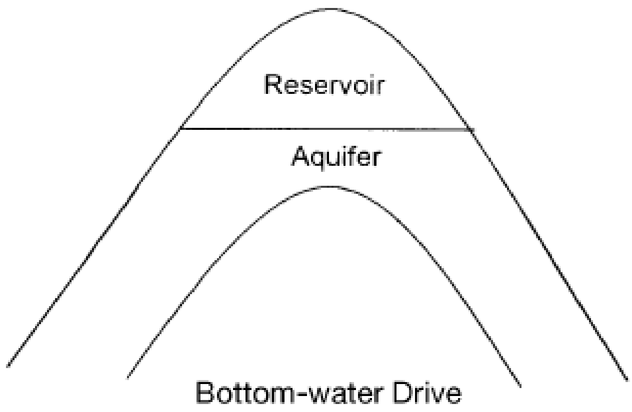
2- Water Production: Early excess water production occurs in structurally low wells.

3- Gas-Oil Ratio: there is normally little change in the producing gas-oil ratio during the life of the reservoir.

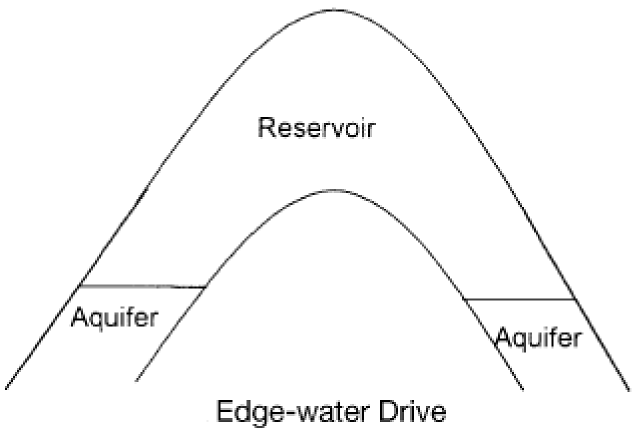
4- Ultimate Oil Recovery: Normally ranges from 35 to 75 percentage of the original oil in place.

The Main Properties Of Drive Mechanisms

4-The Water-Drive Mechanism:



1.Bottom Water Drive: occurs directly beneath the oil.



2.Edge Water Drive: occurs off the flanks of the structure at the edge of the oil reservoir.

The Main Properties Of Drive Mechanisms

5-The Gravity-Drainage-Drive Mechanism:

1.Reservoir Pressure: Rapid pressure decline.

2.Gas-Oil Ratio: Low gas-oil ratio from structurally low wells. This is caused by migration of the evolved gas unstructured due to gravitational segregation of the fluids. On the other hand structurally high wells have increasing gas-oil ratio.

3.Water Production: Little or no water production especially in structurally high wells.

The Main Properties Of Drive Mechanisms

Ultimate Oil Recovery the Gravity-Drainage-Drive mechanism Will vary widely depending on the following parameters:

1.Permeability in the direction of dip: Good permeability in the direction of migration of the oil is a prerequisite for efficient gravity drainage.

2.Dip of the Reservoir: If the reservoir dip increases the condition will be better for gravity drainage mechanism.

3.Reservoir-Production Rates: Since the gravity-drainage rate is limited, the reservoir-producing rates should be limited to the gravity-drainage rate, and do not exceeds it.

4.Oil Viscosity: The gravity-drainage rate increases as the reservoir oil viscosity decreases.

The Main Properties Of Drive Mechanisms

6- The Combination Drive Mechanism

Two combinations of driving forces can be presented in combination drive reservoirs.

1.Depletion drive and weak water drive

2.Depletion drive with a small gas cap and a weak water drive.

Then, of course, gravity segregation can play an important role in any of the before mentioned drives.

The Main Properties Of Drive Mechanisms

6- The Combination Drive Mechanism

Ultimate recovery from combination-drive reservoirs is usually greater than recovery from depletion-drive reservoirs but less than recovery from water drive or gas-cap driver reservoirs.

In most combination-drive reservoirs, it will be economically feasible to institute some type of pressure maintenance operation, either gas injection, water injection or both of them.

Performance Methods: The Material Balance Equation

Application: OIIP, GIIP (assumes adequate production history available), recoverable reserves (assumes OIIP and GIIP known). Use in a mature field with abundant geological, petrophysical, and engineering data.

Accuracy: Highly dependent on quality of reservoir description and amount of production data available. Reserve estimates variable.

The material balance equation (MBE) has long been recognized as one of the basic tools of reservoir engineers for interpreting and predicting reservoir performance.

Performance Methods: The Material Balance Equation

The MBE when properly applied, can be used to:

1. Estimate initial hydrocarbon volumes in place

2. Predict future reservoir performance

3. Predict ultimate hydrocarbon recovery under various types of primary driving mechanisms.

In it's simple form, the equation can be written on volumetric basis as:

Initial volume=volume remaining + volume removed

The Material Balance Equation

Basic Assumptions in the MBE

1- Constant temperature: Pressure-volume changes in the reservoir are assumed to occur without any temperature changes. If any temperature changes occur they are usually sufficiently small to be ignored without significant error.

The Material Balance Equation

Basic Assumptions in the MBE

2- Pressure equilibrium: All parts of the reservoir have the same pressure and fluid properties are therefore constant throughout. We use the Black Oil model.

The Material Balance Equation

Basic Assumptions in the MBE

3- Constant Reservoir Volume: Reservoir volume is assumed to be constant except for those conditions of rock and water expansion or water influx that are specifically considered in the equation.

The Material Balance Equation

Basic Assumptions in the MBE

4- Reliable Production Data: All production data should be recorded with respect to the same time period. If possible, gas-cap and solution gas production records should be maintained separately.

The Material Balance Equation

Several of material balance calculations required the total pore volume (P.V) as expressed in terms of the initial oil volume (N) and the volume of the gas cap (G).Defining the ratio m as:

$$m = \frac{\text{Initial volume of gas cap}}{\text{Volume of oil initially in place}} = \frac{G\,B_{gi}}{N\,B_{oi}}$$

Solving for the volume of the gas cap gives:

$$\text{Initial volume of the gas cap} = G\,B_{gi} = m\,N\,B_{oi}$$

The Material Balance Equation

The total volume of hydrocarbon system is then given by:

Initial oil volume + initial gas cap volume = (P.V) $(1 - S_{wi})$

$$N B_{oi} + m N B_{oi} = (P.V)(1 - S_{wi})$$

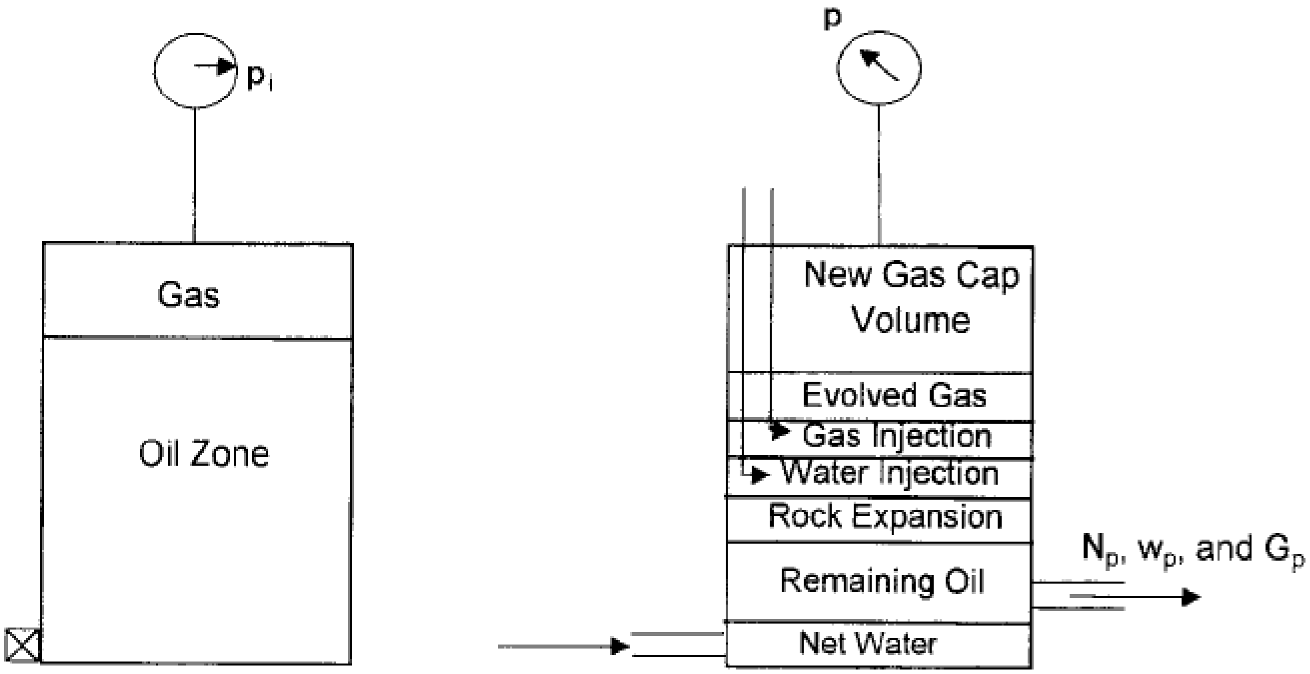
or

$$P.V = \frac{N B_{oi}(1 + m)}{1 - S_{wi}}$$ (

where S_{wi} = initial water saturation
N = initial oil in place, STB
P.V = total pore volume, bbl
m = ratio of initial gas-cap-gas reservoir volume to initial reservoir oil volume, bbl/bbl

The Material Balance Equation

MBE derivation:



The Material Balance Equation

MBE derivation:

The left hand side of the equation :

Pore volume occupied by the oil initially in place at p_i

$+$

Pore volume occupied by the gas in the gas cap at p_i

$=$

The Material Balance Equation

MBE derivation:

The right hand side of MBE is:

Pore volume occupied by the remaining oil at p

+

Pore volume occupied by the gas in the gas cap at p

+

Pore volume occupied by the evolved solution gas at p

+

Pore volume occupied by the net water influx at p

+

Change in pore volume due to connate water expansion and pore volume reduction due to rock expansion

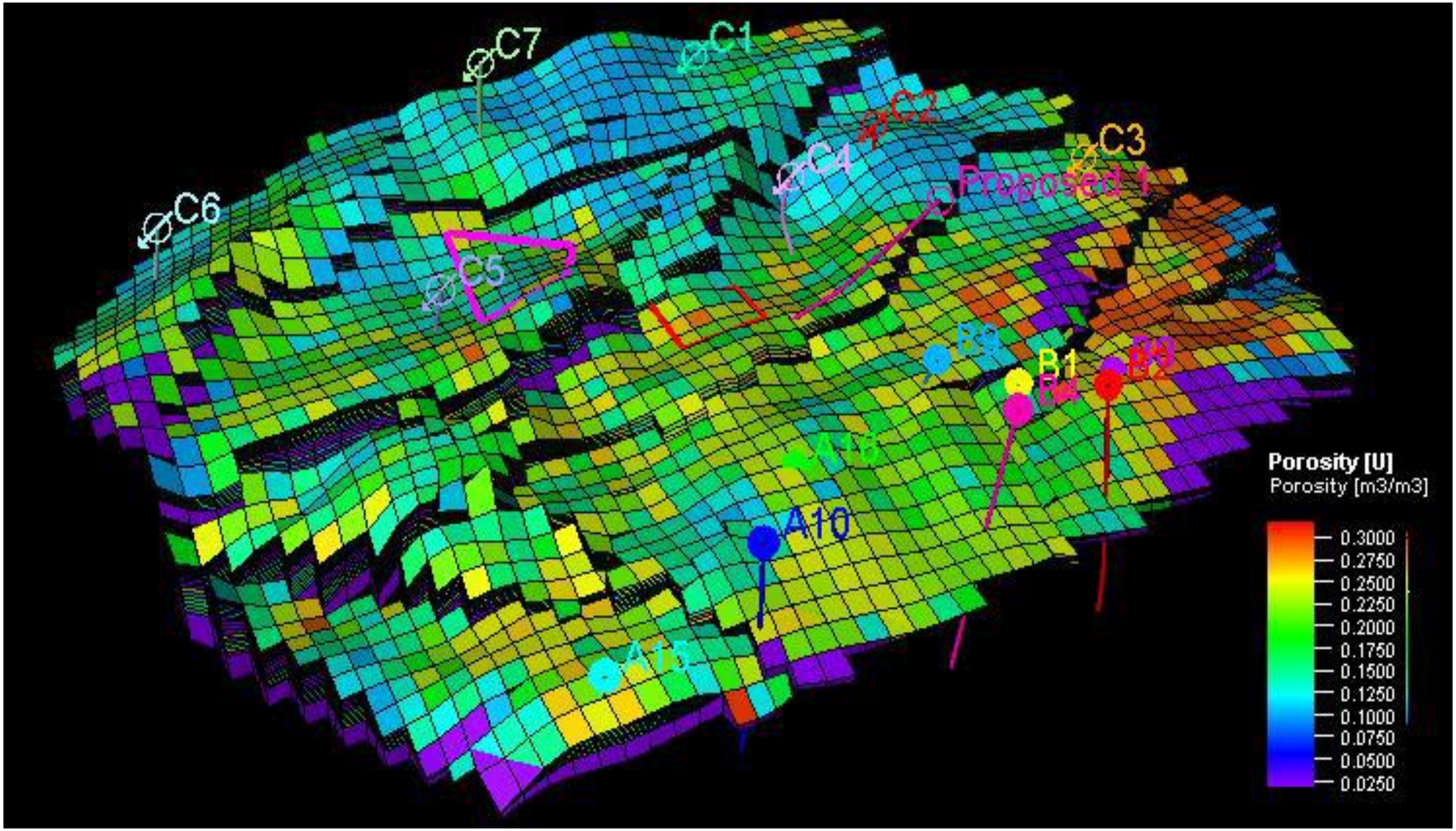
+

Pore volume occupied by the injected gas at p

+

Pore volume occupied by the injected water at p

Performance Methods: Reservoir Simulation

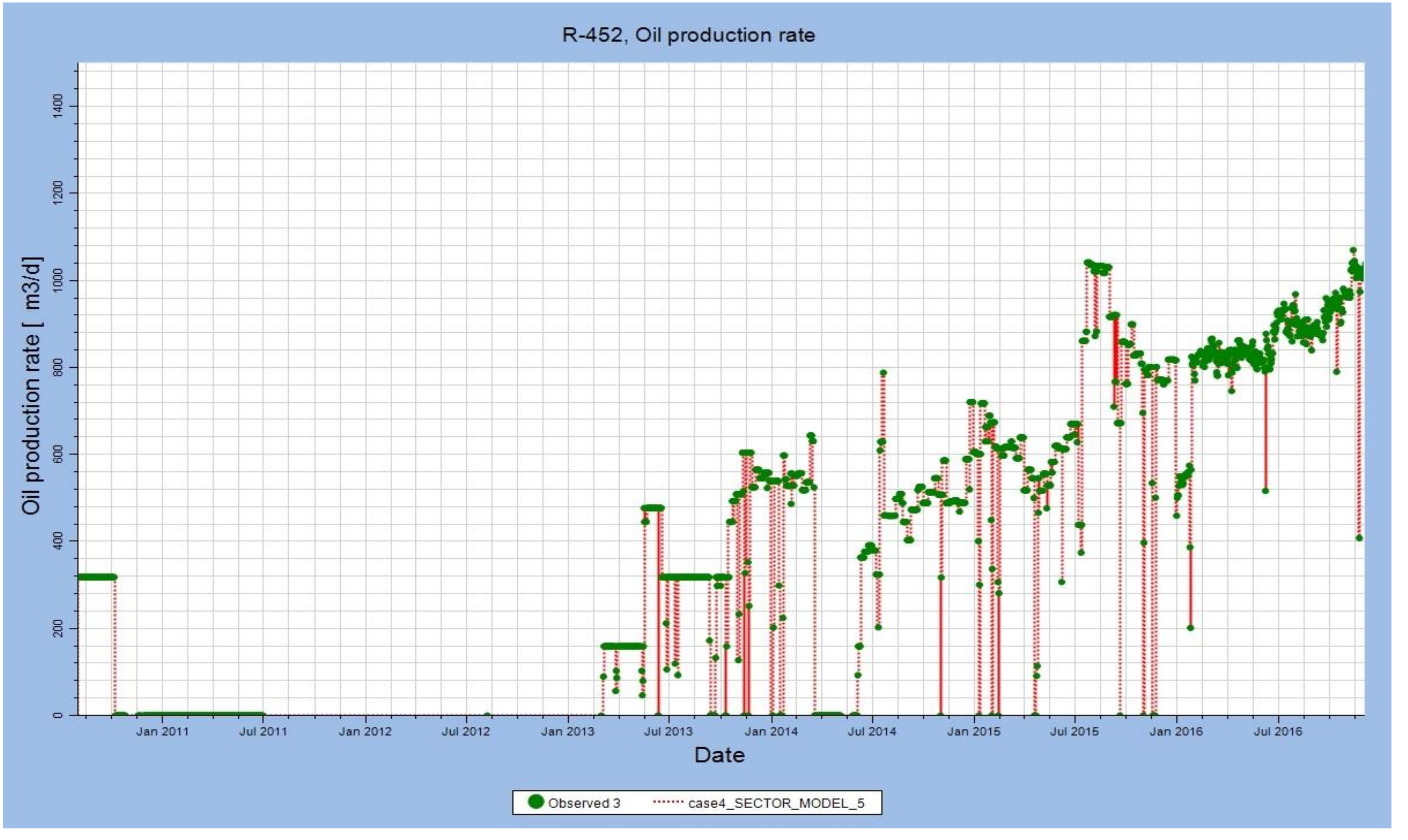


Performance Methods: Reservoir Simulation

Reservoir simulation may be considered a form of material balance analysis in which the spatial distribution of rock, fluid, and rock/fluid properties in the reservoir are represented in a computer model by a grid system, or a set of interconnected "tanks".

The computer model may be used to calculate oil and/or gas initially in place, to match observed pressure performance history, and to forecast future production rates. The grid system may be configured to simulate the well or reservoir (or sections of the reservoir) under study. For some applications, the reservoir (or well) model may be coupled with models to simulate production facilities.

Performance Methods: Decline Curve analysis and History



Performance Methods: Decline Curve analysis and History Matching

Application: Recoverable reserves. Use after a moderate amount of production data is available.

Accuracy: Dependent on amount of production history available. Reserve estimates tend to be realistic.

Decline curve analysis is a means of predicting future oil well or gas well production behavior and life based on past production history with time.

While history matching is the process of building one or more sets of numerical models (representing a reservoir which account for observed and measured data).