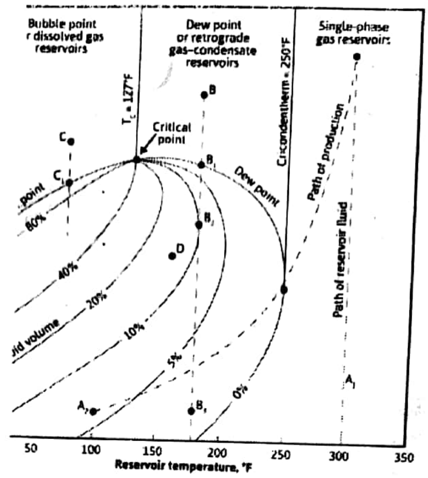
(1) Discuss briefly about wet and Dry gas reservoir with specifications with phase diagram.

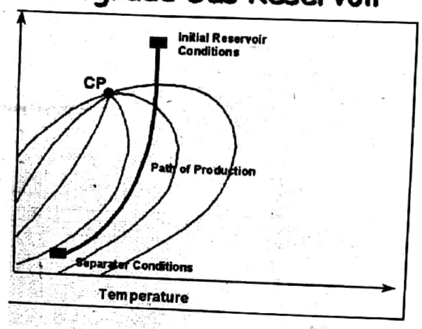
The fluid classification is dependent on the fluids composition and local temperature and pressure. Fortunately the classification can be predicted by a phase envelope that describes the fluid's temperature pressure relationship.

When reservoir conditions lie to the right of the two phase region, the fluid is classified as Dry Gas.

Dry gas remains entirely in the gas phase as pressure depletes in the reservoir. Dry gas systems are mainly composed of Methane. In contrast wet & retrograde gases are composed of light hydrocarbons and small but significant portion of heavier hydrocarbons.



Phase Diagram of a Retrograde Gas Reservoir

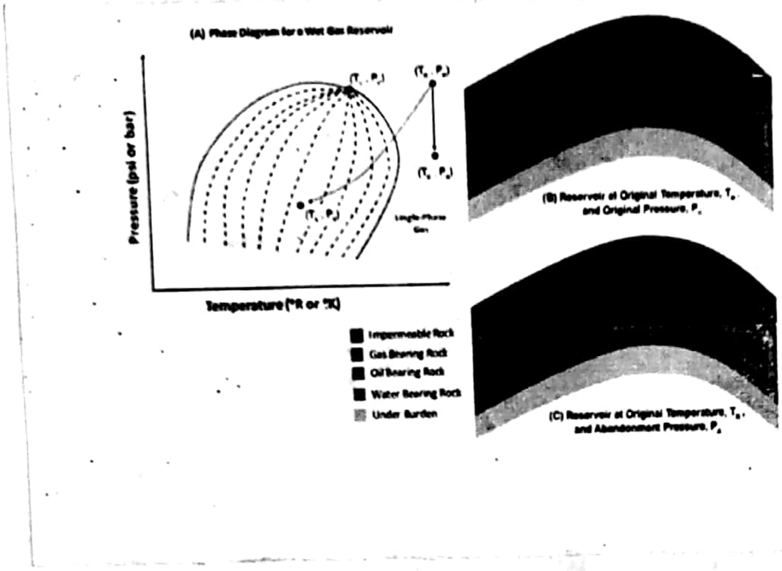


<u>Wet gas:</u>

Natural gas that contains significant heavy hydrocarbons such as propane, butane and other liquid hydrocarbons is know as wet gas or rich gas. The general thumb is if the gas contains less ... methane)

The entire phase diagram of a wet gas will lie below the reservoir Temperature

Dry Gas: Natural Gas that occurs in the absence of condensate or liquid hydrocarbons or gas that had condensable hydrocarbons removed.



The pressure path line does not enter into the phase envelope in the phase diagram, thus there is only dry gas in the reservoir.

Note, the surface separator conditions also fall outside the phase envelope.

Department of petroleum Engineering

PE 8603 Reservoir Engineering-II

Unit - V

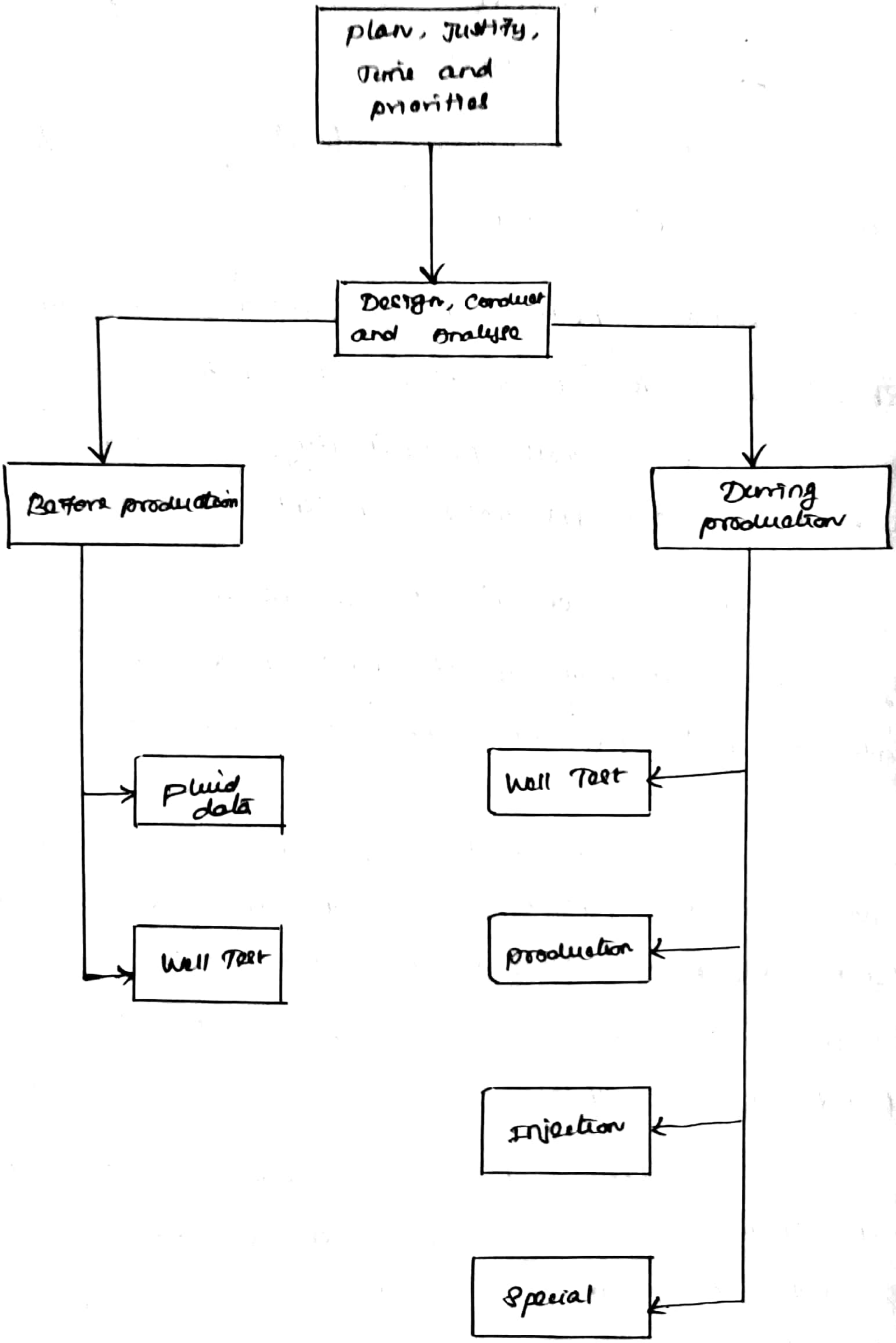
1 Interpret the mathematical basis of Bottom hole Analysis.

Initial Bottom hole pressure measurements should be made, preferably at each well and at a selected key gas well periodically. According to woods and Abib, key gas wells represent 25% of the total wells.

It is essential to establish the specifications of what and how much well data need to be gathered and procedure and frequency to be followed.

Most bottom hole pressure are higher than the formation pressures. usually an excess pressure of 200-300 psi is designed into the drilling fluid program. This prevents entry of unwanted formation fluid into a wellbore.

This pressure differential is usually not known very accurately. when a chip or cutting is made, fluid must fill the fracture space below the chip.


plan, justify, time and prioritise
Design, conduct and analyse
Before production
During production
Fluid data
Well Test
Well Test
Production
Injection
Special

The differential pressure has two effects at the hole bottom.

* It forces the chip against the formation
* It changes the rock properties themselves

fluid to fill the cracks below the chips can come from three sources.

✓ Drilling fluid ertoring the cracks from the wellbore

✓ filtrate flowing through the cake at the bottom of the hole or the chip

✓ formation fluid flowing through the pores of the rock.

The exponential relationship does not fit all of the data in the titerature or all unpublished data author has seen nor match the standard reciprocal relationship between ROP & $m+\Delta p$.

② Explain differential equations for radial flow in a porous medium.

The flow of a single, compressible fluid through porous, permeable rock can be described using a partial differential equation known as diffusivity equation. Modified forms of the diffusivity equation can be used to describe gas flow.

A similar equation can be derived for multiphase flow as well, and that equation is the basis for reservoir simulation.

Diffusivity eqn is at the very heart of reservoir engg & an intuitive understanding of this equation is essential.

Key concepts:

- Mass conservation
- Use of constitutive equations for v & P
- Assumption in the linearized diffusivity eqn.
- Dimensionless eqn.
- ~~Radius~~ Radius of Investigation
- Diffusivity.

Many physical systems - ranging from solar collectors to river deltas to flow in reservoirs.

Conservation equation for a radial flow geometry, because this geometry is especially useful for well testing and inflow analysis

Consider a cylindrical shell of radius 'r' and thickness Δr

flow in at r' − flow out at $r+\Delta r$
= Accumulation between r & $r+\Delta r$

flow in at r

Mass inflow = Area x superficial velocity x Density x Time

$= 2\pi r h \times \mu\,(r)\,\rho\,\Delta t$

flow out at $r+\Delta r$

$= \left[2\pi\,(r+\Delta r)\,h\right] u\,(r+\Delta r)\,\rho\,\Delta t$

accumulation

$(2\pi r \Delta r h \phi \rho)_{r+\Delta r} - (2\pi r \Delta r h \phi \rho)_r$

Combining the eqn

$(2\pi r h)\,u\,(r)\,\rho.\,\Delta t - 2\pi\,(r+\Delta r)\,h u\,(r+\Delta r)\,\rho.\,\Delta t$
$= (2\pi r \Delta r h \phi \rho)_{r+\Delta r} - (2\pi r \Delta r h \phi \rho)_r$

Dividing by $2\pi r h \Delta r$

$$\frac{hu\,(r)\,\rho_o(r) - (r+\Delta r)\,u\,(r+\Delta r)\,\rho_o\,(r+\Delta r)}{\Delta r} = \frac{(r\phi\rho)_{r+\Delta r} - (r\phi\rho)_r}{\Delta t}$$

If we take the limit Δr & Δt go to zero.

$$\boxed{\frac{-\partial}{\partial r}(r\rho u) = r\frac{\partial \phi\rho}{\partial t}}$$

(3) How do you acquainted data for reservoir management and explain its importance.

Reservoir management has been defined by a no. of author. Basically sound reservoir mgmt. practice relies on the utilization of available resource (i.e human technological and financial) to maximize profit / profitability index from a reservoir by optimizing recovery while minimizing capital investment and operating expenses.

Reservoir mgmt involves making certain choices. Either let it happen, or make it happen. we can leave it to chance to generate some profit from a reservoir operation without ongoing deliberate planning or we can enhance recovery and maximize profit from the same reservoir through sound management practice.

Data Acquisition and analysis

Reservoir Management starting from developing a plan, implementing a plan, monitoring and evaluating the performance of reservoir requires a knowledge of the reservoir that should be gained through an integrated data acquisition and analysis program.

The key steps are

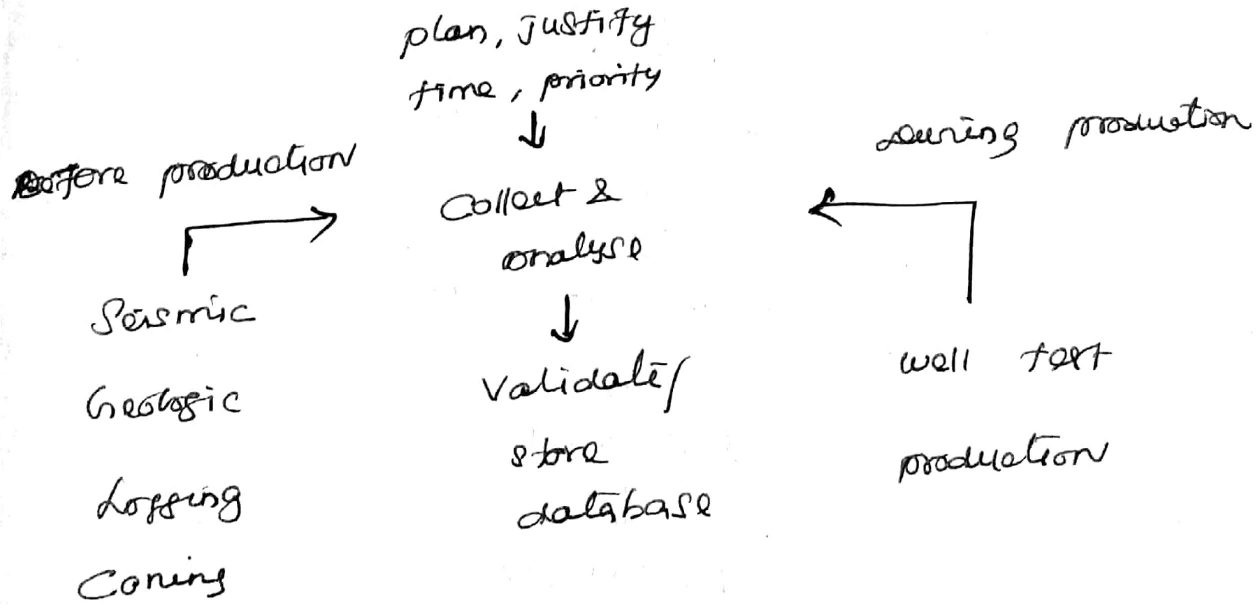
i) plan, justify, time and priorities

ii) Collect and analyze

iii) validate / store (Data base)

An enormous amount of data are collected and analysed during the ~~file~~ life of a reservoir. An efficient data management program of

Collecting
analysing
storing
&
retrieving needed for sound reservoir management. Its poses great challenge.



(A) What is reservoir data? How does it help in reservoir simulation and Management discuss it.

The main objective of reservoir Management is the economic optimization of oil & gas recovery which can be obtained by the following.

data:

- Geological
- Geophysical
- Engineering

Reservoir Management process (RMP)

RMP

↓

Settling Stratergy

↓

developing plan

↓

Implementation

↓

monitoring

↓

Evaluating

↓

completing.

Reservoir management has been described as the judicious use of various means available to maximize benefits from a reservoir.

There are numerous reasons why some reservoir management program fail. perhaps the most important reason why a reservoir management program is developed and implemented poorly is un integrated group effort.

Reservoir Simulation:

Reservoir simulation is an area of reservoir engineering in which computer models are used to predict the flow of fluids. [Typically (oil, water & gas)] through porous media.

Reservoir Simulation model:

A simulation model applied to the growth of a bacterial colony. Now let us consider what we want to model or simulate when we come to develop petroleum reservoir, clearly, petroleum reservoir are much more complex than our simple example since they involve many variable.

many variable e.g. pressure, oil saturation flow meters, valves, pipe etc..) that are distributed through space and that vary with time.

A simple example of a simulation model.

A simple model is one which shows the main features of a real system or resembles it in behaviour, but is simple enough to make calculation on. These calculation may be analytical a numerical.

- ✓ By analytical we mean that the equation that represent the model can be solved using mathematical techniques.
- ✓ Techniques such as those used to solved algebraic or differential equation
- ✓ An analytical solution would normally be written in term of "well know" equation or function [x^2, $\sin x$, e^x, etc...]

(5) Enumerate on the characteristics of fluid and production system.

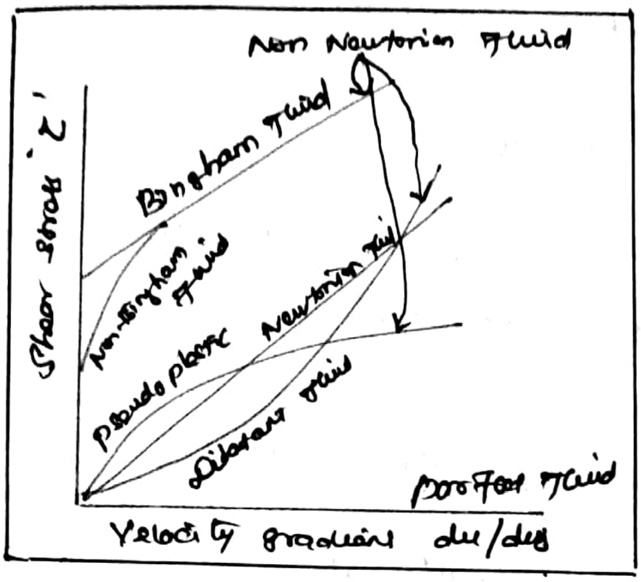
Characteristics of fluids are density, specific volume, specic gravity, viscosity, surface tension and compressibility

Types of reservoir fluids

Natural Gas
Crude oil system
Reservoir water system

properties of natural Gas

* apparent molecular weight (Ma)
* Standard volume (Vsc)
* specific volume (V)
* Density (ρ_g)
* specific gravity (γ_g)
* Gas formation volume factor (B_g)
* Gas compressibility (z)
* Viscosity (μ_g)



production system: (Basic elements)

The basic elements of petroleum system

- Reservoir
- Well bore
- Tubular goods & associated equipment
- Surface well head
- Flow lines
- processing equipment
- artificial lift equipment.

The principles of fluid flow through the production system is important in estimating the performance of individual wells & optimizing well & reservoir productivity.

In most general sense, the production system is the system that transports reservoir fluids from the subsurface reservoir to the surface, and processes and treats fluids, and prepare the fluids for storage & transfer to a purchaser.

flow through production system:

* various components of the production system and understanding their interaction generally leads to improved well productivity through analysis of the entire system.
* To design a well completion or predict the production rate properly.
* A systematic approach is required to integrate the production system components
* system analysis [More commonly called Nodal Analysis]
* To analyse & design well completions.
* To understand the flow of reservoir fluids

(6) Give an account on Reservoir Management and reservoir simulation.

The prime objective of reservoir management is the economic optimization of oil & gas recovery which can be obtained by the following steps.

i) Identify and define all individual reservoir in a particular field

ii) physical properties

iii) Deduce past & predict future reservoir performance

iv) Define and modify (if necessary) wellbore and surface system.

v) Initiate operating control at the proper time.

vi) Consider all pertinent economic and legal factor.

Reservoir Management has generally been successfull in recognizing the value of other disciplines eg.

- Geophysics
- production operation
- drilling & different engg function

Fundamentals of Reservoir Management.

Although the synergism provided by the interaction between geology and reservoir engineering has been quite successful, reservoir management has generally been successful in recognizing the value of other disciplines.

The main objectives are

- ✓ Identify and define all individual reservoir
- ✓ Deduce past and predict future
- ✓ define and modify well bore
- ✓ To modify surface system
- ✓ Initiate operating control
- ✓ Consider all pertinent economic & legal factor

The main objectives of reservoir management is the economic optimization of oil & gas recovery which can be obtained by the above steps.

Reservoir Management

Data
1. Geological
2. Geophysical
3. Engineering

Technology
1. Seismic
2. Geologic
3. Geostatistics
4. Engineering
5. Drilling
6. Well completions

Integration

Tools
1. Seismic Interpretation
2. Tomography
3. Data acquisition
4. Logging
5. Completion & facilities
6. Geologic modelling
7. Pressure Transient.

People
1. Management
2. Geoscientists
3. Engineers
4. Land / Legal.

Reservoir Management has been described as the judicious use of various means available to maximize benefits from a reservoir.