PETE 310

Lecture # 15

Properties of Black Oils

Definitions

(pages 224-240)

PETROLEUM ENGINEERING 310

Please adhere strictly to the rules indicated in this test

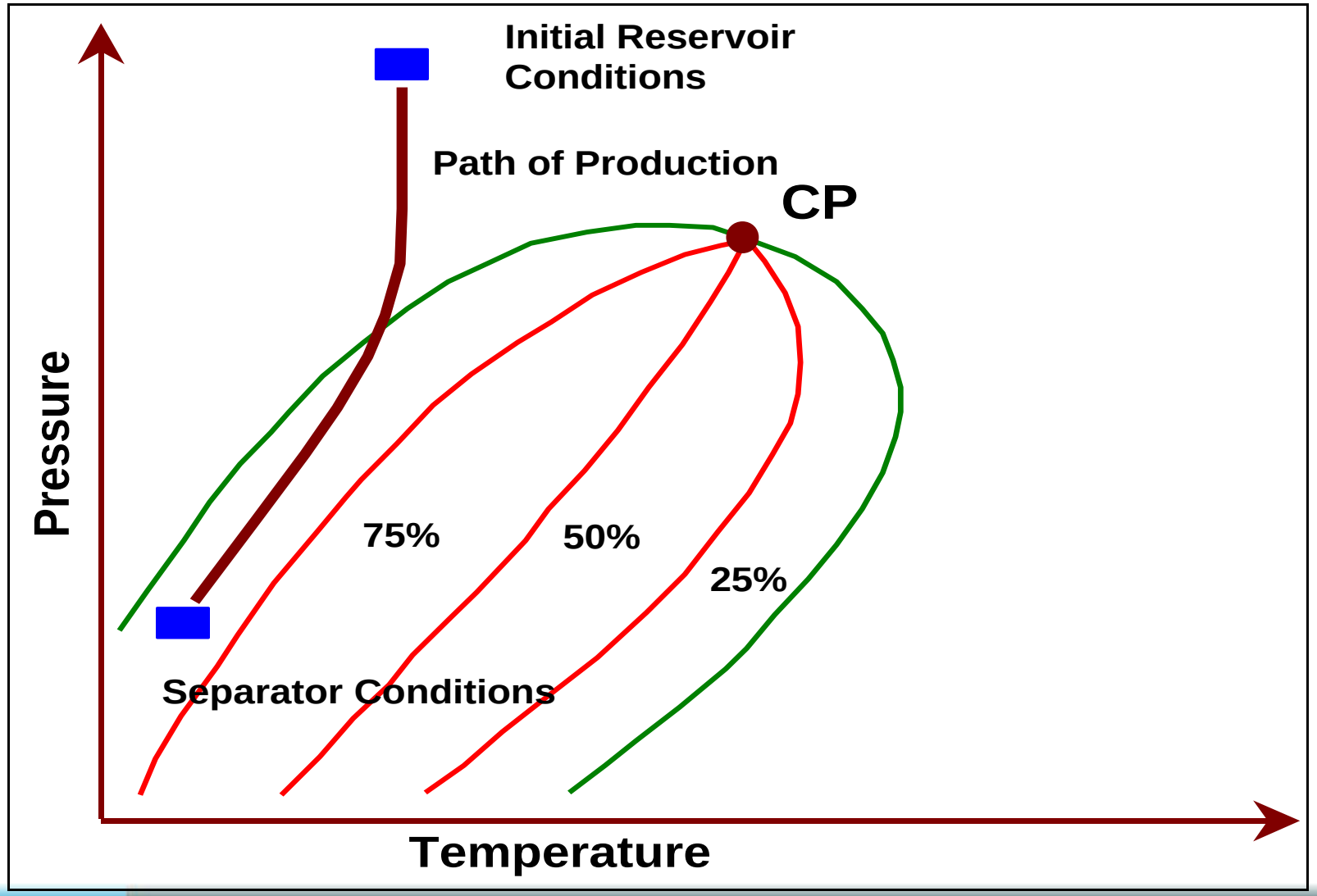
- Disable your cell phone (no text messages either)
- Use your own calculator pencil, ruler, and eraser.
- You cannot use a laptop
- Write all your work on the test paper and in the space provided for the answer, do no write on the back.
- Grading will be based on approach and answers.

PETROLEUM ENGINEERING 310

Please adhere strictly to the rules indicated in this test

- Do not fold or un-staple this examination booklet.
- This examination is open book, notes, HW, and SPE papers you cannot talk to anybody but me or the TA's.
- Raise your hand if you have a question and we'll go to your desk.
- Do not even look into your neighbor's paper.
- Show all your work!!!! Answers with no evidence of calculations where they are required will not be graded.
- Time allotted for the test is 120 minutes.

Recall…. Black Oil Phase Diagram



A Reservoir Engineer Questions

- How much oil is in the reservoir?
- How can I get it out?
- How fast?

Oil Properties Used in Reservoir Engineering…

- Formation Volume Factor of oil B_o
- Total Formation Volume Factor of oil B_t
- Solution Gas oil Ratio R_s
- Coefficient of Isothermal Compressibility C_o

Oil Properties Used in …Production, EOR, Transportation…

- Thermal Expansion Coefficient (EOR – Steam flooding) β_o
- Interfacial Tension (EOR)
- Oil Viscosity μ_o (EOR, transportation, production)

- NOTE: Density is related to B_o

Learning Goals

- Understand the behavior of those PVT properties (Bo,Rs,…) vs P and type of fluid (now)
- Evaluate PVT properties from (later)
  - Field data
  - Laboratory studies
  - Correlations

Definitions

- **Specific gravity of a liquid**

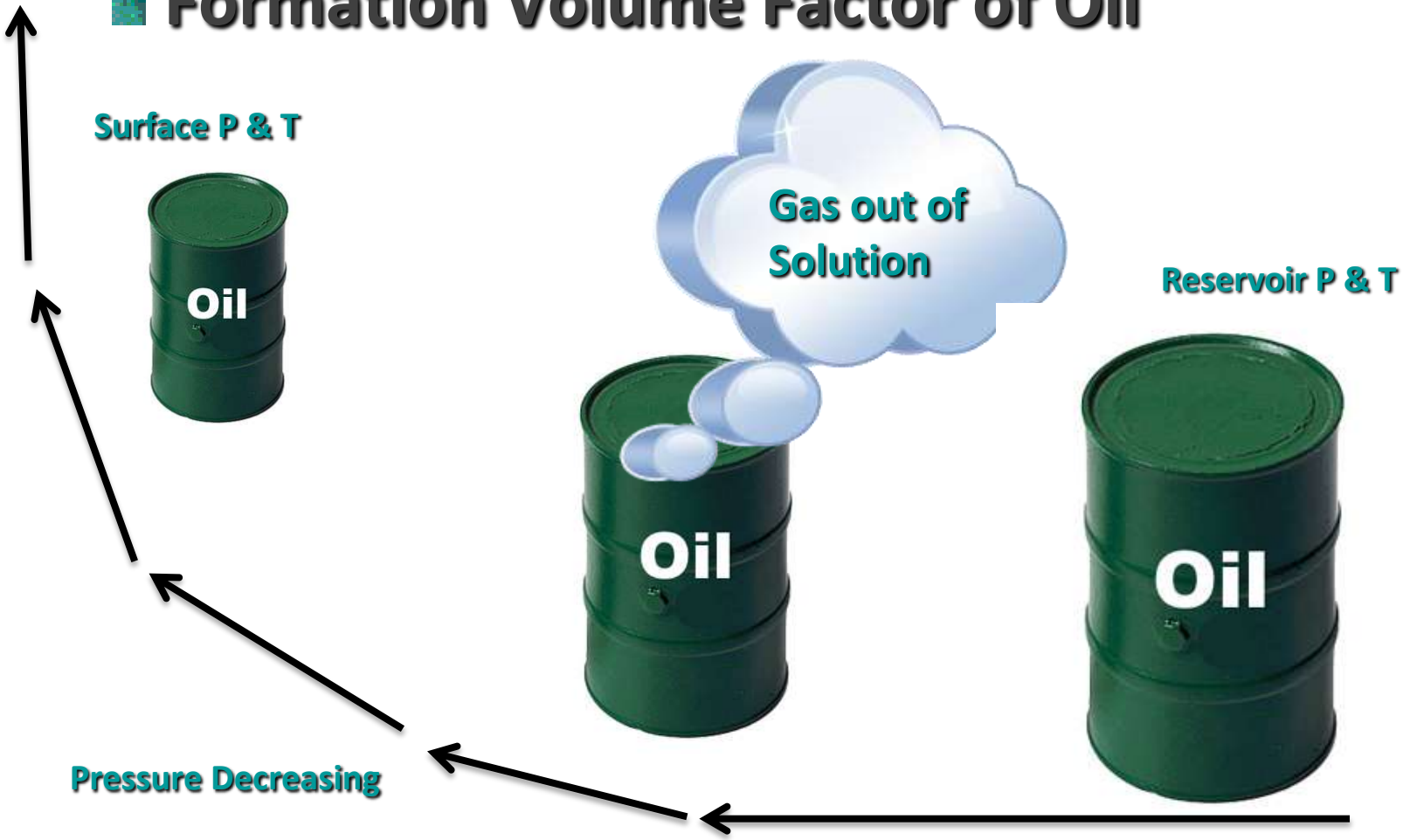
$$\gamma_o = \frac{\rho_o(P_1, T_1)}{\rho_w(P_1, T_1)}$$

- **API gravity**

$$^{o}API = \frac{141.5}{\gamma_o} - 131.5$$

Definitions

- Formation Volume Factor of Oil



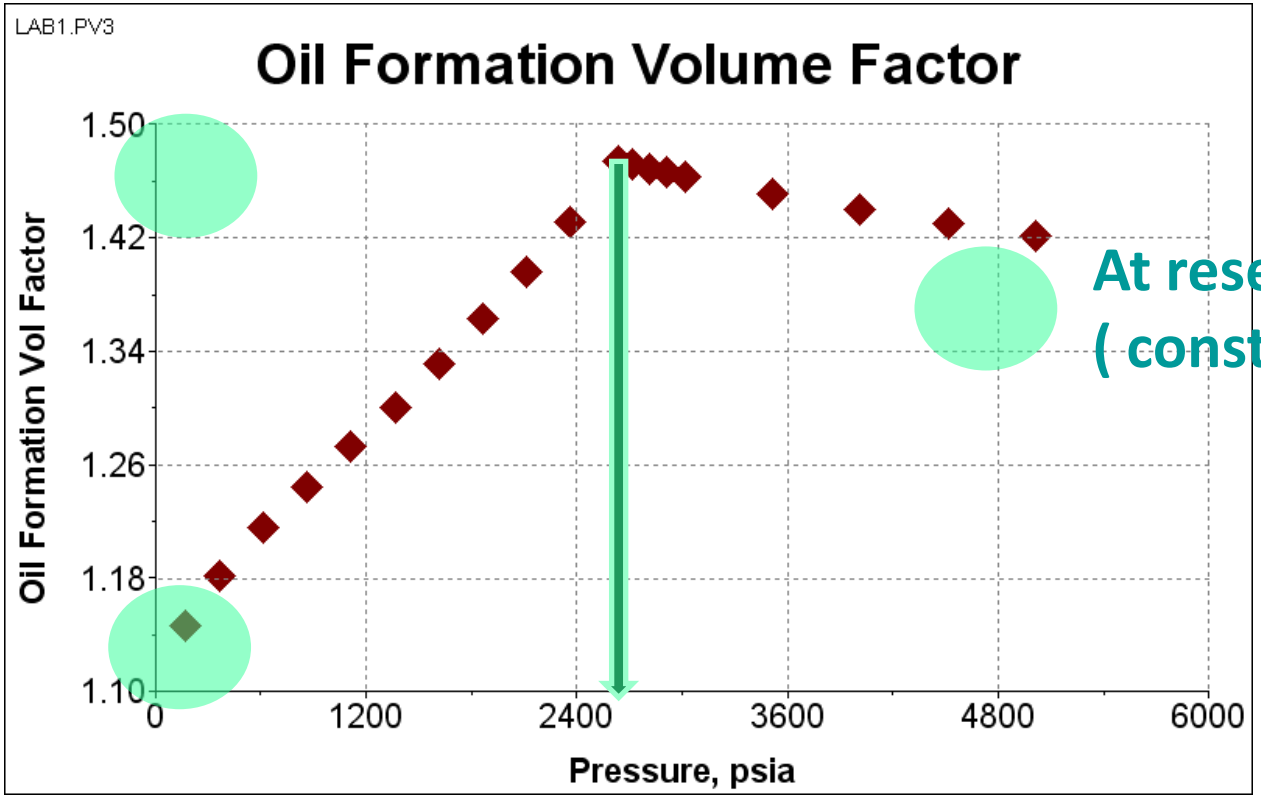
Definitions

$$Bo = \frac{\text{Volume of Oil} + \text{Dissolved Gas at Reservoir P \& T}}{\text{Volume of Oil Entering Stock Tank at Tsc, Psc}}$$

Units [=]

Reservoir barrels (bbl) /Stock tank barrels (STB)

General Features of Bo



At reservoir T
(constant)

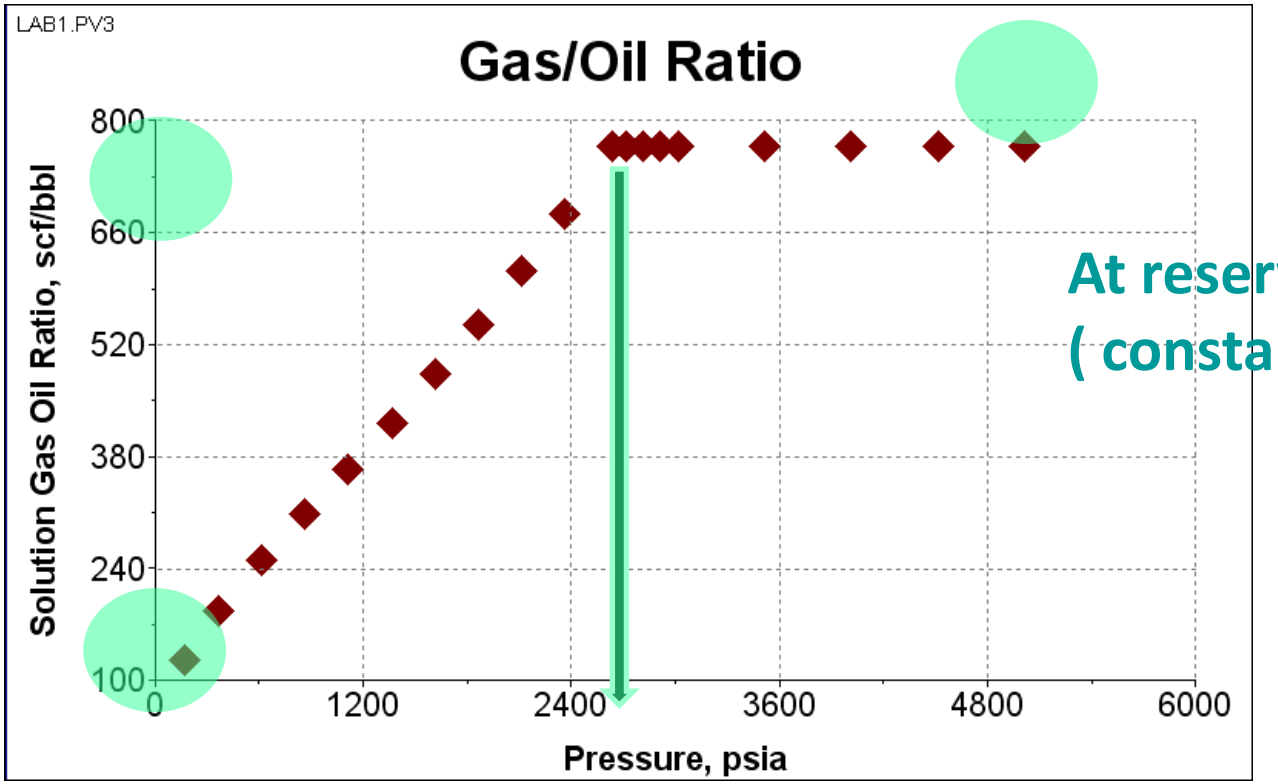
Solution Gas Oil Ratio (Rs)

- How much gas is dissolved in the oil volume per volume basis
- Rs depends upon pressure, temperature and oil type

Units [=]

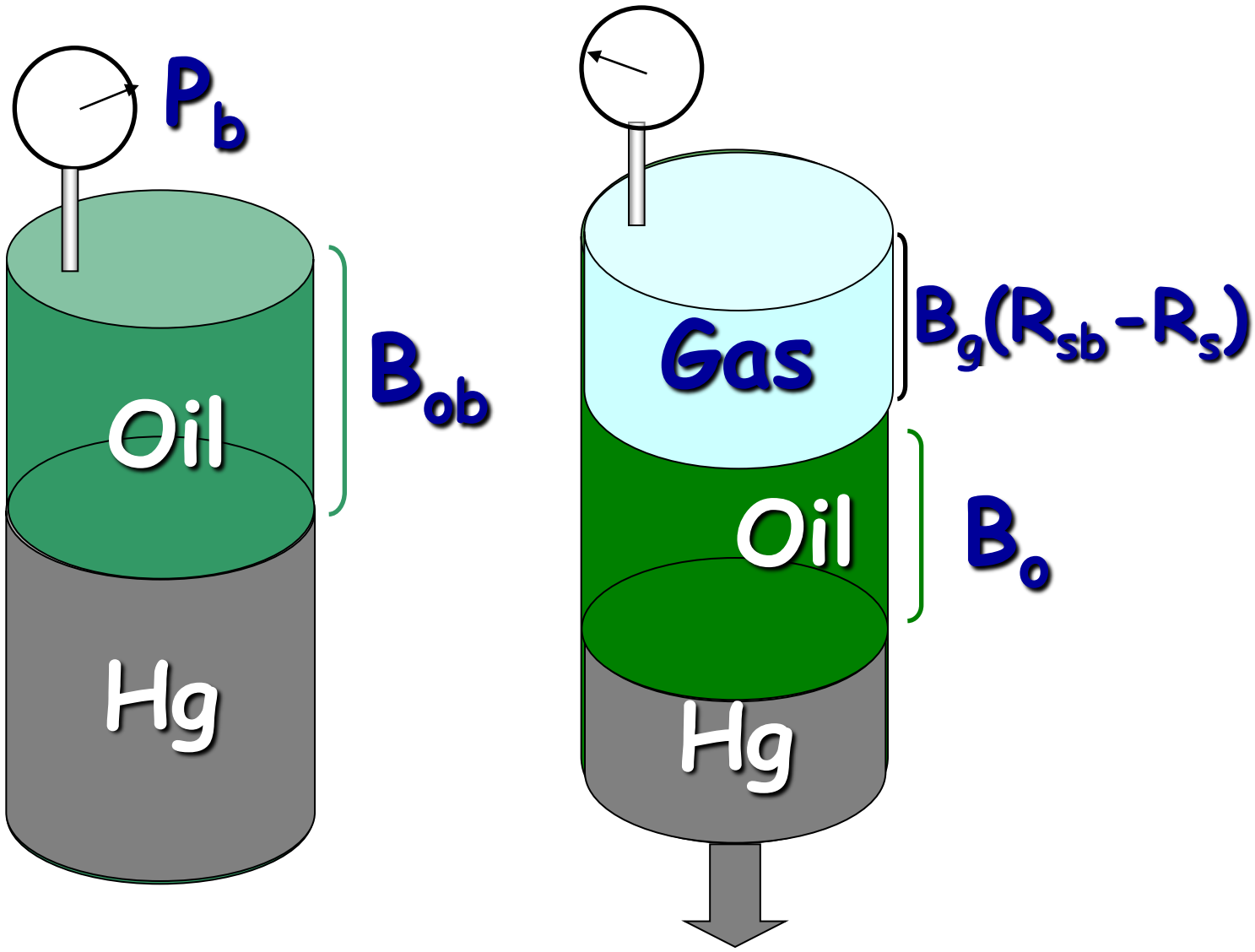
SCF gas /STB oil

General Features of Rs



At reservoir T
(constant)

Total Formation Volume Factor Bt



Definition of Bt

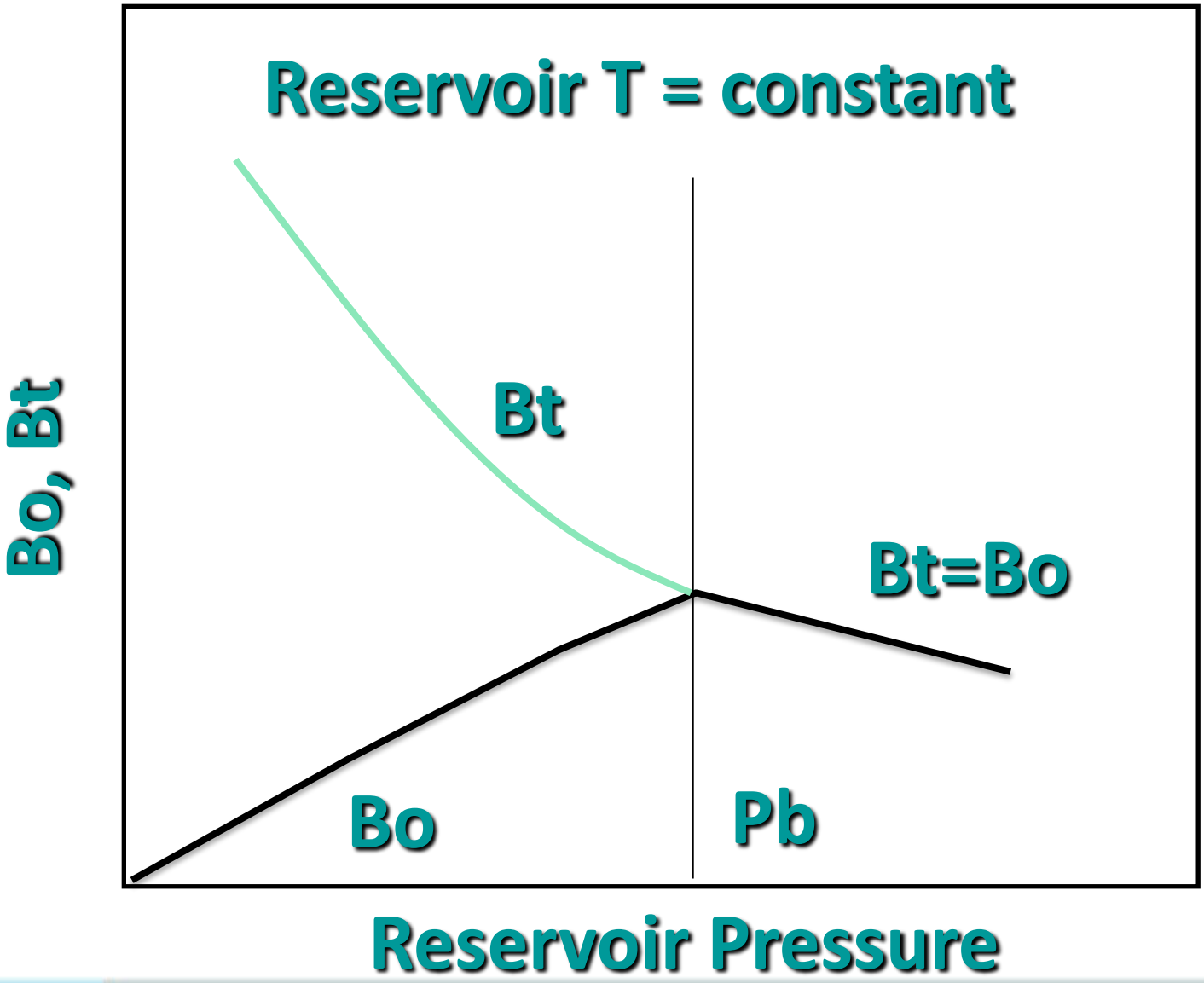
- Also called Two-phase formation volume factor

$$B_t = B_o + B_g\left(R_{sb} - R_s\right)$$

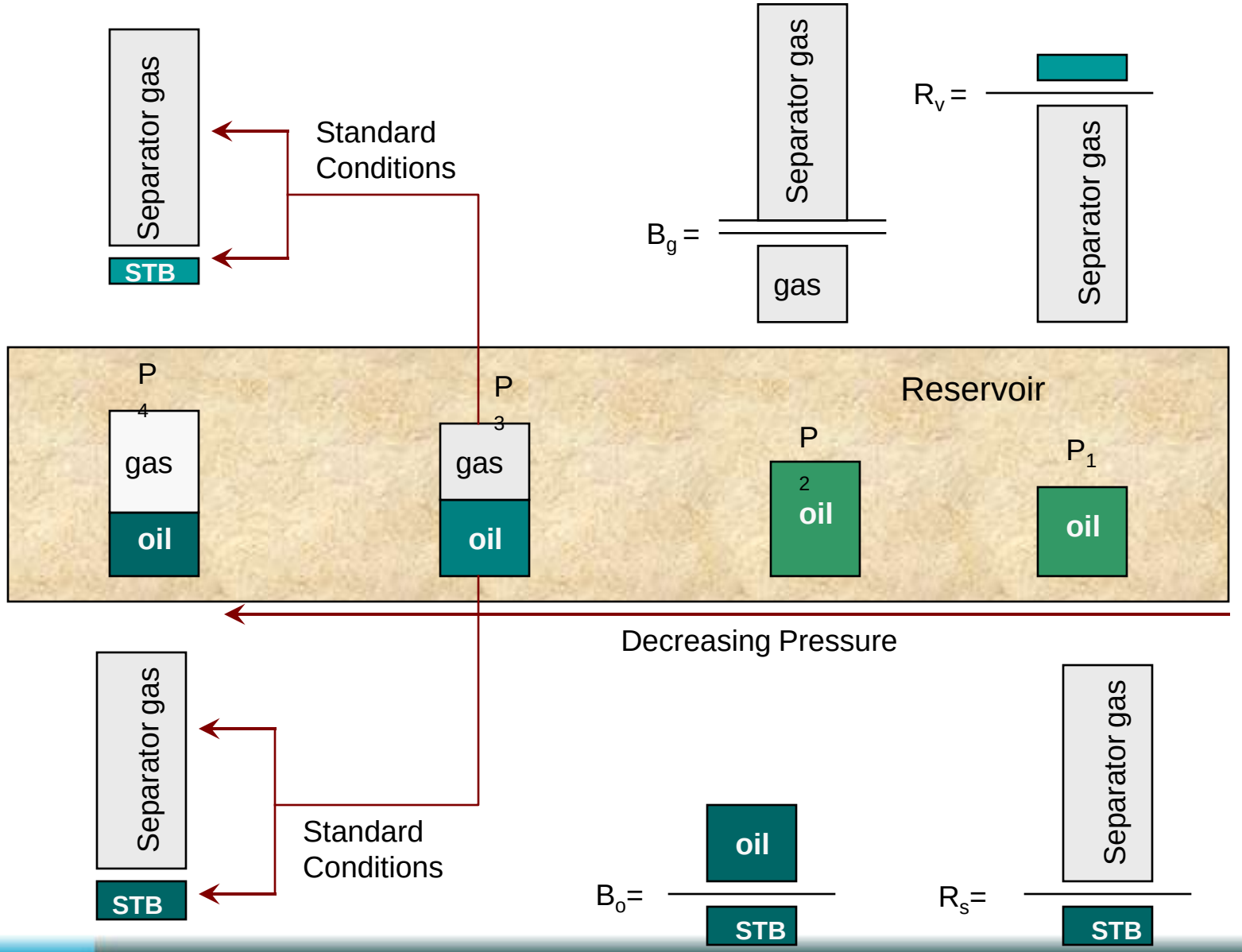
Units…

bbl/STB + bbl/SCF * (SCF/STB)

General Shape of Bt



Definition of Oil & Gas PVT Properties



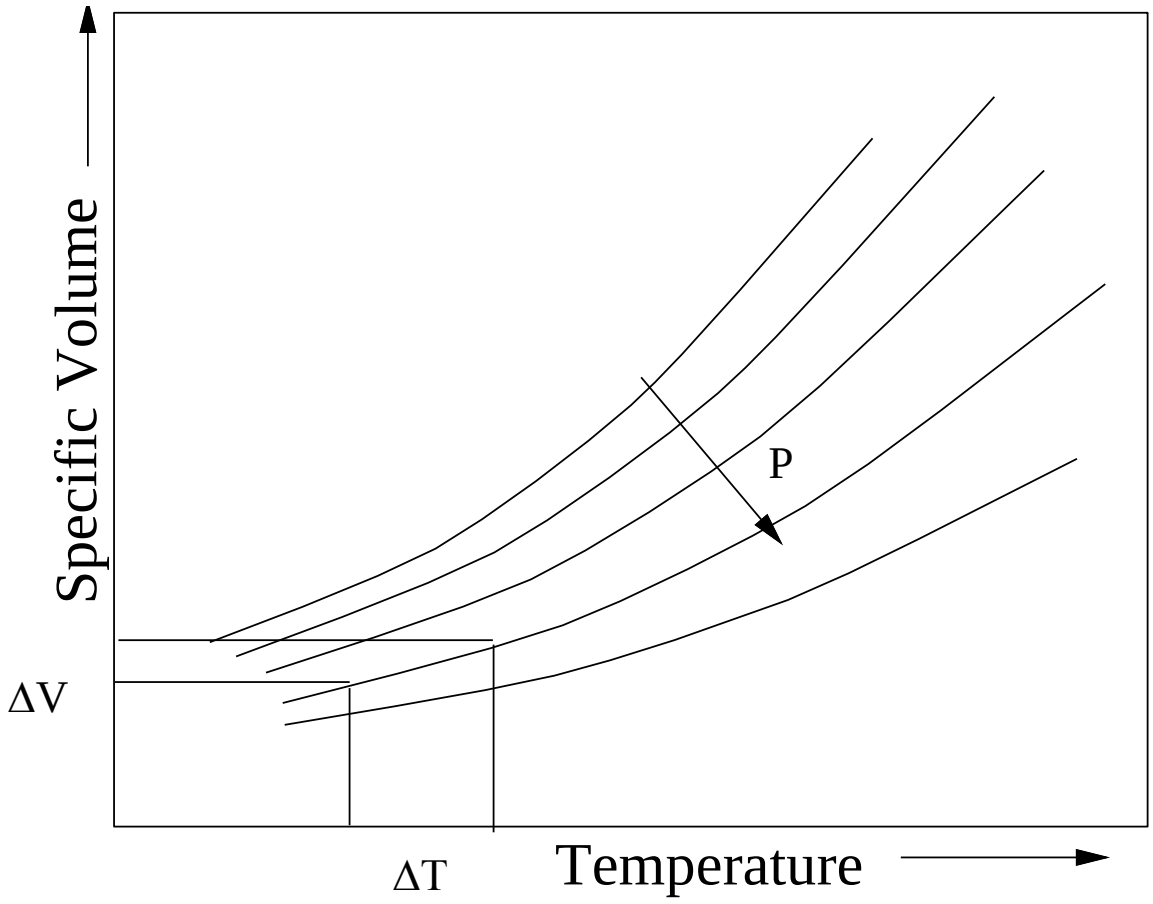
The Coefficient of Isothermal Compressibility of Oil

- Provides Instantaneous change of volume with P at constant T

$$C_o\left(P_A, T_A\right) = -\frac{1}{V}\left[\frac{\partial V}{\partial P}\right]_{T_A}$$

alternatively using molar volume and specific volume

Coefficient of Thermal Expansion



(Use in Steam Injection Processes)

Oil Viscosity

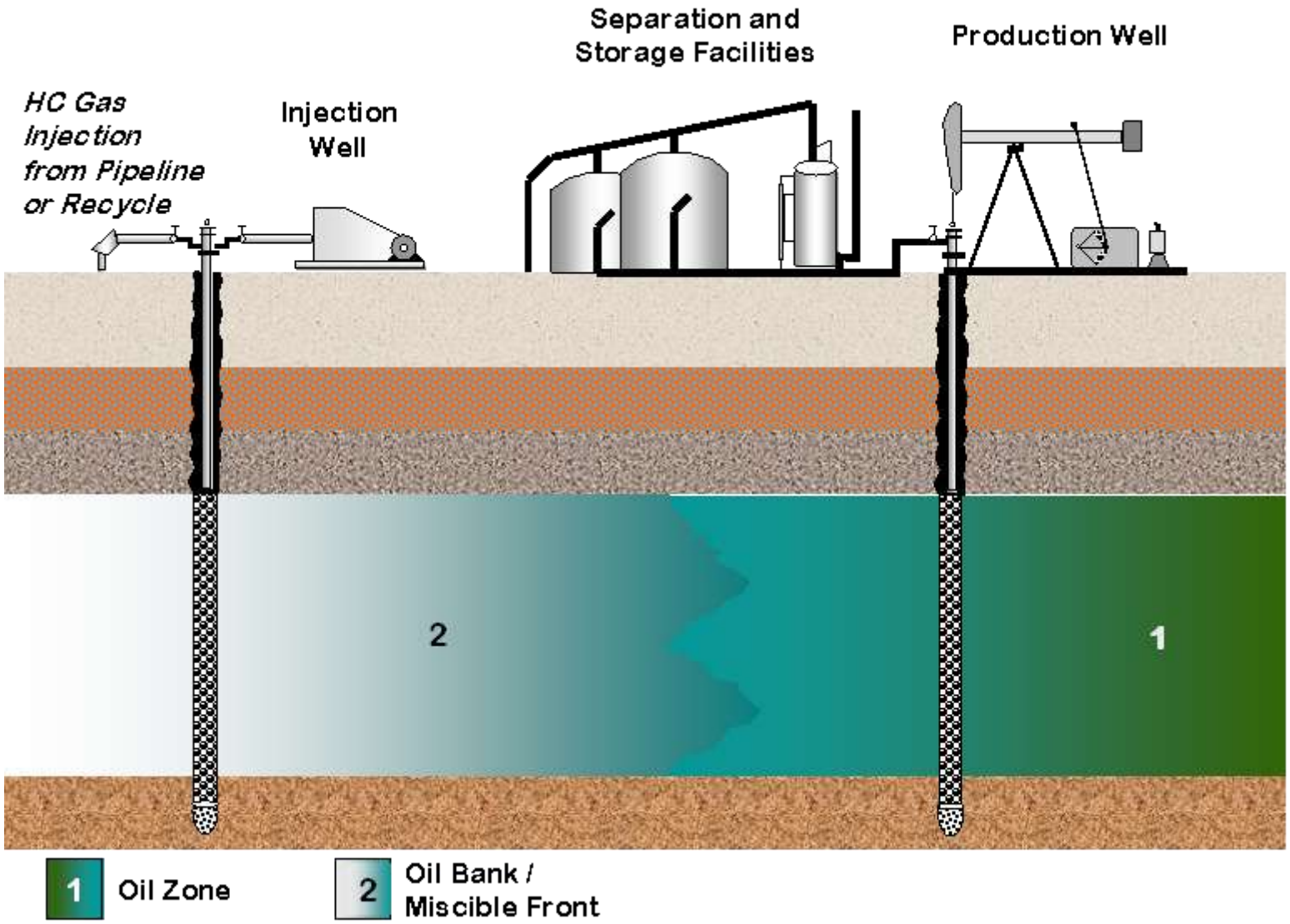
- Viscosity is a measure of the resistance to flow exerted by a fluid
- This is called dynamic viscosity and has units of

  centipoise = g mass / 100 sec cm
- Kinematic viscosity is viscosity / density, units are in

  centistokes = centipoise /g/cc

Needs of Crude Oil Viscosity

- Calculation of two-phase flow
- Gas-lift and pipeline design
- Calculate oil recovery either from natural depletion or from recovery techniques such as waterflooding and gas-injection processes


Separation and
Storage Facilities
Production Well
HC Gas
Injection
from Pipeline
or Recycle
Injection
Well
2
1
1
Oil Zone
2
Oil Bank /
Miscible Front

Variation of Oil Viscosity