PETE 310

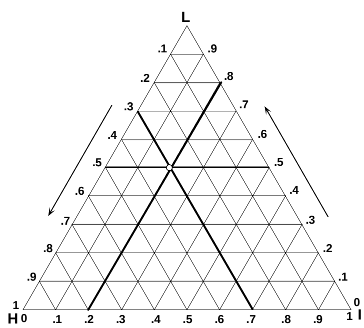
Review Lecture # 7

Three & Multicomponent Mixtures…

Plus

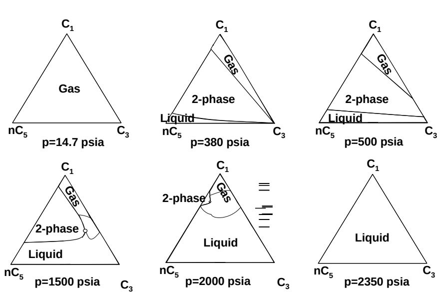
Lecture # 8 – Chapter 5

Ternary Diagrams: Review



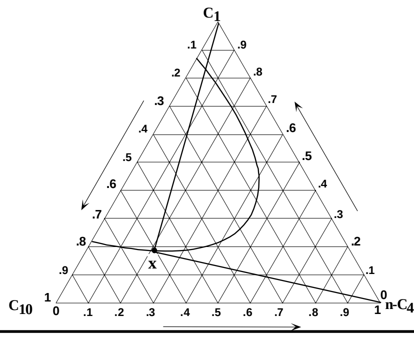
Ternary Diagrams: Review

Pressure Effect



Ternary Diagrams: Review

Dilution Lines



Ternary Diagrams: Review

Quantitative Representation of Phase Equilibria - Tie (or equilibrium) lines

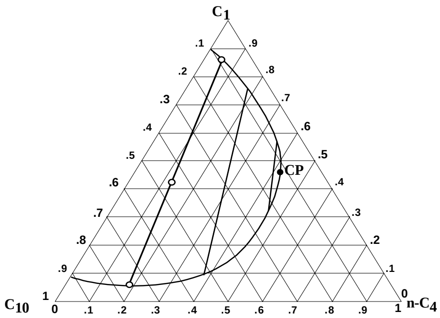
- Tie lines join equilibrium conditions of the gas and liquid at a given pressure and temperature.
  - Dew point curve gives the gas composition.
  - Bubble point curve gives the liquid composition.

Ternary Diagrams: Review

Quantitative Representation of Phase Equilibria - Tie (or equilibrium) lines

- All mixtures whose overall composition (z_i) is along a tie line have the SAME equilibrium gas (y_i) and liquid composition (x_i), but the relative amounts on a molar basis of gas and liquid (f_v and f_l) change linearly (0 – vapor at B.P., 1 – liquid at B.P.).

Illustration of Phase Envelope and Tie Lines



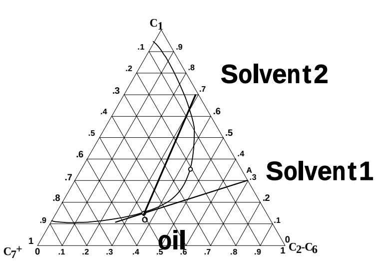
Uses of Ternary Diagrams

Representation of Multi-Component Phase Behavior with a Pseudoternary Diagram

- **Ternary diagrams may approximate phase behavior of multi-component mixtures by grouping them into 3 *pseudocomponents***
  - **heavy (C_7^+)**
  - **intermediate (C_2-C_6)**
  - **light (C_1, CO_2 , N_2- C_1, CO_2-C_2, ...)**

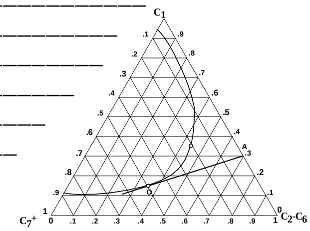
Uses of Ternary Diagrams

Miscible Recovery Processes



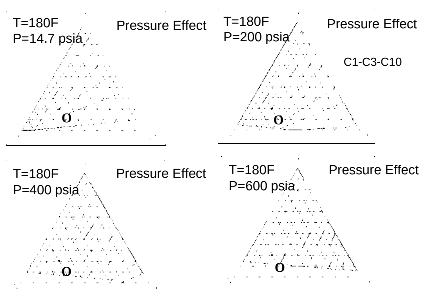
Exercise

Find overall composition of mixture made with 100 moles oil "O" + 10 moles of mixture "A".



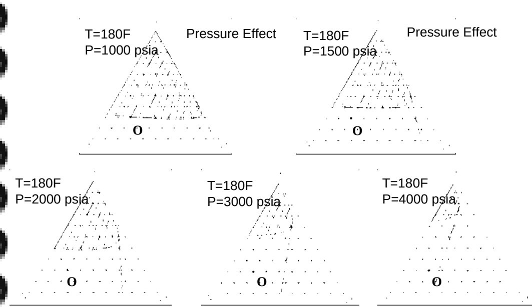
Practice Ternary Diagrams

Pressure Effect



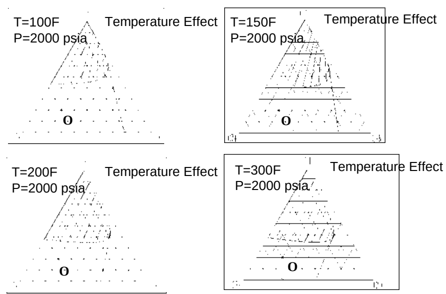
Practice Ternary Diagrams

Pressure Effect



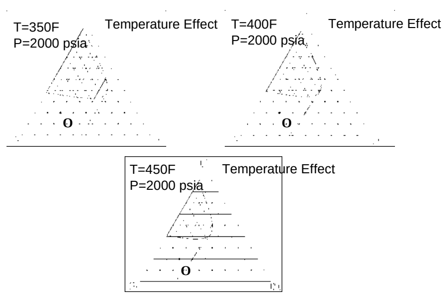
Practice Ternary Diagrams

Temperature Effect

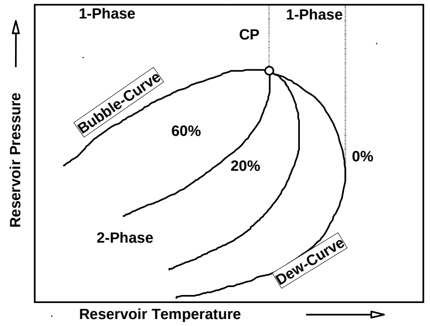


Practice Ternary Diagrams

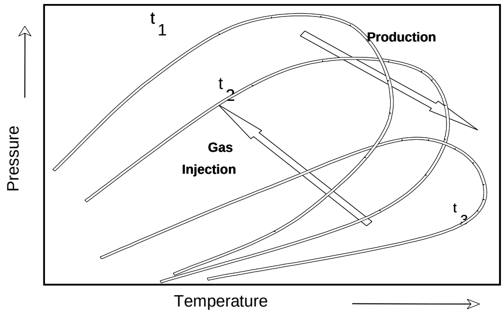
Temperature Effect



Pressure-Temperature Diagram for Multicomponent Systems



Changes During Production and Injection



PETE 310

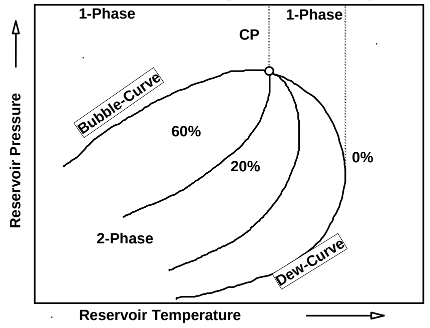
Lecture # 8: Five Reservoir Fluids (Chapter 5)

PETE 310 - Phase Behavior

Pressure vs. Temperature Diagrams

- ❑Used to visualize the fluids production path from the reservoir to the surface
- ❑To classify reservoir fluids
- ❑Visualize miscible processes

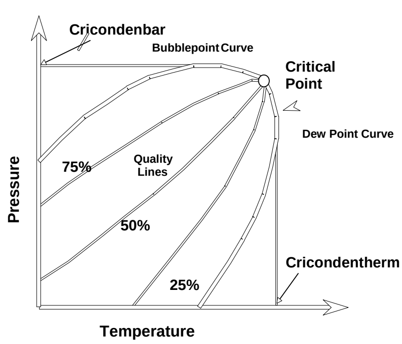
Pressure-Temperature Diagram for Multicomponent Systems



Why do we need to classify Reservoir Fluids?

- ❑ Determine fluid sampling
- ❑ Determine types and sizes of surface equipment
- ❑ Dictate depletion strategy
- ❑ Determine selection of EOR method
- ❑ Determine techniques to predict oil & gas reserves
- ❑ Determine Material Balance calculations

Phase Envelopes

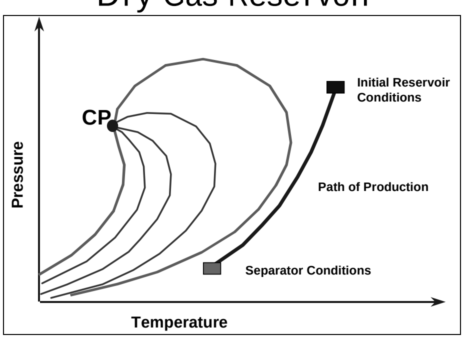


Fixed Composition

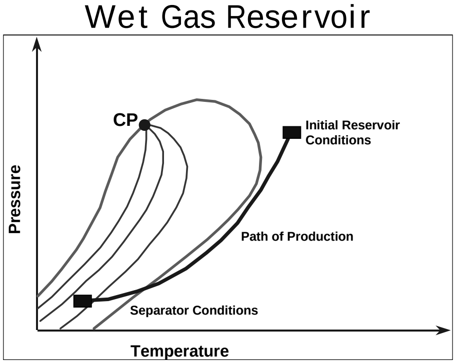
Classification of Reservoirs based on Phase Diagram

- Gas Reservoirs (Single Phase)
- Gas Condensate Reservoirs (Dew-Point Reservoirs):
- Undersaturated Solution-Gas Reservoirs (Bubble-Point Reservoirs):

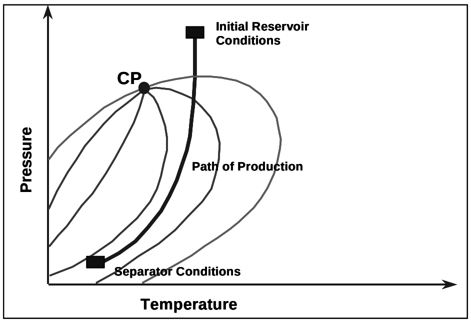
Phase Diagram of a Dry Gas Reservoir



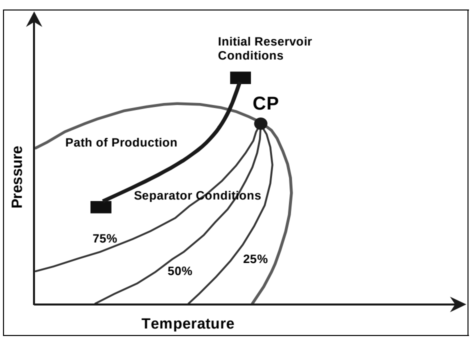
Phase Diagram of a Wet Gas Reservoir



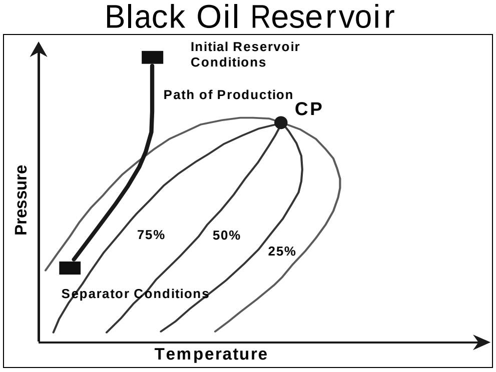
Phase Diagram of a
Retrograde Gas Reservoir



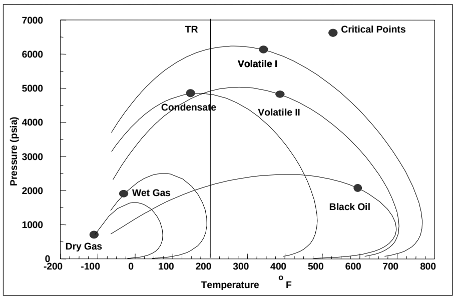
Phase Diagram of a
Volatile Oil Reservoir



Phase Diagram of a
Black Oil Reservoir



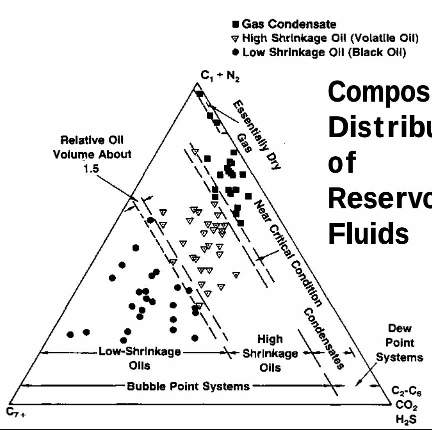
Phase envelopes of different mixtures with different proportions of same HC components



Typical Reservoir Fluid Compositions

Component	*Black Oil*	*Volatile Oil*	*Gas Condensate*	*Wet Gas*	*Dry Gas*
C_1	48.83	64.36	87.07	95.85	86.67
C_2	2.75	7.52	4.39	2.67	7.77
C_3	1.93	4.74	2.29	0.34	2.95
C_4	1.60	4.12	1.74	0.52	1.73
C_5	1.15	3.97	0.83	0.08	0.88
C_6	1.59	3.38	0.60	0.12	
C_7^+	42.15	11.91	3.80	0.42	
$M_wC_7^+$	225	181	112	157	
GOR	625	2000	18,200	105,000	-
Tank °API	34.3	50.1	60.8	54.7	-
Liquid Color	Greenish Black	Medium Orange	Light Straw	Water White	-

Compositional Distribution of Reservoir Fluids



Classification of Reservoirs based on Production and PVT data

GAS CONDENSATE RESERVOIRS:

- ❑GOR between 70,000-100,000 SCF/STB
- ❑Density greater than 60 °API
- ❑Light in color
- ❑C_7^+ composition $\leq$ 12.5%

Classification of Reservoirs based on Production and PVT data

VOLATILE OIL RESERVOIRS:

- ❑GOR between1,000-8,000 SCF/STB
- ❑Density between 45-60 °API
- ❑Oil FVF greater than 2.00 (high shrinkage oils)
- ❑Light brown to green in color
- ❑C_7^+ composition $\geq$ 12.5%

Classification of Reservoirs based on Production and PVT data

BLACK OIL RESERVOIRS:

- ❑GOR less than 1,000 SCF/STB
- ❑Density less than 45 °API
- ❑Reservoir temperatures less than 250 °F
- ❑Oil FVF less than 2.00 (low shrinkage oils)
- ❑Dark green to black in color
- ❑C_7^+ composition > 30%

Assignment

- Read and make a summary of revised & newer criteria for classification of Reservoir Fluids from given paper by William D. McCain in JPT September 1994

JPT paper Study Guide

- What are the distinctive features of black oils in terms of
  - Initial GOR & GOR vs time
  - Initial API & API vs time
  - Compositions
  - Color

JPT paper Study Guide

- What are the distinctive features of volatile oils in terms of
  - Initial GOR & GOR vs time
  - Initial API & API vs time
  - Compositions
  - Color

JPT paper Study Guide

- What are the distinctive features of Condensate gases in terms of
  - Initial GOR & GOR vs time
  - Initial API & API vs time
  - Compositions
  - Color

JPT paper Study Guide

- What are the distinctive features of Dry gases in terms of
  - Initial GOR & GOR vs time
  - Compositions