Research Summary

Impact of confinement on dew point pressure in unconventional gas condensate reservoirs

Elham Parsa, Colorado School of Mines

Problem Statement

- The research project conducted by Tuba Firincioglu investigated the effects of capillary discontinuities and surface forces on bubble point pressure of tight-oil reservoirs
- The results were incorporated into a special black-oil reservoir simulator (COZsim)
- Confinement is also expected to influence the dew-point behavior of unconventional gas-condensate reservoirs
- This research will extend the previous work to study the effects of capillary pressure and surface forces on dew point pressure of unconventional gas condensate reservoirs.

Importance

- Condensation especially around the wellbore decreases the well deliverability significantly
- Better estimation of dew point pressure helps to manage production by minimizing condensate drop-out in gas condensate reservoirs
- It has now been established that dew-point pressure obtained from PVT data does not represent the phase behavior in confinement of nano-pores
- When the condensate drop out begins, liquid and gas phase pressures are different by an amount controlled by the effect of confinement

Importance

- There are conflicting results in the literature about the effect of confinement on dew point pressure; a comprehensive investigation is required to reconcile the differences
- It is important to develop new relations to describe the phase transitions and interfacial dynamics of gas-condensate systems under nano-scale confinement
- Accurate black-oil simulation of unconventional gas-condensate reservoirs requires prediction of phase properties at corresponding pressures and confined fluid properties

Objective

- Improve understanding of confined condensate phase behavior
- Develop correlations of condensate phase behavior as function of an appropriate measure of confinement
- Improve numerical modeling of unconventional gas-condensate reservoirs and provide better prediction capabilities

Literature Review

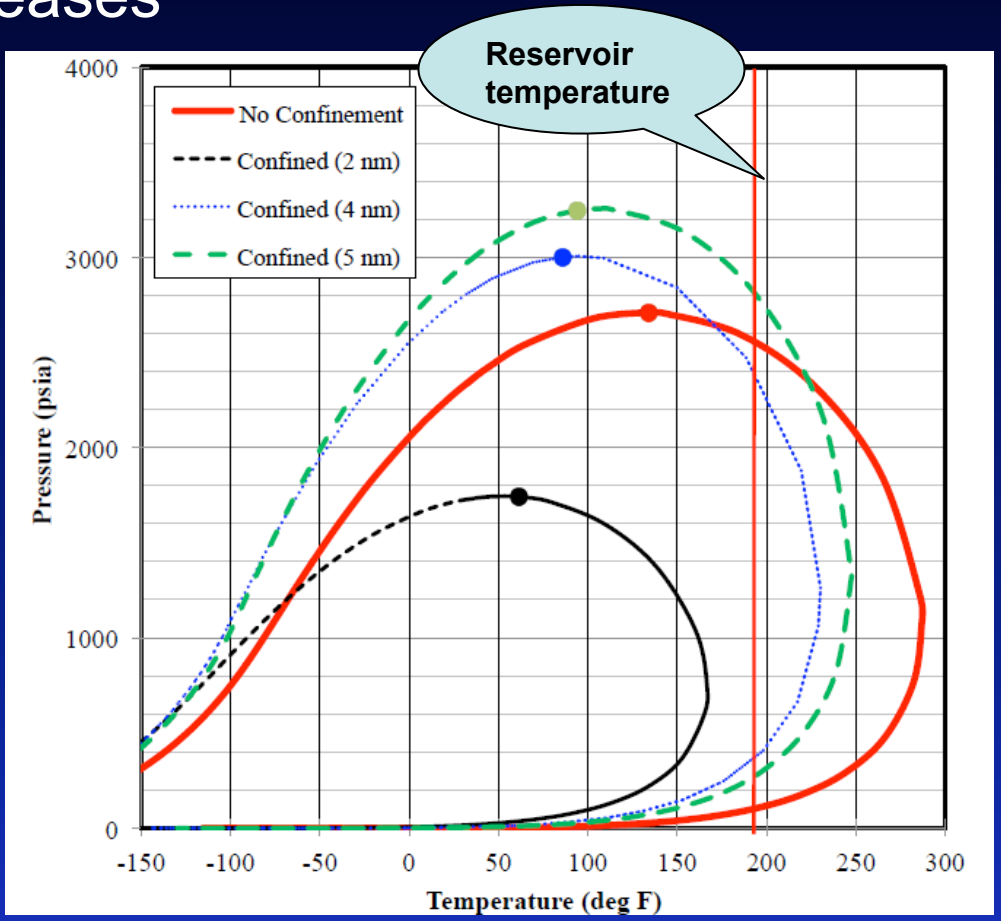
In a number of studies published in the literature, the effect of confinement has been reported to increase the dew-point pressure

- Dew point pressure of gas condensate in porous media can be 10 to 15 percent higher than those observed in conventional PVT cells. (Trebin and Zadora 1968)
- Brusilorsky at 1990 showed that surface curvature makes the dew point increase and bubble point decrease.
- Capillary pressure and adsorption increase the dew point. In the low permeability formations this effect is more obvious. (Ping 1996)

Literature Review

More recent studies, reaffirmed that the dew-point pressure decreases as pore size decreases

- Sapmanee et al. 2011 showed that the dew point could be higher or lower than that predicted without the effect of confinement
- Their work indicated a shift of the critical point (and the phase envelope) to the left (lower temperatures)

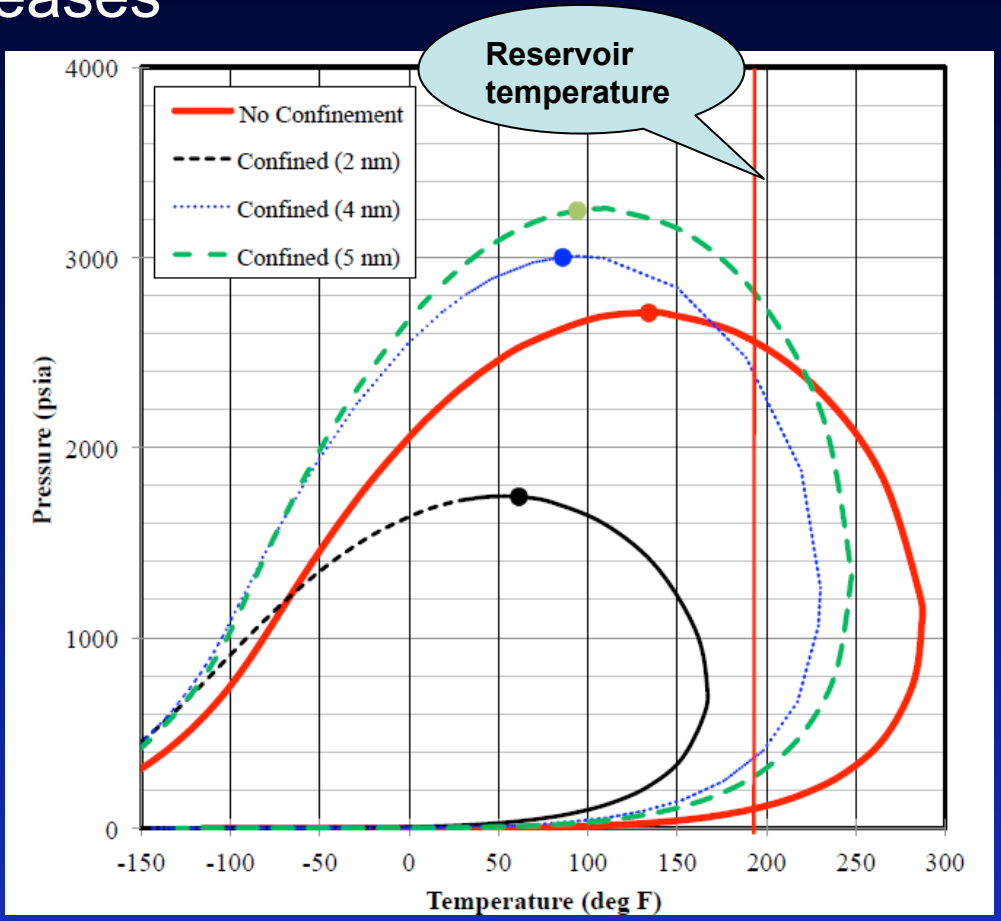


Kanin Sapmanee, 2011

Literature Review

More recent studies, reaffirmed that the dew-point pressure decreases as pore size decreases

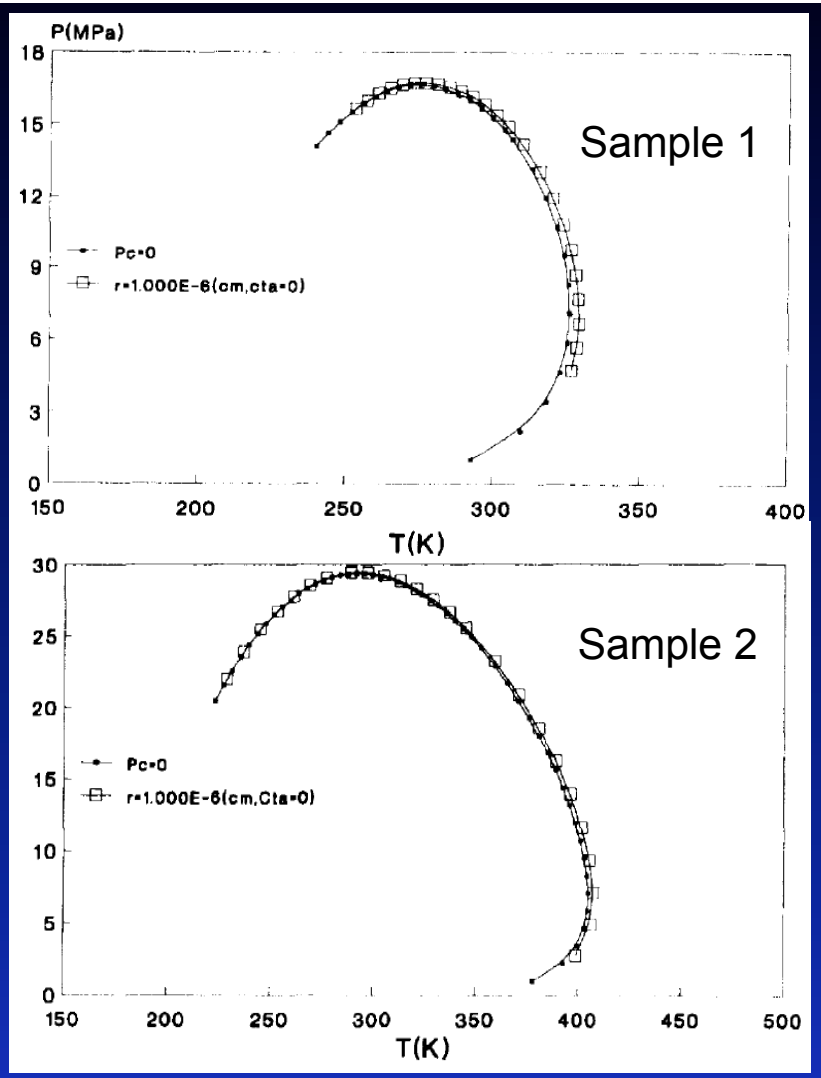
- Kanin at 2011 showed that confinement has significant effect on phase behavior of reservoir fluid.
- For example in ternary synthetic gas condensate mixture, critical point shifts to the left as pore size decreases.



Kanin Sapmanee, 2011

Literature Review

- Capillary pressure makes the dew point increase (phase envelope shifts to the right)
- Samples with different compositions show different changes in the same confinement media
- Sample 1 consists of C1, C3 and C5
- Sample 2 consists of C1 to C7+ and CO2, H2S and N2



Guo Ping et al. 1996

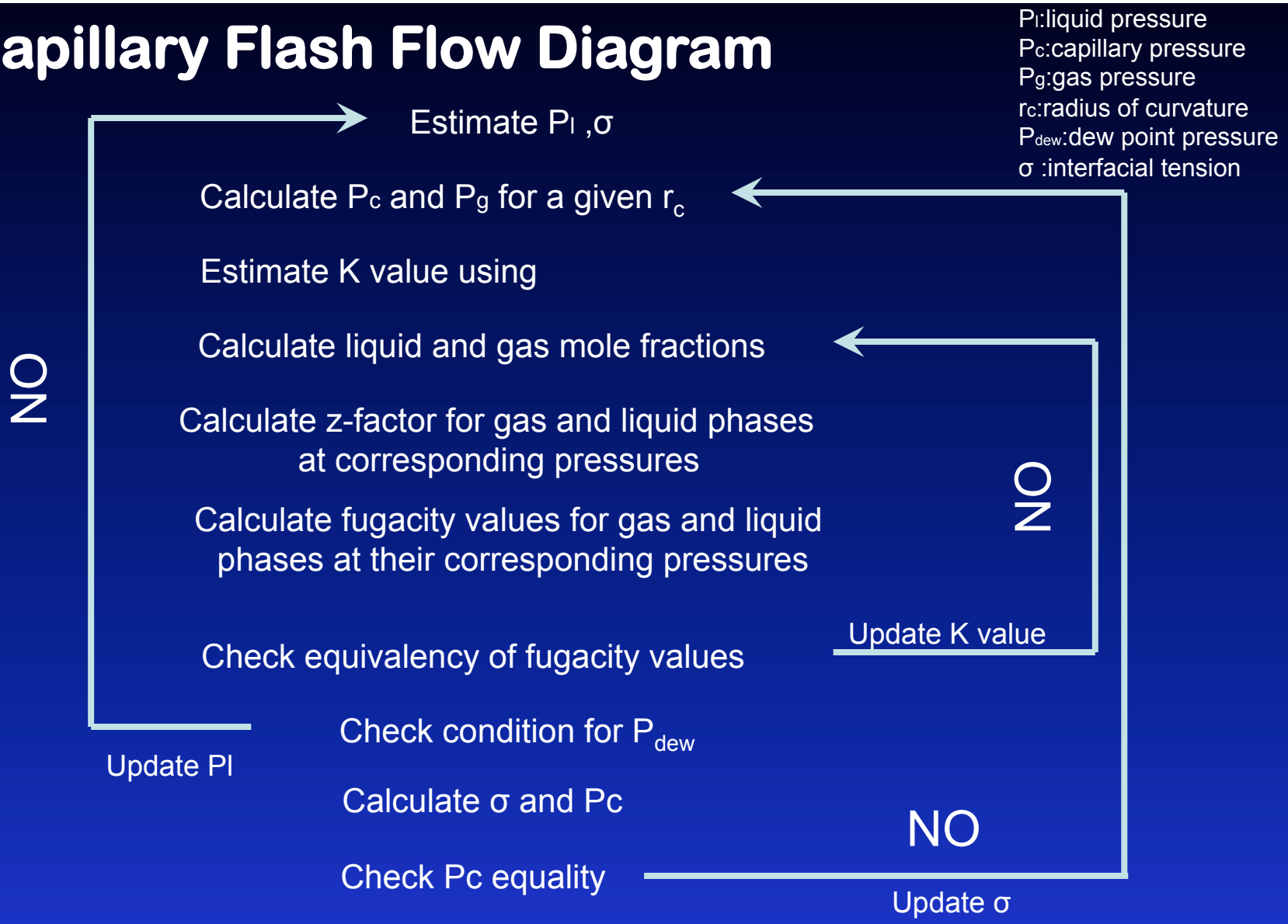
Approach

- It is important to quantify the impact of confinement on dew point in a simple way that is applicable to modeling
- Flash calculations are commonly used to determine the compositions at equilibrium and dew point can be calculated using

$$\sum_i \frac{z_i}{K_i} = 1$$

Approach

Capillary Flash Flow Diagram



Approach

- Consider the effect of van der Waals, electrostatic, and adsorptive forces in phase equilibrium calculations

  For liquid flow in nano-pores, the contribution of van der Waals surface forces on phase behavior has been found to be insignificant compared to capillary forces (Firincioglu et al. 2012).

Approach

- The findings will be provided in a format that can be incorporated into reservoir modeling applications

- Sensitivity tests will be performed using COZSim to assess the impact of confinement on flow performance.

Thank You