Research Summary

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

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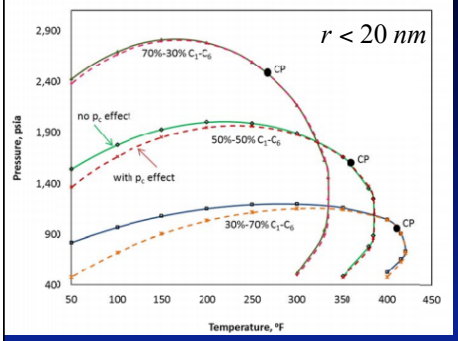
Importance

- 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

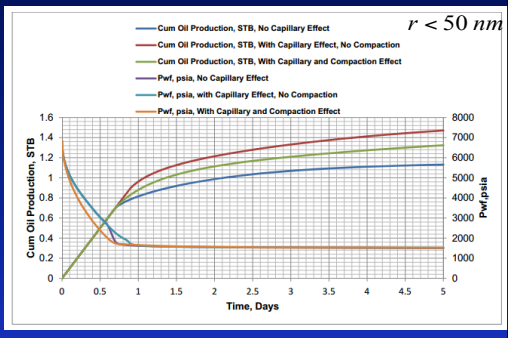
Importance

- 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

Literature Review

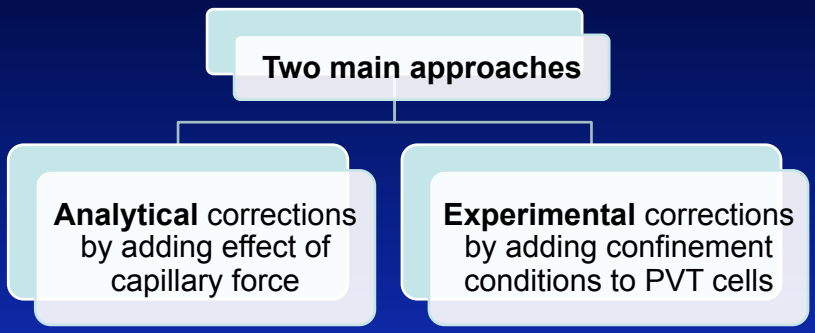


B. Nojabaei et al. 2012



Y. Wang et al. 2013

Improving the EOS for Confined Resrvoirs



Modeling PR EOS by Adding Capillary Effect

$$p_{cap} = p_g - p_L = \frac{2\sigma\cos\theta}{r}$$

$$\sigma = \left[(Par)_L \rho_L - (Par)_g \rho_g \right]^v$$

$$(Par)_L = \sum_{i=1}^{C} x_i Par_i \qquad (Par)_g = \sum_{i=1}^{C} y_i Par_i$$

$$(Par)_i = (8.21307 + 1.97473\omega_i) T_{ci}^{1.03406} p_{ci}^{-0.82636}$$

Jianyuan Pang et al. 2013

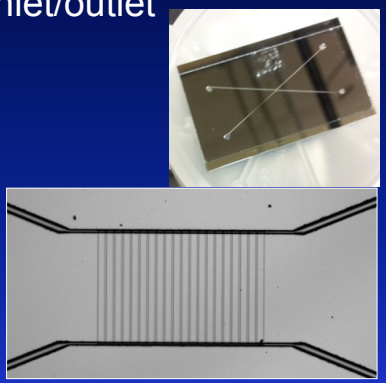
$$r = \frac{ab}{a+b}$$

Lei Wang et al. 2014

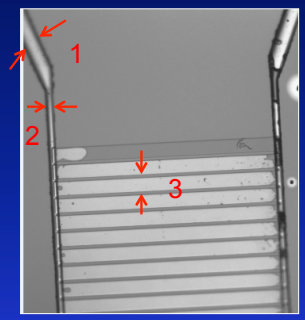
Doing negative flash using p_L to calculate liquid fugacity and z-factor while using $p_g=p_L+p_{cap}$ to calculate gas fugacity and z-factor

Laboratory Experiment

- Nano chips made of silicon and covered with Pyrex glass
- Three different size channels
- 4 inlet/outlet



Channel	Depth	Width	Lengh
1	10 µm	25 µm	
2	10 µm	10 µm	600 µm
3	500 nm	25 µm	400 µm



Chip Preparation

1- Cleaning the chip and Pyrex to remove any possible contamination and dust

* Piranha solution (75% H2SO4 +25% H2O2	* Takes 15 minutes and everything should be under hood

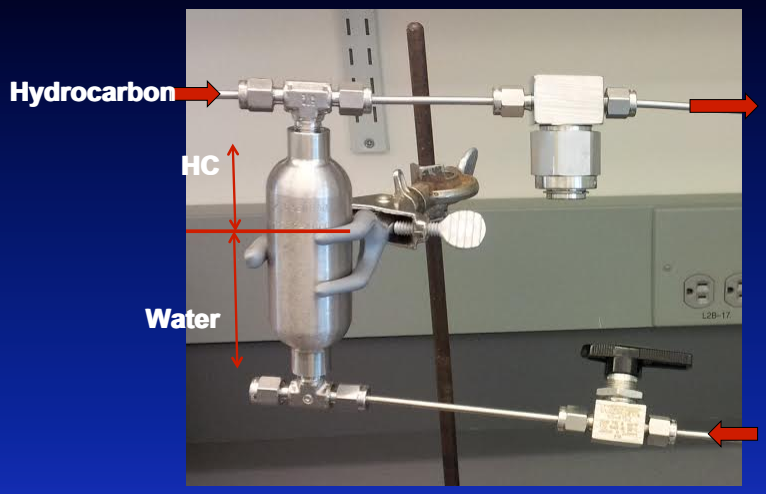
2- Binding the chip and Pyrex

* high voltage : 800 volts high temperature: 320 ˚F	* Takes between 4 to 10 hours

3- Binding 4 ports to the Chip-Pyrex

* Epoxy rings as adhesive	* 1 hour at 350 ˚F

Experiment Set Up



Lab Results

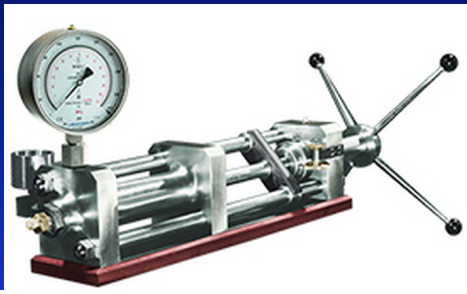
- Butane condensation: at room temperature (~ 68 ˚F) and 35 psi
- In all channels condensation happened at the same time
- Two different liquids (light gray, dark gray)
- Hysteresis: Condensation didn't evaporate after stopping the injection even with increasing temperature and injecting N2 at high pressure (150 psi)
- Since water is pushing the gas it might entered to chip and trapped there

Lab Results

- Applied vacuum (-0.8 atm) for 3 days to suck condensation out of chip, but still some liquid remained inside (concluded that capillary pressure inside chip is bigger than 0.8 atm)
- Redid the experiment with remained condensation inside the chip
- Dew point pressure increased this time to above 50 psi at room temperature (~ 68 ˚F) (in spite of our expectation that presence of some liquid may accelerate condensation)

New Set of Experiment

- Replaced the pump and water cylinder with a stronger pump that has piston on it
- Replaced the unknown composition butane with 99.99% propane (gas composition is necessary to do modeling)
- Prepared new chip with same dimensions



Thank You