

THE VOLUMETRIC MATERIAL BALANCE II

PRINCIPLE

THE VOLUME EXPANSION THAT A RESERVOIR SYSTEM UNDERGOES BETWEEN TWO PRESSURES EQUALS THE NET VOLUME VOIDAGE OF FLUIDS MEASURED AT THE SECOND PRESSURE.

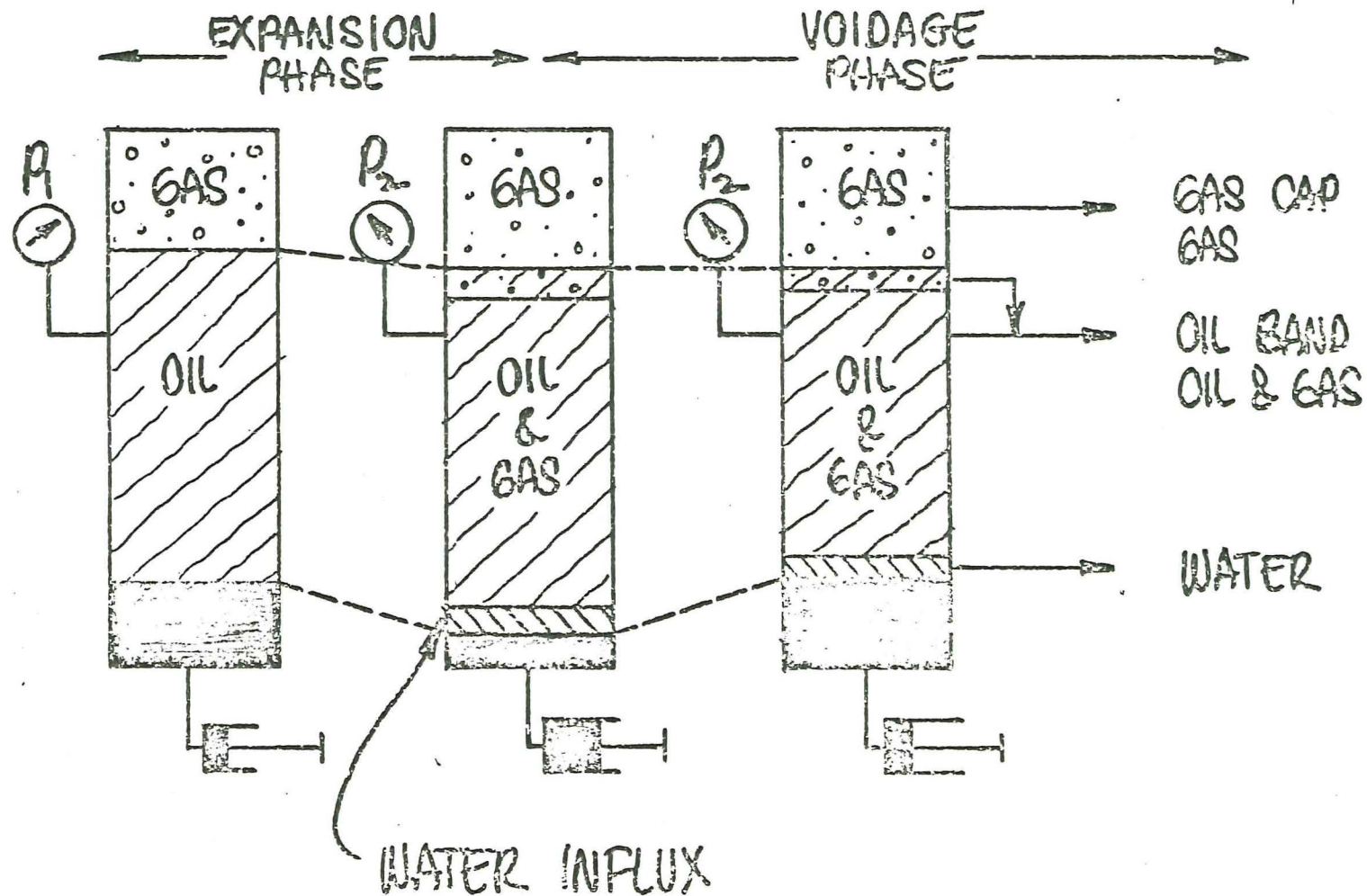
EXPANSION PARAMETERS

1. GAS CAP HYDROCARBONS
2. OIL BAND HYDROCARBONS
3. INTERSTITIAL WATER
4. ROCK MATRIX

VOIDAGE PARAMETERS

1. OIL & GAS PRODUCTION
2. WATER PRODUCTION
3. WATER INFLUX (NEGATIVE)
4. WATER INJECTED (NEGATIVE)
5. GAS INJECTED (NEGATIVE)

SCHEMATIC REPRESENTATION OF VOLUMETRIC MATERIAL BALANCE



THE VOLUMETRIC MATERIAL BALANCE III

PRINCIPLE: EXPANSION = VOIDAGE

EXPANSION (RESERVOIR BARRELS)

$$\text{GAS CAP} = m N B_{ti} \frac{B_g}{B_{gi}} - m N B_{ti} = m N B_{ti} \left(\frac{B_g}{B_{gi}} - 1 \right)$$

$$\text{OIL BAND} = N B_t - N B_{ti} = N (B_t - B_{ti})$$

$$\text{INTERSTITIAL WATER} = N B_{ti} (1+m) \left(\frac{S_{wi}}{1-S_{wi}} \right) \bar{c}_w \Delta p$$

$$\text{ROCK MATRIX} = N B_{ti} (1+m) \left(\frac{1}{1-S_{wi}} \right) \bar{c}_f \Delta p$$

VOIDAGE (RESERVOIR BARRELS)

$$\text{OIL \& GAS PRODUCTION} = N_p B_t + N_p (R_p - R_{si}) \frac{B_g}{5.615}$$

$$\text{WATER PRODUCTION} = W_p B_w$$

$$\text{WATER INFUX} = - W_e$$

$$\text{WATER INJECTED} = - W_i B_w$$

$$\text{GAS INJECTED} = - G_i \frac{B_g}{5.615}$$

THE VOLUMETRIC MATERIAL BALANCE IV

PRINCIPLE: EXPANSION = VOIDAGE

$$N(B_t - B_{ti}) + m N B_{ti} \left(\frac{B_g}{B_{gi}} - 1 \right) + N B_{ti} \frac{(1+m)}{(1-s_{wi})} [\bar{c}_w s_w + \bar{c}_f] \Delta p \\ = N_p \left[B_t + (R_p - R_{si}) \frac{B_g}{5.615} \right] + W_p B_w - W_e - W_i B_w - G_i \frac{B_{ig}}{5.615}$$

SPECIAL SITUATIONS

(1) UNDERSATURATED OIL ABOVE BUBBLE POINT

$m = 0$; $R_p = R_{si}$; $\bar{c}_w$ AND $\bar{c}_f$ MUST BE INCLUDED

(2) INITIAL GAS CAP

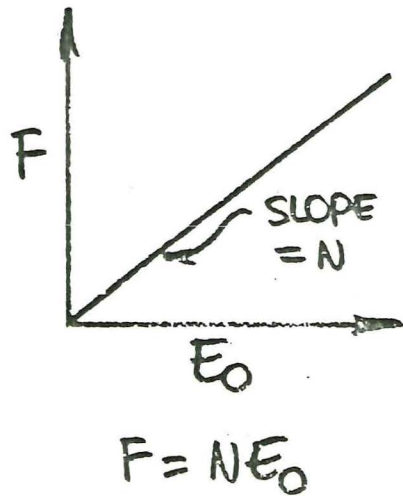
$m > 0$; EXCESS PRODUCED GAS $(R_p - R_{si}) N_p$ MAY BE SEPARATED INTO GAS CAP GAS AND OIL BAND GAS. B_g OF CAP GAS MAY DIFFER FROM B_g OF BAND GAS.

THE MATERIAL BALANCE AS A STRAIGHT LINE

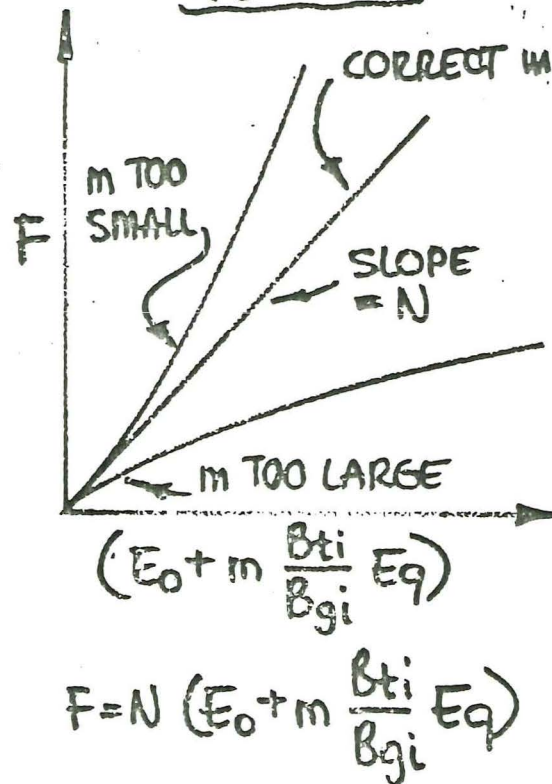
$$N(B_t - B_{ti}) + mN \frac{B_{ti}}{B_{gi}} (b_g - B_{gi}) + W_e = N_p B_o + \frac{(G_p - N_p R_s)}{5.6} b_g + (W_p - W_i) B_w$$

$$NE_o + mN \frac{B_{ti}}{B_{gi}} E_g + C \sum \Delta P_Q (\Delta t_p) = F$$

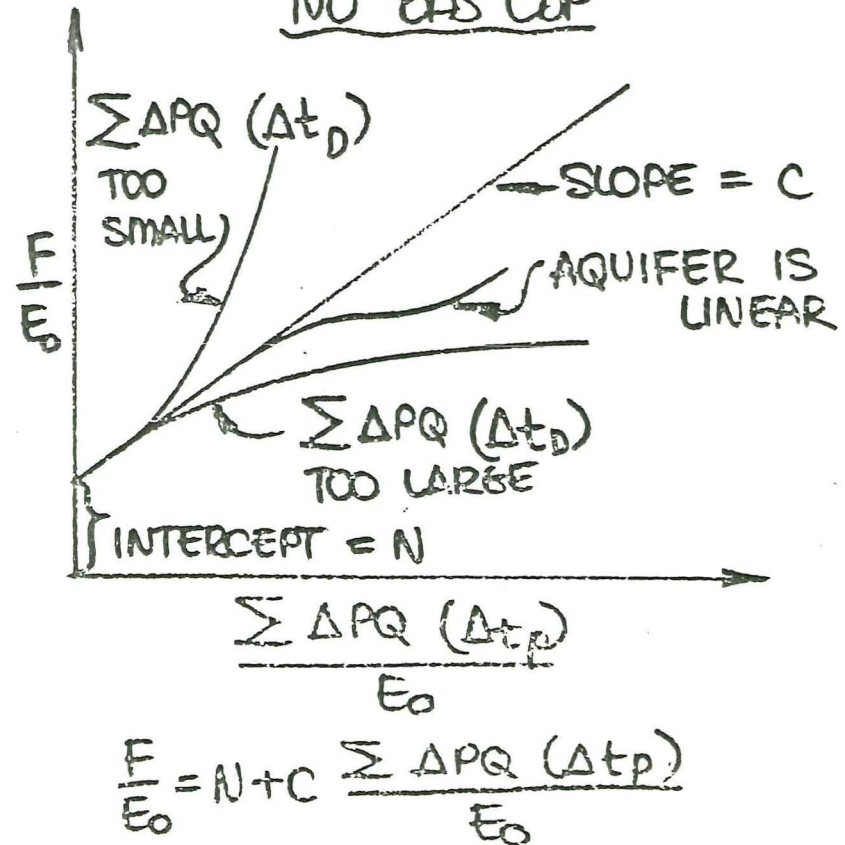
NO W.D.
NO GAS CAP



GAS CAP
NO W.D.

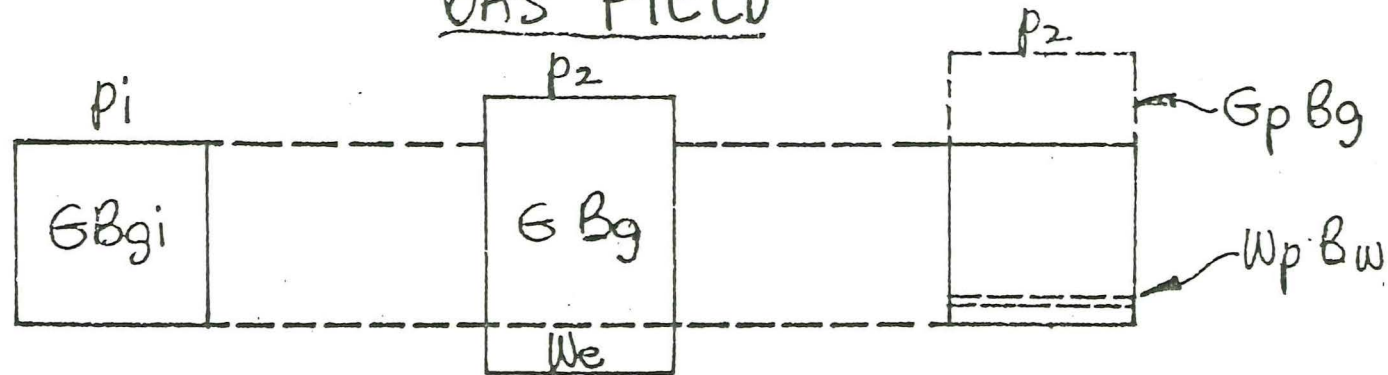


WATER DRIVE
NO GAS CAP



THE VOLUMETRIC MATERIAL BALANCE

GAS FIELD



PRINCIPLE: EXPANSION = VOIDAGE

EXPANSION: (RESERVOIR VOLUMES - 10^3 ft^3)

$$\text{GAS} = G B_g - G B_{gi} = G (B_g - B_{gi})$$

INTERSTITIAL WATER & ROCK MATRIX = NEGLECTIBLE

VOIDAGE: (RESERVOIR VOLUMES - 10^3 ft^3)

$$\text{PRODUCED GAS} = G_p B_g$$

$$\text{PRODUCED WATER} = W_p B_w$$

$$\text{WATER INFLUX} = -W_e$$

$$G (B_g - B_{gi}) = G_p B_g + W_p B_w - W_e$$

THE MATERIAL BALANCE AS A STRAIGHT LINE

GAS RESERVOIR

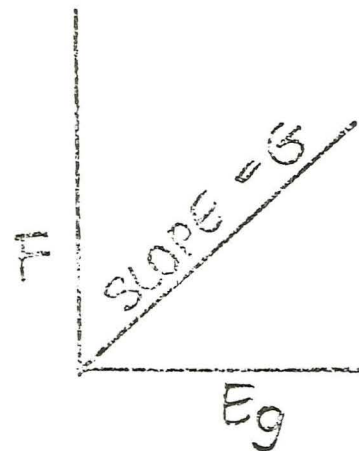
$$G_p B_g + W_p B_w - N_e = G (B_g - B_{gi})$$

$$\text{LET: } G_p B_g + W_p B_g = F \\ (B_g - B_{gi}) = E_g$$

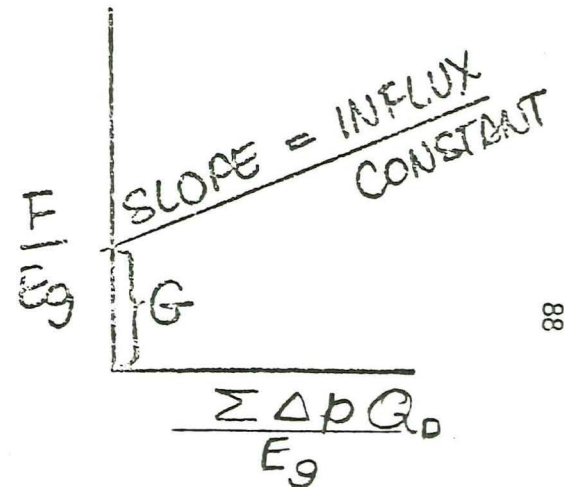
$$\text{THEN } F = G E_g + N_e$$

$$\frac{F}{E_g} = G + \frac{N_e}{E_g}$$

NO WATER INFUX



WATER INFUX



PIRSON'S FORM

$$\frac{N(B_t - B_{ti})}{N_p B_o + (G_p - N_p R_s) \frac{B_g}{5.6}} + \frac{m N B_{ti} \left(\frac{B_g}{B_{gi}} - 1 \right)}{N_p B_o + (G_p - N_p R_s) \frac{B_g}{5.6}} + \frac{(W_e - W_p) B_w}{N_p B_o + (G_p - N_p R_s) \frac{B_g}{5.6}} = 1$$

$$\frac{\text{OIL EXPANSION}}{\text{TOTAL VOIDAGE}} + \frac{\text{GAS CAP EXPANSION}}{\text{TOTAL VOIDAGE}} + \frac{\text{NET WATER INFLUX}}{\text{TOTAL VOIDAGE}} = 1$$

$$DDI + SDI + WDI = 1$$

IF D = DEPLETION DRIVE RECOVERY FACTOR

S = SEGREGATION DRIVE RECOVERY FACTOR

W = WATER DRIVE RECOVERY FACTOR

TOTAL RECOVERY FACTOR

$$= (D)(DDI) + (S)(SDI) + (W)(WDI)$$