Properties of Oilfield Waters

Lectures # 30 – 31

PETE 310

Topics

- Brine composition and density
- Water (brine) compressibility
- Formation volume factor and Pb
- Viscosity
- Mutual solubilities (gas in water, water in gas)

Water Production Issues

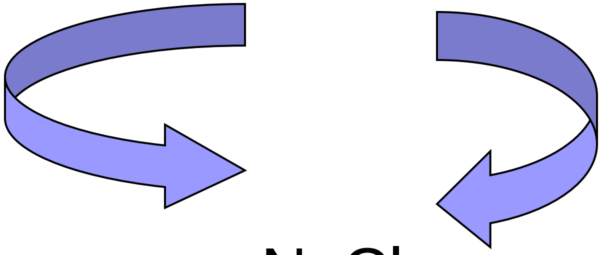
- Oil and gas wells produce more water than oil (7 bbl/1 bbl oil in Texas)
- Composition of co-produced water determines need for anti-scaling additives
- Regulations limit disposal and beneficial use options
- Environmental impact

Oilfield Water Issues

- Expensive Oilfield Water Management
- Diversity of Oilfield Waters (amount, compositions)
- Corrosion, Scale Control and Plugging
- Microbiological Problems
- Water Quality for Water-flooding, Steam Injection or Surface Disposal
- Injectivity Decline in Water Injection Wells

Dissolved Solids in Brines

- Cations
  - Na^{+}
  - K^{+}
  - Li^{+}
  - Ca^{++}
  - Mg^{++}
  - Ba^{++}
  - Fe^{++}
  - Sr^{++}

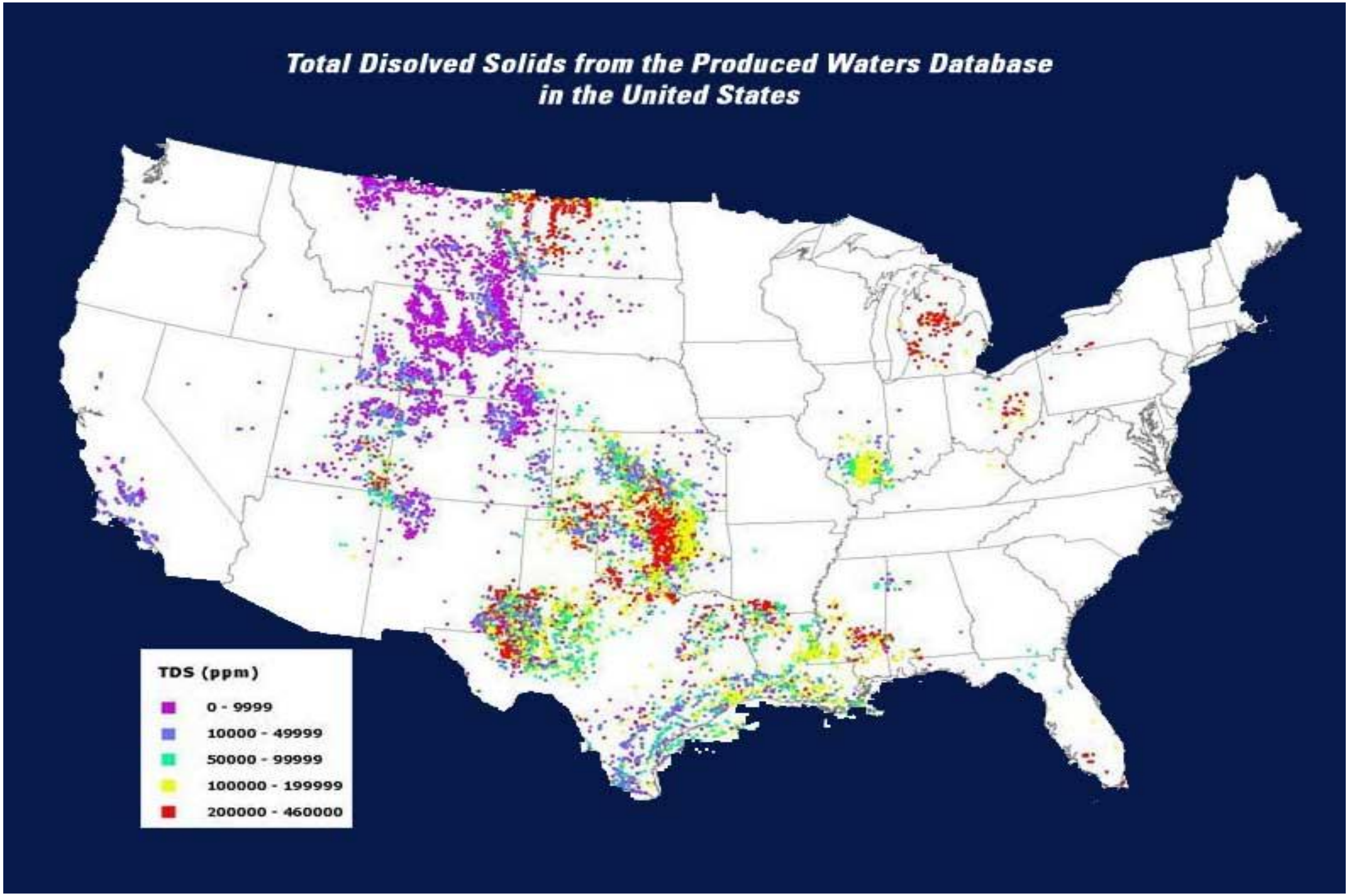


NaCl

SALTS

- Anions
  - Cl^{-}
  - $SO_4^{=}$
  - $CO_3^{=}$
  - CO_3H^{-}
  - NO_3^{-}
  - Br^{-}
  - I^{-}

Total Dissolved Solids (TDS)



Measures of Solids Concentration

TABLE 16–1

Summary of nomenclature and units for concentration of dissolved solids in formation waters (adapted from Monograph Series, SPE 9, 38)

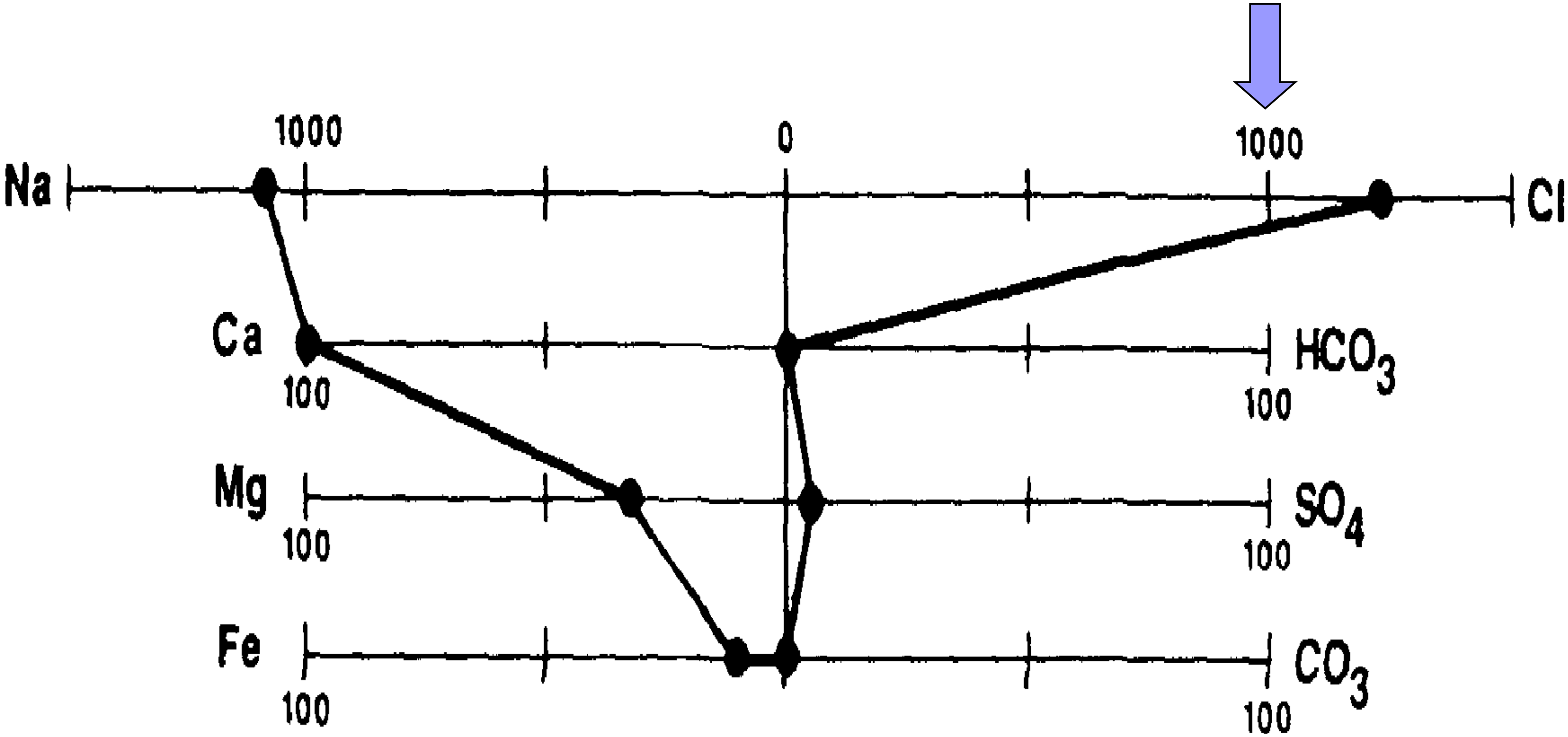
Term	Symbol	Definition	Equations
Molality	C_m	$\frac{\text{g mole solid}}{\text{1000 g pure water}}$	
Molarity	C_M	$\frac{\text{g mole solid}}{\text{1000 ml brine}}$	
Normality	C_N	$\frac{\text{eq wt solid}}{\text{1000 ml brine}}$	
Milliequiv-alents per liter	$C_{meq/l}$	$\frac{\text{meq solid}}{\text{1000 ml brine}}$	$C_{meq/l} = 1000 \times C_N = C_{mg/l}/\text{eq wt}$
Weight percent solids	C_W	$\frac{\text{g solid}}{\text{100 g brine}}$	$C_W = C_{ppm} \times 10^{-4}$
Parts per million	C_{ppm}	$\frac{\text{g solid}}{10^6 \text{ g brine}}$	$C_{ppm} = C_W \times 10^4 = C_{mg/l}/\rho_w$
Milligrams per liter	$C_{mg/l}$	$\frac{\text{g sold}}{10^6 \text{ ml brine}}$	$C_{mg/l} = \rho_w \times C_{ppm} = \rho_w \times C_W \times 10^4$
Grains per gallon	$C_{gr/gal}$	$\frac{\text{grains solid}}{\text{gal brine}}$	$C_{gr/gal} = 17.1 \times C_{mg/l} = 17.1 \times \rho_w \times C_{ppm}$

where ρ_w is in g/cc at standard conditions

ρ_w is
brine density
which depends upon
solids in solution

Stiff Diagrams

Milliequivalents per liter



Typical Concentrations

Cation	Ion concentration, ppm	Anion	Ion concentration, ppm
Sodium	23,806	Chloride	41,312
Calcium	1,906	Bicarbonate	51.5
Magnesium	375	Sulfate	283
Iron	297	Carbonate	0
Barium	0		

TDS = 68,030 ppm → 6.8% → get ρ_w → convert to mg/l

Cation	Ion concentration, mg/l	Anion	Ion concentration, mg/l
Sodium	24,939	Chloride	43,278
Calcium	1,997	Bicarbonate	54
Magnesium	393	Sulfate	296
Iron	311	Carbonate	0
Barium	0		

Conversions: mg per liter → milliequivalents per liter

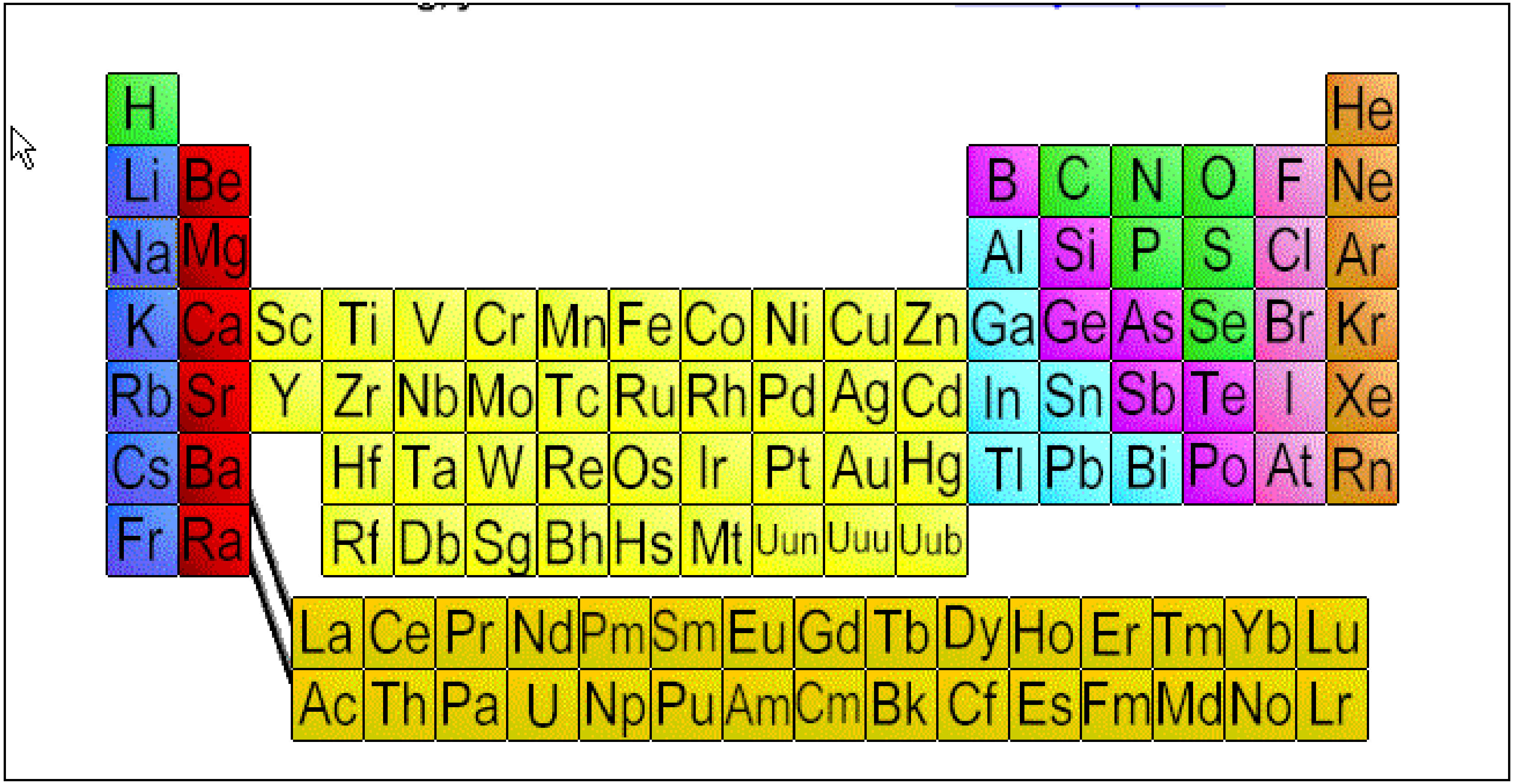
- See examples in text

Conversions: mg per liter → milliequivalents per liter

- Valence is # of charges (+ or -). Expressed as equivalent wt per g mole
  - Ca^{++} has ionic weight of 40.08 g/g mole
  - Equivalent weight is
    - 40.08 g/g mole/2 eq wt/g mole = 20.4 g/eq wt
- Atomic weight divided equivalent weight is mg / meq
- Milliequivalents per liter of calcium are
  - *** mg/l / 20.04 mg/meq = ***

Periodic Table

[Info for each element here!]



More information here → http://pearl1.lanl.gov/periodic/default.htm

Bubble Point Pressure of Oilfield Water

- Pb is the same as the Pb of the coexisting oil due to thermodynamic equilibrium

Formation Volume Factor (B_w)

- Depends upon pressure
- Depends upon temperature

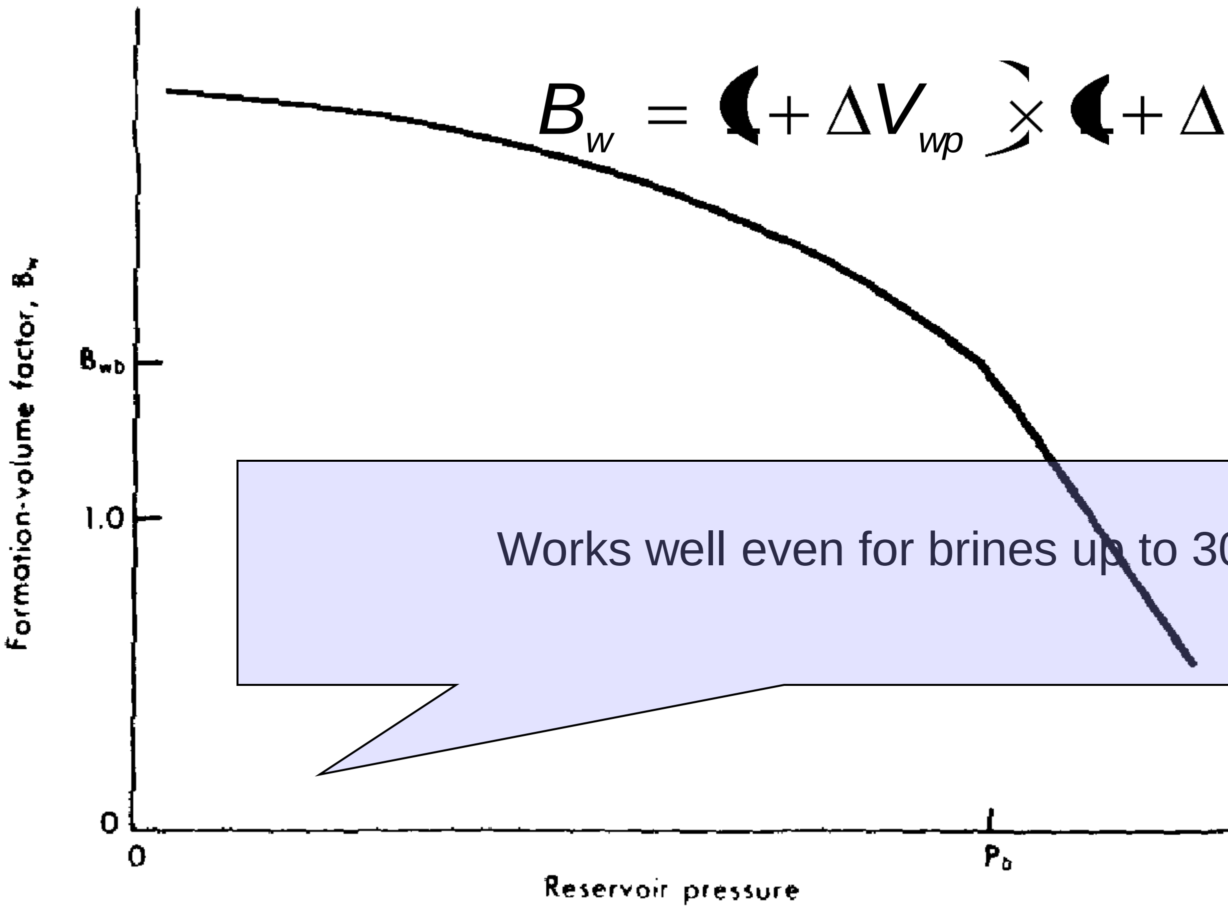
Offsetting

- Depends upon gas in solution

– negligible effect -

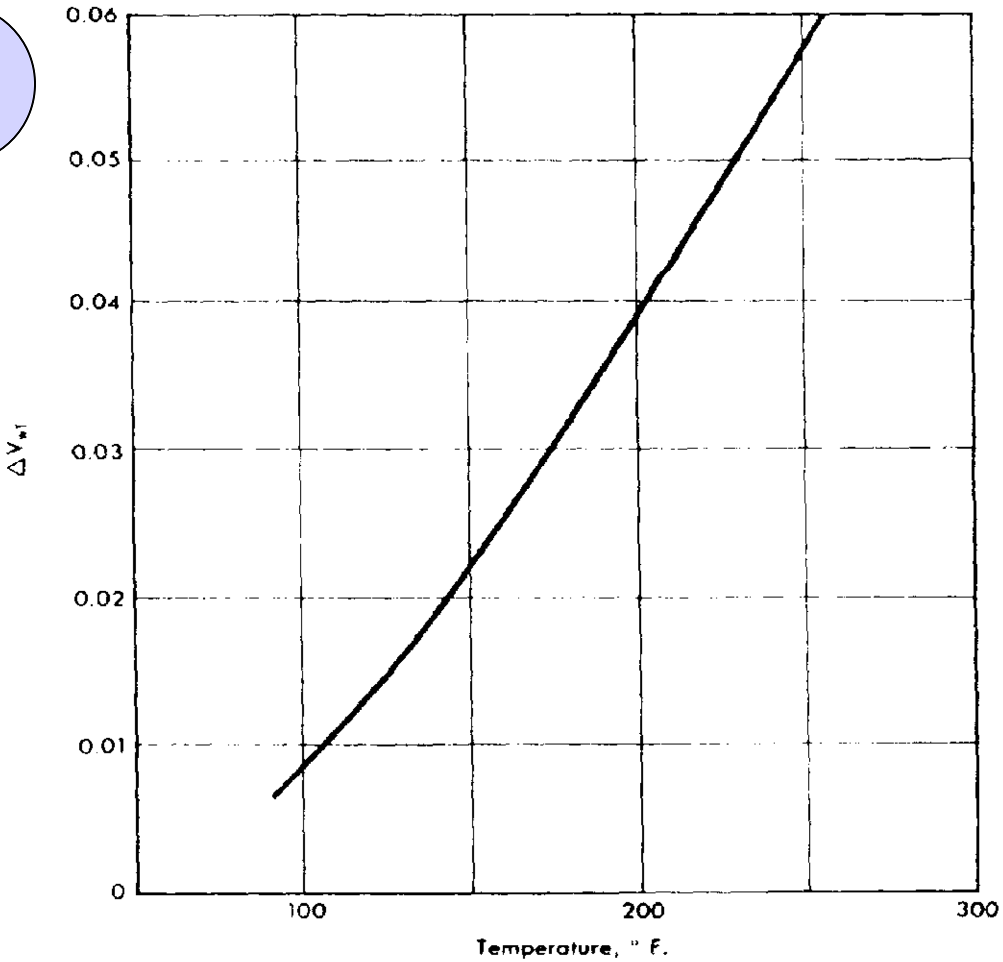
Formation Volume Factor of Water (B_w)

$$B_w = (1 + \Delta V_{wp})(1 + \Delta V_{wT})$$



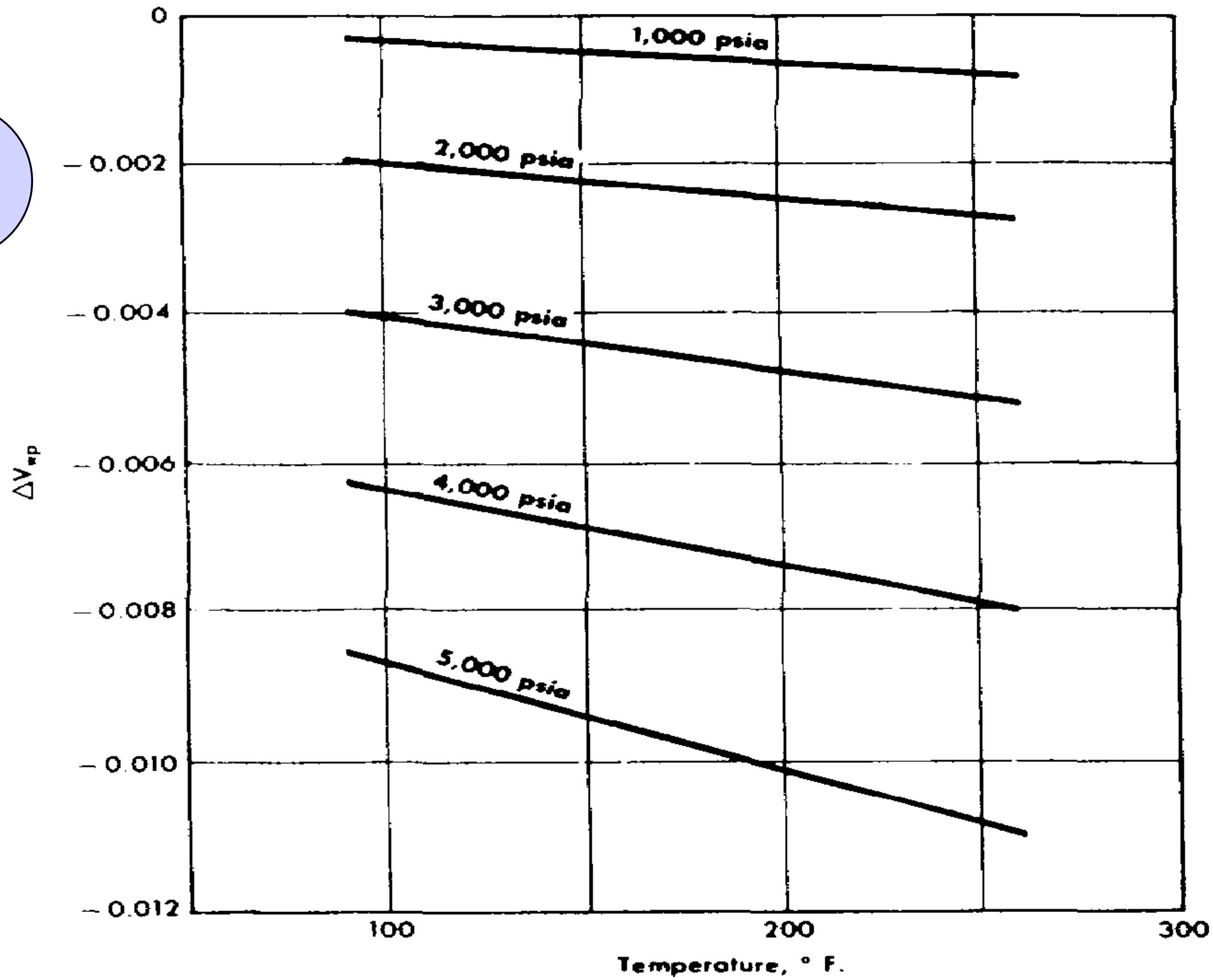
Works well even for brines up to 30% TDS

Temperature Correction

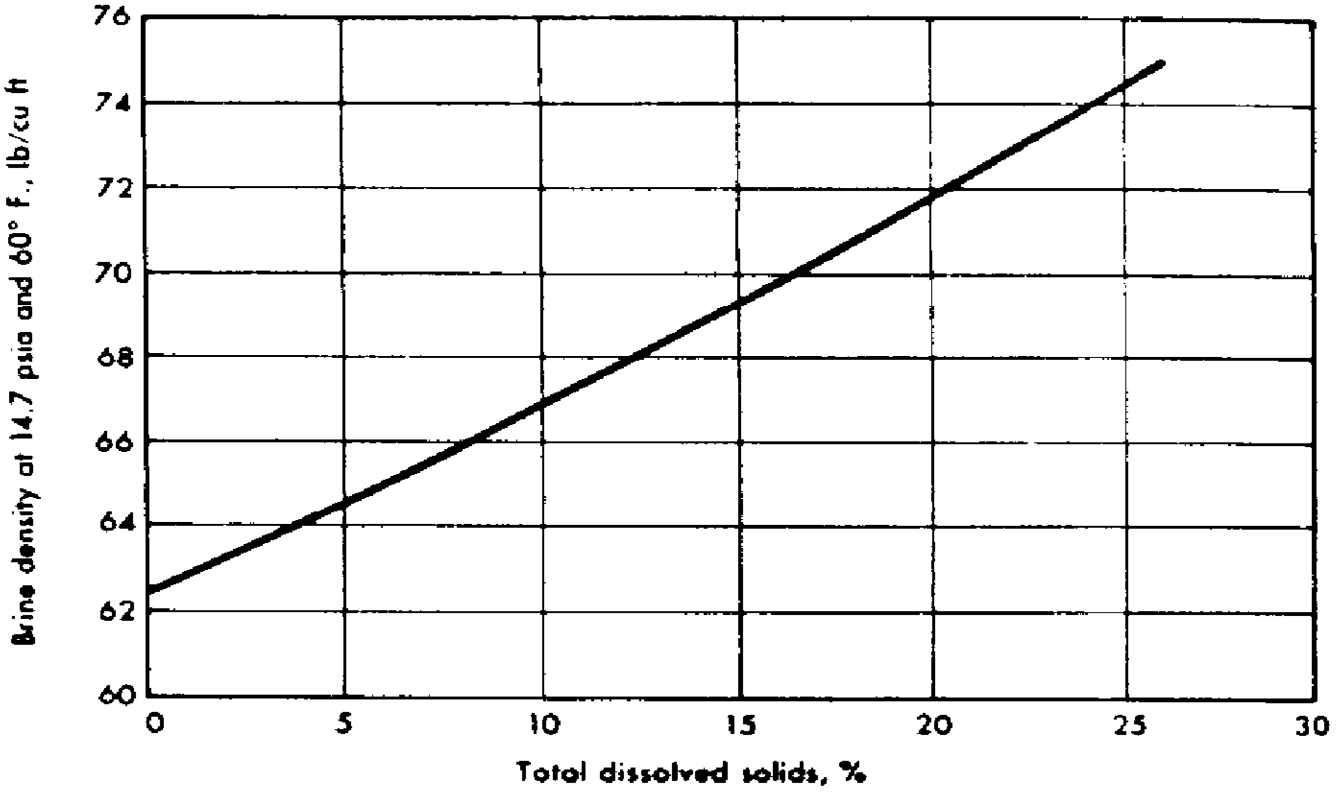


Pressure Correction

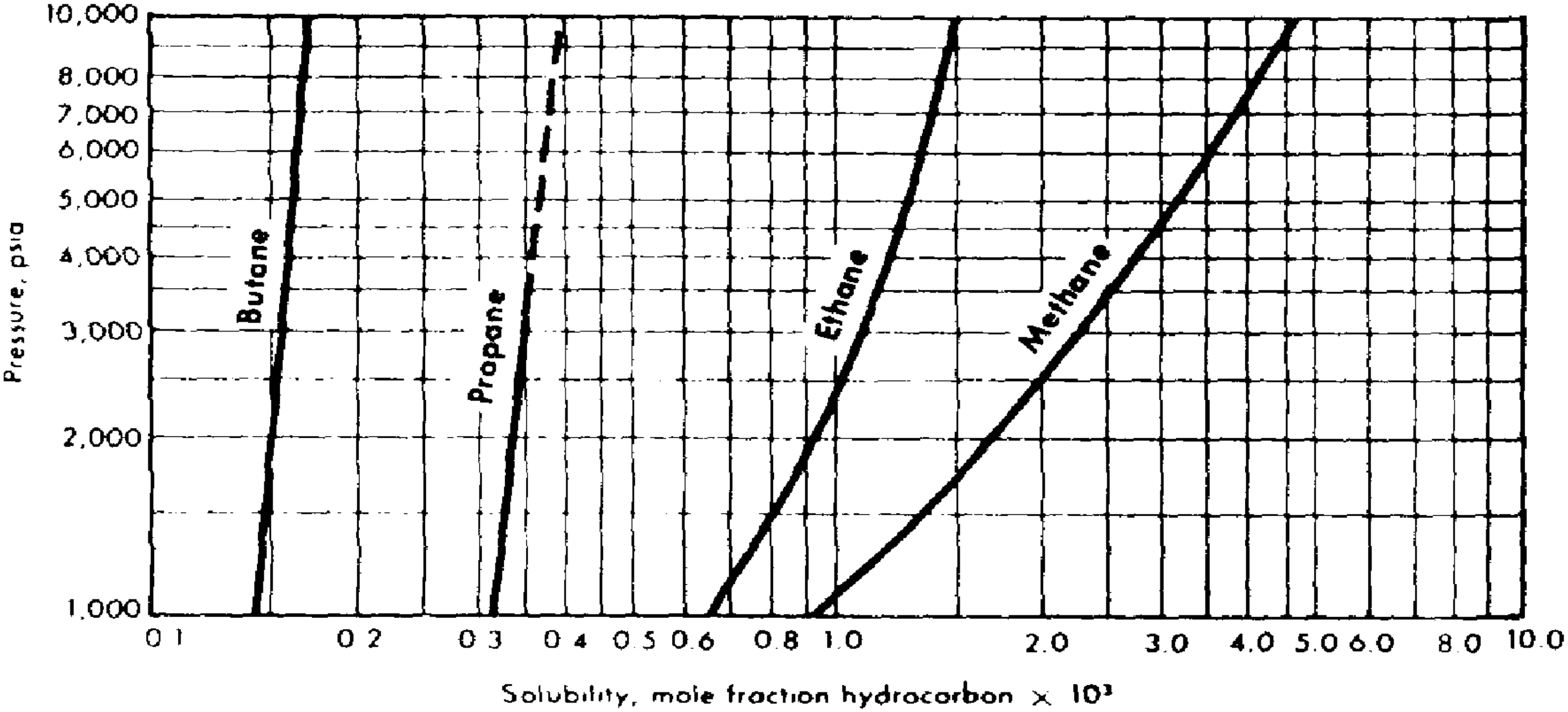
-



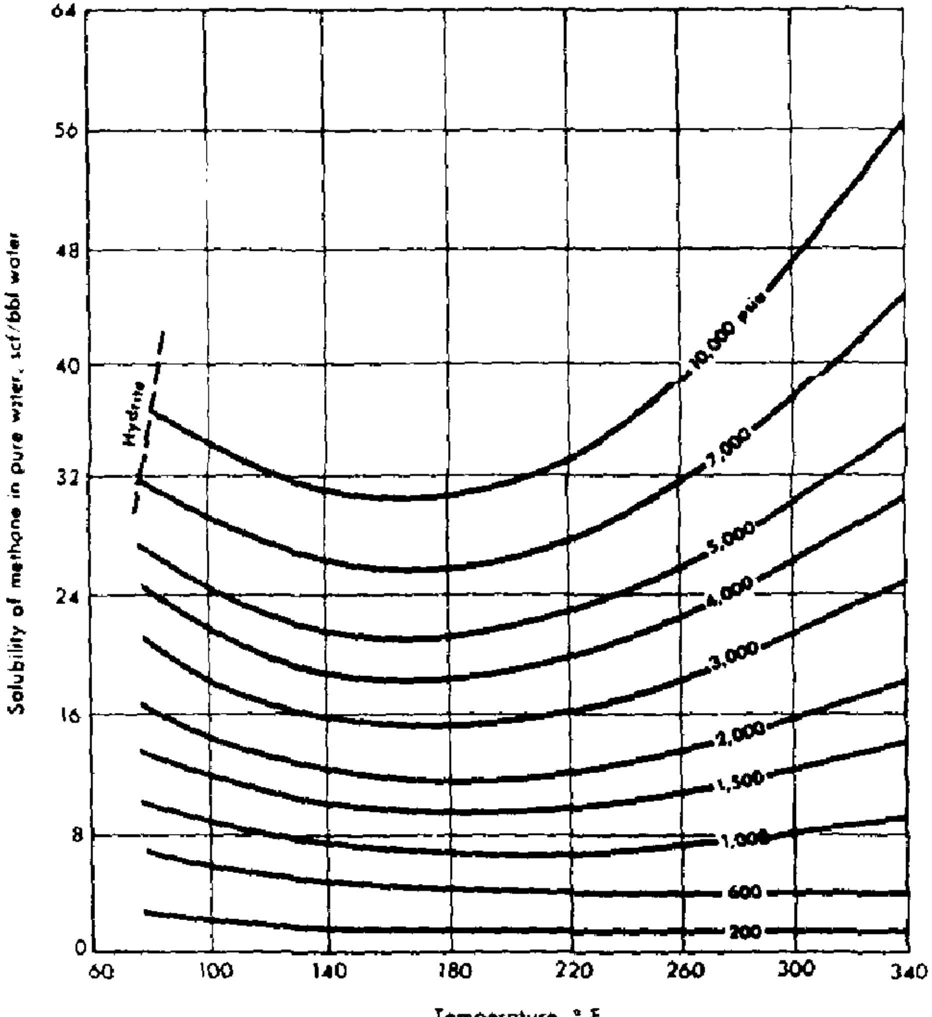
Effect of TDS on Brine Density



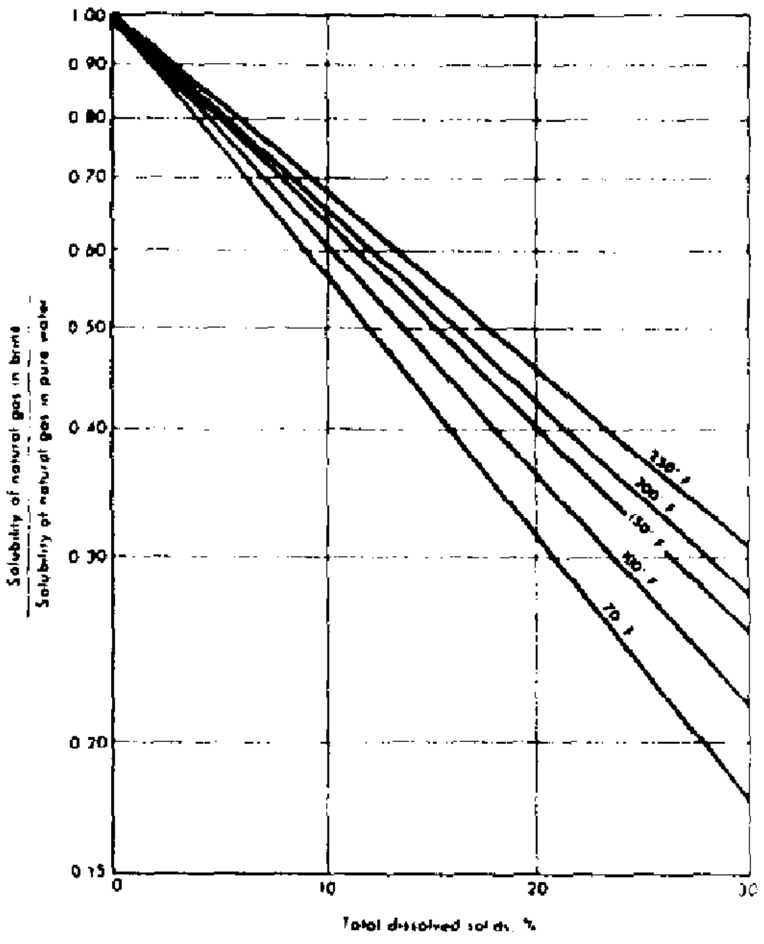
Solubility of Hydrocarbons in Water



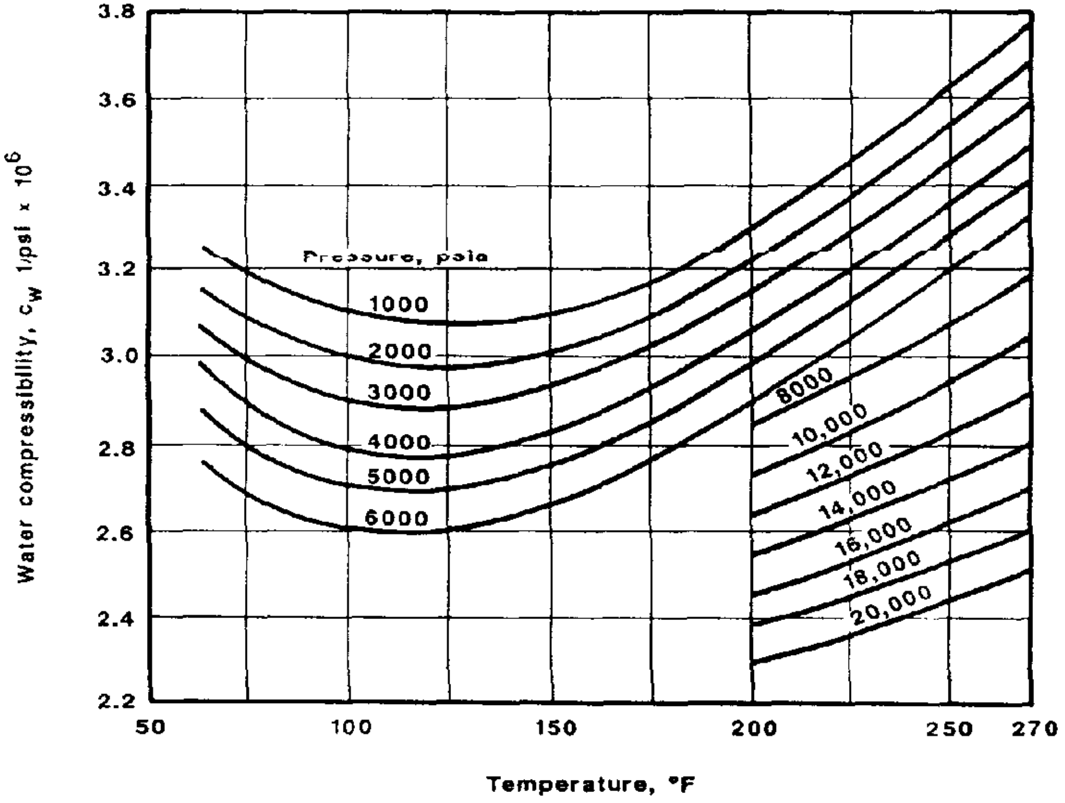
Solubility of Methane in Water



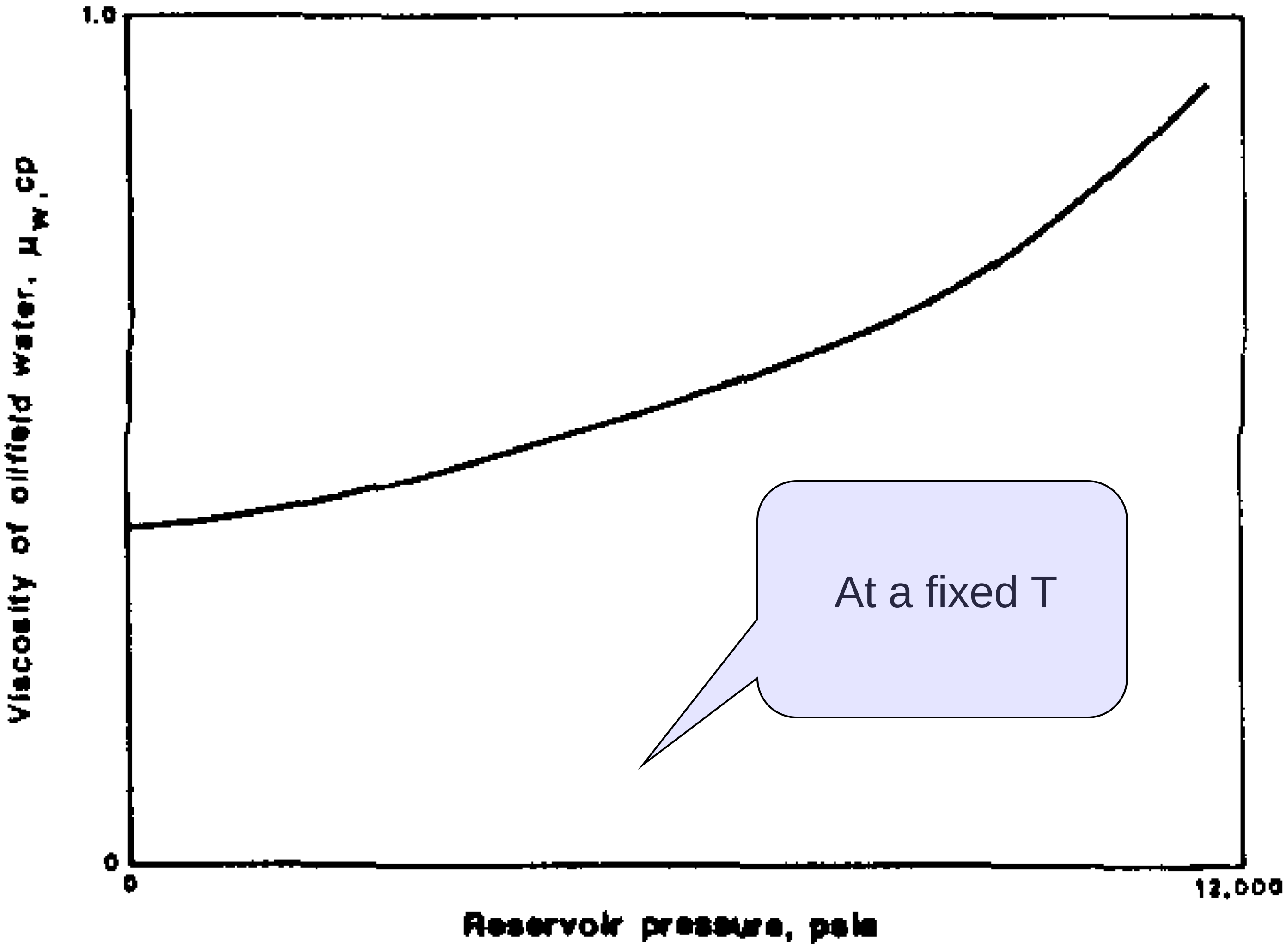
Effect of Salinity on solubility of gas in water



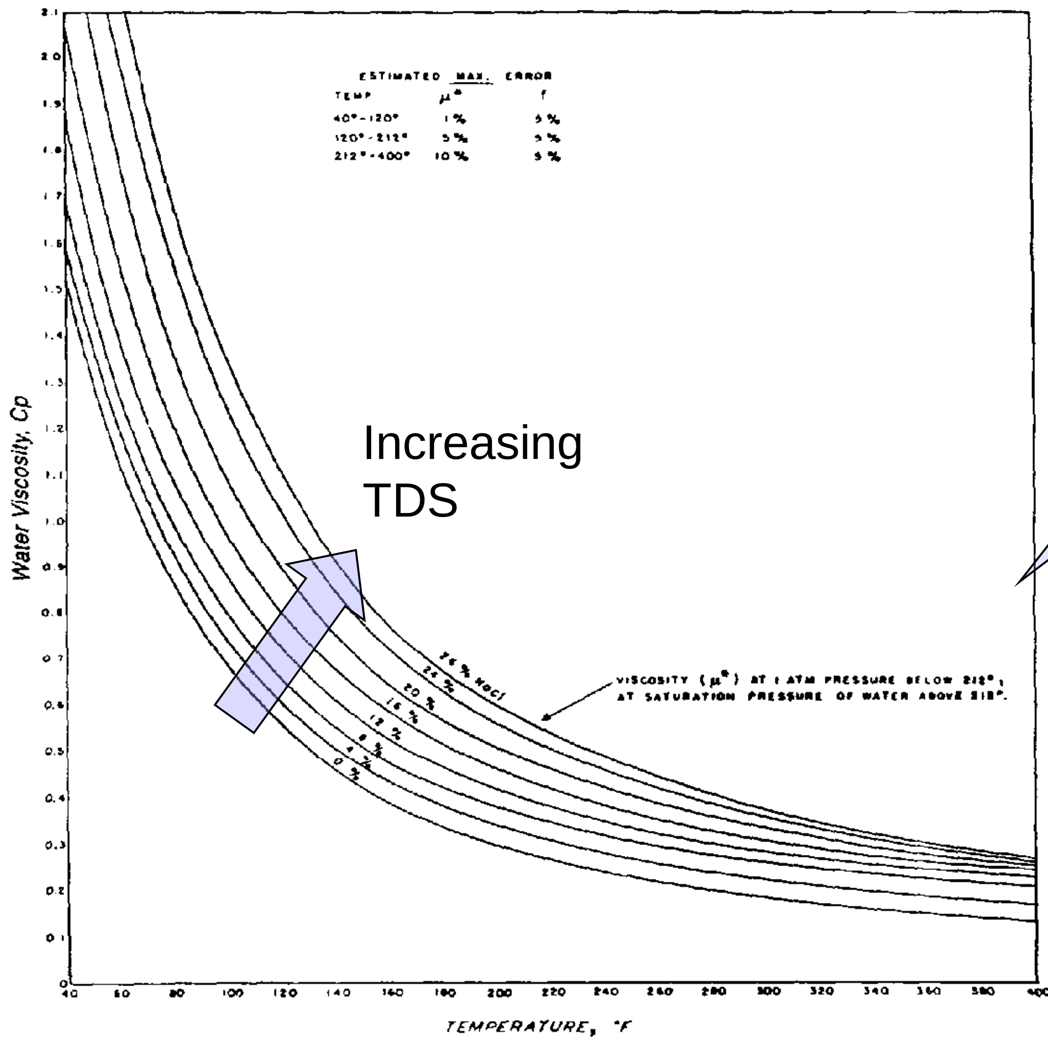
Coefficient of Isothermal Compressibility (C_w)



Viscosity of Water versus Pressure

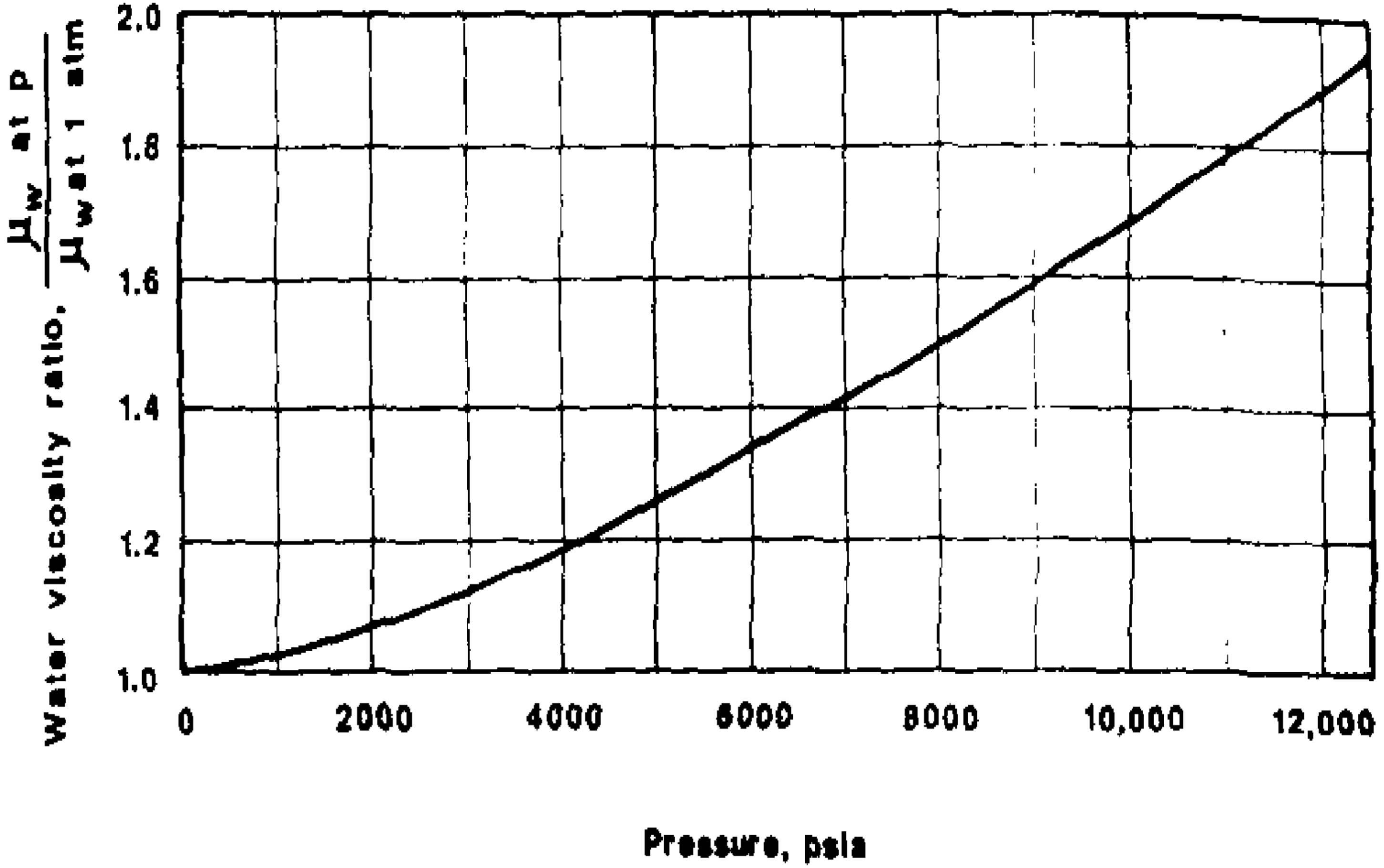


Water (Brine) Viscosity versus TDS

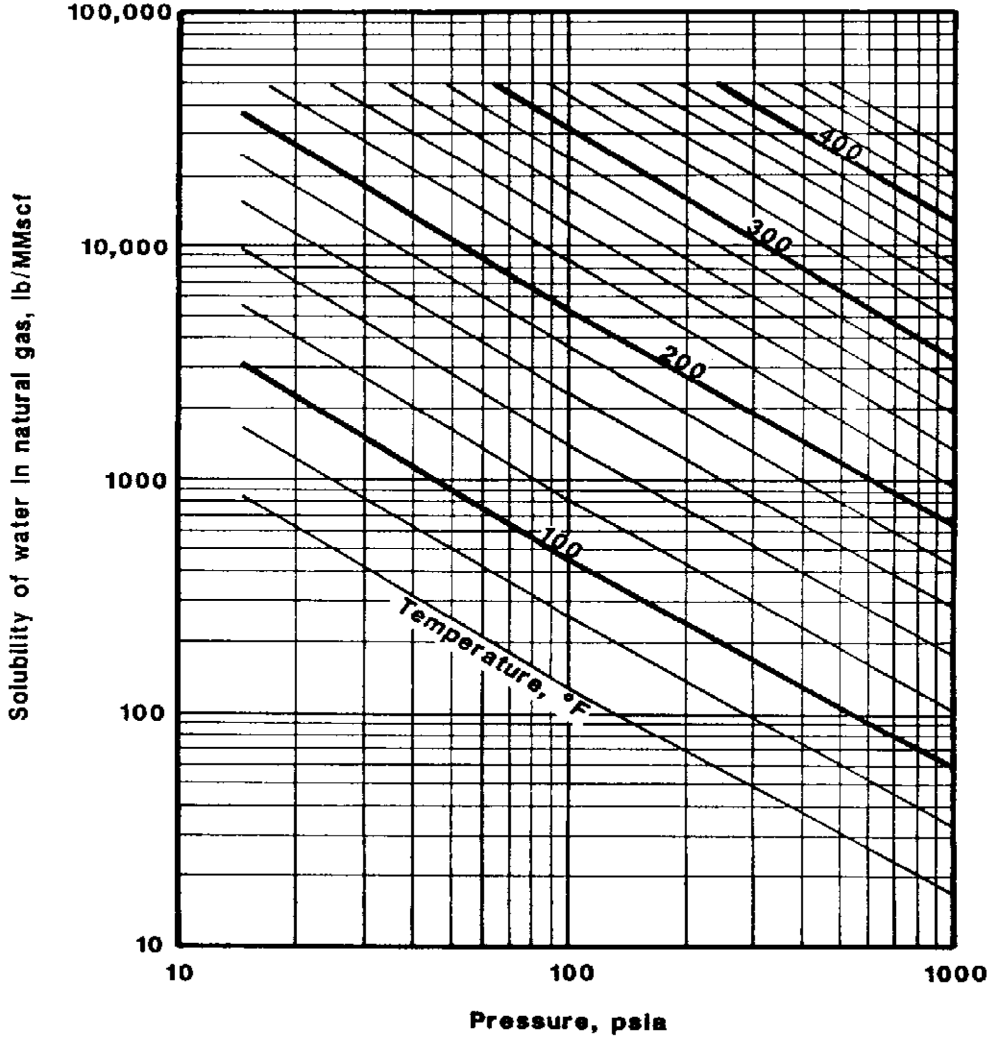


At atmospheric pressure

Viscosity of Water at Reservoir Pressure

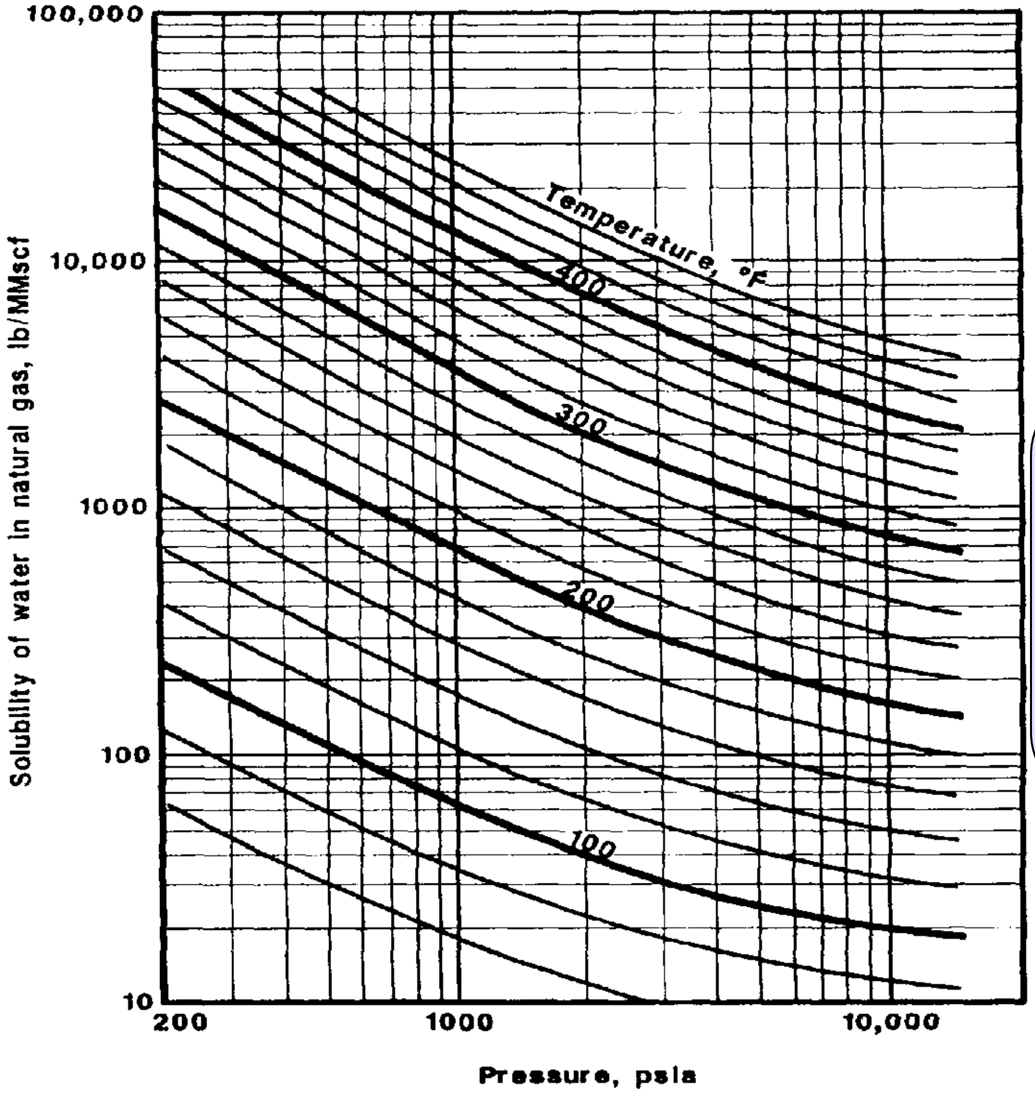


Solubility of Water in Natural Gas (low pressure)



Lb of water / MMSCF

Solubility of Water in Gas (high P)



Lb of water / MMSCF

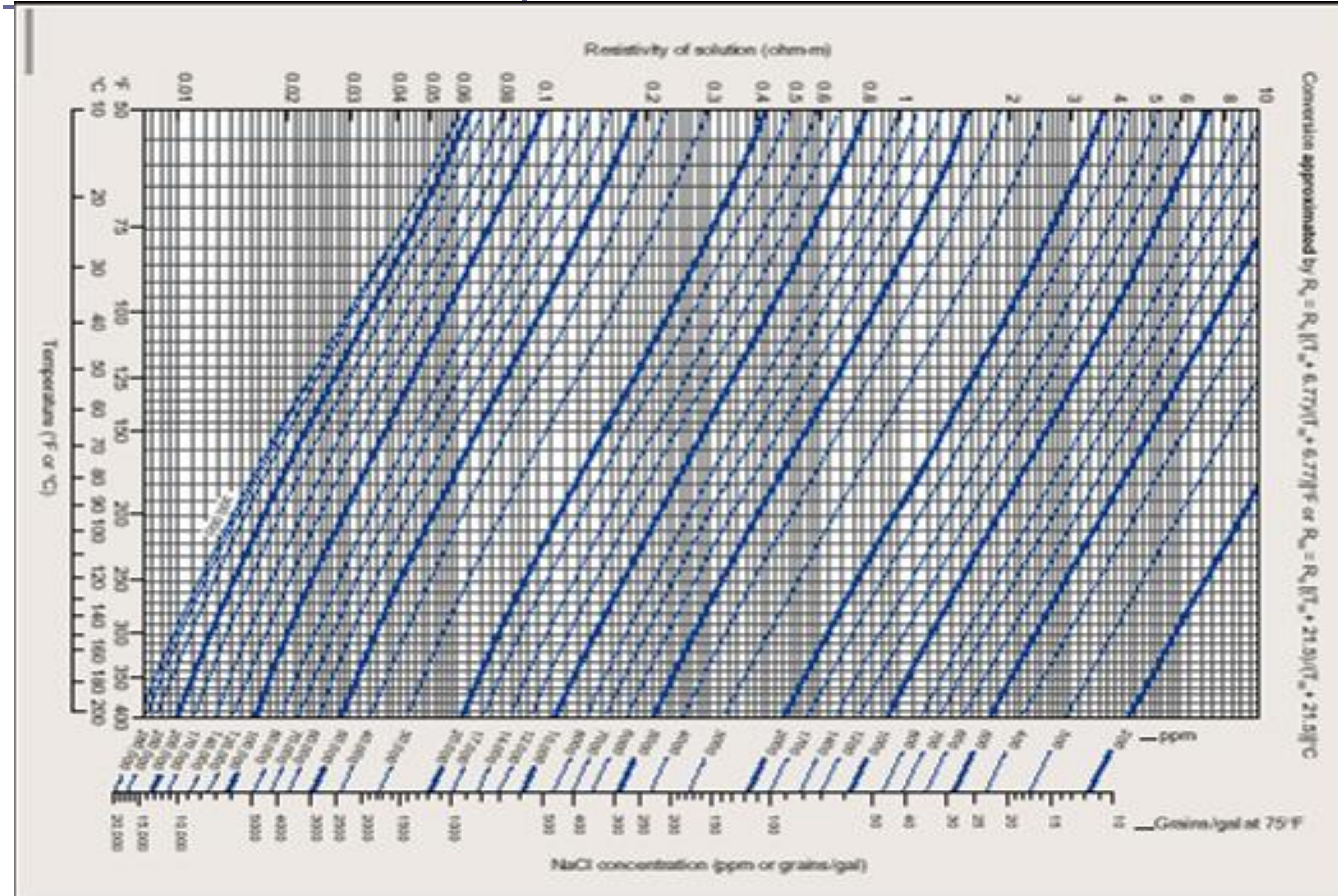
To evaluate
dehydration requirements
(equipment, chemicals)
In
natural gas processing

Resistivity of Oilfield Water

- Use in logging tools
- Formation evaluation
- Resistivity is inversely proportional to conductivity

  R_w = rA/L = [ohm/meters]

Calculate Resistivity or TDS



Gas-Water IFT