Module for:

Resistivity Log Calculations

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Resistivity Log Calculations: Basics

- Apparent Water Resistivity ($R_{wa}$):
  - Select model for Formation Factor ($F$)
    - $F = a/\phi^m$ (select $a$ and $m$ as appropriate for formation)
    - Calculate $R_{wa} = R_t/F$ (use porosity logs for $\phi$ estimates)
    - Apply in water zone.
  - Use smallest estimate of $R_{wa}$.

- Water Resistivity from SP Approach:
  - Governing relation: (in a water zone)
    - $R_w = R_{mf} \cdot 10^{SP/K}$ (Correlation for $K$: $K = (T_f + 505)/8$)

- Water Saturation:
  - Governing relation: (Archie's second law)
    - $S_w = [(a/\phi^m)(R_w/R_t)]^{1/n}$
Hingle Plot:

- Governing relation:
  \[(S_w)^n = (a/\phi^m)(R_w/R_t) = (aR_w)/(\phi^mR_t)\]

- Exponentiating the entire relation by \(1/m\) gives:
  \[(S_w)^{n/m} = (aR_w)^{1/m}(1/R_t)^{1/m}(1/\phi)\]
  Or, \((1/R_t)^{1/m} = (1/aR_w)^{1/m}(S_w)^{n/m}\phi\)

Approach:

- Concept: \((1/R_t)^{1/m}\) versus \(\phi\); Slope = \((S_w)^{n/m}(1/aR_w)^{1/m}\)

- Assume: \(a=1, m=n=2\)

- Plotting Function: \((1/R_t)^{1/2}\) versus \(\phi\); Slope = \(S_w/(R_w)^{1/2}\)

Interpretation:

- \(S_w = 1\) case has maximum slope, estimate \(R_w\) from this case.

- Knowing \(R_w\), generate other lines using:
  \[(1/R_t)^{1/2} = (1/aR_w)^{1/2}(S_w\phi)\]
Example Hingle Plot — Note that in this plot the density log function ($\rho_d$) is substituted for porosity (gives $\rho_m$ at intercept) (Jensen (2002)).
Resistivity Log Calculations: Pickett Plot

- Pickett Plot:
  - Governing relation:
    - \((S_w)^n = (a/\phi^m)(R_w/R_t) = (aR_w)/(\phi^m R_t)\)
    - Solve for \(R_t\):
      \[R_t = (aR_w)/(\phi^m (S_w)^n) = (aR_w) (\phi^{-m}) ((S_w)^{-n})\]
    - Taking the logarithm:
      \[\log(R_t) = \log(aR_w) - m\log(\phi) - n\log(S_w)\]
  - Concept:
    - \((aR_w)\) = constant.
    - \((S_w)\) is constant for a given \(\log(R_t)\) versus \(\log(\phi)\) trend.
  - Approach:
    - Plot \(\log(R_t)\) versus \(\log(\phi)\).
    - Establish \(S_w = 1\) trend.
  - Interpretation: (select \(m\) and \(n\) as appropriate)
    - Using \(S_w = 1\) trend, estimate \((aR_w)\) (intercept at \(\phi = 1\)).
    - Use \(R_t = (aR_w) \phi^m (S_w)^{-n}\) to generate \(R_t - \phi\) trends for \(S_w\) values.
Resistivity Log Calculations: Pickett Plot (2/2)

- Example Pickett Plot — Note the $S_w=1$ trend (Jensen (2002)).
- Example Pickett Plot — Note the $S_w$ trends (Jensen (2002)).