Kozeny-Carman Equation:

\[ k_{KC} \text{ (md)} = \alpha \frac{R^2}{S_f F} \]

where,
- \( k \) = permeability, md
- \( S_f \) = shape factor, dimensionless (1.7 < \( S_f \) < 3)
- \( R \) = ratio of pore volume to pore surface area, dimensionless
- \( F \) = Formation factor, dimensionless
- \( \alpha \) = conversion constant to yield permeability in md

Berg Equation:

\[ k_{Berg} \text{ (md)} = 20.2 \phi^{5.1} D^2 \text{ (Assumed valid for } \phi > 0.30) \]

where,
- \( k \) = permeability, md
- \( \phi \) = porosity, fraction
- \( D \) = median grain diameter, micrometers

Timur Equation:

\[ k_{Timur} \text{ (md)} = \frac{a \phi^b}{S_{wi}^2} \]

where,
- \( k \) = permeability, md
- \( \phi \) = porosity, fraction
- \( S_{wi} \) = irreducible wetting phase saturation, fraction
- \( a, b \) = empirical constants

Coates(-Denoo) Equation:

\[ k_{Coates} \text{ (md)} = \left[ 100 \phi_e^2 \left( 1 - S_{wi} \right)^2 \right] \]

where,
- \( k \) = permeability, md
- \( \phi_e \) = effective porosity, fraction
- \( S_{wi} \) = irreducible wetting phase saturation, fraction

Exponential Model: Empirical model—uses semilog plot of \( k \) versus \( \phi \)

\[ k = a \exp(b \phi) \]

Brooks-Corey-Burdine Model: (Semi-analytical model reduced to simplest form)

\[ k = a \left( 1 - S_{wi} \right)^b \phi^c \text{ (} a, b, \text{ and } c \text{ are empirical constants) } \]
E.A. Cotton Well No. 1 (Burleson Co., TX): Core and Well Log Data—"Reservoir" Interval
Region covered by CORE and LOG data.
Correlation Plot: $k$ vs. $\phi_{Core}$
Correlation Plot: \( k \) vs. \( SP \) (from log)

Legend: Well E.A. Cotton No. 1
- All Permeability Data (2620-2680 ft)

Lower Zone
Upper Zone

Core Permeability, md

\( SP \), mv
Correlation Plot: \( k \) vs. \( S_{w,\text{Core}} \)
Correlation Plot: $k$ vs. $R_t$ (from log)
**Petroleum Engineering 620 — Fluid Flow in Petroleum Reservoirs**

**Petrophysics Lecture 2 — Correlation of Petrophysical Data**

---

**Regression Equation: Lower Zone**

\[ k = 8192.3 \phi_{\log}^{1.474} R_i^{-0.1558} \text{SP}^{0.009757} \]

**Regression Equation: Upper Zone**

\[ k = 8.896 \times 10^{-4} \phi_{\log}^{0.3452} R_i^{0.2373} \text{SP}^{2.2368} \]

**Regression Equation: All Data**

\[ k = \exp(\alpha_0 + \alpha_1 x + \alpha_2 y + \alpha_3 z + \alpha_4 xy + \alpha_5 xz + \alpha_6 yz + \alpha_7) \]

- \( \alpha_0 = -333.363 \)
- \( \alpha_1 = -301.691 x \)
- \( \alpha_2 = 116.878 xy \)
- \( \alpha_3 = -31.321 xyz \)
- \( \alpha_4 = 122.846 y \)
- \( \alpha_5 = -33.143 yz \)
- \( \alpha_6 = 93.678 z \)
- \( \alpha_7 = 82.053 xz \)

- \( x = \ln(\phi_{\log}) \)
- \( y = \ln(R_i) \)
- \( z = \ln(\text{SP}) \)
Region covered by CORE and LOG data.
**Additional Materials from:**

Figure 1: Permeability-porosity plot showing data fields for subsequent figures.
Figure 6: Permeability-porosity data from an Upper Carboniferous sandstone by Fuchtbauer (1967).

Figure 7: Permeability-porosity data from the Tertiary Baust einschichten sandstone by Fuchtbauer (1967).
Figure 19: Summary sketch of the impact of grain size, sorting, clay, and interstitial cements upon permeability-porosity trends.

Figure 20: Theoretical model by Berg (1970) incorporating porosity, grain size, and sorting.
Figure 23: Data from three US oil fields, by Timur (1968).

Figure 24: Permeability data from three US oil fields as a function of porosity and residual water saturation, after Timur (1968).
Figure 28: Empirical relationship among permeability, porosity, and $T_1$ from nuclear magnetic resonance measurement by Sen et al. (1990).
Additional Materials from:

Table 1. Porosity is the helium porosity, permeability is in mD, Sw is the water saturation reached for resistivity measurements, R is measured resistivity in ohm-m, F is the normalized resistivity or formation factor computed using a saturation exponent (n) of 2, and R_w = 0.17 ohm.m. Error (%) is the error in F obtained assuming an error of 10% in n.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Porosity</th>
<th>Perm (mD)</th>
<th>Sw</th>
<th>R  (ohm m)</th>
<th>F</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A11</td>
<td>0.07</td>
<td>10</td>
<td>0.80</td>
<td>29.81</td>
<td>112.94</td>
<td>4</td>
</tr>
<tr>
<td>A16</td>
<td>0.07</td>
<td>6</td>
<td>0.70</td>
<td>37.44</td>
<td>108.01</td>
<td>7</td>
</tr>
<tr>
<td>A33</td>
<td>0.07</td>
<td>12</td>
<td>0.80</td>
<td>24.99</td>
<td>94.95</td>
<td>4</td>
</tr>
<tr>
<td>A82</td>
<td>0.08</td>
<td>7</td>
<td>0.65</td>
<td>88.29</td>
<td>216.49</td>
<td>9</td>
</tr>
<tr>
<td>A87</td>
<td>0.10</td>
<td>50</td>
<td>0.76</td>
<td>19.34</td>
<td>65.67</td>
<td>6</td>
</tr>
<tr>
<td>A89</td>
<td>0.08</td>
<td>26</td>
<td>0.82</td>
<td>32.08</td>
<td>126.43</td>
<td>4</td>
</tr>
<tr>
<td>A117</td>
<td>0.11</td>
<td>103</td>
<td>0.75</td>
<td>23.47</td>
<td>76.76</td>
<td>6</td>
</tr>
<tr>
<td>B31</td>
<td>0.11</td>
<td>107</td>
<td>0.85</td>
<td>14.91</td>
<td>63.47</td>
<td>3</td>
</tr>
<tr>
<td>B86</td>
<td>0.09</td>
<td>78</td>
<td>0.85</td>
<td>25.02</td>
<td>106.07</td>
<td>3</td>
</tr>
<tr>
<td>B101</td>
<td>0.11</td>
<td>121</td>
<td>0.84</td>
<td>18.23</td>
<td>76.54</td>
<td>3</td>
</tr>
<tr>
<td>B102</td>
<td>0.10</td>
<td>157</td>
<td>0.90</td>
<td>11.28</td>
<td>54.23</td>
<td>2</td>
</tr>
<tr>
<td>B108</td>
<td>0.08</td>
<td>29</td>
<td>0.83</td>
<td>44.69</td>
<td>179.50</td>
<td>4</td>
</tr>
<tr>
<td>F510</td>
<td>0.15</td>
<td>592</td>
<td>0.90</td>
<td>9.24</td>
<td>44.28</td>
<td>2</td>
</tr>
<tr>
<td>GT3</td>
<td>0.17</td>
<td>704</td>
<td>0.91</td>
<td>5.47</td>
<td>26.79</td>
<td>2</td>
</tr>
<tr>
<td>GW18</td>
<td>0.16</td>
<td>637</td>
<td>0.91</td>
<td>6.70</td>
<td>32.98</td>
<td>2</td>
</tr>
<tr>
<td>GW19</td>
<td>0.18</td>
<td>912</td>
<td>0.92</td>
<td>6.91</td>
<td>34.19</td>
<td>2</td>
</tr>
<tr>
<td>GW23</td>
<td>0.18</td>
<td>965</td>
<td>0.92</td>
<td>3.55</td>
<td>17.56</td>
<td>2</td>
</tr>
<tr>
<td>GW28</td>
<td>0.18</td>
<td>896</td>
<td>0.86</td>
<td>3.94</td>
<td>17.32</td>
<td>3</td>
</tr>
<tr>
<td>H27</td>
<td>0.25</td>
<td>3630</td>
<td>0.89</td>
<td>1.76</td>
<td>8.24</td>
<td>2</td>
</tr>
<tr>
<td>H42</td>
<td>0.24</td>
<td>2894</td>
<td>0.88</td>
<td>1.87</td>
<td>8.59</td>
<td>2</td>
</tr>
<tr>
<td>H74</td>
<td>0.24</td>
<td>3079</td>
<td>0.85</td>
<td>2.38</td>
<td>10.18</td>
<td>3</td>
</tr>
<tr>
<td>F410</td>
<td>0.06</td>
<td>1</td>
<td>0.70</td>
<td>51.24</td>
<td>147.38</td>
<td>7</td>
</tr>
<tr>
<td>F570</td>
<td>0.10</td>
<td>32</td>
<td>0.71</td>
<td>17.40</td>
<td>51.88</td>
<td>7</td>
</tr>
</tbody>
</table>

\[ k = a(\phi - c)^b \quad (c = c_{\text{max}} \exp[-c_1\phi^{c_2} F^{c_3} S_{\lambda_{\text{w}}}^{c_4}]) \]