Lecture (7)

Calculation of Rw from Sp log

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Water resistivity or R_w, is a critical component of log analysis in calculating water saturation using the Archie equation. R_w can be measured from a sample of formation water taken from the zone of interest at the well site or a nearby well, or it can be calculated using spontaneous potential (SP) log data.

Data required

To calculate R_w from SP, we need the following data:

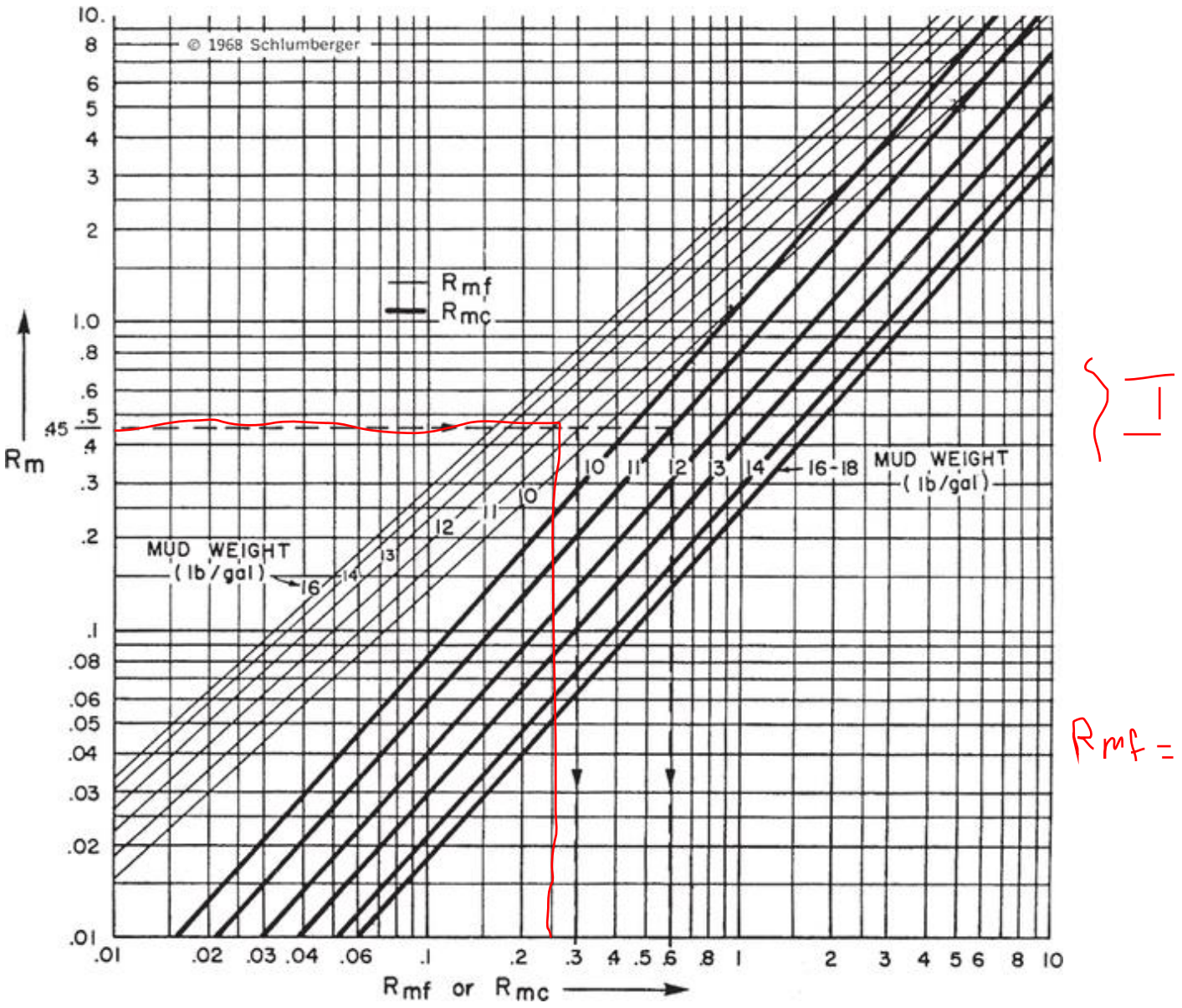
- Resistivity of the mud filtrate (R_{mf}) at measured temperature, found on the log header. If only mud resistivity (R_m) is given, convert it to R_{mf} as explained below.
- Bottom-hole temperature (BHT) and total depth, found on the log header.
- SP reading from a porous zone at least 20 ft thick. (A bed thickness correction is necessary if the zone SP is measured from is less than 20 ft thick.).

Converting r_m to r_{mf}

- Enter R_m and move across (Figure 1) to the appropriate mud weight.
- Project to the bottom of the chart to estimate R_{mf}

$Sw + Sh = \%100 = 1$

$Sh = 1 - Sw$



$R_{mf} = 6.25$

Figure 1 SP log data. Copyright: Schlumberger.

Steps for calculating Rw

There are five steps for calculating R_w from the SP log. The list below summarizes these steps, which are detailed in the rest of this section.

1. Estimate formation temperature.
2. Convert R_{mf} to formation temperature.
3. Convert R_{mf} to R_{mfeq} .
4. Read SP response and estimate R_{we} .
5. Convert R_{we} to R_w and NaCl at formation temperature.

Step 1: Estimate formation temperature

Formation temperature (T_f) can be estimated by using the following formula:

$$T_f = T_s + D_f \frac{BHT - T_s}{TD}$$

where:

- T_s = average surface temperature
- D_f = depth to the formation
- BHT = bottom-hole temperature (found on log header)
- TD = total depth (make sure BHT and TD are from same log run)

Step 2: convert r_{mf} to r_{mf} at formation temperature

Follow this procedure to convert R_{mf} (measured at surface temperature) to R_{mf} at formation temperature.

1. Enter Figure 2 along the resistivity of solution axis and the temperature axis using the measured values

2. for R_{mf} and surface temperature found on the log header.
3. Follow the appropriate salinity line intercepted at step 1 to the appropriate formation temperature and mark on the chart.
4. Project down the chart from this mark to the resistivity scale and read R_{mf} at formation temperature. Record the value of R_{mf} at a specific temperature.

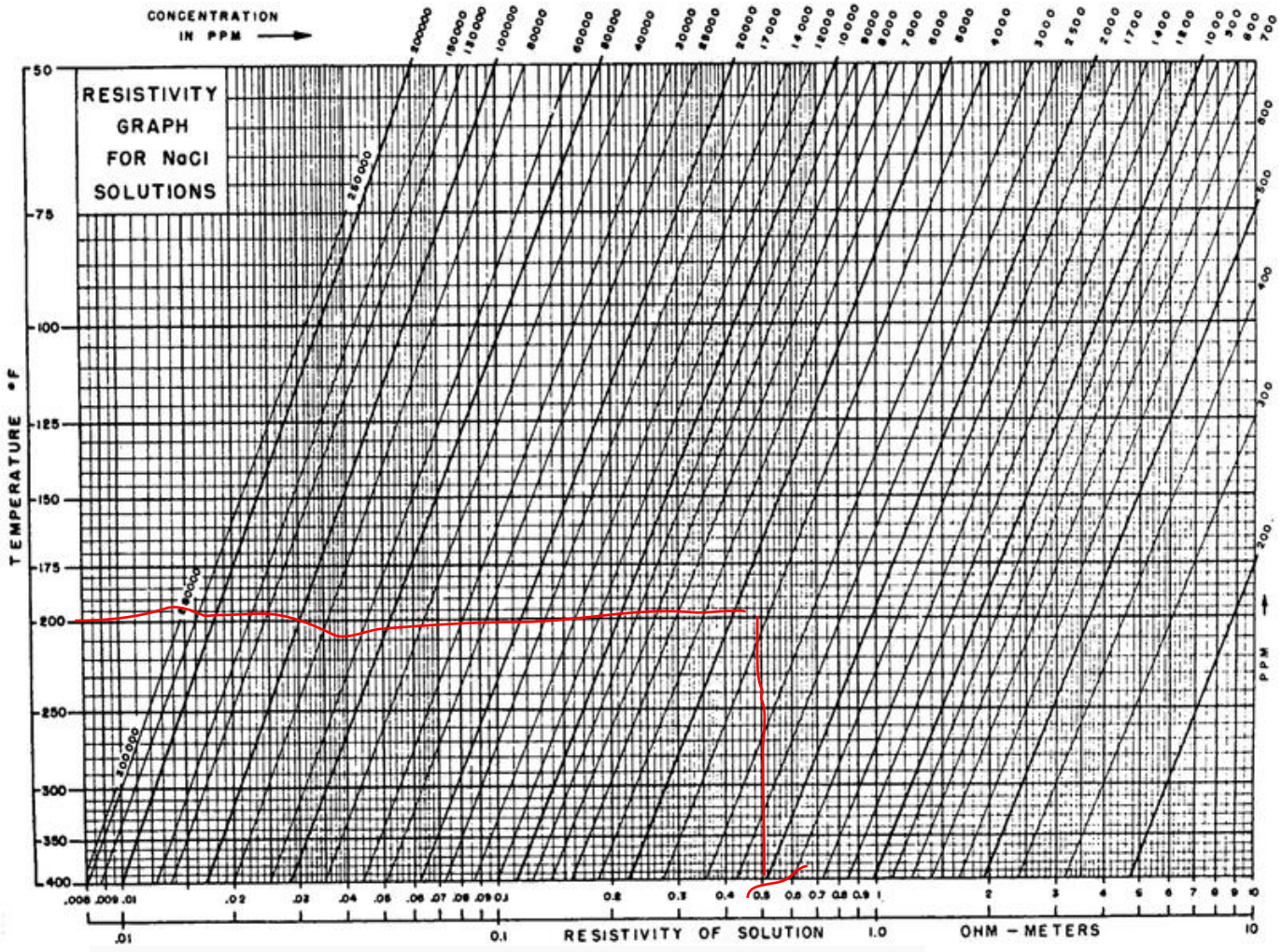


Figure 2 SP log data. Copyright: Schlumberger

Step 3: convert rmf to rmf eq

Use the R_{mf} at formation temperature obtained above and follow the procedure below to convert R_{mf} to equivalent mud filtrate resistivity (R_{mfeq}).

1. Enter Figure 3 with R_{mf} at formation temperature on the vertical axis.
2. Move across the chart to the appropriate formation temperature contour, and mark this point on the figure.
3. Read down to R_{mfeq} . This value is used in the equation

$R_{we} = R_{mfeq}$ (R_{mfeq} /R_{we} value).

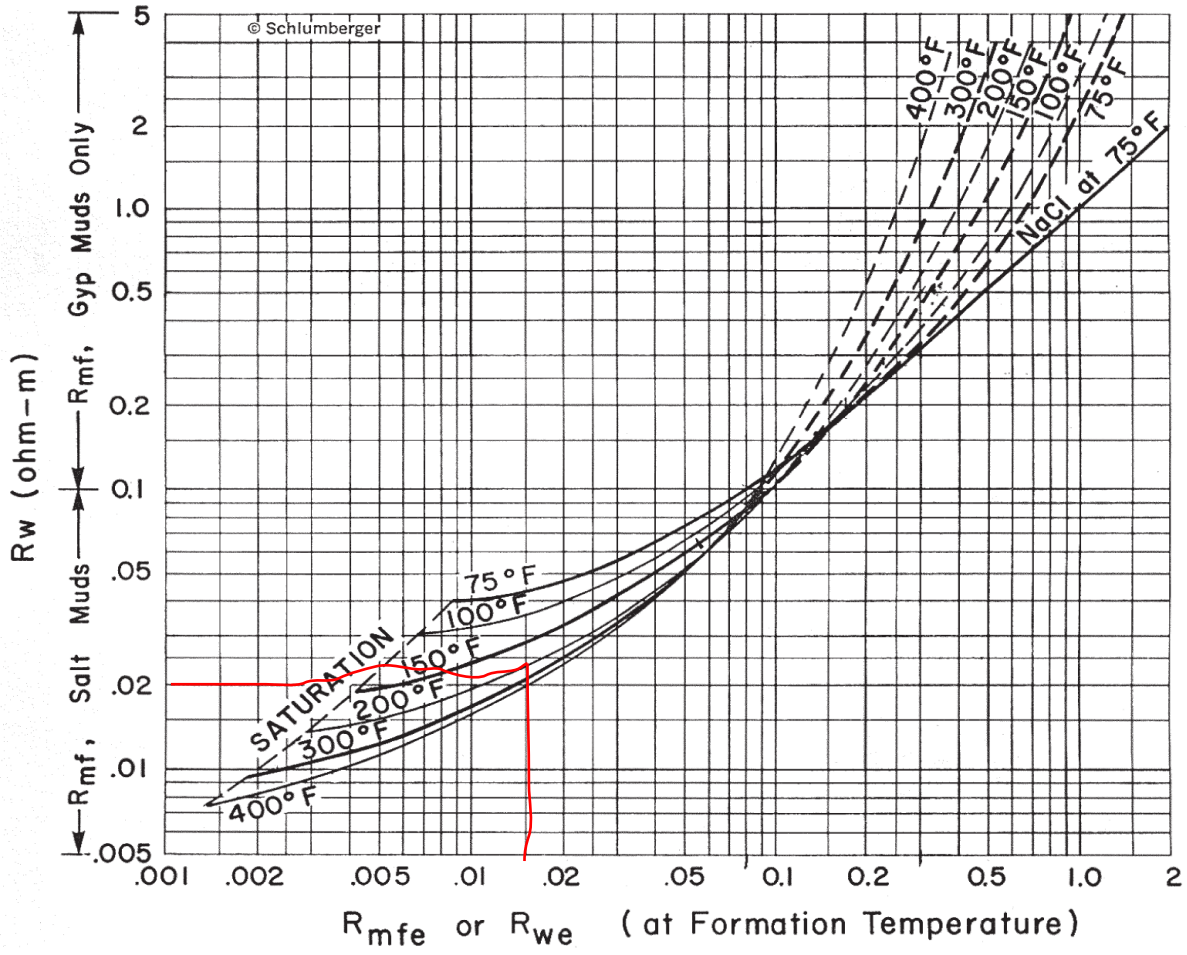


Figure 3 SP log data. Copyright: Schlumberger.

Step 4: convert SP to r_{we}

Follow the procedure below to convert SP from the zone of interest to equivalent formation water resistivity (R_{we}).(Fig.4)

1. On the log, establish the shale base line for the SP curve.
2. Read the maximum SP response in a zone at least 20 ft thick.
3. Enter the base of Figure 4 with SP (SP is negative if it deflects to the left of the shale base line). Follow the SP grid line up the chart to the appropriate formation temperature. At this point, move across the chart and read the $R_{mf\ eq}$ /R_{we} Value.
4. Solve for R_{we} using the equation R_{we} = R_{mfeq} /(R_{mfeq} /R_{we} value).

Step 5: convert r_{we} to r_w

Follow the procedure below to convert R_{we} to R_w.

1. Enter Figure 3 again with R_{we} (along the base). Move up the chart until R_{we} intersects the temperature slope.
2. Directly across from the intersection point, read R_w from the vertical axis.

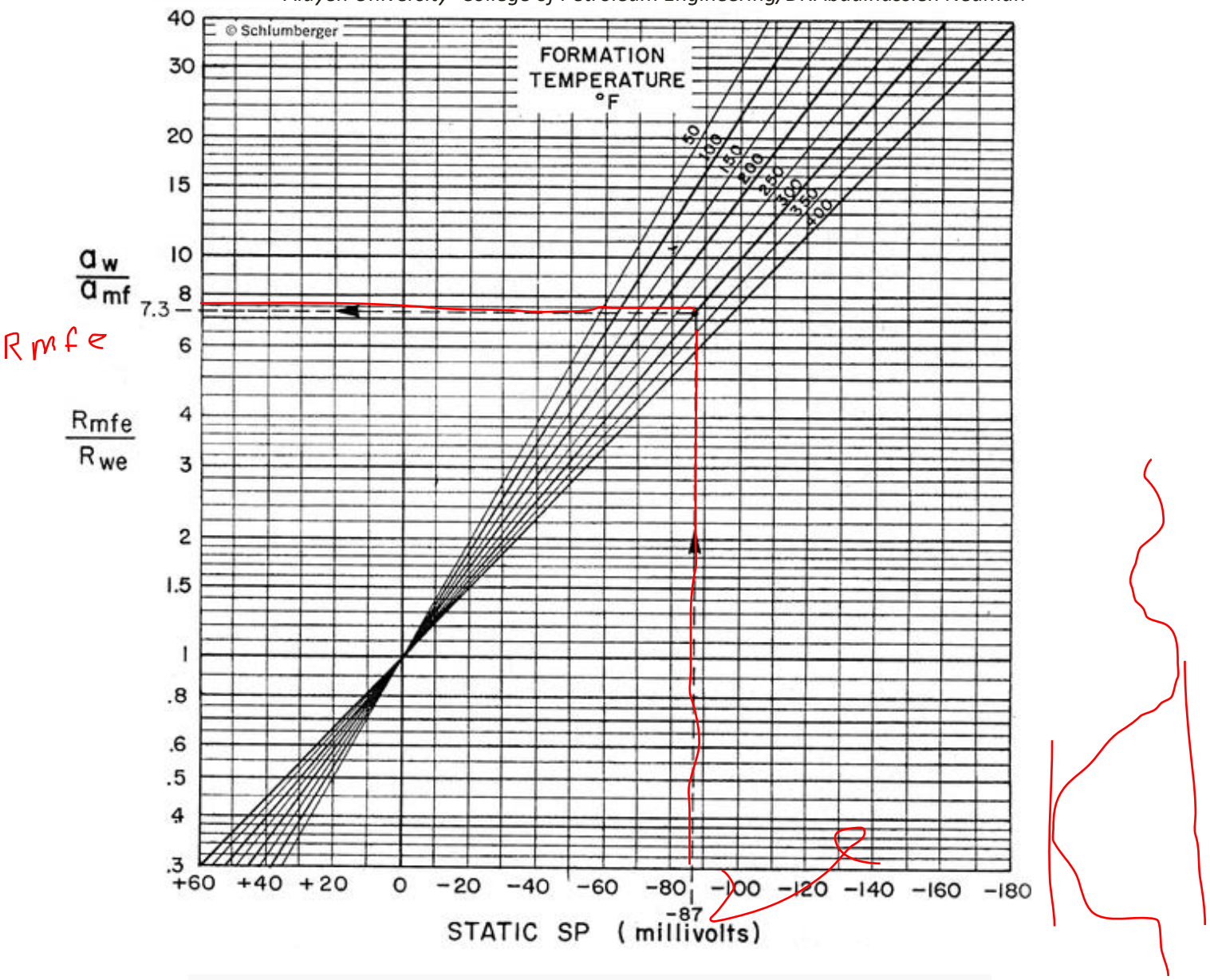


Figure 4 SP log data. Copyright: Schlumberger