Determination of Formation Water Resistivity (Rw) in Shale Reservoirs

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In recent years hydrocarbon-bearing shale has become an important reservoir rock in the United States. Commercial production has been established in Texas, Louisiana, Oklahoma, Michigan, North Dakota, Colorado, and the northeastern states. Log analysis of these reservoirs and potential reservoirs is critical to the evaluation of the productive potential and the determination of hydrocarbon reserves. An important parameter to determine both productive potential and hydrocarbon reserves is the reservoirs hydrocarbon saturation (Sh) which is obtained by first calculating the reservoirs water saturation (Sw) then Sh = 1.0 –Sw. In order to calculated Sw in a shale reservoir the standard Archie water saturation equation Sw = [(0.81/F^2)*(Rw/Rt)]^0.5 must be modified to account for the clay in the shale. One of the commonly used Sw Equations is the Simandoux Equation. However, a value for the resistivity of the formations water (Rw) is necessary in both equations.

The following procedure can be used to determine Rw in shale by employing the Apparent Water Resistivity (Rwa) Method:

1.) Determine shale resistivity (Rsh) [low resistivity shale]
2.) Using Fnl and rb data calculate Ftotal and Vcl using simultaneous equations with Sw = 1.0.
3.) Calculate CECshale [or laboratory measured CECshale]
    CECshale = Vcl * CECclay [CECclay based on clay mineralogy]
4.) Calculate shale cementation exponent (m)
    m = 1.8 + (0.6*CECshale) Dewan, 1983
5.) Calculate shale formation factor (Fsh)
    Fsh = 1/(Ftotal^m)
6.) Rwa = Rsh/Fsh [lowest Rwa is Rw]

The example presented is from the Mississippian Barnett Shale in Throckmorton County, Texas. Two shale intervals were analyzed (4702’ to 4712’ and 4786’ 4798’) and

the minimum Rwa was 0.048 ohm-m. Rw from the Mississippian Chester Limestone (4746' – 4785') calculated from the Spontaneous Potential (SP) was 0.043 ohm-m. The log analysis of the Organic-Rich Barnett Shale (4713' to 4744') resulted in eight feet of potential hydrocarbon reservoir (4738' to 4744').