SALINITY DEPENDENCE OF SHALY SAND PARAMETERS FROM MEMBRANE POTENTIAL MEASUREMENTS

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Abstract

The Yuan-Diederix equation relates the conductivity of a brine saturated rock sample to the brine conductivity and membrane and Nernst potentials for the sample for a given salinity contrast. It can be used for determining the salinity dependence of shaly sand parameters because the equation can be determined from parameters measured at essentially one salinity. This paper applies membrane potential measurements and the Yuan-Diederix equation to describe the salinity dependence of the clay conductivity, C_e, the shaly sand formation resistivity factor, F*, the shaly sand lithology exponent, m*, and the equivalent quadrature conductance, λ.

Data from the Waxman-Smits Group 2 samples for which conductivity and membrane potential data have been simultaneously measured allow the determination of C_e, F* and m* as a function of salinity. The clay conductivity generally decreases with decreasing salinity. Accordingly, any shaly sand model should incorporate a salinity dependent clay conductivity as the Waxman-Smits model does. When the clay conductivity is smaller than the brine conductivity, F* is found to be constant, verifying that the Waxman-Smits assumption of constant F* is valid. When the clay conductivity is larger than the brine conductivity, F* generally increases with decreasing salinity implying that the Waxman-Smits assumption of constant F* is not always valid. A consequence of salinity-dependent F* is that membrane potential measurements may be necessary for cases where the clay conductivity exceeds the brine conductivity. In this salinity range, m* also increases. The salinity effects are much greater for samples containing montmorillonite.

New simultaneous conductivity, membrane potential and induced polarization data are reported here for a set of very shaly sandstones which confirm the salinity dependence of C_e, F* and m*. The new data are used also to determine the salinity dependence of the equivalent quadrature conductance, λ. The results agree very well with Vinegar-Waxman induced polarization data on shaly sands. It is found that induced polarization measurements also directly yield the clay conductivity.