RECONCILIATION OF LOG AND LABORATORY DERIVED IRREDUCIBLE WATER SATURATIONS IN A DOUBLE POROSITY RESERVOIR

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ABSTRACT Reconciliation of the irreducible water saturation measured in the laboratory on capillary pressure curves and determined in-situ by logs has been achieved by a study of the resistivity index correlated with the pore size distribution of different samples of a limestone reservoir.

The reservoir is an oolithic limestone with a bimodal pore size distribution ; three ranges of porosity are identified ; the macroporosity or intergranular porosity with large pores, the microporosity or intragranular porosity with fine pores and an intermediate porosity with pores of medium size. The distribution of these three classes of porosity is variable from one sample to another.

Resistivity index variation versus water saturation was determined, with corresponding capillary pressure curves, using the porous plate method on a water-oil system, oil being dead crude oil. Afterwards, mercury injection was carried out on the same samples in order to get the pore size distributions.

Using an appropriate transposition factor, the capillary pressure curves obtained by both methods are shown to be quite similar, except in the low capillary pressures portion. In this part, water oil curves are below the mercury curves due to the slight oil wettability of the reservoir. It is then possible to correlate the water saturation variations with the pore sizes.

The variation of the resistivity index with the water saturation, in a logarithmic form, shows three different slopes ; only the first one, at high water saturations, leads to an Archie value of n around 2. The slope variations are observed for water saturations correlating with the successive displacements of water by oil in the three classes of porosity.

So, the Archie value of n around 2 is only applicable to the samples that contain macroporosity and for high values of water saturation, that is in the transition zone of the reservoir. In the oil zone, the resistivity of the rock that contains water only in the microporosity is much higher than that predicted by the Archie law. Using n = 2 for the interpretation of the resistivity logs leads to underestimate the irreducible water saturation. This is critical in low permeability zones, i.e. where no macroporosity is detected.