EFFECT OF WETTABILITY ON ELECTRICAL AND RESERVOIR PROPERTIES OF TERRIGENOUS ROCKS

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Extended Abstract

An investigation was carried out to determine the effect of wettability on electrical resistivity, membrane potential, adsorptive activity, and reservoir properties of terrigenous sedimentary rocks. The rocks studied were from oil- and gas-bearing deposits of West Siberia. Natural and artificial processes that cause rock wettability changes toward greater oil-wetness were investigated. Experiments were carried out to determine best methods for selectively dissolving specific rock minerals to alter wettabilities in sedimentary silty-sandstones and claystones. The water-wetting and oil-wetting capacities of minerals were defined by measuring contact angles of oil and water droplets placed on the mineral surfaces under water or oil respectively. Wettabilities were described by Amott indices. It was shown that, as rock wettabilities change toward greater oil wetness, the adsorptive ability (hydroscopic humidity) of the rock decreases and some deterioration in filtering capacity features are observed. In particular, placing a thin oil-wetting film at the pore surface causes the effective pore volume and porosity to decrease. Porosity reductions from 0.5-1.0 % and permeability reductions from 15-45 % were noted when pores within rock core plugs were coated by thin oil-wetting films. Measured porosities for hydrophobic (oil-wet) reservoir rocks differ depending on whether water or kerosene is used as the saturating fluid. For oil-wet rocks, porosities defined by water saturation are less than porosities defined by kerosene saturation. The difference can be as much as 0.5 3.0%. This difference decreases when the samples are saturated for 3 to 6 hours at a pressure of 60 atm.[1]

Our work has shown that shifts in rock wettability toward greater oil-wetness coincide with reductions in the diffusive-adsorptive activity (A_{da}) for fully water saturated rocks. For example, the characteristic influence of wettability alteration for several samples with 100% water saturation is shown in Figure 1. In modelling the natural oil- and water-saturation state of rocks, the magnitude of their diffusive-adsorptive activity increases with their oil-wetness. Figure 2 provides correlations between the diffusive-adsorptive activity of rock in water-wet ($A_{da,w}$) and in oil-wet ($A_{da,o}$) states. It is shown that the magnitude of A_{da} increases greatly as a rock sample becomes more oil-wet.

These results were verified by interpretation of borehole SP log data. Where hydrophobic rock layers are observed, potential amplitude variation on SP logs can reach 40-60 % of amplitudes for hydrophilic rock layers. Based on these findings, new concepts have been developed[2] to describe wettability-dependent mechanisms and forming features of rock electrochemical activity. A_{da} magnitudes depend on several properties:

$$A_{da} = \nu \cdot 69.6 \cdot [S_{rw}/(S_w - S_{sw})] \quad (1)$$

Where S_{rw}, S_w and S_{sw} are boundary water, total water and insulate water contents respectively, and ν is the geometrical pore space factor.

Electrical resistivities of sandstone-clay rocks from the deposits under investigation are characterised by "n" factors using the well-known Archie-Dakhnov equation. For the rocks tested, "n" ranges from 1.7 to 1.9. After changing rock samples to an oil-wet state, our experiments[3] have shown that "n" values range from 2.3-2.35. The literature describes other tests in which "n" values of 4.5 and higher were recorded. Such date could to take place for homogeneous hydrophobic rocks or for artificial mediums. In nature oil-and-gas saturated pores and subcapillary pores surfaces of terrigenous rocks has the different ore selective character of wettability.

The basis for these observations has been described through research and experimentation. An electrical conductivity model is suggested for the hydrophobic rocks studied in this project. Techniques for obtaining (borehole surveys, petrophysical descriptions) and interepreting resistivity data for oil-wet rocks are also suggested.

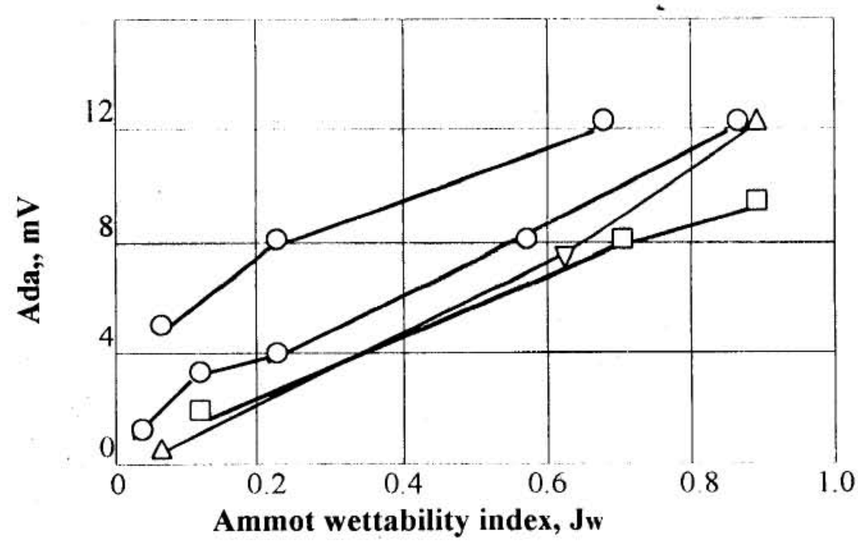

Fig. 1 Illustration of influence wettability **Jw** for **Ada** water saturated rock (S_w=100%).

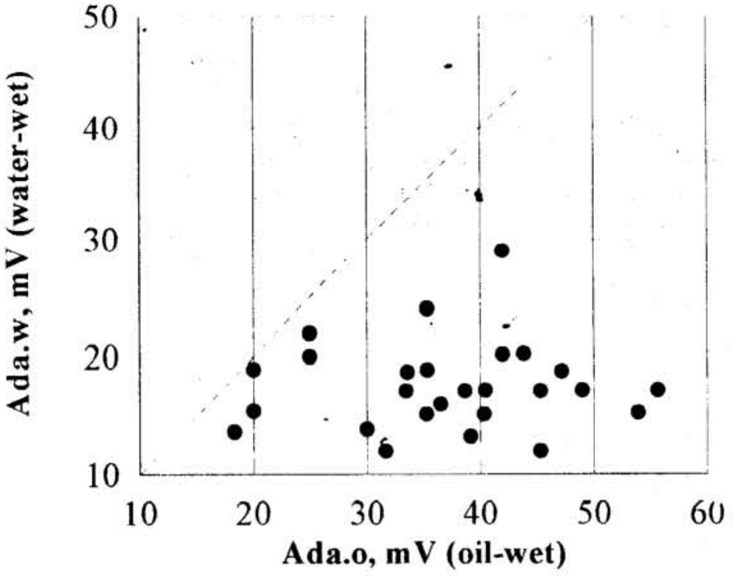

Fig. 2 Comparison of diffusive-adsorptive activities for water-wet (Ada.w) and oil-wet (Ada.o) conditions (Sw=Swr).

References.

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