Interactive Assessment of the Sensitivity of Well Logs to Static and Dynamic Petrophysical Properties of Rock Formations

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Simulation of the process of mud-filtrate invasion considers the interplay of mud properties and petrophysical properties of rock formations. Capillary pressure, relative permeability, porosity, permeability, and salt mixing govern the time evolution of fluid distribution in the near-borehole region. In addition, overbalance pressure and mud properties determine the flow rate of invasion from spurt loss to steady-state imbibition. Mud and petrophysical properties can have a significant impact on well logs acquired with multiple radial zones of investigation. It is difficult to ascertain by visual inspection in what way a given well log is influenced by mud-filtrate invasion.

We have developed an interactive, user-friendly PC interface to efficiently assess the influence of mud-filtrate invasion on well logs. The interface allows the user to systematically test the sensitivity of static and dynamic rock formation properties on induction and laterolog measurements acquired in vertical wells. This is achieved by simulating the process of immiscible fluid displacement in permeable formations between water-base mud and in-situ hydrocarbons and connate water. The interface also allows one to ascertain the impact of salt mixing, initial water saturation, and irreducible water saturation on resistivity logs. Moreover, the user may systematically assess the influence of Archie's parameters on well logs, including the possibility of conductivity enhancement due to dispersed clay. Several examples are shown of the application of the PC interface to quantify the behavior of non-conventional logs, including the cases of tight-gas sands, water-hydrocarbon transition zones, and high contrast of salt concentration between mud filtrate and connate water.