A SIMPLE AND CONVINCING WATER SATURATION VS. HEIGHT FUNCTION FOR RESERVOIR MODELLING

Abstract:

To determine a field's hydrocarbon in place, it is necessary to model the distribution of hydrocarbon and water throughout the reservoir. A water saturation vs. height (SwH) function provides this for the reservoir model. A good SwH function ensures the three independent sources of fluid distribution data are consistent. These being the core, formation pressure and electrical log data. The SwH function must be simple to apply, especially in reservoirs where it is difficult to map permeability or where there appears to be multiple contacts. It must accurately upscale the log and core derived water saturations to the reservoir model cell sizes.

This presentation clarifies the, often misunderstood, definitions for the free-water-level (FWL), transition zone and irreducible water saturation. Using capillary pressure theory and the concept of fractals, a convincing SwH function is derived from first principles. The derivation is simpler than with classical functions as there is no porosity banding. Several case studies are presented showing the excellent match between the function and well data. The function makes an accurate prediction of water saturations, even in wells where the resistivity log was not run, due to well conditions. Logs and core data from eleven fields, with vastly different porosity and permeability characteristics, depositional environments, and geological age, are compared. These demonstrates how this SwH function is independent of permeability and litho-facies type and accurately describes the reservoir fluid distribution.

The function determines the free water level, the hydrocarbon to water contact (HWC), net reservoir cut-off, the irreducible water saturation, and the shape of the transition zone for the reservoir model. The function provides a simple way to quality control electrical log and core data and justifies using core plug sized samples to model water saturations on the reservoir scale. The presentation describes how the function has been used to predict fluid contacts in wells where they are unclear, or where the contact is below the total depth of the well. As the function uses the FWL as its base, it explains the apparently varying HWC in some fields and how low porosity reservoirs can be fully water saturated for hundreds of feet above the FWL.

This simple convincing function calculates water saturation as a function of the height above the free water level and the bulk volume of water and is independent of the porosity and permeability of the reservoir. It was voted the best paper at the 1993 SPWLA Symposium in Calgary.

Bio:

Steve Cuddy is a retired Petrophysicist, having worked with Schlumberger, BP, and Baker Hughes. He holds a PhD in petrophysics at Aberdeen University. He also holds a BSc in physics and a BSc in astrophysics and philosophy. He is the inventor of the Fractal FOIL Function that describes the distribution of fluids in the reservoir model. He writes AI software and has 45 years industry experience in petrophysics. In recognition of outstanding service to the SPWLA, Steve was awarded the Distinguished Service Award in 2018.