Day Two
Break Out Session Tow
Moderator: E. Craig Phillips

What is the best way to measure Remaining Oil Saturation?

In our workshop exercise we were asked to determine the Remaining Oil Saturation. This could be for a reservoir where an reservoir engineering material balance study could tell is about the remaining oil saturation of the reservoir; however, we interpreted our objective as the determination of the remaining oil saturation at the wellbore. In this instance the Remaining Oil Saturation (ROS) is a snapshot in time of the present oil saturation at the well. It is not the final Residual Oil saturation (Sor) as used as an endpoint for relative permeability where the relative permeability to oil has gone to zero.

Probably the best technique for remaining oil saturation is to use resistivity. However, mixed or unknown salinities can be very problematic for this technique as well as the Archie imbibition 'n' is typically not known. The imbibition 'n' is usually much higher that the drainage 'n' that is commonly measured from electrical property studies from core. Varying Wettability can also be an issue also with 'n'. Providing that the salinity is known and the proper 'n' is employed, through casing resistivity could be used in a cased hole environment .

Another technique that was discussed would be to take a low invasion core with a sponge core liner. This can be a very good method if the oil from the drilling mud (Oil Base Mud or OBM) is not being introduced to the system or the oil is not being flushed out of the core as the result of coring and flushing. In high permeable formations it might be impossible to ensure that no Water Base Mud (WBM) invasion has occurred. In this case a tracer can be employed to be more certain that invasion has not occurred. The sponge liner would collect the oil that is expelled from the core as the core barrel is brought to the surface. The core residual oil and sponge oil represent the remaining oil saturation with the appropriate shrinkage corrections. Pressure Core Barrels have been used in the past as well as tracers too.

A dynamic flow test could also be used if the relative permeability and fractional flow curves are known. The remaining oil can be backed into from the fractional flow data reported for the interval being tested.

There were numerous other techniques that were discussed for Remaining Oil saturation, but most of these techniques are measured in the Sxo region and are probably reading somewhere between Remaining Oil and Residual Oil saturations with a Water Base Mud (WBM). With an OBM these techniques could result in a number higher than the true remaining oil saturation. The other techniques that were discussed were:

Techniques that were discussed for cased hole environment
TDT type logging
CO logging in mixed salinity environment
Cased hole resistivity

Open hole environment

NMR measurements are usually shallow measurements, but the tools can be run with the proper activations that capitalize on the T1, T2 or diffusive contrasts of the formation fluids that you are trying to characterize.
Dielectric for a salinity independent saturation in the Sxo region.