Efficient Testing and Sampling Methodology in Compartmentalized Reservoirs*

Ihsan Murat Gok[1], Pascal Millot[1], Dang Dai Hoang Trieu[1], and Tung Huynh Thanh[1]

[1]Schlumberger Oilfield Services

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Abstract

Wireline formation testing (WFT) has been utilized in the oil and gas industry mostly for static formation pressure measurement, downhole fluid analysis and sampling, interval pressure transient test (IPTT) and in-situ stress test. One of the common challenges in the reservoirs is that hydrocarbon accumulations consist of multiple layers and compartments (tens to hundreds) with variable reservoir quality, hydrocarbon types. Classical testing approach is not preferable solution in this type of reservoirs due to cost and poor time efficiency.

Understanding some basic fluid properties before committing to any production test is essential. Downhole PVT sampling with WFT is efficient way to understand extensive fluid properties. However, it is not efficient in highly compartmentalised reservoir due to limited bottle capacity and cost. Advanced fluid analyser equipped with WFT contain multiple sensor and provides not only fluid type but also some fluid properties in real time such as composition, solution gas oil ratio, density, viscosity and pH measurements. Improved accuracy of fluid analyzer enables fluid profiling comparison of fluid properties between layers, help to understand compositional gradient and compartmentalization.

Interval pressure transient tests (IPTTs) using packer-probe or probe-probe wireline formation testers provide dynamic permeability and anisotropy information with increased vertical resolution along the wellbore. IPTT results are used to calibrate NMR continuous permeability curve that can be used to estimate production potential of all layers using simulators. Although IPTT gained significant popularity in the industry over conventional drill stem test (DST), some operational difficulties and efficiency issues were practiced in particularly dual packer module of WFT. A new advanced probe has been introduced recently to overcome the challenges experienced with dual packer in IPTT and sampling. New probe attempts to combine the larger flow area of dual packer with easy deployment of conventional probe tool.

In this paper, three case studies are presented. In the first example, several pay zones were determined from logging while drilling data in a sandstone reservoir. It is quite tough to differentiate hydrocarbon type from logging data. Based on offset well drill stem test (DST) data, high CO_2 content was expected in some zones. Unfortunately, neither mud logging nor LWD/wireline measurements are able to quantify the CO_2 content of the formations. Wireline formation sampling has a critical role in these cases for operators leading to DST decision. Performing wireline sampling jobs and capturing samples from small number of zones is extremely critical. Operator should flash most of these samples on the rig for a quick analysis of the gas composition immediately to assess the need for DST. Furthermore, the information would only become available after the run when samples are flashed on the rig. Clearly, this approach is impractical for discoveries comprising numerous thin reservoirs. Therefore, this approach has been improved by using formation tester with advanced fluid analyzer in order to rapidly quantify vertical variations in fluid composition. Therefore, this approach has been improved by using formation tester with advanced fluid analyzer in

order to rapidly quantify vertical variations in fluid composition. Several fluid identification stations were selected to identify the fluid type in real time. This allowed the formation-testing programme to be continually adjusted in response to the downhole composition measurements in order to select the most valuable and representative samples for dedicated PVT laboratory work. Subsequent comparison and delumping of the downhole compositions produced a reliable estimate of CO_2 content and basic PVT parameters in all significant reservoir sands.

The detailed comparison of fluid analyzer results with PVT analyses for both gas and oil zones confirmed the validity of the new generation fluid analyzer measurements. Wireline formation testing and sampling with a new generation fluid analyzer is the only cost and time effective way to understand the fluid distribution in real time. Time-consuming sample acquisition was minimized and only performed in critical reservoirs for calibration; leaving more time to determine the downhole fluid composition in multiple reservoirs.

The second case study demonstrates application of an IPTT obtained from a dual-packer “mini-DST” on thin, high CO_2 hydrocarbon-bearing sand to calibrate the NMR continuous permeability curve. This was then used to model the deliverability of a thick, low CO_2 reservoir without the need for a full production DST. Calibrated permeability curve with fluid data obtained from downhole fluid analysis and PVT analysis were used in reservoir simulator for productivity index estimation. Finally, production on surface was estimated using wellbore simulator for different completion scenario. Essentially, IPTT and DFA combined with NMR log enabled the operator to obtain permeability information confidently, which is quite critical for field development in the case of not having DST test.

Third example is also from shallow deltaic river sand. Fluid distribution identification with representative sample and permeability evaluation are main logging objectives. We showed sampling and IPTT test from oil zone with new generation advanced probe. This example clearly showed the difficulties faced with dual-packer and conventional cylindrical probes in oil zones. The detailed comparison of fluid analyzer results with PVT analyses is performed for this station as well and an acceptable match was obtained for all measurements oil discovered in this section, which increases confidence in advanced fluid analyzer measurements made where no corresponding sample was obtained.