High Resolution Core Measurements for Improved Reservoir Characterization and Log-Core Depth Corrections

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Introduction

Core data is often collected and used to tune and calibrate the predictions from logging tools. Routine core properties such as porosity, grain density and fluid saturations are extremely valuable for improving the accuracy of logging tool predictions for reservoir characterization. However, there are several challenges to using this core data to tune logs. One challenge is proper depth corrections between logs and core, since depth alignment is the first step required before any further analysis of the core data. The second challenge is to understand the variability of properties measured at the core scale, and to identify which level of variability can be seen at the scale of logging too output data. This presentation provides case studies that focus on addressing both of these challenges.

Theory and/or Method

At the core scale, porosity is measured on the basis of density via 1D and 2D CT scanning. Traditionally 1D scout scans are used only to obtain a visual image of the core, analogous to a core photograph. This can be used to identify parameters such as high density zones visibly present in the core, and to identify regions of good vs. poor core recovery. 2D axial (cross-sectional) scans are used to quantify the CT density profile in the core. These scans are more expensive to run than the simple 1D scans, and also require much more time. Recently, methods have been developed to quantify the scout scans. This allows for a simple density profile to be quickly generated, which allows for log-core depth corrections to be made in a non-destructive manner, while still maintaining a fast turnaround of core.

The value of running 2D axial scans on specialized intervals of interest is not just that it provides a density/porosity profile, but also that these images provide a density map of the core. In heterogeneous media, these density maps are crucial to understanding the scale of the heterogeneity present in the reservoir.

Finally, NMR measurements can be used to generate a measurement of fluid saturation vs. length in the tested core pieces. Methods have been developed to obtain high resolution NMR spectra (i.e. every 1 – 2 cm along the length of the tested core). Saturations made at this high resolution are compared to saturation measurements made over a larger scale (e.g. every 10 – 15 cm along the core). This allows for an understanding of whether there is value to obtaining such high frequency information, and how point-source core measurements of fluid saturation can be used to compare to the scale of logging tool output numbers.

Examples

Three case study examples are provided in this study. The first case study is an example of a heavy oil well, for which core material was acquired over several potential heavy oil-bearing zones of interest.

CT scout scan data is converted to a linear density profile for this core, and the linear density profile is compared to the profile that can be obtained from high resolution 2D axial scanning of the same core. The CT 1D density profile is then compared against the in-situ log density profile. This example illustrates both the application and also the challenges in doing depth correction in unconsolidated samples.

The second case study is a smaller piece of oil sand, for which high resolution CT data is acquired, along with high resolution NMR measurements of fluid saturations. This example demonstrates the methodology and the challenges in measuring water saturation within an oil sand. The high resolution fluid saturation data is also compared to lower resolution saturation information, in order to study whether this high resolution data is required for characterization in oil sand formations.

Finally, the third case study presented is a high resolution CT and NMR study of a conventional oil system in a low permeability reservoir (Bakken core). Here the challenge in measuring in-situ fluid contents and saturations in this low permeability system are illustrated.

Conclusions

Coupled CT and NMR analyses are used to obtain high resolution density/porosity and fluid saturation measurements in different reservoir materials. An example is shown for a core-log depth correction for an entire cored well in a heavy oil sand. Examples are also shown illustrating the challenges and value of running high resolution measurements on bitumen-bearing oil sand and on low permeability Bakken core.