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Technical Evaluation of the Carbon/Oxygen logs Run in Blocks V and VI of the Lamar Field in the Maracaibo Lake Basin, Venezuela.

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Summary

In order to monitor the hydrocarbons residual saturation on mature fields through cased holes, conventional open hole tools do not work due to the presence of casing, production tubing and cement. In response to these limitations, pulsed-neutron tools were developed in order to evaluate such wells.

Specifically, Carbon/Oxygen (C/O) logging technology can be used to evaluate candidate wells to be recompleted since they measure the actual oil saturation of cased wells and allows one to identify by-passed zones independently of water salinity. However, in the last decade, the use of this technology for monitoring residual hydrocarbon saturations in the Maracaibo Lake Basin (West Venezuela) has decreased to the point that it has not being exploited recently, mostly due to lack of confidence in the results given for these tools in the past.

My investigation sought the reasons why such results have not been as expected, analyzing the causes of discrepancies between the results and the actual production behavior, to determine whether it is associated with reservoir characteristics, hole environment conditions or due to the interpretation of the acquired data.

Theory and/or Method

To achieve my objective, the data provided by three different service companies (Schlumberger, Halliburton and Weatherford), which consisted in the carbon/oxygen ratios curves, was reinterpreted “in-house”, by using commercial petrophysical software and a linear equation for oil saturation (which had not been done before in PDVSA, where I worked as an intern during this study). During the data interpretation, a well-by-well comprehensive study was performed, considering different aspects of the well logging environment, as the configuration of the completion of the wells and the wellbore fluid distribution during the logging job. These two aspects are important since both, the presence of double casing or casing and producing pipe along the logging interval and the fact that oil or water is within the borehole will affect the response of the tools and it has to be taken into account for the interpretation of the data.

In addition, the results were compared with petrophysical and geological data from neighboring wells available at the moment of the logging job as well as data from well drilled after the logging job. Finally, the production behavior (before and after the logs were run in the wellbores) where studied in order to compare it with the interpretations provided by vendors.

Examples

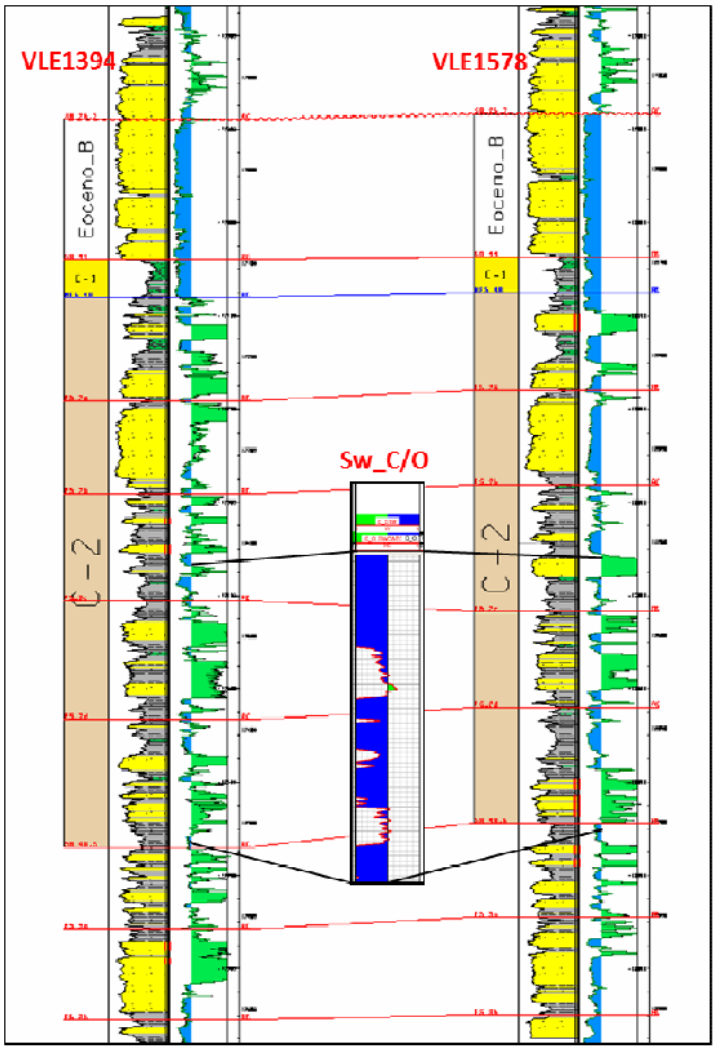

Fig. 1. Comparison of C/O response (in the middle) with two neighboring (drilled after the C/O logging) wells showing different fluid saturations.

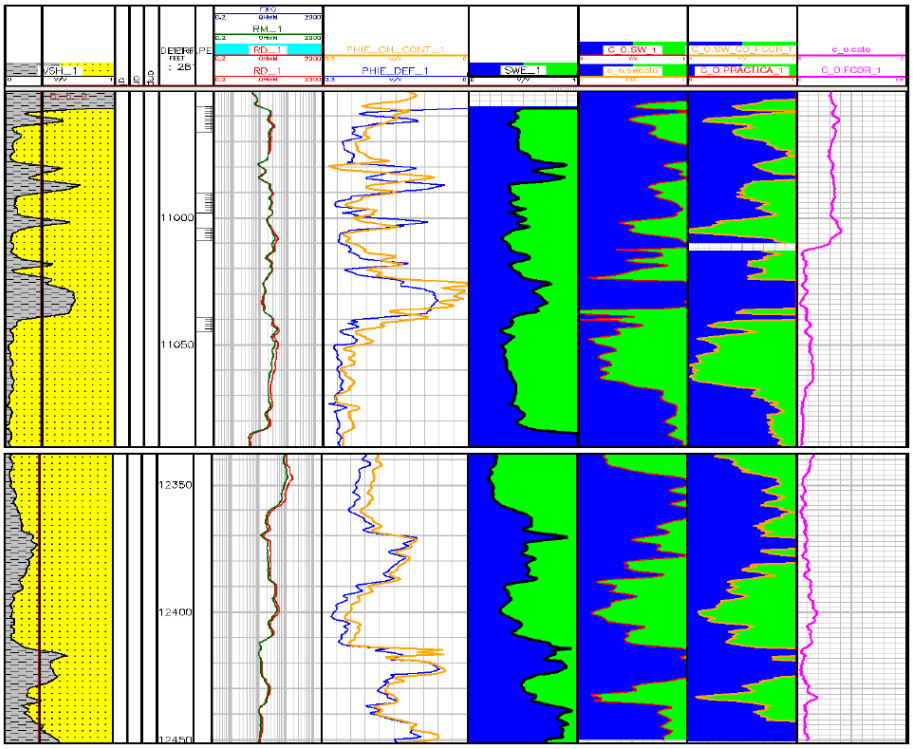

Fig. 2. Comparison of Sw interpretations. Track 4: Open hole interpretation. Track 5: Vendor interpretation. Track 6: In-House interpretation showing very good match between the interpretations performed in-house and the one provided by vendors.

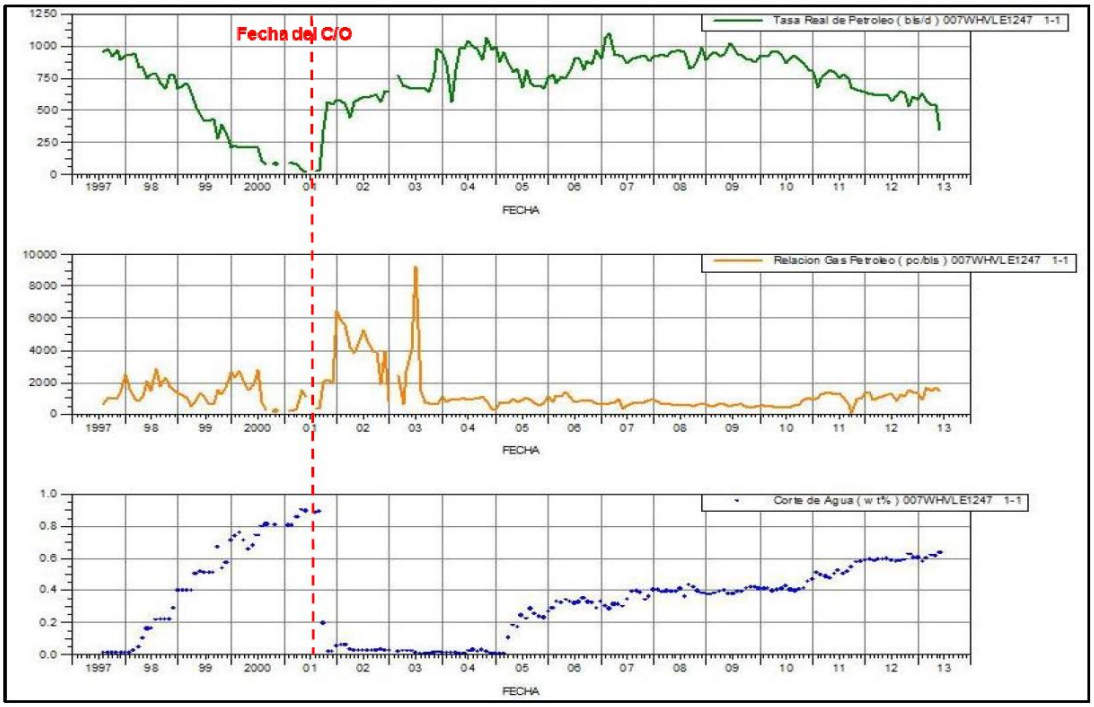

Fig. 3. Production data before and after C/O logging used as part of the evaluation of the interpretation provided by vendors.

Conclusions

In this study it was found that poor pre-job planning was largely responsible for previous disappointing results, since half of the wells where the technology was applied did not meet the conditions required by the technology. Another significant finding of this study was that C/O data can actually be processed and interpreted by operators, using a commercially available petrophysical software. This allows one to obtain in most cases, quantitative results similar to those given by service companies, which also provides a way to control the quality of the interpretations before making any decision that involves high financial investment.

Below is a bullet points summary of the main findings of the investigation:

- 5 out of the 8 wells evaluated with the Carbon/Oxygen technology showed at least one by-passed interval with hydrocarbon production prospectivity.
- High interpretation uncertainty was observed in the intervals where there is more than one tubular (double casing or casing/tubing) and in the zones where the fluid hold-up (water, oil and gas distributions) in the wellbore is unknown.
- Re-invasion of fluids from the wellbore to the formation affects the interpretation of the results when the technology is run in static wells.
- Carbon/Oxygen technology is a useful tool to evaluate mature fields through cased holes as long as a good pre-job planning is performed in order to select the candidate wells, taking into account all the aspects that may affect the tool responses.

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