SELF-COMPENSATED CASED-HOLE PULSED NEUTRON SPECTROSCOPY MEASUREMENTS

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Abstract:

Formation elemental composition and mineralogy measurements, including organic carbon from recently developed spectroscopy tools, provide critical information for formation evaluation in both conventional and unconventional reservoirs. These measurements can be obtained under cased-hole conditions by using a slim pulsed neutron tool with two spectroscopy detectors. One primary limitation is that users must manually provide offsets for the elements (Si, Ca, and Fe) present in casing and cement before performing the oxide closure computation to obtain elemental concentrations. This process is time-consuming, and the results could be inaccurate and subjective, especially without any local reference. Another limitation is that the formation element signals are smaller in cased hole than in open hole. This increases the noise in the oxide-closure-derived environmental yield-to-weight normalization factor (FY2W), which is propagated to all the elemental weight fractions.

A self-compensated spectroscopy algorithm was developed to overcome these two limitations. The key breakthrough is the use of raw measurements with very high precision from the two spectroscopy detectors to predict FY2Ws instead of using the oxide closure or inelastic capture (INCP) closure methods. The capture FY2W is mainly determined by the borehole and formation sigma. It can be characterized by using multiple measured apparent sigma values in different timing gates from multiple detectors, which have different sensitivities to borehole and formation sigma. The inelastic FY2W is mainly determined by the borehole and formation geometry and hydrogen index. It can be characterized by using count rate ratios in both burst-on (inelastic) and burst-off (capture) timing gates from multiple detectors. This method reduces the noise in the FY2Ws by an order of magnitude, which improves the precision of all the final elemental weight fractions.

Two independent sets of apparent elemental weight fractions can be calculated from the two spectroscopy detectors. The measured elements from the detector with shorter spacing are more sensitive to the borehole environment including the casing and cement, whereas the ones from the detector farther away are more sensitive to the formation. This enables self-compensation for casing and cement effects. The new processing can be done without user intervention and results in a more accurate, more precise, and less subjective elemental composition and mineralogy. More than 1,600 laboratory measurements in different conditions were used to characterize the algorithm. Several log examples demonstrate the excellent performance of the new compensated spectroscopy measurements in cased hole, which are validated by core data, cuttings analysis, and measurements from a high resolution spectroscopy logging in the same wells before they were cased.

Bio:

Tong Zhou is a Principal Tool Physicist at Schlumberger's Houston Formation Evaluation Center. He joined Schlumberger in 2006 as a postdoc research scientist at Schlumberger Doll Research located at Cambridge Massachusetts. In 2009 he transfered to Houston to work on development of Pulsar* multifunction spectroscopy. He holds a PhD in nuclear engineering from North Carolina State University (USA).