**High Resolution Spectral Gamma Ray Log (HRSGR): Applications for Unconventional Reservoirs**

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**Abstract**

The development of a high resolution spectral gamma ray logging procedure for use with conventional whole core analysis provides detailed definition of geochemical and geological data in unconventional reservoirs, such as the Marcellus, Haynesville, and Barnett formations. Increasing the spectral gamma ray sampling rate from the industry standard of two measurements per foot to five samples per foot provides superior data quality that is used to show small-scale changes in the amounts of potassium, thorium, and uranium, which serve as proxies for lithology and organic content (TOC) in thin bedded to thinly laminated sequences (centimeter to millimeter scale bedding).

High resolution data provides detailed stratigraphic information that can be used for interwell correlation to field-scale correlation of otherwise non-correlatable units. In addition, by identifying potentially organic-rich zones in otherwise homogenous appearing rocks, the high resolution spectral gamma logs can also be used as a screening tool for geochemical sampling and analysis, resulting in high quality data from fewer samples. Geological events are also readily identified, such as phosphate-rich zones, storm beds, and fining-upward or coarsening-upward sequences. High resolution spectral gamma data has become an essential part of complete core analysis protocols for the interpretation of unconventional reservoirs.
ABSTRACT

The development of a high resolution spectral gamma ray logging procedure for use with conventional full diameter core provides detailed definition of geothermal and geological data in unconventional reservoirs, such as the Marcellus, Haynesville, and Barnett Formations. Increasing the spectral gamma ray sampling rates in the industry standard of two measurements per foot to five measurements per foot provides superior quality data that is useful to show small-scale changes in the amounts of potassium, thorium, and uranium, which serve as proxies for unconventional reservoirs, such as shale basins. High resolution data provides detailed stratigraphic information that can be used for internal correlation of otherwise non-comparable units. In addition, by identifying potentially organic-rich zones in otherwise homogeneous appearing rock, the high resolution spectral gamma log can also be used as a screening tool for geotechnical sampling and analysis, resulting in high quality data from lower samples. Geotechnical events are also readily identified, such as phosphate-rich zones, storm beds, and fibrous-upward or coarsening-upward sequences that are otherwise masked by the low density of data. High resolution spectral gamma data has become an essential part of complete core analysis protocols for the interpretation of unconventional reservoirs.

GOAL

The goal of this research is to develop a simple method to more closely characterize the lithology and organic content of thin-bedded, unconventional reservoirs, by modifying existing equipment or techniques that are commonly available at the wellsite or in a laboratory setting.

METHODOLOGY

Conventional Spectral Gamma (CSG) Logging is a method of measuring gamma-ray emanating naturally from rock and representing the three component decay chains of potassium, thorium, and uranium based on their characteristic energy range. The sample rate of standard downhole gamma ray logging and conventional core gamma ray logging is two samples per foot.

High Resolution Spectral Gamma Ray Logging (HRSGR) methods measure the same radiation as the standard methods, but it differs in the sampling rate: increasing from 2 samples per foot to five samples per foot.

A whole core sample is placed on a timed belt, and moved through a floating chamber of the spectral logging apparatus. Each sample is subjected to a ninety-second duration of "cooling" to enable the radiation of the sodium iodide scintillation detector (also known as the crystal). The crystal, when hit by a gamma ray, emits a light pulse detected by a photomultiplier tube which creates light pulses that range from 1.1 MeV in the core. The spectral core gamma measures both the amount of pulses as well as the energy level of the emitted gamma rays.

The successive counts are subsequently processed to remove any counts detected from missing core, and a log is created using proprietary Weatherford Laboratories software. One has the CSG and HRSGR logs are completed, they are compared to the total gamma log for depth correction and quantitative correlation. Gross depth step adjustments are made based on the comparisons of all three logs, correcting for the total gamma log and the downhole gamma log (when available).

Both the CSG and the HRSGR data can be imported into standard petrophysical software (e.g., PETRA) for analysis.