

PS 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 logging procedure for use with conventional full diameter core 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 measurements 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 of otherwise not-correlatable units. In addition, by identifying potentially organic-rich zones in otherwise homogeneous appearing rock, 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 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

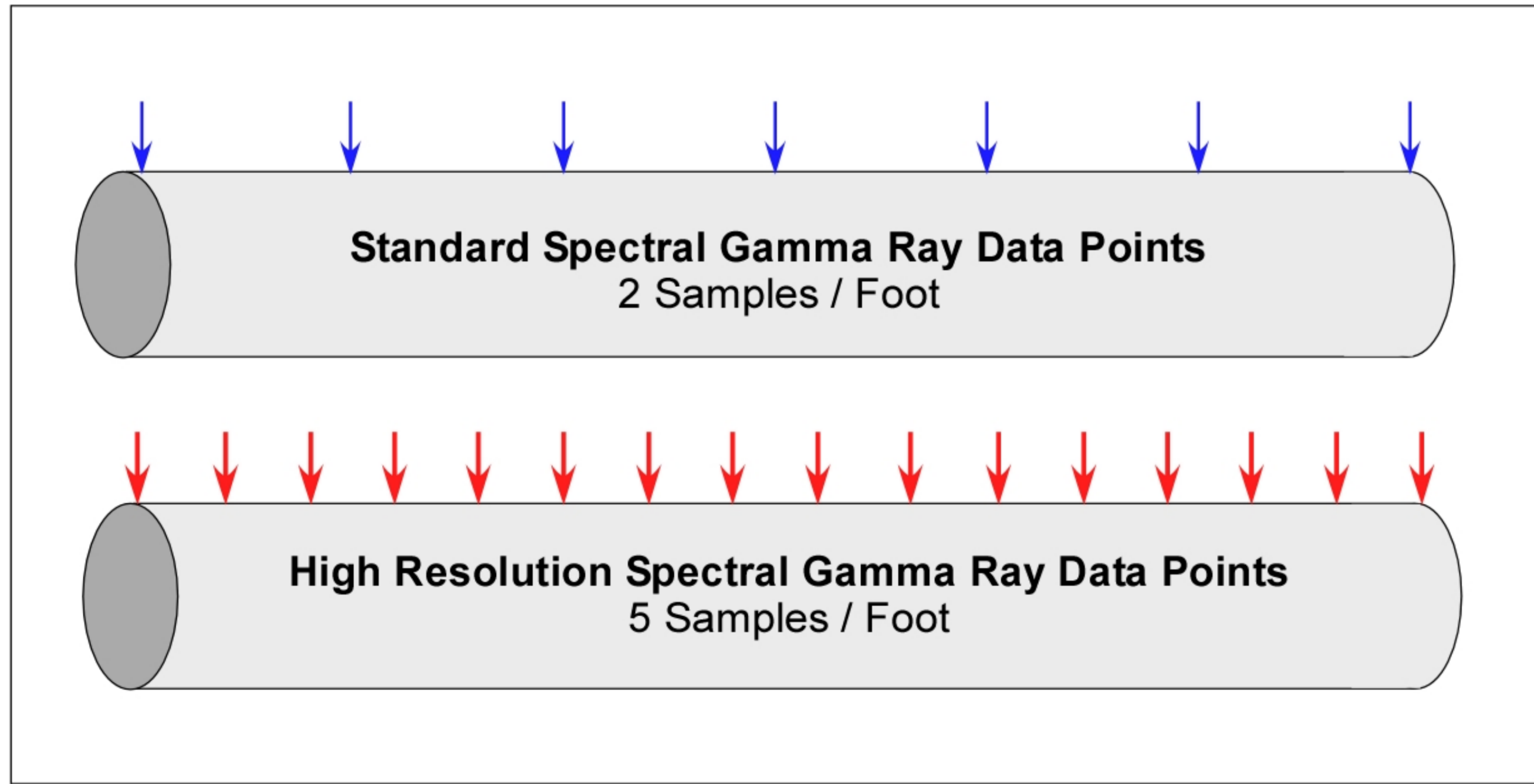
The goal of this research is to develop a simple method to more closely characterize the lithology and organic content of thin-bedded, unconventional reservoirs, by modifying existing equipment or techniques that are commonly available at the wellsite or in a laboratory setting.

METHODOLOGY

Conventional Spectral Gamma (CGS) Logging is a method of measuring gamma radiation emanating naturally from rock and separating the three component decay chains of potassium, thorium, and uranium based on their characteristic gamma radiation signature. 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 differed in the sampling rate – increasing from 2 samples per foot to five samples per foot.

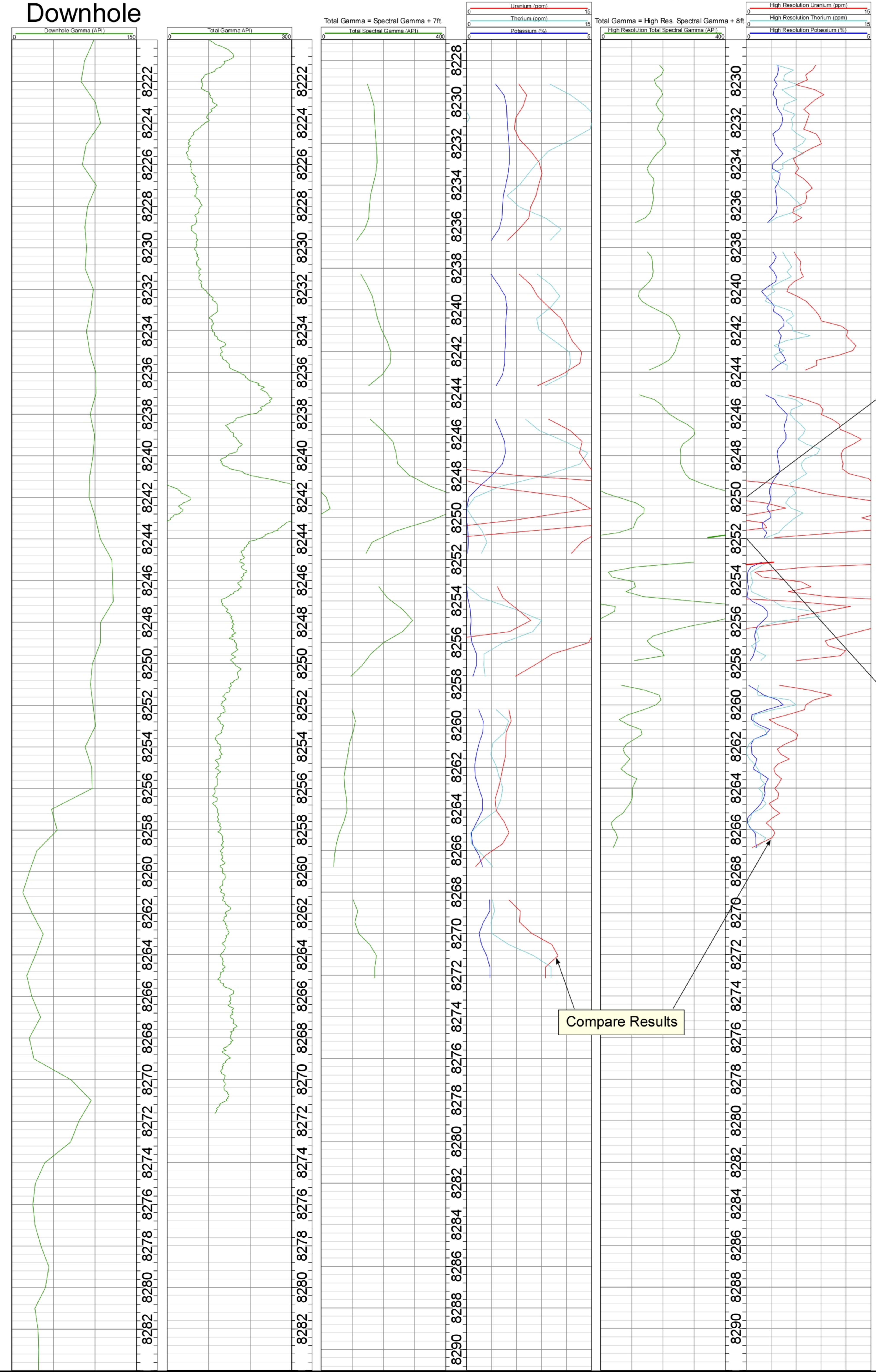
A whole core sample is placed on a timed belt, and moved through a flooding chamber of the spectral logging apparatus. Each sample is subjected to a ninety second duration of “flooding” to enable the ionization of the sodium iodide scintillation detector (also known as the crystal). The crystal, when hit by a gamma ray, emits a light pulse detected by a photomultiplier tube which creates light pulses that are correlative to the amount of gamma radiation in core. The spectral core gamma measures both the amount of pulses as well as the energy level of a given pulse.



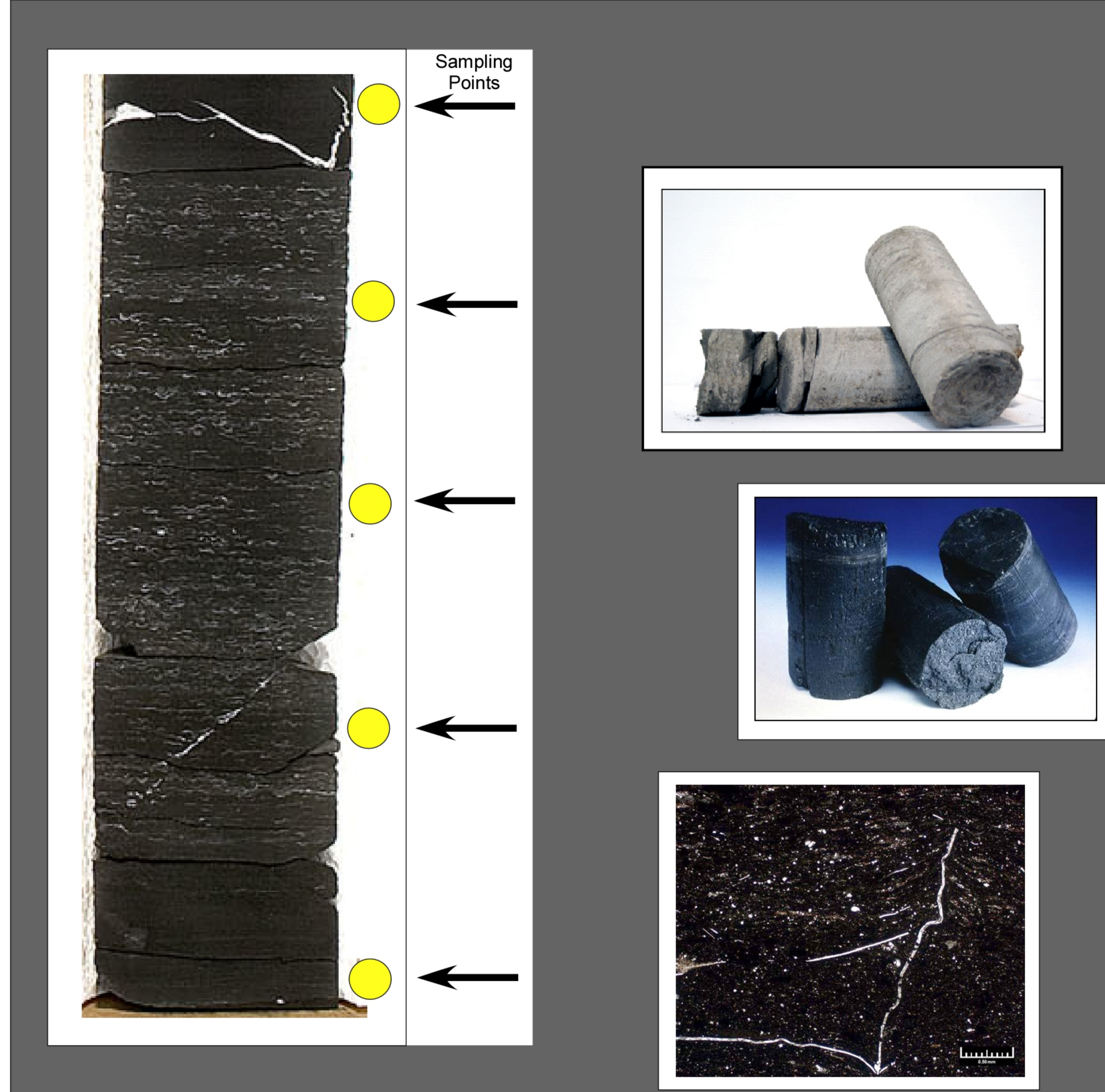
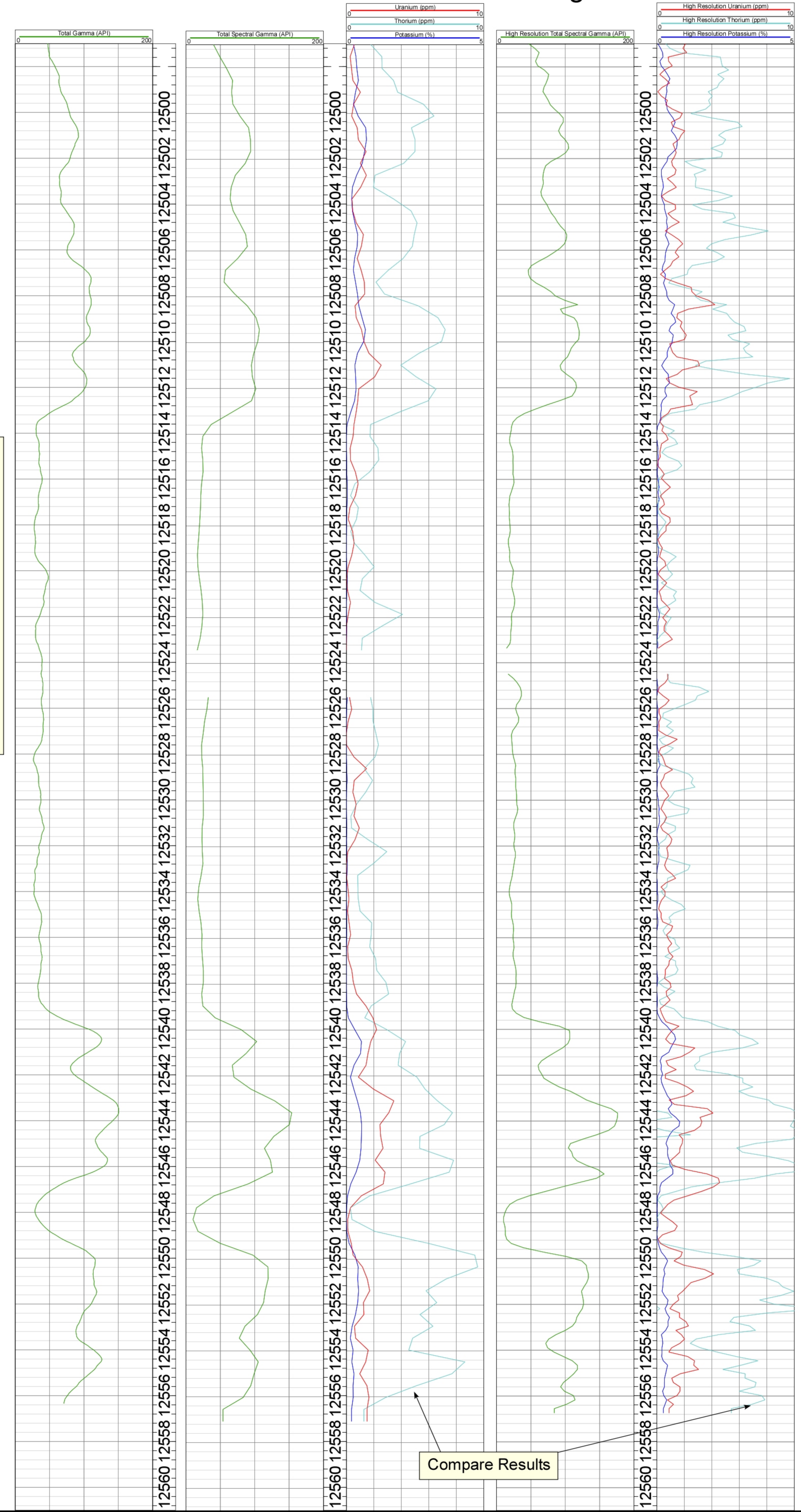
The successive counts are subsequently processed to remove any counts detected from missing core, and a log is created using proprietary Weatherford Laboratories software. Once both the CGS and HRSG logs are completed, they are compared to the total gamma log for depth correction and quantitative correlation.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

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

Case Study 1



Case Study 2



CONCLUSIONS

By simple modification of the procedures used with standard well site or laboratory based gamma ray detection devices, significantly better vertical resolution of the geological character of core samples is easily obtained using HRSG methods. This is especially beneficial when determining the small scale variations of thin bedded reservoirs or unconventional shale gas reservoirs. Detailed information can be obtained about changes in mineral composition, organic content, location of unconformities, transgressive surfaces, bedding parallel faults, small-scale trends of grain size or organic richness, etc. In addition, HRSG data can be used as a method to high-grade sample selection for TOC or other organic geochemistry analyses.

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