

Gamma-ray logging supports uranium exploration, lithological correlation and equivalent uranium estimation. Total count logging is faster and more cost-effective, while spectral logging provides separate potassium, uranium and thorium measurements for greater interpretive confidence. Method selection should balance cost, programme scale and data quality, with laboratory checks for uranium-series disequilibrium required before grade or resource estimation.

INTRODUCTION

Gamma-ray logging is the main borehole geophysical technique of interest in the exploration for uranium. Gamma-ray measurements detect variations in the natural radioactivity originating from changes in concentrations of the trace elements uranium (U) and thorium (Th) as well as changes in the concentrations of the major rock forming element, potassium (K). Since the concentrations of these naturally occurring radioelements vary between rock types, natural gamma-ray logging provides an important tool for mapping lithology and correlating stratigraphy. In the case of uranium deposits, gamma logging can also assist with estimating in-situ grade and grade thicknesses of intersected ore zones.

TOTAL COUNT GAMMA

There are two types of logging systems used to measure gamma rays in a borehole. The simplest of these is the total count logging system which is commonly used as a lith/depth correlator and in the uranium exploration industry for simple eU concentration measurement.

This system however, has no radioelement discrimination capability, so all the natural gamma

rays from any radioactive source are detected and affect the amplitude of the total count gamma the log presented.

The native output for the total count gamma is counts per second (CPS) log and in this form it is useful litho-stratigraphic correlator. By correlating the CPS data against sources with known U concentrations a conversion factor can be calculated to convert the raw CPS data into an eU log, where the e implies an estimate of U concentration.

These eU logs are a staple in uranium exploration due to their cost effectiveness when a large number of holes have to be evaluated. Being both faster to acquire and process than the spectral gamma, not requiring specialist processing. The downside to the eU log is the assumption that any peak in the eU log will be associated with an increase in the U concentration and discounts the influence of the K and Th variations in the total count log.

SPECTRAL GAMMA

The second system is the spectral gamma (gamma ray spectrometry). This system measures a complete energy spectrum from approximately 10 KeV to 3000 KeV at each measurement. The gamma rays are counted in 255 channels usually ~12 keV wide. As the full gamma spectrum is captured the raw spectral data can be processed post logging to yield elemental concentrations for K, U and Th along with a total count gamma log. Spectral gamma logging and processing is not as quick as total count gamma logging but does provide specific radio element concentrations not possible from the total count alone. The spectral gamma system does require careful calibration at a test facility for a robust calibration model to be created.

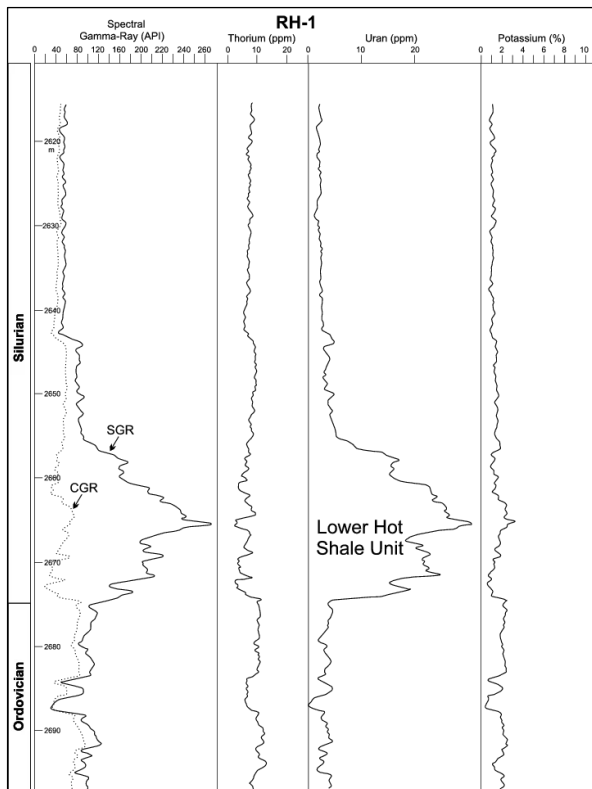
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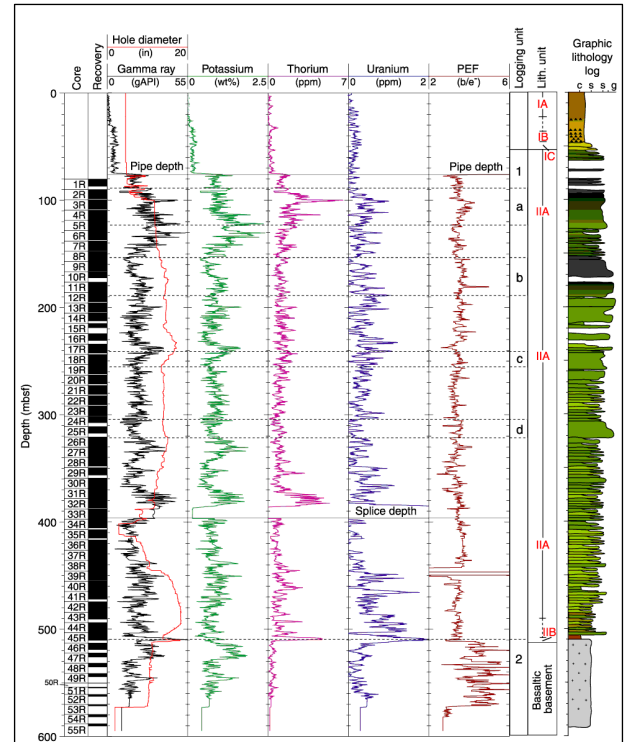


SOMETHING TO CONSIDER

Both the total count and spectral gamma logs are affected by the equilibrium of the radioelement decay series, specifically the U decay series as it the most complex. Any dis-equilibrium will have a negative impact on the veracity of the output products for either logging system. This is something that should be checked by laboratory analysis before accepting the downhole log results as acceptable, specifically if being used for grade or grade thickness estimation.



Above is a spectral gamma-ray log of the lowermost Silurian organic-rich (hot) shale in well RH-1 in the western Risha area (northeast Jordan). The organic-rich interval is significantly enriched in uranium, with maximum concentrations of 30 ppm, whereas thorium and potassium values remain rather constant. CGR = computed gamma-ray (Th and K radiation), SGR = spectral gamma-ray (total radiation). (Anatomy of a world-class source rock: Distribution and depositional model of Silurian organic-rich shales in Jordan and implications for hydrocarbon potential: S. Luening2005).



Summary of natural gamma ray logs in Hole 1201D; total gamma ray emission, potassium, thorium, uranium, and photoelectric effect (PEF) curves are displayed along with the graphic lithology log. The depths of the pipe and the splice between the two uplogs are marked. Logging units are marked, and coarser turbiditic beds a-d are highlighted. In the graphic lithology log, c = clay, s = silt, s = sand, g = gravel. (proceedings of the ocean drilling program, volume 185, Texas university).