QA/QC Procedures for Gamma Probe eU% Data

The most common method used to determine in-situ uranium grades from drillholes in the USA is down-hole gamma logging in RC or rotary drillholes, and the conversion of probe-measured counts-per-second (CPS) to "equivalent" in-situ uranium grades (eU% or eU_3O_8%). Although it is an indirect measurement of uranium grade that requires diligent attention to calibration and correction factors, the eU-determined grade is essentially equivalent to any other analytical method, and should have quality assurance and quality control (QA/QC) protocols in place to guarantee the accuracy and precision of results. Understanding and implementing gamma-log QA/QC procedures provides companies with improved quality information in their uranium drillhole database and satisfies international resource reporting requirements for data verification. The most common QA/QC protocols include **Standard, Blank and Duplicate assays**, and **Check assays** from a second analytical lab. There are equivalents to these procedures for down-hole radiometric measurements.

Standards: Where the analytical process for chemicals would incorporate standard reference materials (SRMs), the gamma probe's equivalent would be the probe calibration report from a known drillhole in a specially constructed test pit. These calibration holes are typically located at government-run nuclear testing facilities. The U.S. Department of Energy maintains a calibration facility for radiologic instruments in the western U.S. at Grand Junction, Colorado. The gamma probe is inserted in the test pit hole and logged dynamically, as in an ordinary drillhole, through a known thickness and grade of homogenized uranium mineralized material. A calibration report from the facility will provide the K-factor (conversion factor) for determining eU% grade, and other correction factors (water factor, casing factor, hole diameter) for the specific gamma probe in use. Primary probe calibration should be done on a regular basis; at least yearly.

Secondary forms of calibration can be carried out in the field at the project site, and should be a regular part of the gamma-logging process. Portable calibration sleeves containing a low-level radioactive source, such as thorium, can and be used before logging each drillhole to provide a "standard or calibration" reading. In addition, where possible, a control hole with mineralization should be designated for each project as a "standard or calibration" hole to remain open for re-logging at the beginning of each day, for each probe in operation. These secondary forms of calibration allow the detection of instrument error or instrument drift and provide verification of depth readings.

Blanks: A drillhole in known barren rocks can provide a measure of background radiation and a check of the gamma probe instrumentation. A control hole with mineralization and unmineralized background radiation can often act as a hole that measures background radiation as well. Background radiation may be due to potassium (K) or thorium (Th), and minimal or no uranium, and it may be necessary to establish a background level in CPS or eU that should be subtracted from eU data in low grade uranium mineralization where the background is a significant percentage of the total radiometric signature.

Duplicates: Duplicate assay equivalents are a must, and should include:

- re-logging a percentage of drillholes with the same gamma-probe (duplicates), and
- re-logging a percentage of drillholes with a different gamma-probe, by the same contract logging company (replicates)

This process will detect instrumentation errors such as gamma drift and digital depth measurements and provide a verification of the accuracy or repeatability of the eU determinations.

Check Assays: Outside (secondary lab) checks include:

- re-logging a percentage of drillholes with a third-party gamma-probe, using a different contract logging company (outside check on duplicate analyses), and
- re-logging a percentage of drillholes with a spectral probe that measures K, U, and Th, providing a verification check of grade from uranium and relative amounts of background K and Th.

Other Checks:

- **Prompt Fission Neutron** (PFN) logging a percentage of drillholes for a) verification of uranium grades, and b) state of equilibrium in comparison with gamma logs (Delayed Fission Neutron or DFN tools as well);

- **Chemical Assays**: Globally comparing eU data distribution from gamma logging with the global chemical assay-data distribution of drillhole samples (for example RC drill sample). Both sets of measurement represent the deposit, but by using different sampling methods and different sample volumes. However, it is possible to achieve a global comparative check on radiometric versus chemical assays and an indication of equilibrium. I refer to this as the "differential" between chemical and radiometric analyses, hole by hole and globally; it is not a measure off equilibrium.
- **Equilibrium:** A state of equilibrium, or the ratio of chemical U to radiometric U (U/eU) for the same sample volume, is best done on core or reverse circulation (RC) samples. Uranium equilibrium measurements are not per se a QA/QC procedures, but are an important procedure that should be done, and can be critical for oxidized state uranium mineralization or mineralization that exists above a current water table where leaching and re-distribution of chemical uranium might be expected. A common analytical method is called "closed can" radiometric analysis, where a sample (RC or Core) is allowed to equilibrate in a sealed canister for approximately 3 to 4 times the half-life of radon gas, and the radiometric eU is, therefore, back-calculated and compared to an ICP or XRF chemical analysis for the sample.
- **Twin Holes or Confirmation Drilling:** This type of verification drilling is also not a QA/QC procedure per se, but it and be a vital data verification procedure, particularly when a uranium deposit is defined entirely by historical drilling. It does provide a check on historical data. Many uranium deposits have a high nugget effect, and in such cases it is preferable to avoid direct on-to-one drillhole comparisons and instead conduct "representative" confirmation drilling across the deposit, and compare the data sets globally.

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