09/25/2014; 4:35PM

Using Cuttings-Based Elemental, Mineralogical, and Organic Data to Assist Drilling Operations: The First 12 Years and Directions for the Future

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During the last decade, improvements in portable analytical technologies and advances in interpretive knowledge have allowed cuttings to become a primary source of data to aid in wellbore positioning. Wellsite-deployable X-ray fluorescence (XRF) instruments can quickly and accurately measure 30+ elements, including the standard major elements (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, S, and Cl) and key trace elements (V, Cr, Co, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr, Nb, Mo, Ba, Hf, Pb, Th, and U). This data is generated within 30 minutes of cuttings collection at the shaker, and can be immediately tied to a previously-defined chemostratigraphic zonation developed from core and cuttings in offset wells. This detailed information can significantly increase confidence in stratigraphic position, and can be used to actively adjust wellbore trajectory.

Elemental wellbore positioning has been used successfully in sandstone, carbonate, carbonate-evaporite, and shale reservoir sequences over the last decade. The advent of shale resource plays, however, has accelerated the acceptance of the technique. For example, redox-sensitive trace metals (mainly V, Ni, Mo, and U) can be effectively used as proxies for organic richness in shales due to their association with anoxic/sulfidic depositional environments. This provides valuable chemostratigraphic and chemosedimentologic information for direct identification of oil-bearing and gas-bearing intervals, and their proximity to brittle zones.

The more recent introduction of wellsite X-ray diffraction (XRD) analysis now permits mineralogical data (quartz, opal-CT, feldspars, total clay, carbonates, sulfides, apatite, anhydrite, barite, etc.) to be collected in tandem with elemental data. In shale reservoirs, the bulk mineralogy data improves the accuracy of brittleness determinations and identification of target zones. For sandstone reservoirs, the quantification of feldspar types and total clay provides valuable constraints on the chemostratigraphic correlation and potential reservoir quality.

Cuttings-based data is complementary to LWD data, and an approach combining elemental / mineralogical data and LWD gamma response can be particularly useful for geosteering and formation evaluation. The elemental data also provides an important backup for LWD tools, as an elemental gamma response can be continuously calculated from measurements of K, Th, and U in cuttings. In high-temperature plays, cuttings analysis may assume a more important role; since surface XRF and XRD instruments are unaffected by hostile downhole conditions, the drilled section can still be completely characterized provided that hole-cleaning conditions are reasonable.

The future of applied cuttings analysis at wellsite will be driven by two factors:

- As instrumentation improves, it will be possible to generate and communicate elemental and mineralogical data in near-real time. This will allow the data to be used routinely for assisting wellbore positioning, similar to LWD gamma steering today.
- Because the combined elemental / mineralogical data is large and comprehensive (up to 45 values per sample), it lends itself well to multivariate statistical techniques, allowing prediction of additional critical FE parameters. Direct estimation of porosity and permeability from cuttings in sandstones has already shown promising results.