An Innovative Workflow to Refine Exploration Phase Assessment of Unconventional Prospects; Using XRD Analysis Data and 3D Geo-Modeling Techniques

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Abstract

XRF data collected from 13 wells, and sampled from Drill-cuttings at 5m (16ft), was analyzed and compared with raw log data that was re-sampled to the same 5m intervals. Correlations between a number of mineralogical indicators and the raw logs revealed spatial trends in the data, both from a vertical stratigraphic profile as well as geographically. This was used to generate a stochastic, 3D geo-model tying in more than 140 wells to populate the model with key parameters. Normalized elemental anomalies were correlated with log values in order to establish facies criteria based on both lithological provenance and petrophysical cut-offs, thereby highlighting what are believed to be more fracturable shales. Variogram analysis of the spatial distribution of this binary 'facies' category, combined with secondary trends (associating log signatures with postulated regional paleo-geography indicators), provided the basis for building a 3D geo-cellular model of petrophysical facies. Multiple facies realizations were generated (using Sequential Indicator Simulation,) thus capturing the uncertainty in both its size and distribution within each zone of interest. Along with the facies of interest, other associations were identified between some trace elements and total organic carbon (TOC,) which in turn had their own relationship with log signatures. These relationships allowed TOC to be co-simulated across the region, again capturing uncertainties in both the amount and distribution of TOC within the model. Similar methods were used to profile SiO_2, $CaCO_3$ and clay content honouring vertical trends, in an attempt to better identify optimal fracture ability within the shales of interest. The resulting summary statistics and probability maps high-grade areas of interest, capture more accurately geo-spatial distribution of key mineralogical indicators, and thus help to better quantify estimates of potential hydrocarbon volumes early in the exploration phase.