Determination of Reservoir Properties from XRF Elemental Data in the Montney Formation

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Summary

Portable X-Ray Fluorescence (XRF) instruments allow a large amount of data to be obtained rapidly, with minimal sample preparation or drilling impact, and at low cost. Rock powders, cuttings, slabs or core faces can be analysed directly using this non-destructive technique. XRF analyses provide highly precise, and if calibrated properly, accurate data on the bulk chemistry. Proprietary normative mineral algorithms are applied in order to convert the elemental chemical data to mineralogy. Mineral abundances determined from the XRF analyses correlate well with those obtained by X-Ray Diffraction, thin section point coounting and SEM analyses. The vast majority of the data fall within the 5% envelope expected from the precision of the XRD analyses when compared with XRF determined mineralogy. Mineralogy in the Montney is variable and the most abundant minerals are calcite, dolomite, quartz, feldspar and illite. Minor amounts of phospahtes, pyrite, and TOC are also present.

Mineralogy and trace element data are used to determine reservoir properties through a set of semi-emperical equations. Porosity and mechanical properties, including Poisson's ratio and Young's modulus, determined by XRF algorithms correlate well with values obtained from wireline logs and lab analyses in vertical wells. Formation specific algorithms developed from vertical wells can be applied to cuttings analysed from horizontal production wells, where conventional log analyses are impractical or too expensive. The information obtained is particularly valuable for geosteering purposes if conducted on site in real time or for post well completion planning. Data obtained using portable X-Ray Fluorescence instruments provide a cost-effective means for optimization of both completions and production from horizontal wells.

XRF Modelling (Vertical Core)

XRF analysis can be conducted over an entire vertical well in order to determine a chemical stratigraphy and locate potential areas of interest. Elemental abundances provide a wealth of data that can be used to distinguish various chemical stratigraphic units. Each unit can be distinguished with relative ease using basic elemental abundance suites.

The major rock forming elements acquired through XRF methods are excellent for identifying rock formations and sub-units in the subsurface which can be correlated from well to well. Normative mineral algorithms are then applied to convert the elemental chemical data to mineralogy (Figure 1). Mineral composition and rock fabric parameters can then be used to develop algorithims for modelling reservoir properties including porosity and and mechanical properties such as Poisson's ratio and Young's modulus. The mechanical properties appear to be fabric controlled and each mineral contributes to the make-up of a specific fabric. Understanding these relationships makes it possible to predict the mechanical properties of a rock using only the mineralogy and fabric. The mechanical properties in unconventional shale reservoirs are very important in oil and gas exploration. If a rock is too ductile or too strong it may not be possible to hydraulically fracture.

XRF analysis also yields a large quantity of chemical information on trace elements. Elements related to gamma can be used to creatre a spectral gamma suite along with a combined XRF generated gamma signature. Depth shifting can be applied by relating the XRF gamma back to wireline or core gamma. Carbon itself is too light to detect using XRF, but trace elements related to TOC can be used to locate zones with high source rock potential as well as the presence of solid bitumen. Areas of interest are located through XRF using relatively simple interpretations such as molecular percentages and TOC estimates to screen out samples for more expensive or time consuming lab analyses. Intervals with higher TOC trace element indicators are likely to have higher TOC values. The concentrations of trace elements are related to the original TOC content and that portion which was preserved.

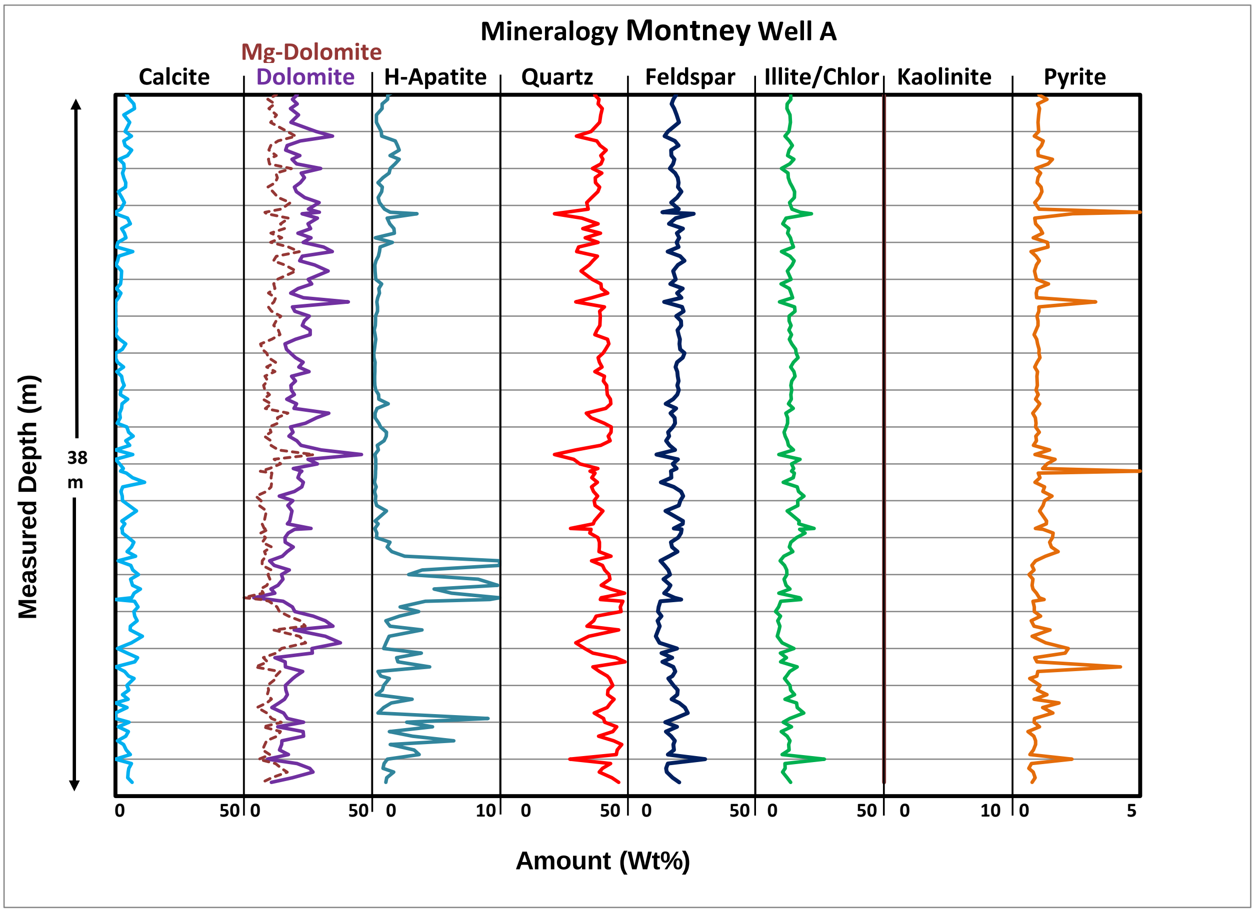

Figure 1: XRF Calculated Mineralogy Logs From Core. Continuous colored curves show XRF calculated mineralogy.

A reservoir quality log suite is shown in figure 2 for a core in the Montney Formation. In order to properly evaluate the target reservoir the most important factors are gathered into one log suite we designate as "Reservoir Quality". The key factors selected for this log suite are larger grained detrital framework components, total clay, total carbonate, mechanical properties, porosity and TOC. These properties can help locate zones with the best mineralogy (low cement, low clay). High resolution XRF analysis can locate the best interval for well placement.

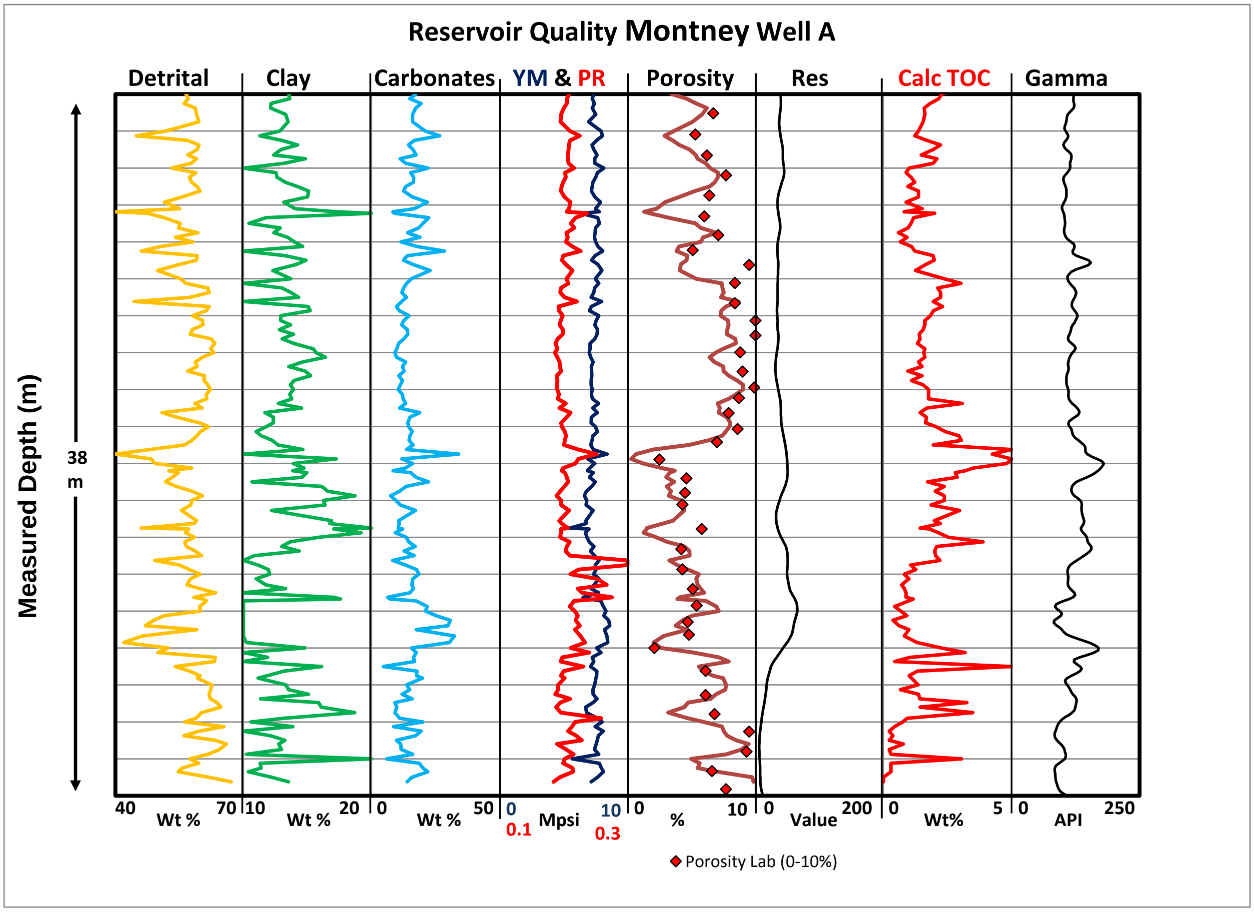

Figure 2: XRF Reservoir Quality Logs From Core. Continuous colored curves show XRF calculated data for mineral groups, mechanical properties, calculated porosity and TOC. Wirleine log GR and resistivity along with lab measuresd porosities (red diamonds) are also displayed.

XRF Logging (Horizontal Well)

Algorithms developed from vertical wells can be used to log horizontal wells through the analysis of drill cuttings. Chemical logging of the horizontal well can be completed during or after drilling with no effect on rig operations and without putting any tools in the well. On-site analysis can help the geologist determine the stratigraphic location of the well in order to remain within the target interval. Future projects can be enhanced through post well analysis. Reservoir quality is useful for evaluating production and hydraulic fracture results.

Conclusions

Portable X-Ray Fluorescence instruments allow a large amount of data to be obtained in a short amount of time with minimal sample preparation. The cost of these non-destructive analyses are quite low in comparison to conventional techniques. Portable X-Ray Fluorescence instruments are capable of analysing rock powders, cuttings, slabs or core faces directly. XRF analyses provide highly precise, and if calibrated properly, accurate data on the bulk chemistry of a sample. Elemental data obtained from the XRF analyses can be useful in determination of a chemical stratigraphy.

Geoscientists and engineers are more familiar with and more frequently work with mineralogy and reservoir properties rather than elemental composition. XRF Solutions have developed normative mineral algorithms to convert bulk chemical data into mineralogy. Reservoir properties, porosity, Poisson's ratio and Young's modulus are determined from a semi-empirical specific mineral interaction model. Mineral abundances and reservoir properties determined from the XRF analyses correlate well with those obtained by more costly techniques.

Formation specific algorithms are developed from vertical wells. Once these are developed they can be applied to cuttings analysed during the drilling of horizontal wells. The information obtained is particularly valuable for geosteering purposes and/or in real time or post well completion planning. Data obtained using portable X-Ray Fluorescence instruments provide a cost-effective means for optimization of both completions and production from horizontal wells.