Applications of Portable XRF for Chemical Stratigraphy: Horn River Basin

Darren P. Juss*, University of Calgary and Alberta Innovates Technology Futures, Calgary, Alberta, Canada
dpjuss@gmail.com
and
Ronald J. Spencer, University of Calgary and Alberta Innovates Technology Futures, Calgary, Alberta, Canada
Thomas C. Weedmark, University of Calgary and Alberta Innovates Technology Futures, Calgary, Alberta, Canada
Francois Marechal, Quicksilver Resources Canada, Alberta, Canada

GeoConvention 2012: Vision

Introduction

The shale units of the Horn River Basin represent a potential world class hydrocarbon play juxtaposed alongside several challenges faced by producers. Identification of lithofacies and compositional changes by binocular microscope and natural gamma measurements tends to be difficult due to the homogenous appearance of the shale. As producers continue to face depressed gas prices for the foreseeable future it is imperative that methods be examined to increase the efficiency of the drilling process. The portable X-Ray Fluorescence (XRF) tool has the potential to determine target zones and steer the drilling of wells in real time.

Methods

Drill cuttings were collected at 5m intervals from several wells located in northeast British Columbia. Cuttings were commercially cleaned and allowed to dry prior to analysis. Approximately 2g of cuttings are ground into a fine powder with a mortar and pestle and placed inside a specially designed plastic cup. Precision of the instrument is high, but accuracy is variable depending on the particular element and factory settings. Before samples are run a set of known standards are analyzed on the instrument. Each standard is analyzed at least five times; the known values for a certain element are then plotted against the results given by the instrument. By running three to four standards that contain varying amounts of certain elements a curve of best fit can be plotted through the points on the resulting graph. The equation of the curve is used to determine the true amount of a given element present in a sample. Samples are then run in "mining plus mode" and "soil mode." Each test takes approximately two minutes with mining plus measuring major elements (Si, Al, Fe etc) and soil mode being more useful for trace elements.

Data and Results

Using the chemical data acquired through XRF we developed 2 key data sets referred to as gamma and majors. The gamma dataset compares K, U and Th concentrations measured with the XRF to data from spectral gamma logs (Figure 1).
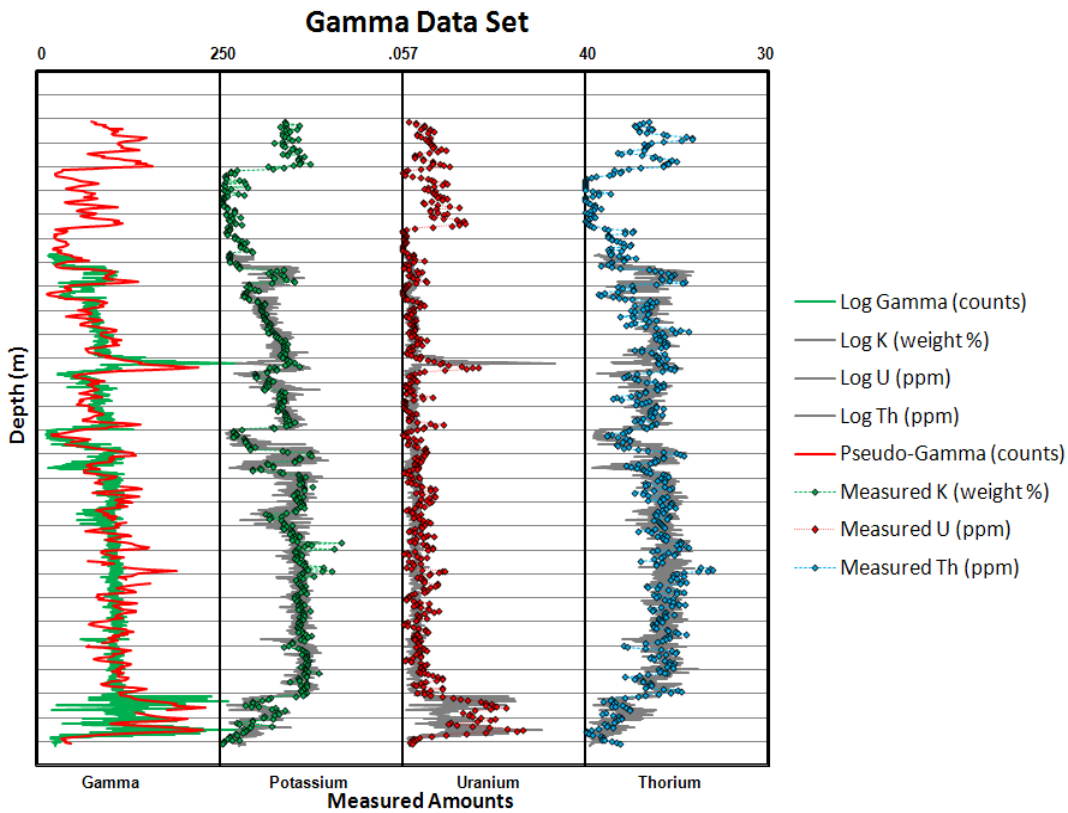
Gamma Data Set

Figure 1. XRF and Log Gamma Comparison. Depth markers have a spacing of 100m.

We can confirm sample depths and create pseudo-spectral gamma logs by overlaying the XRF data on the well logs. Data from the XRF are run through a low pass filter to reduce scatter. A multiplier for each curve is applied to the XRF values to produce expected gamma counts. The multipliers are adjusted in order to get the best match between the log data and measured XRF data; the counts are added together to produce the Pseudo-Gamma curve. This enables us to build spectral gamma logs along the build and horizontal portions where conventional logging may not be feasible or practical.

The major element data set is essential for locating desirable hydraulic fracturing targets within the shale sequence. Elemental concentrations are converted to oxides and sulphides then normalized to reflect CaC03, Si02, Al2O3, K2O, Fe2O3, and FeS2 percentages within the rock (Figure 2). Even minor changes in lithology can be clearly defined. We interpret the interval below the Mississippian unconformity to be part of a second order global cycle (Devonian to Carboniferous). Within this interval we interpret four 3rd order cycles which are each divided into several 4th order cycles (Figure 2). These cycles appear to correlate with the cores examined.

We are able to pick out several carbonate markers above the Horn River shale in the Fort Simpson. These markers are important for accurately landing horizontals. There are 5 specific carbonate markers which are continuous throughout this portion of the basin; C-1, C-2, C-3, Victoria Scarp (VS), and Marechal Horizon (MH). From a fracturing standpoint there are two main contributing factors to brittleness which are SiO2 and Al2O3 proportions. Higher SiO2 values tend to make the rock more brittle while higher Al2O3 amounts generally have the opposite effect. We are currently in the process of linking specific chemical compositions to fabrics and both of these to Poisson's Ratio values. By

correlating specific markers between wells we can create basin wide cross sections. This information can be used to dictate the location of future drilling sites.
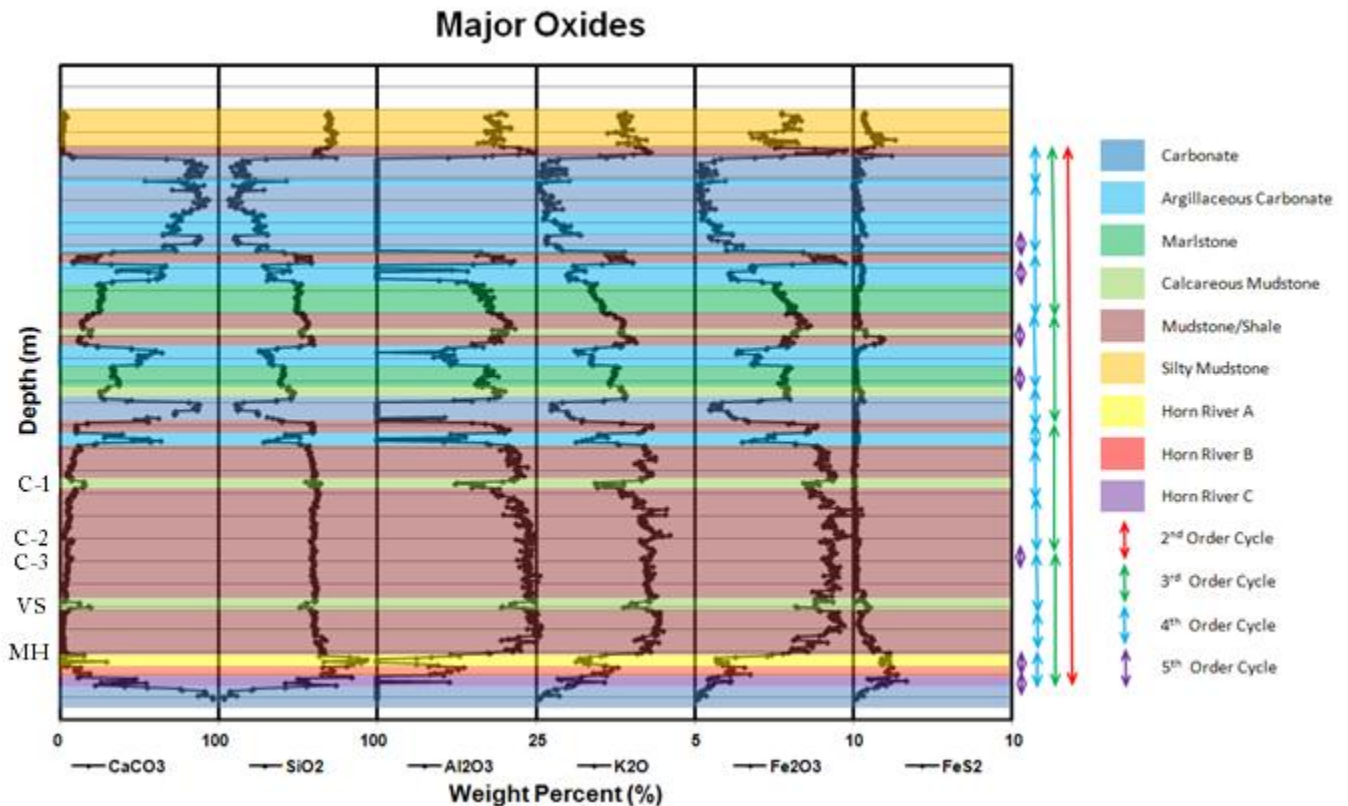

Figure 2. Normalized Major Oxides. Trends in oxide percentages make it possible to interpret changes in lithology from top to bottom. Sequence stratigraphy has been applied to the interpreted lithologies. One full cycle is designated as one HST to the next HST. The HST is marked by the top of the deepest relative sea level unit. The overall shallowing upward sequence appears to be part of a 2nd order cycle from the Devonian to the Carboniferous. It appears that up to 5th order cycles can be discerned at this resolution. Within the Horn River shale units the most brittle (possibly most cemented) interval is Unit A. Unit B appears to be quartz rich detrital shale with increasing carbonate content and small degree of cementation. Unit C is predominantly a marlstone with abundant carbonate debris flows and quartz rich detrital silt/shale layers. Each depth marker has a spacing of 100m.

Conclusion

The ease of use and relative low cost of portable XRF instruments make them a potentially valuable wellsite tool. The ability to quickly and accurately determine changes in lithology during drilling is vital when exploiting long horizontal targets that are relatively thin. As more XRF data are collected from wells during and post drilling, regional mapping of reservoir quality will be possible.

Acknowledgments