GeoConvention
Calgary • Canada • March 7-11 2016
OPTIMIZING RESOURCES

Methods and tools to identify and characterize best productive shale zones

Jean-Yves Chatellier, Renee Perez** and Amjed Cheema****

Tecto Sedi Integrated Inc., ** Geochemical Research and Engineering Inc., * ProGeo Labs*

Summary

Several rock properties need to be analyzed together in order to identify the best target zones within a shale package. Among these, brittleness, total organic content (TOC), porosity-permeability, water saturation and presence or absence of bitumen are the most relevant. These parameters are best studied using cores and are least understood in horizontal wells for which data collection is much more restricted.

The present review will address the strength and limitations of tools ranging from gas canister, rock-eval or leco TOC, XRF, shade of grey profiling as well as gas and isotope composition from chromatography, isotubes and isojars. Understanding each of these individual types of measurements is critical to a reliable characterization of any horizontal well, and should be considered prior to choosing a completion strategy.

Representativity of each of these measurements needs to be clearly understood. For instance, how to compare a spot measurement such as TOC against canister gas volumes that come from a foot long core. Reliability of some measurements need to be assessed, especially log derived porosity and TOC calculations when bitumen is present.

Vertical variability in gas composition is common in thick shale units. One important question to be answered is if it is best to target dryer gas with higher deliverability or wetter gas with lower gas production rate. A vital parameter, not often addressed, is the representativity of gas produced with respect to the gas composition in the reservoir. Pore restriction by cement or by bitumen can be addressed by an integration of organic and inorganic geochemistry together against total gas production rates.

Introduction

Increasing efficiency through innovation has always been the name of the game in the oil industry; the unconventional shale development is an outstanding example of it especially on the hydraulic fracturing and development side. Todays low price environment is forcing companies to do more with less and making the most of the information, already collected or to be collected.

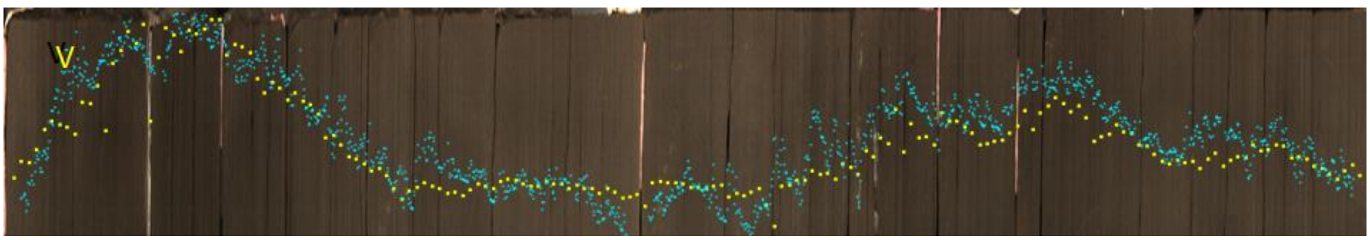
Optimizing frac designs to maximize the stimulated rock volume requires us to extract and integrate all of the information that has been recorded. This is where the industry will find value for money and keep innovation at a minimum cost.

Theory and/or Method

Total Organic Content

Whereas higher TOC content can be linked to maximum gas produced, TOC is a point measurement whereas the produced gas volume is derived from a larger mass of rock such as a foot long gas canister. Our study showed a better correlation between gas produced and shades of grey because the spectral analysis was made on the photo of the complete canister rock content (Figure 1).

There is a direct correlation between the shades of grey and the TOC content/proxy as very well expressed by some Montney core photos (Figure 2) and the same approach can be easily applied to photos of the cuttings vial content. TOC can also be calculated using XRF Molybdenum, Vanadium and Nickel content and integrated in the analysis.



Very good match between Vanadium content from XRF every cm and shades of grey every 0.2mm – core length equals 1.77m

Figure 1 A comparison between shades of grey and Vanadium as proxy for TOC – core slab from a Cypress well

All of these efforts are required for a precise TOC estimation, because TOC and porosity calculations from wireline logs can be erroneous in the presence of bitumen and absence of cores in horizontal wells.

Bitumen

In some shale packages, such as the Montney, bitumen identification and quantification is a common problem. A newly proposed workflow to tackle the bitumen issue has been built on the integration of inorganic and organic geochemistry.

The first pass is to identify pore blockage by comparing isojars and isotubes or gas chromatography and blended cuttings gas. The larger compositional differences indicate that heavier hydrocarbons are remaining in the reservoir. In order to identify bitumen, the second phase of the analysis is to semi-quantify pore blockage by carbonate or quartz cement; this is simply done by XRF analysis of the “blended” cuttings using Si/Zr and Ca/Mn approaches. Any pore blockage not associated with mineral cement is considered to be linked to bitumen.

Historical versu ideal data sets

Different workflows need to be considered when dealing with already collected data (historical) versus data acquired in future wells following a timed protocol. Thus whereas composition derived from isotubes or gas chromatography is not time sensitive; composition from isojars partially depends on the how long the cuttings have been retained in the jar before the analysis.

Thus for historical data the best results are obtained comparing pairs of isotubes and isojars from single wells because the analysis of the critical isojars should have been made around the same time. The problem of comparing various wells is that some of the delay in analyzing the isojars may range from a few days to many weeks/months.

For future wells, we recommend to stick to a routine workflow and timing for the analyses of isojars or for multiple samplings of cutting gas. That would allow for better reliability when comparing different wells.

Examples

Figure 2 involving canisters collected in the upper members of the Utica illustrates how cautious we need to be when linking productivity to rock appearance and rock properties such as TOC content. Note the match between produced gas and average shade of grey (TOC proxy) in the transgressive Indian Castle, versus an inverse trend between gas produced and grey scale in the shallowing upward distal facies of the Upper Dolgeville. Neither of these two intervals has been the main target for hydraulic fracturation because of brittleness; the Indian Castle being shaly and ductile and the Upper Dolgeville being less easy to frac than the Lower Dolgeville.

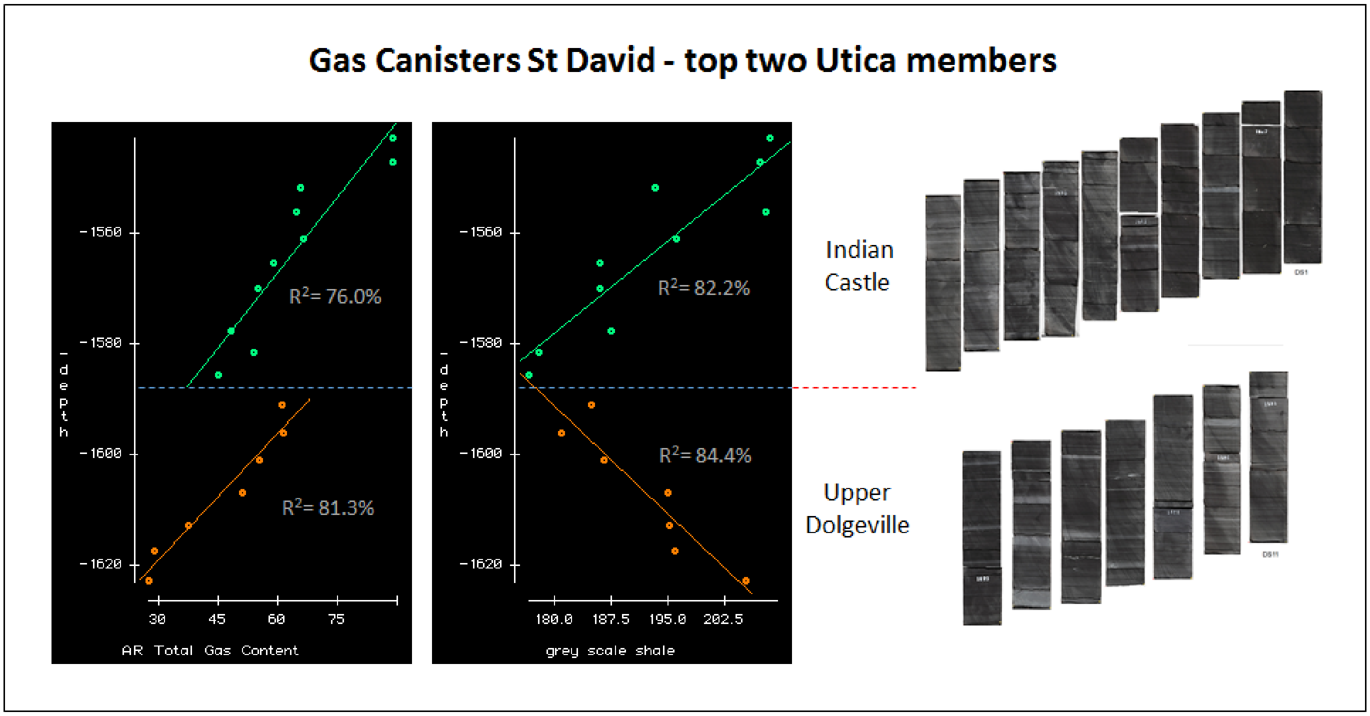


Fig. 2 Total gas calculated versus TOC proxy using grey scale from core canisters in Utica of Saint David, Saint Lawrence Lowlands in Quebec

The Lower and Upper Dolgeville are both shallowing upward cycles with increasing upward produced gas volume per canister in contrast to decreasing TOC upward trends.

The gas composition from free flowing gas (isotubes or chromatography) compared with that of the gas composition of the cuttings can be analyzed using various techniques including isotopes and phase envelopes. The later giving many useful parameters such as the cricondenbar and cricondentherm values (Fig.3) that can be used to characterize how tigh a shale is in absence of cores. Figure 3 shows cricontemperatures from phase envelopes created using compositions from isojars and isotubes in one Montney vertical well in Altares; the profile is compared to elemental compositions and to wetness from gas chromatography. This approach is very reliable in horizontal wells because of the lower depth uncertainty when dealing with isojars as the borehole stays longer in the same lithology and only gradually moves through the stratigraphy (in absence of any faulting).

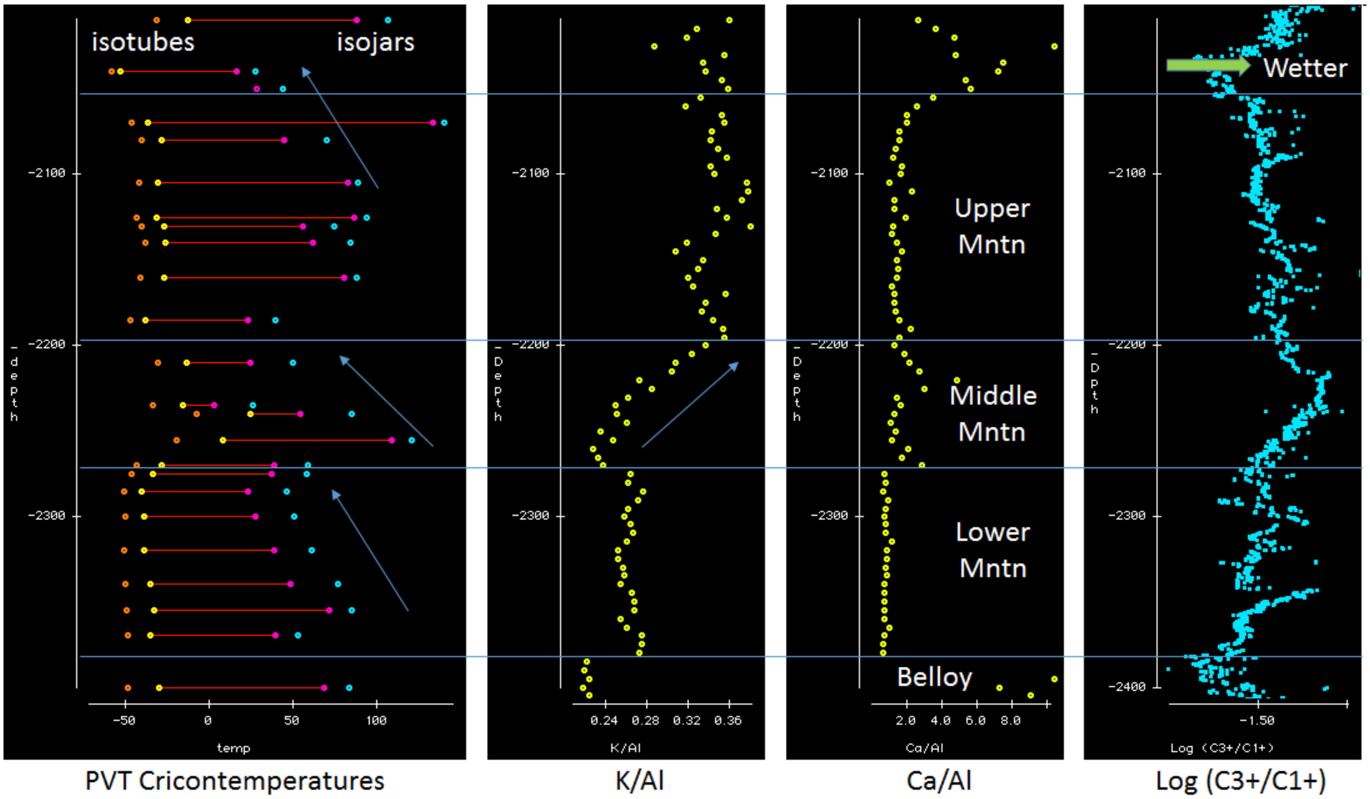


Fig.3 Complementarity of data from various sources in a vertical Montney well – a few of many parameters that can be compared

Conclusions

Simple and inexpensive techniques, applied to historical data collected in older wells can give new insights of relative productivity of various shale units and can be easily applied to horizontal wells. In the light of todays depressed oil and gas prices, a more elaborate data collection should rely on better defined time related protocols that would allow for the acquisition of optimum quality data at a lower cost.

Acknowledgements

The authors would like to thank Continental Labs for their technical support that led to the proposed workflow for bitumen.