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Reservoir Analysis Using Gas Chromatography

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Summary

Hydrocarbons analysis from the extracted drilling mud produces the earliest data while drilling and is routinely performed by the GWD and mud logging contractors. The incorporation and use of this data into the formation evaluation is then dealt with by the wellsite geologists and the production team.
While the potential for evaluation of a reservoir should be one of the most important results of hydrocarbon analysis, there are only a few publications that deal with it. The culprits for this situation are poor gas while drilling equipment for gas data acquisition which leads to less reliability of the gas data. Inadequate methods of interpretation of the geological environment follows in this same line.
These factors could explain why there is little knowledge among the downstream and upstream parties regarding the potential of gas data within the evaluation of a reservoir.
The main goal of this presentation is to show that a better use of gas while drilling data interpretation for early formation evaluation is linked directly to the efficiency of the equipment used and holds unexploited potential for efficient early management of the reservoir.
The equipment used for the acquisition of this data has undergone improvements in the last decades, the main one being on the gas assembly line.
For wellsite geologists the next challenge would be to perform a better analysis of the fluids while drilling, using new methods like GOR (gas oil ratio), biodegradation and cross plotting ratio. The GOR method allows us to obtain detailed data that can contribute to operations success in real time at the rig site as well as in reservoir modeling studies.

Theory / Method / Workflow

The gas while drilling method is based on a logical approach to gas shows in combination with drilling and mud logging data, and correlated with electric logs, pressure logs and well testing.

The data used in this method are:

- C_1, C_2, C_3, iC_4, nC_4, iC_5 and nC_5 (ppm), separated and quantified by gas chromatography using Flame Ionization Detectors (FID), Thermal Conductivity Detectors (TCD) or Infrared Detectors (IFR).
- TG (Total Gas), expressed in ppm of equivalent methane in air, and obtained through one of the FID, TCD or IFR devices.

The method workflow and the main steps are the following:

1. Data process: first of all we have to collect the geological and drilling data, and then use of software as Excel, where gas data is plotted with other data as ROP, GR, mud flow and bit size. The depth data base should be cleaned of distinctive events such as trip gas, connection gas, calibration, etc.

2. Quality control – it is used in the exploration & production process and is based on the next basis:
    - C_1 < saturation threshold of the chromatograph;
    - C_1/C_2 ratio < maximum value defined for a given chromatograph: $\%(C_1+C_2)$ instead of $\%C_1$ if C_1/C_2 > specification;
    - C_1, C_2, C_3, iC_4, nC4, iC_5, nC_5 > quantification threshold: usually a minimum value of 10 ppm is assumed;
    - $TG/\sum Ccor = 1 +/- 20\%$,

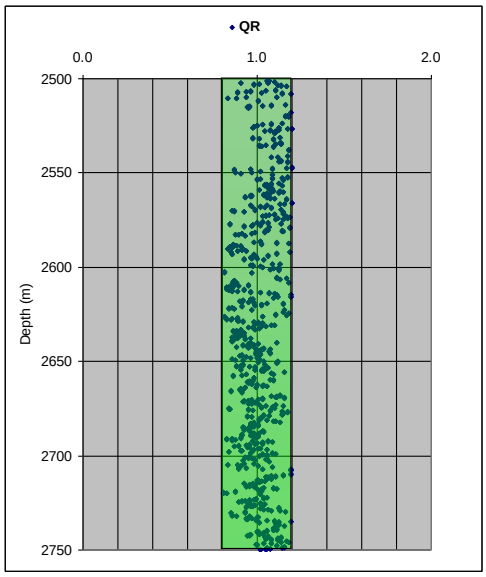
      $$\sum Ccor = C_1+2xC_2+3xC_3+4x(iC_4+nC_4)+5x(iC_5+nC_5),$$

      This formula checks the consistency between the TG detector and the gas chromatograph results:

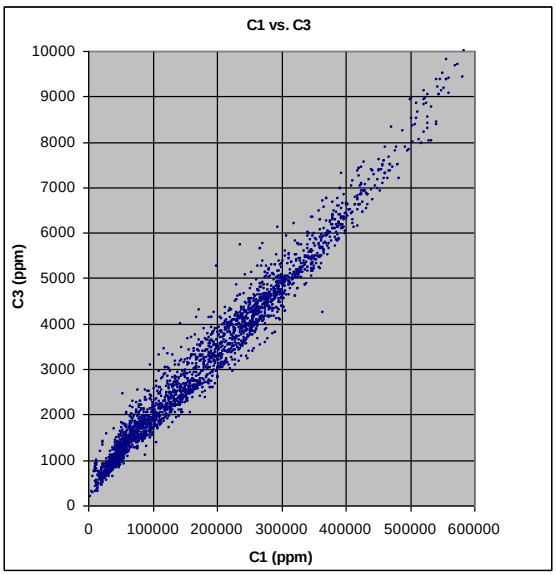
      $TG/\sum Ccor = 1$: good calibration;

      $TG/\sum Ccor < 1$: calibration problem: data are suspect;

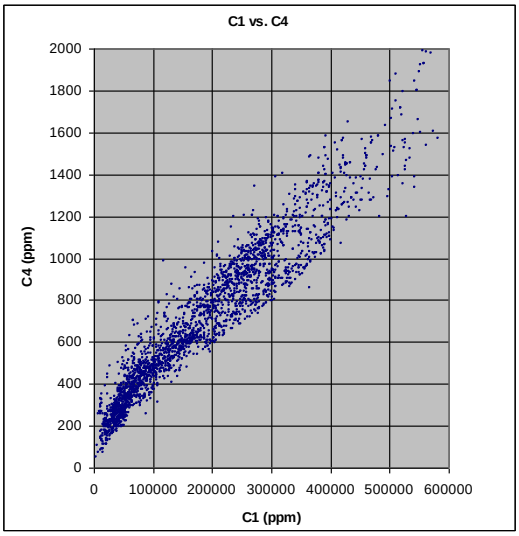
      $TG/\sum Ccor > 1$: calibration problems, or presence of organic matter from the reservoirs, or presence of an aquifer or a tight level within reservoirs.
    - High sensitivity - very important for heavy gases (butane and pentane), as an early indication of biodegradation.
    - High accuracy – indication of drilling mud contamination or recycling gas.



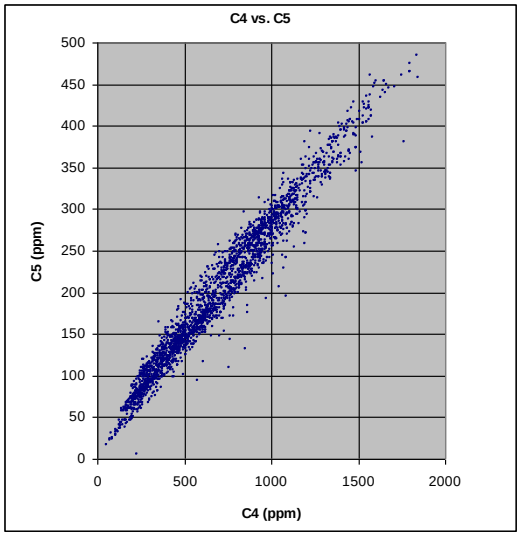
Quality Control



High Accuracy



High Accuracy & Sensitivity



High Accuracy & Sensitivity

3. Analysis – it is accomplished while drilling and is meant to observe trends and changes in gas data progress with depth, being a qualitative and semi-quantitative method, as follows:
    - evaluation of oils, condensate & wet gas content;
    - optimization of the strategy for fluid identification and perforation prior to well testing;
    - early identification of levels containing biodegraded oil;
    - identification of reservoirs saturated with hydrocarbons with different maturity;
    - identification of fluid contacts where logs show uncertainties;
    - sketching of the seal efficiency within the reservoir;
    - geo-steering in horizontal wells;
    - identification of depleted reservoir levels;
    - identification of thin hydrocarbon-bearing reservoirs in a multi-layer environment where electric logs are blind;
    - identification of GOR.

Results, Observations, Conclusions

The gas ratios while drilling method enhances the petroleum exploration & production process, reducing uncertainties for hydrocarbon bearing reservoirs.

Moreover, a good calibration of the TG & chromatograph detectors is essential for hydrocarbon fluid behavior differentiation. If the detectors are not calibrated properly it is impossible to get a reasonable interpretation for thin hydrocarbon-bearing reservoir identification.

The use at rig site of TCD or FID analyzers is a vital technical progress of gas acquisition for the formation evaluation. Preliminary results show the potential of this way of monitoring the mud gas while drilling.

Novel/Additive Information

Western Canadian Sedimentary Basin consists mostly of tight formations, especially west of 5th meridian, like Montney, Duvernay, Cardium, Glauconitic Sandstone, Slave Point carbonates and so on.

It has been stated that this formations usually generates light oils & gas condensates after the completion operations.

Due to low permeability of the specific lithologies, the amount of heavy hydrocarbons released into the mud system while drilling is not as high as the lighter components. The traditional methods such as Pixler & Haworth gas ratios are not accurate for interpretation of oil / gas bearing zones. After few years of observation, we developed new methods of gas ratio based on several oil companies dataset, which are matching quite well the testing production.

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