Evaluation of Coal Bed Methane through Wire Line Logs
Jharia field: A Case Study
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ABSTRACT: Methane produced from coal beds was for years a nightmare for the mining industry. Coal bed constitutes a new type of reservoir for the oil and gas industry to explore. This new reservoir does not lend itself readily to conventional well log analysis. However, new log analysis techniques have developed which increases the chance for a successful well. This study is summarized with a procedure to evaluate the parameters of proximate analysis using wire line logs of Barakar formation of Jharia Block in the State of Jharkhand. Methane produced from coal beds is a developing resource in the States of W. Bengal & Jharkhand. The evaluation of this resource is done by coring and testing. Core analysis and production tests are essential information to use with log analysis to make meaningful evaluation from wire line logs. The objective of this case study was to establish a relation of the wire line log value to evaluate the parameters of proximate analysis and to match with the laboratory evaluated values. Further, a model has been designed to evaluate the values as quick look interpretation technique. The proximate analysis data from the wells of Jharia field in which coal core was cut was used to calibrate the log analysis in this case study. Barakar formation in this area has predominantly high to medium volatile bituminous coal. The evaluation technique required to be tested for their accuracy before being used for coal beds of different rank.

INTRODUCTION
The evaluation of coal bed methane wells are being done by coring and testing. The method requires a well to be drilled, cored, completed and tested to know the reserve potential. Thus evaluating a well is quite expensive. Log analysis methods have been suggested to evaluate a coal bed methane potential using wire line logs. The information provided by log analysis includes the parameters of proximate analysis, i.e. ash, moisture, fixed carbon & volatile matter. Nothing can replace the physical core data to evaluate the well. Still in areas where no core data is available, an approach to determine the quality of the coal for the production of coal bed methane reserves through wire line data has been attempted.

This case study applies current log analysis techniques to four nos. of wells drilled in Jharia field. These wells were drilled primarily to produce methane gas from the Barakar formation. All the wells were cored and analyzed to know the rank of the coal. The objective of this study was to calibrate the data evaluated through wire line logs with the laboratory data which will help to evaluate the parameters of proximate analysis through wire line logs accurately.

LOGGING PROCEDURE AND LOG CHARACTERIZATION
The suite of logs normally run to evaluate a coal bed includes the resistivity, litho porosity and ancillary data. The density data under the litho porosity are used in determining coal quality, methane content and proximate analysis. The neutron data are used for gas detection in adjacent beds. The resistivity is used for coal bed thickness measurements and coal bed correlation. The spontaneous potential (SP) under ancillary data is used for indication of permeable zones.

Coal seams are relatively easy to identify and correlate on well logs. The bulk density measurements from the density log readily flags coal beds because the surrounding shales have a density value of about 2.65 gm/cc and coal bed density has average density of 1.35 – 1.4 gm/cc. The micro spherically focused log from the resistivity data shows sharp increase in resistivity at coal bed boundaries and generally reads more than 50 ohm mt. The resistivity curves show an increase in resistivity in coal bed due to high resolution of the resistivity tool. The neutron and density porosity curves are similar to each other with a high porosity value, often more than 50%. The gamma ray curve usually indicates less than 60 API units in coal.
CORE TO LOG CORRELATION

The logs are generally averaged to correlate with the core depths. The correlation of the log value is generally done after determining the correction factor. Then after using the log analysis algorithms the parameters are determined. To make the log analysis algorithm site specific, the results are compared with the available core analysis in the area and adjustments are made to the algorithm as necessary. In this study four wells in the Jharia field were cored and analyzed for the proximate analysis. In the present context the three nearby wells (Jharia # A, B, C) were considered to evaluate and compare the results.

The problem in correlating the core and log value generally persists as the vertical resolution of conventional log data is high in comparison to the vertical resolution of core data. Therefore, as a way to compare core and log analysis the log values were averaged over an interval and compared to core analysis averaged over the same interval.

COAL RANK ANALYSIS

Coal rank is usually determined from a proximate analysis measured from a coal sample; the analysis lists the percentage of moisture, ash, fixed carbon and volatile matter. Proximate analysis requires a sample of coal, which is possible while coring a new well. In the case of re-evaluating it is not possible to obtain a sample of coal for analysis. Therefore, a method of determining the proximate analysis from wire line logs can be used to know the rank of coal. With the use of Mullen (1999) algorithm, the wire line log can be used to estimate the proximate analysis. In this study results obtained by log analysis is found to be representative of actual core analysis.

EVALUATION PROCEDURE

In the Jharia field, four wells were drilled up to an average depth of 1000 mts. covering Barakar formation. The coal seams encountered in these wells were thoroughly cored and these cores were analyzed in detail in the RGL, Kolkata to evaluate the parameters of proximate analysis. In this study an attempt has been made to determine the parameters of proximate analysis using wire line logs and correlating the values with the laboratory evaluated values. The aim was to standardize the log data and to develop a quick look chart method to determine the core density, ash & fixed carbon. This is an empirical approach based on the laboratory evaluated results.

The core data is a physical data. A problem arises while comparing core data to log data. The vertical resolution of core data is about 3.0 cms, while the vertical resolution of conventional log data is about 60 cms. Therefore, as a way to compare core and log analysis the log values were standardized to resemble with core data.

The coal seams were averaged over an interval on the basis of the core depths and bulk density (gm/cc) values from the density log of the respective coal seams were picked up to evaluate the parameters. An ‘in house’ software has been developed using Mullen algorithm to evaluate the parameters of proximate analysis using wire line logs. In the present study, the density of the core sample is a very important factor for evaluation. Due to non-availability of laboratory core density data, corrected density data has been generated for evaluation. From the laboratory derived ash volume, using Mullen algorithm, density value of the respective coal seams were determined which is termed as ‘empirical density’.

The density value picked up from the log against the coal seam will be higher than the density of core sample. The deviation in the density value is due to the presence of igneous materials very near to the coal bed, which causes a variation in bulk density. Therefore, correction of log density data is required to match the core data.

In Fig. 2, the density values picked up from the logs of the respective coal seams have been plotted against volume of ash derived from laboratory.

Subsequently in Fig 3, the log density value and the empirical density were plotted with respect to the ash volume...
to find out the difference of two density values and to establish the correction factor. On establishing the correction factor of the respective coal seams, corrected density is determined by multiplying the correction factor with log density. The corrected density value of the respective coal seams was taken to evaluate the parameters of proximate analysis (ash, moisture, fixed carbon & volatile matter). Generally fixed carbon and volatile matter in dry ash free condition are considered for final calculation. Dry ash free is termed as daf.

The log evaluated fixed carbon(daf) has been plotted against the correction factor chart to get the corrected fixed carbon(daf) which can be matched with the laboratory evaluated fixed carbon(daf). The log and lab evaluated fixed carbon (daf) were plotted against corrected density which shows a definite resemblance in the values and trend of the curves. (Fig. 6)

**Estimation of Correction Factor, Ash, Fixed Carbon (daf) (Quick View)**

**Procedure:**
- Enter the Chart no 1, on its abscissa with log obtained Density value, proceed upward to the standard line, and proceed horizontally to determine corrected density.’
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- Ash is determined from the standard Chart no 2, by taking the corrected density value in the abscissa and proceeds upward to the standard line and proceeds horizontally to determine ash.
- Fixed Carbon (daf), considering the corrected density value in the abscissa in Chart 3, proceed upward to the standard line and horizontally the fixed carbon (daf) is determined.
- Vvm (daf) is evaluated by 100 – Vfc (daf)

An example of Quick view

Considering log density value of a coal seam is 1.39 gm/cc
Corrected density = 1.39 X Correction factor (0.965) = 1.34 gm/cc
Considering the standard charts : Corrected density = 1.34 gm/cc, Ash = 19.5, Fixed carbon (daf) = 62.79, hence correction factor = 1.26
Thus Corrected Fixed carbon (daf) = 79.11
Volatile matter (daf) = 100 - Fixed carbon (daf) = 20.89

ANALYSIS OF RESULTS

The data derived from proximate analysis in Table 1 was plotted and the analysis can be summarized as follows:

Table:1 Data derived from Proximate Analysis

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i) The log density value plotted against ash derived from laboratory in Figure 2 inferences that with an increase in density of the coal seam the value of the ash increases from which it can be concluded that with an increase in ash content, fixed carbon will be less and the quality of the coal seam may be moderate to poor.

ii) The log density & corrected density (derived after applying correction factor) were plotted against ash in the ordinate. The result concludes that the trend of the curve of log density value is similar to the corrected density. Due to variation in density value the separation of the curve has been observed which is represented as dashed & continuous line.

iii) In Fig. no. 3, the density of the good quality coal seams is generally in the range of 1.3 to 1.41 gm/cc. In this range there is an effect in the corrected density as the correction factor varies from 0.9 to 0.98. The correction factor has a negligible effect beyond the log density value of above 1.41.

iv) On evaluating the parameters of proximate analysis using Mullen’s algorithm (1999) after establishing the value of synthetic core density termed as corrected density the results of ash value, fixed carbon(daf), volatile matter(daf) obtained from the laboratory and the results derived were plotted keeping corrected density in the abscissa in
Chart nos. 1, 2, 3. From the plot it can be concluded that there is a good compatibility of the evaluated values obtained through wire line logs and laboratory results.

The preliminary result shows log calculated values are very representative of actual core analysis.

CONCLUSION

This study has shown that the log analysis can be a useful tool in evaluating unconventional reservoirs such as coal beds. Different logging procedures using high resolution processing with spectral density log are being suggested to improve the vertical resolution of the density measurement and thereby improve the accuracy of the bed thickness determination and coal quality analysis in new wells.

Log analysis using this technique can be very helpful by using existing well logs where no core data exists. With the more input data the correction factor chart presented can be refined to make the analysis through wire line more accurate in coal beds.

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