

# Study of CBM Wireline Logs Normalization in B Block

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**Abstract:** Logs normalization is an indispensable and basic work for coal-bed methane (Abbreviated as CBM) logging interpretation, and also the key step to realize interpretation from single well to multi-well. B block's DEN and GR logs come from different time periods and different logging companies. In order to finish the following CBM logging interpretation and lithofacies interpretation, type well plus histogram method is selected to finish DEN and GR logs normalization according to the applicable conditions of different normalization methods and B block actual situation. Type well plus histogram normalization methods can reduce the influence of man-made factors of the CBM logs from the actual application, distribution of logs after normalization are more consistent, which would lay the solid foundation of the following CBM development work.

**Keywords:** Coal-Bed Methane, Logs Preprocess, Logs Normalization, GR, DEN

## 1. Introduction

DEN and GR logs are the key factors which influence the accuracy of coal logging interpretation and lithofacies interpretation of coal seam, the reliability of logs is very important. The quality of logs not only effect by the environmental Influence, also for the inaccurate calibration of instrument [1, 2]. Same series of logs may come from different instrument, different standard scale, different calibration of instrument and different measurement during long-term CBM exploration and development [3, 4, 5]. All matter mentioned above cause errors of logs for same well in the different time period. In order to reduce these errors, it is very necessary to normalized DEN and GR logs before they are been used.

## 2. Logs Normalization Workflow

GR and DEN logs from B block are collected as the data base, logs from 154 wells has been remained after quality assurance and quality control, logs which has high sampling rate is resampled, logs merge and split have been dealt with for wells with casing [6, 7]. Type wells are determined according to the selection type well criteria after reprocess of logs[8]. High peak and low peak for DEN and GR logs are picked

directly from distribution of frequency histogram separately. After these preparatory works for DEN and GR logs, linear deformation is used for all logs' normalization. Frequency histogram and BOX diagram of logs are used to test the results. Integrated normalization workflow is show as Figure 1

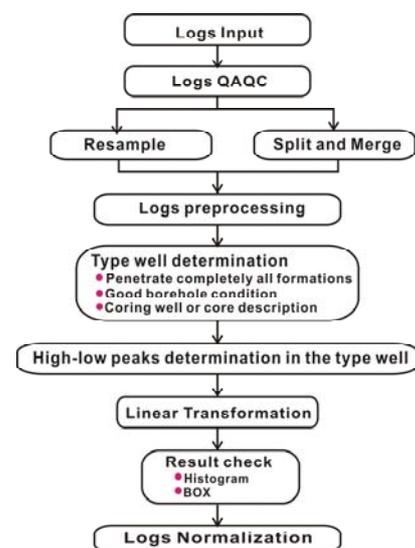


Figure 1. Normalization workflow for wells in B block.

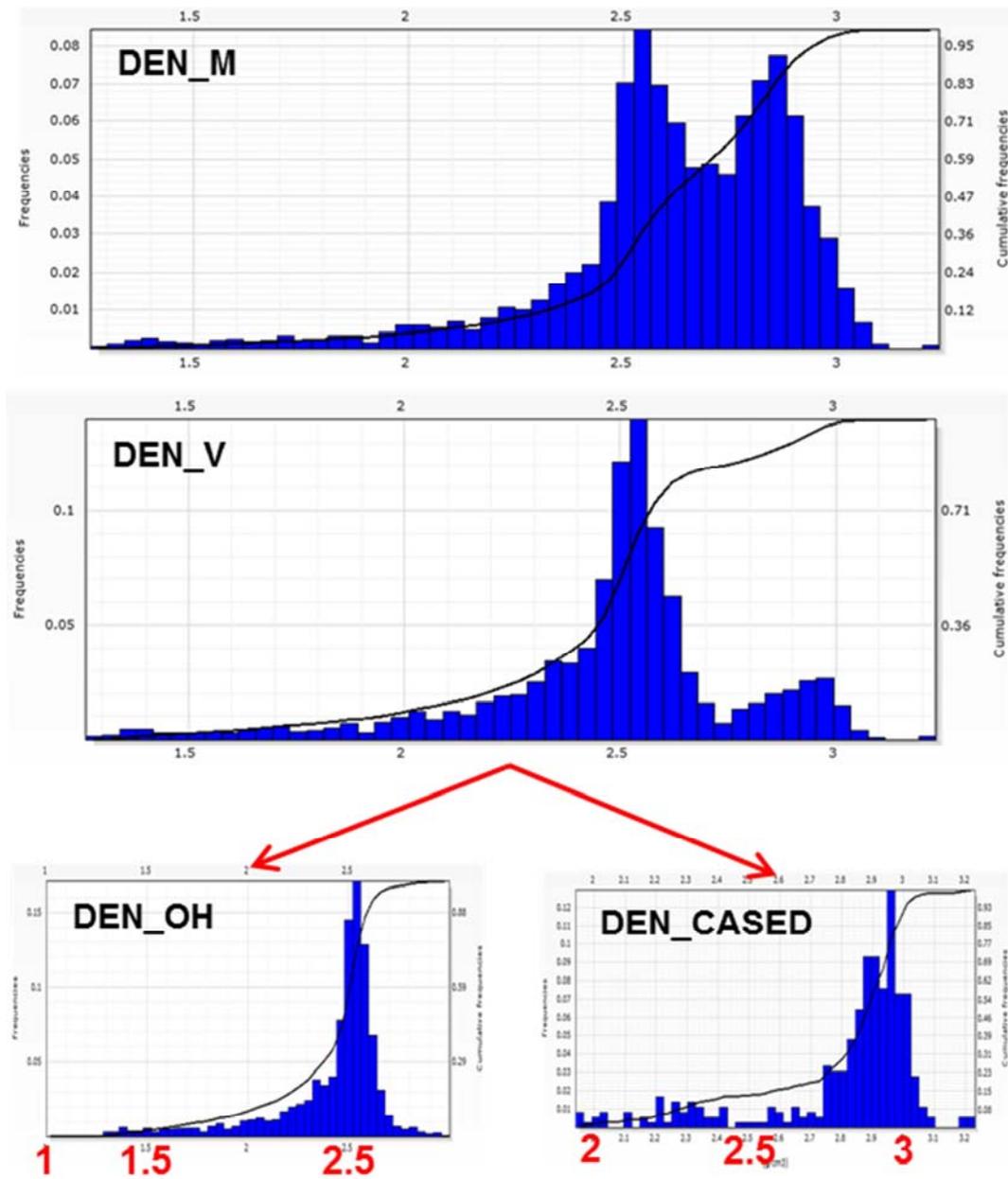
### 3. Logs Collection and Collation

The location of study area is divided into two parts, A part and B part. A part contains 96 wells, while only 82 wells have logs and other 14 wells have no logs. The main logs including DEN, LLD, SSD GR. B part consists of 72 wells, 36 wells of which are cased wells. Logs for B part mainly consist of DEN, GR. The logs come from 6 companies, and time span to get logs is very long, the earliest logs come from 1970's, while the latest logs is collected in 2015. Also the source of logs is different; some logs from drilling hole, while others come from coal mine. Because of these reasons above, all DEN and GR logs has uneven quality. DEN and GR logs from 154 wells are study object of this article, in which 36 wells are cased

wells, others wells are open hole. DEN and GR are logs which should be normalized.

### 4. DEN and GR Logs Preprocess

For all the collected logs from 154 wells, there are three problems, first is although logs belong to the one well, measured at different dates. Second is some logs have too high sampling rate to be utilized. Third is one well at top is cased well, while the bottom is open hole. So these logs must be preprocessed before been used.



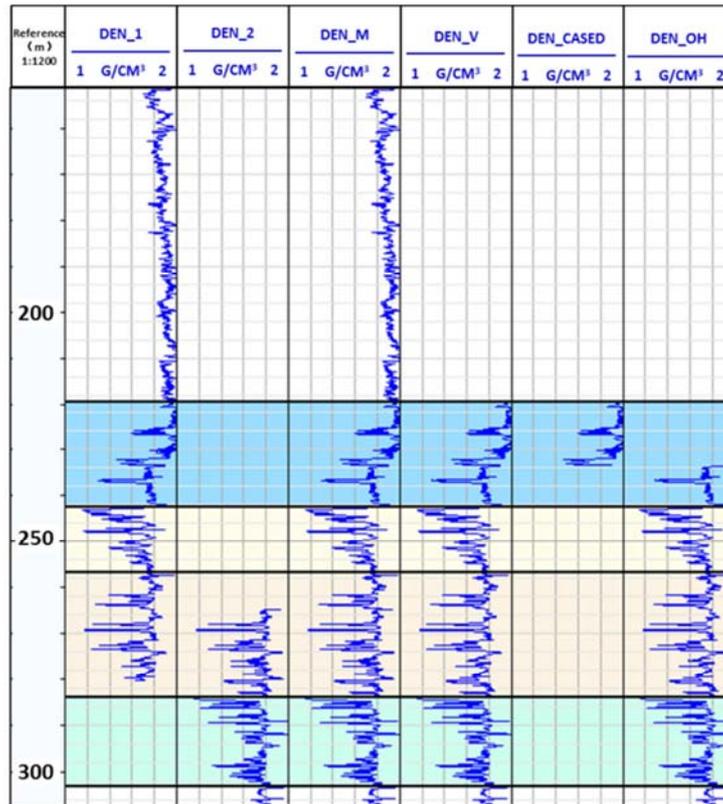


Figure 2. Logs split and merged of A well.

GR and DEN logs of the same well are not always measured at the same time, logs usually measured from bottom of the well, and divided logs into several parts according to the hole diameter. Abnormal logs often appear at the splice of the two logs because the change of hole diameter, top abnormal logs of bottom part will be removed. Logs merge and split is shown as

Figure 2. The different time measured logs DEN\_1 and DEN\_2 are merged by program Techlog, and abnormal data on top of DEN\_M are eliminated. After quality assurance and quality control of merged logs, logs become DEN\_V. In the well which has cased section, logs is divided into two parts: cased part (DEN\_CASED) and open hole part (DEN\_OH).

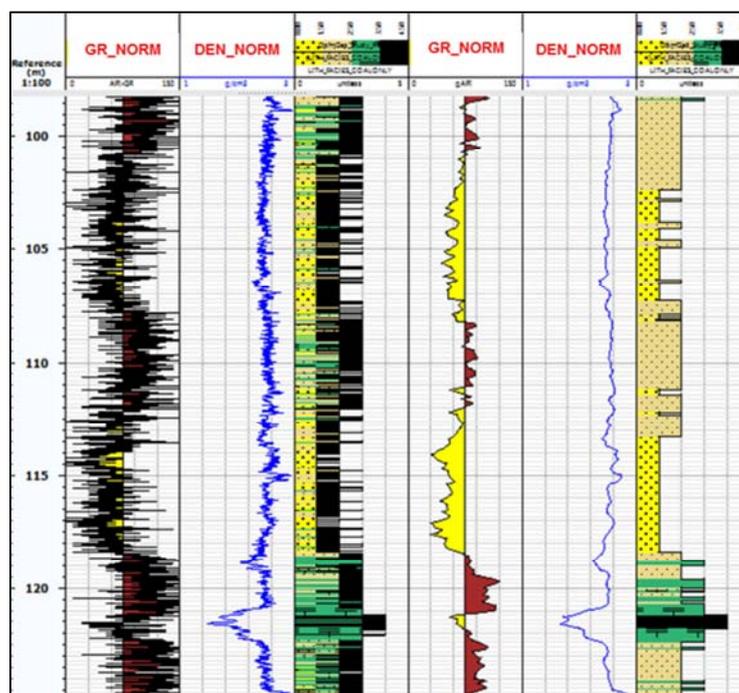


Figure 3. Logs resampling for B well.

B wells are resampled from 0.01 m to 0.1 m (Figure 3). Two lithofacies logs were obtained based on GR and Den logs before and after resampling. They were compared with the geological lithology description in well completion report. According to well completion report, lithology from 107.6 m to 111.8 m is mainly siltstone with occasional sandstone lamina. While buried depth between 111.8 m and 118.4 m is fine to medium grained sandstone, and becoming siltstone. Lithofacies interpretation from logs after resampling can give more accurate information about lithofacies according to the well completion reports.

## 5. Logging Data Normalization

Logs normalization method for coal bearing formation is different from conventional reservoir. Usually three logs normalization methods can be used for coal seam normalization; they are big methods, type well method, and reference layer method [9]. All the coal seam logs normalization faces different challenges. For the big histogram method (Figure 4), logs from most wells are combined into one large composite histogram, which the mean of remaining individual wells must fit. Otherwise, they will be shifted to fit into the composite histogram. The limitation is that the base of this method is built on the assumption all stratigraphic variability is random; if most wells have incorrect log data may yield erroneous results [10].

For the Type well method (Figure 5), one well selected as type well for logs normalization. While other well compared with those of the type well, the limitation is that type well must in settings where there is little distance or geological change.

For the reference layer method (Figure 6), a continuous layer is chosen as the reference layer. For this layer, average of log data calculated for each well. A surface over these averages fitted and used to normalize log of subject wells. The limitation is that find a reference layer is too hard in the fluvial-lacustrine depositional environment.

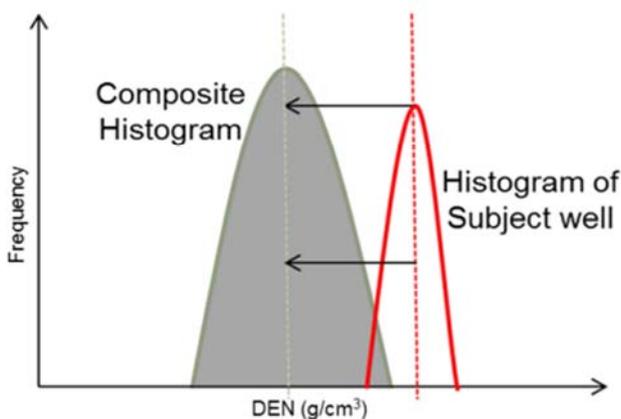


Figure 4. Big histogram method.

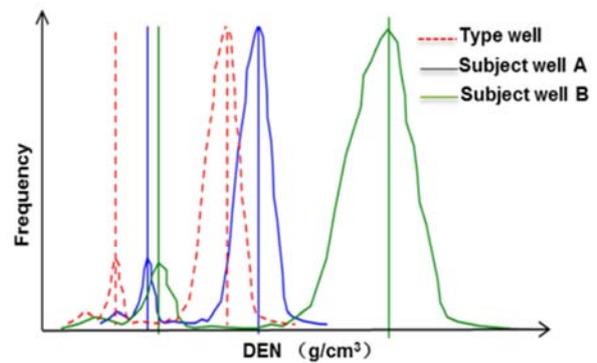


Figure 5. Frequency histogram plot.

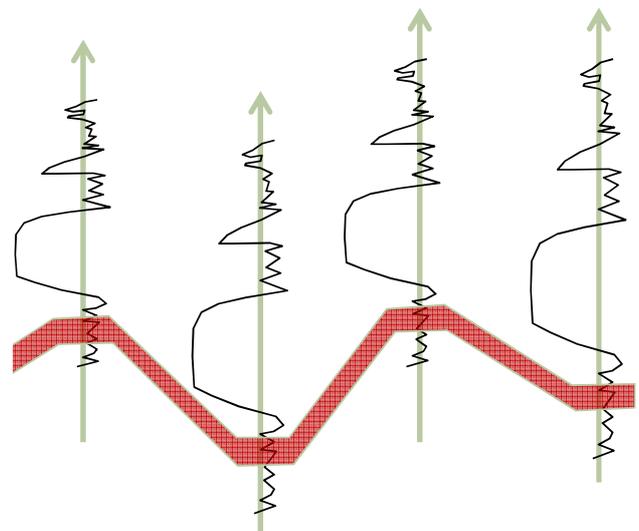


Figure 6. Reference layer method.

B block logs normalization methods for coal bearing formation is the combination of big histogram plus reference layer method. This method try to find type wells and establish a composite histogram for type wells, then the subject wells to be normalized will be shifted to fit composite histogram of type well which near subject well.

### 5.1. Selection of Type Well

All selected type well must meet four conditions below, first is type well must has fine geological description, Second is type well in a good condition, and has no wellbore collapse. Third is type well has continuous core data[11]. Fourth is type well are located as far as possible in the center of B block. Type well of open hole are selected according to the requirements. For the well with "T" casing section, corresponding well without the "T" is selected as type well.

### 5.2. DEN Logs Normalization

After the selection of type wells, the density of siltstone from near type well can be picked directly from the frequency histogram. Average density of coal from near type well is used as the low density peak (Figure 7).

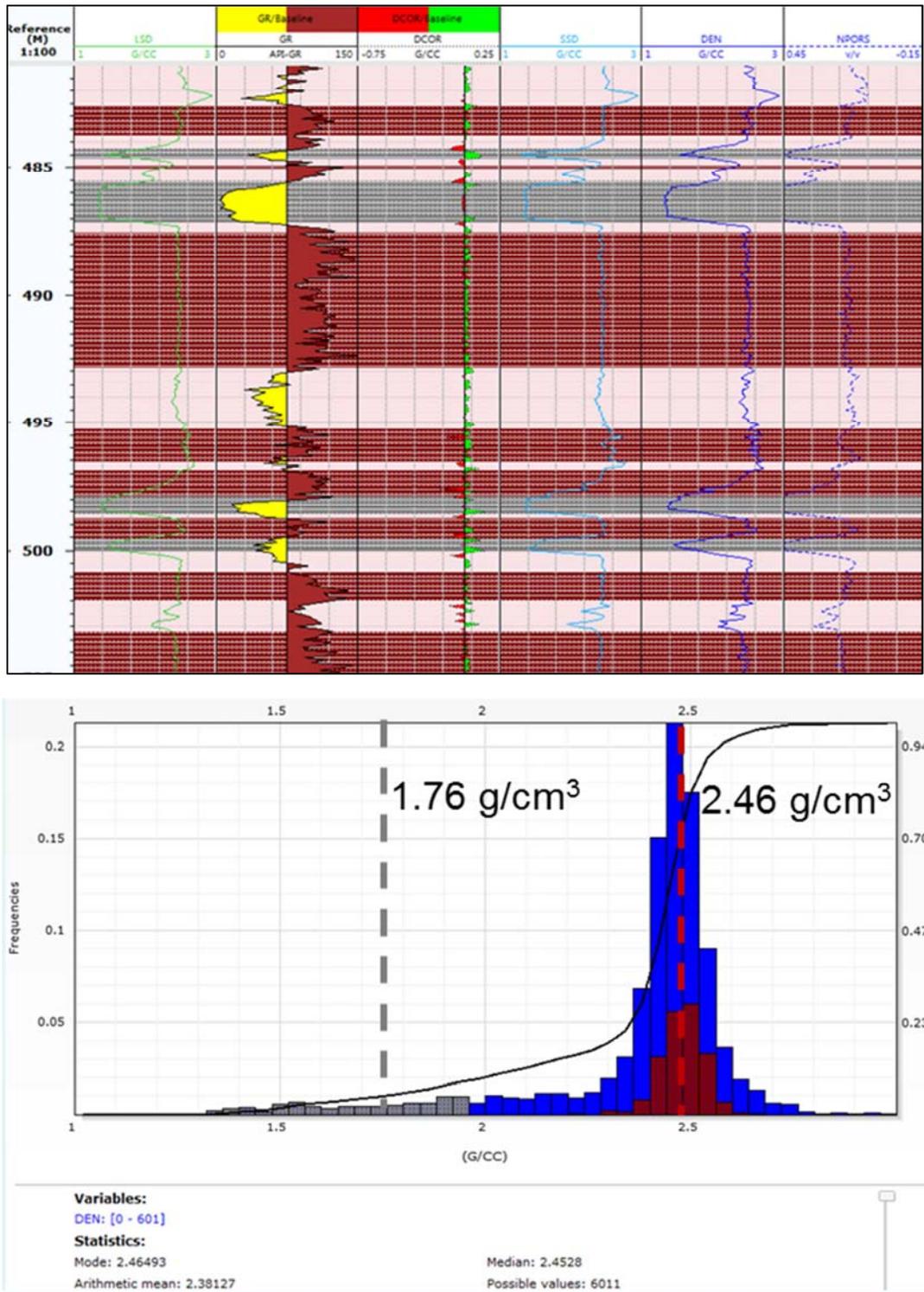


Figure 7. Pick of logs high peak and low peak from frequency.

Distribution range of subject well’s DEN is determined in the cumulative frequency diagram, in the location map, type well near subject well is selected for the DEN logs normalization. Linear transformation has three advantages, first is Linear transformation has simple operation, second is also most important is that Linear transformation is only addition and subtraction of logs, it don’t do any compression,

and logs response of the formation will not be affected, Third is Linear transformation is suitable for batch processing issues. Considered above three advantages, linear transformation is used for logs transformation. For the subject well, linear transformation of the DEN frequency histogram is used to be normalized DEN logs [12] (Figure 8, Figure 9). Totally complete 154 wells’ DEN normalized by using the linear

transformation.

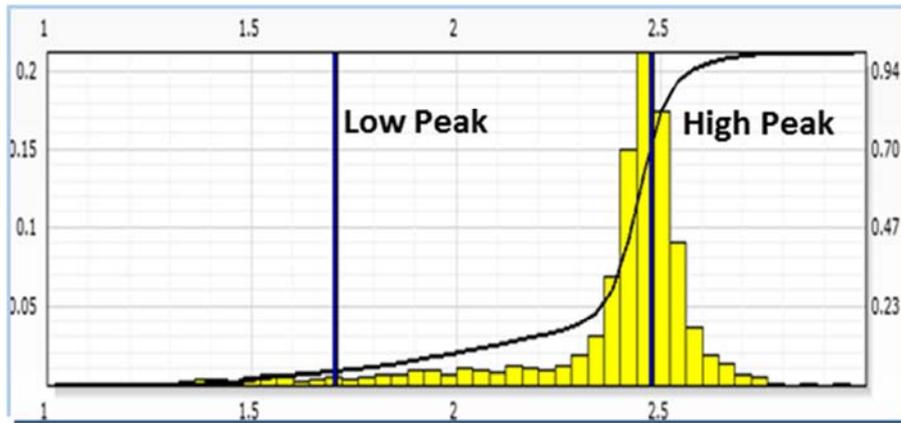


Figure 8. Subject well distribution of den frequency.

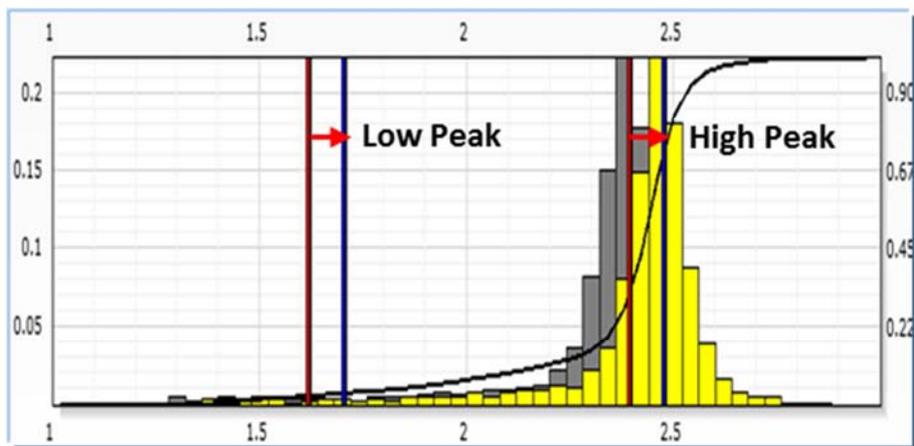


Figure 9. DEN linear transformation of subject well.

### 5.3. GR Logs Normalization

Normalization for GR is similar to DEN, GR of sandstone can be picked directly from the frequency histogram is used as low peak. While average GR picked from mudstone is used as the high peak. distribution range of subject well's GR is determined in the cumulative frequency diagram, the picked

low peak and high peak of GR from type well near subject well is selected for the subject well's GR normalization, linear transformation of the GR is used to normalized GR of subject well (Figure 10, Figure 11). Totally complete 154 wells' GR normalization.

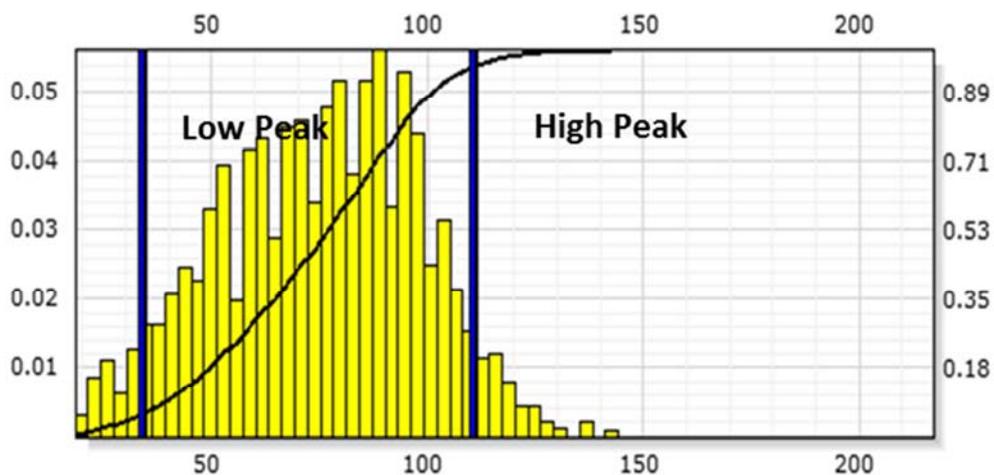


Figure 10. Subject well distribution of GR frequency.

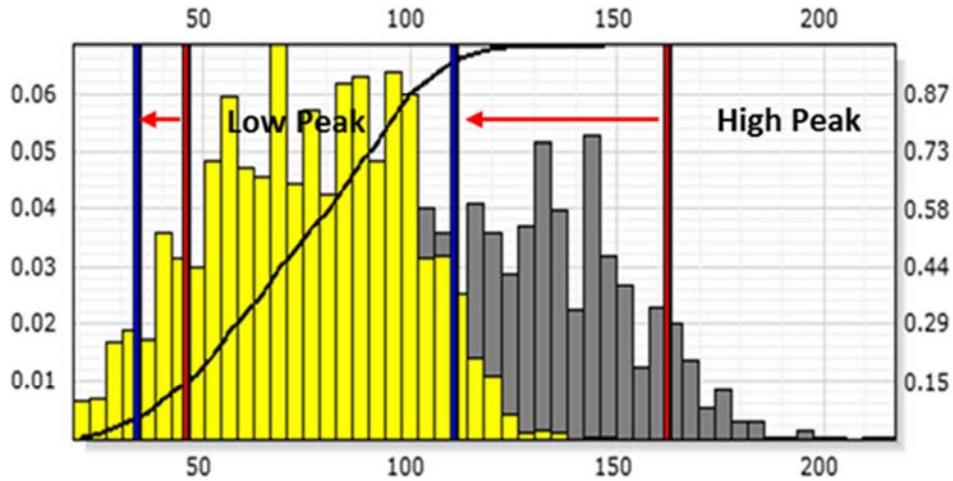


Figure 11. GR linear transformation of subject well.

## 6. Logs Normalization Results

### 6.1. DEN Logs Normalization Results

DEN logs before normalization (Figure 12) show that logs has no distribution pattern and great deal of difference for Density logs existed in all wells. After normalization and (Figure 13), the quality of DEN logs improved obviously and the distribution trend for DEN logs is consistent. The normalized DEN logs would lay a solid foundation for subsequent lithofacies interpretation and logging

interpretation.

DEN normalized value called delta DEN (Figure 13). Generally, when the type well and the subject well were logged by the same service company, its delta DEN is smaller than that when they were logged by different service companies.

Delta DEN can be positive and negative, maximum delta DEN is  $0.098\text{g/cm}^3$ , minimum delta den is  $-0.03\text{g/cm}^3$ , averaging is  $-0.044\text{ g/cm}^3$ , 90% of delta DEN ranging from  $-0.1$  to  $0.1\text{ g/cm}^3$  (Figure 14).

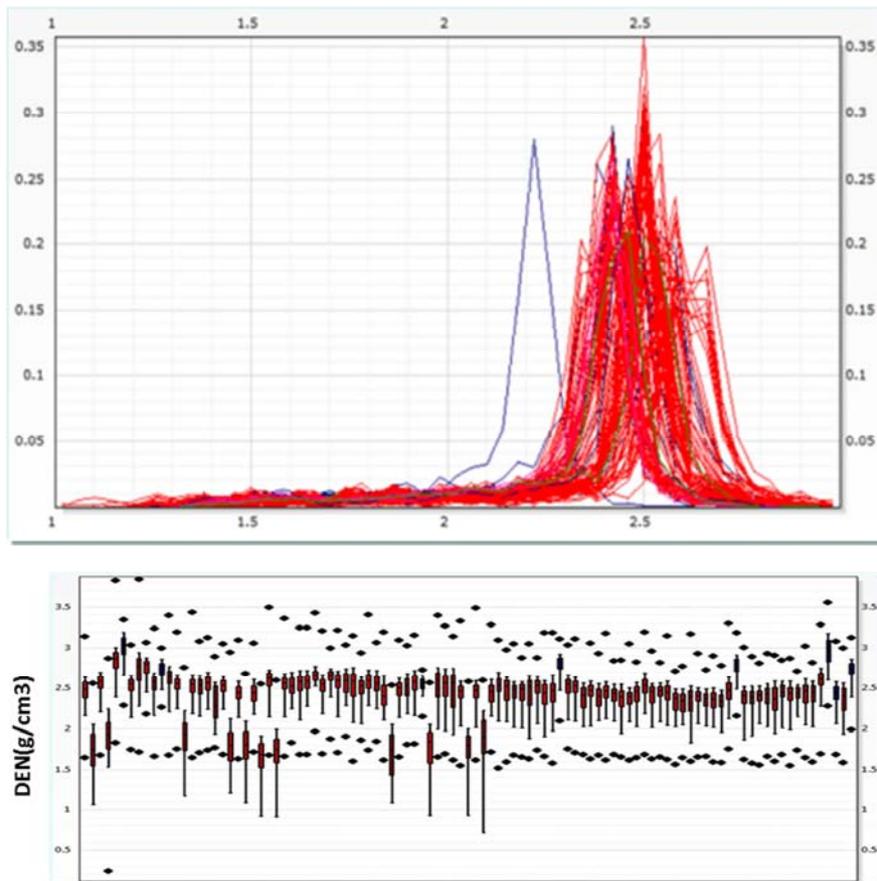


Figure 12. Frequency and box diagram for den before normalization.

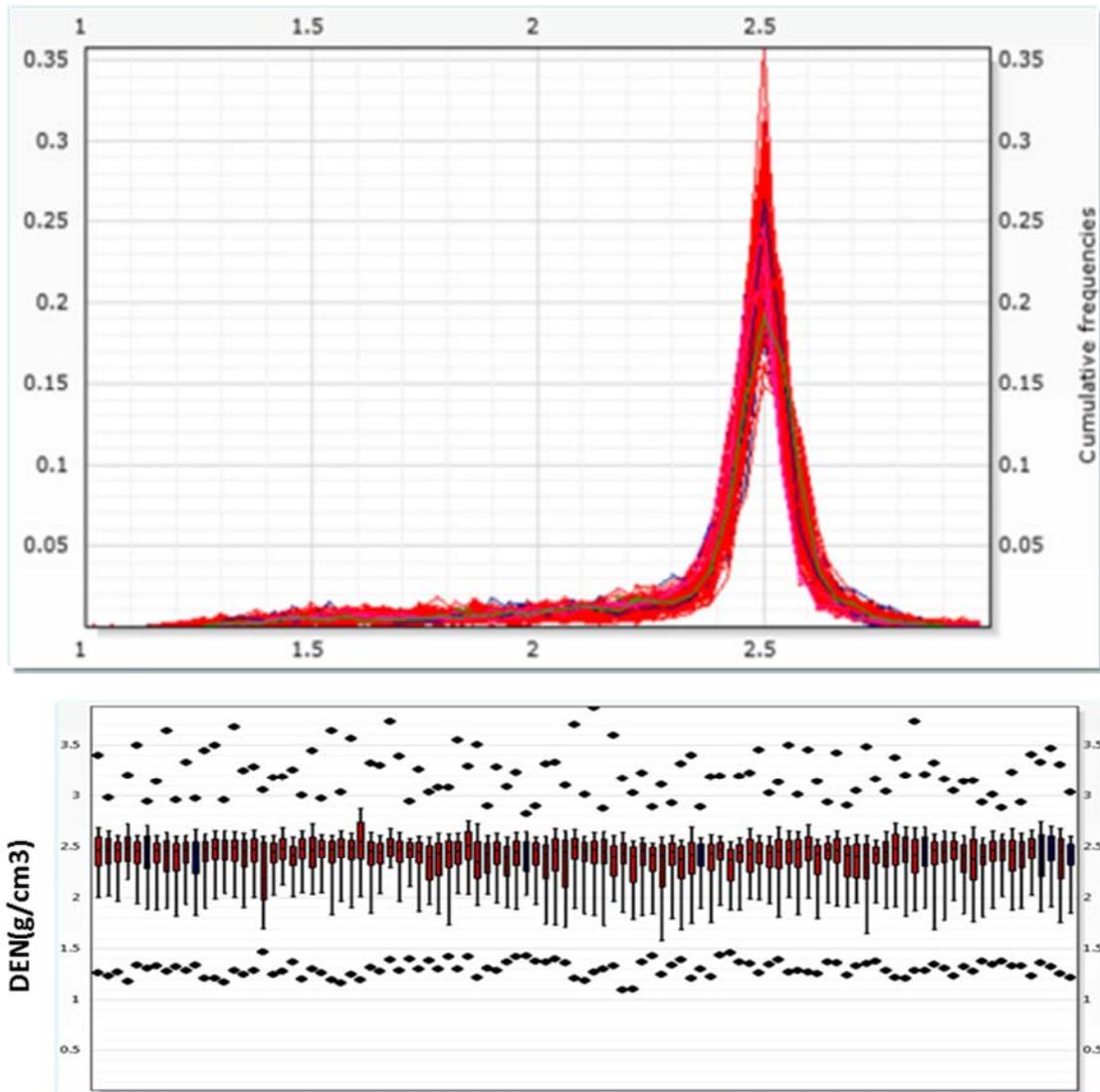


Figure 13. Frequency and box diagram for den after normalization.

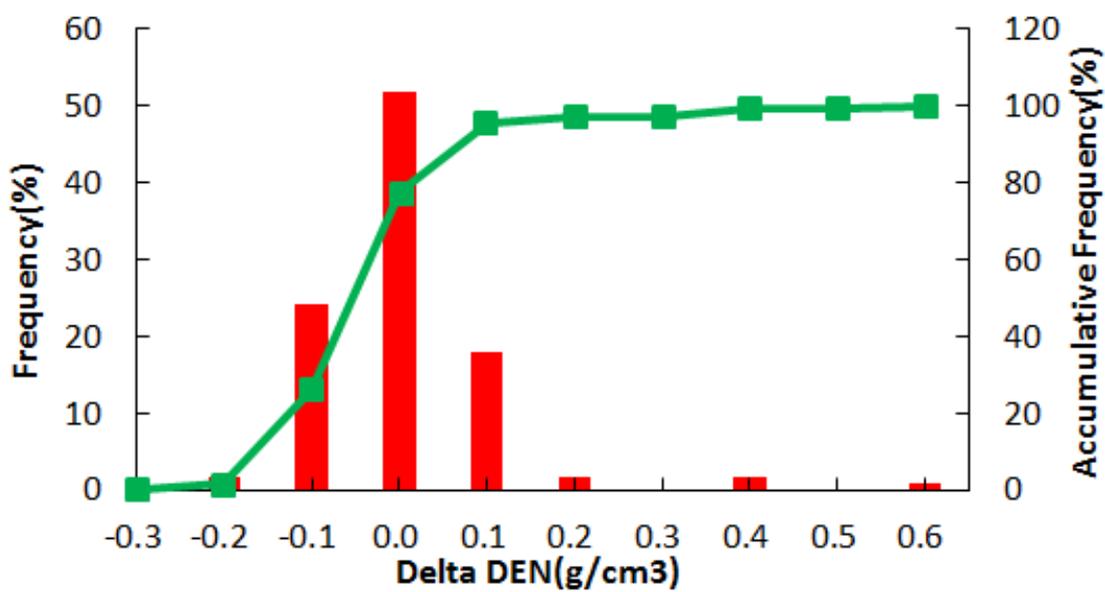


Figure 14. Distribution of normalized DEN.

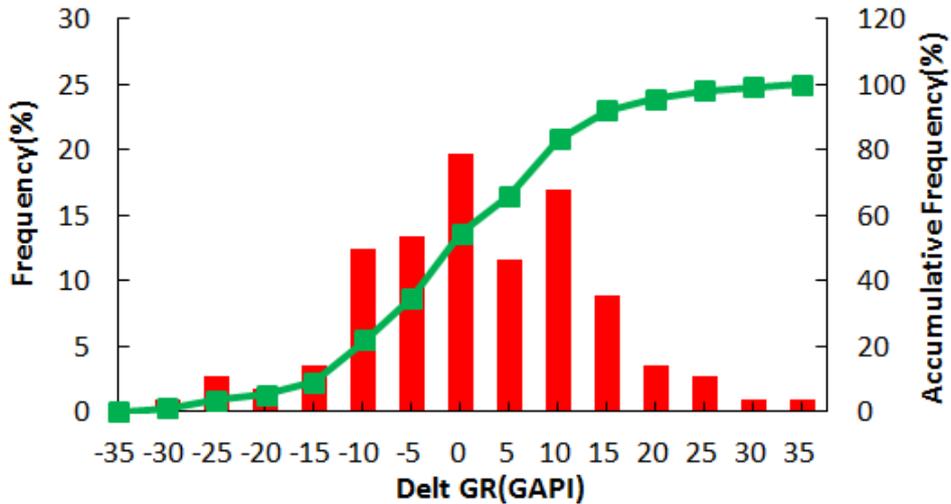


Figure 15. Distribution of normalized GR.

**6.2. GR Logs Normalization Results**

GR logs before normalization (Figure 16) show that logs has no distribution pattern and great deal of difference for Density logs existed in wells. After normalization (Figure 17), the quality of DEN logs improved obviously and the distribution trend for DEN logs is consistent. The normalized

DEN logs lay a solid foundation for subsequent lithofacies interpretation.

GR normalized data called delta GR. Generally, when the type well and the subject well were logged by the same service company, its delta GR is smaller than that when they were logged by different service companies.

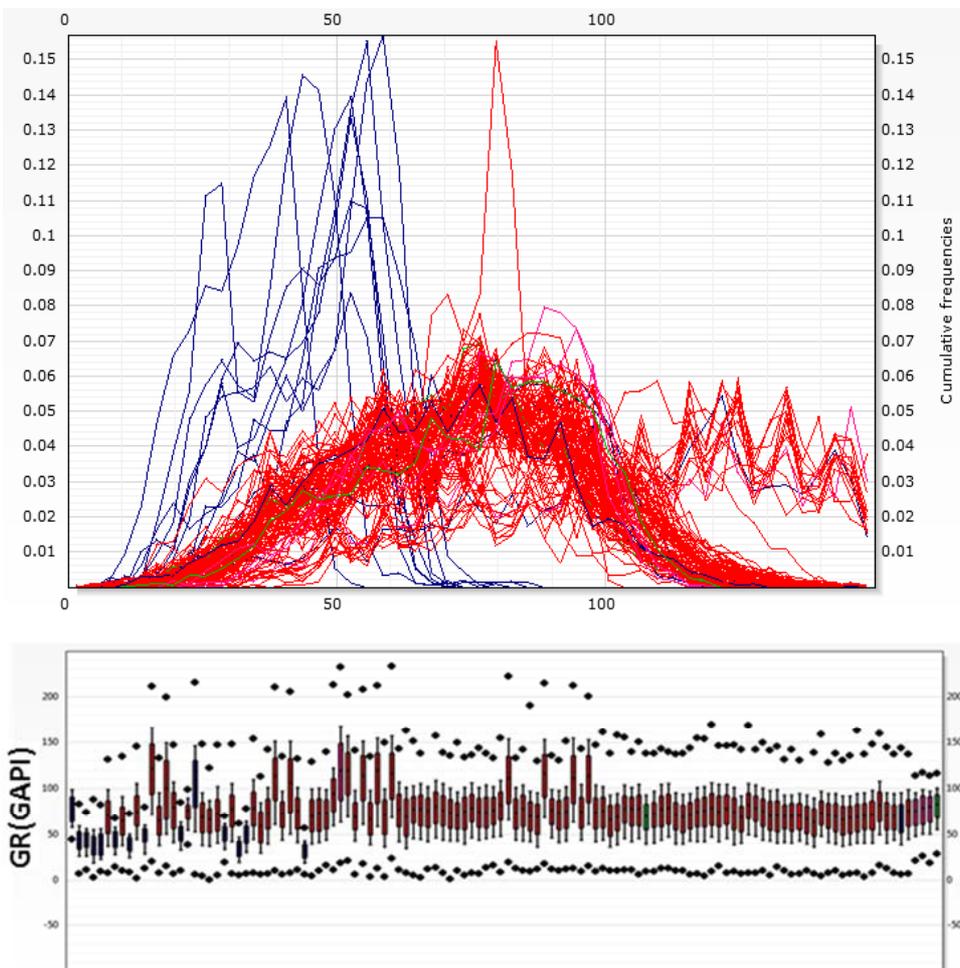


Figure 16. Frequency and box diagram for GR before normalization.

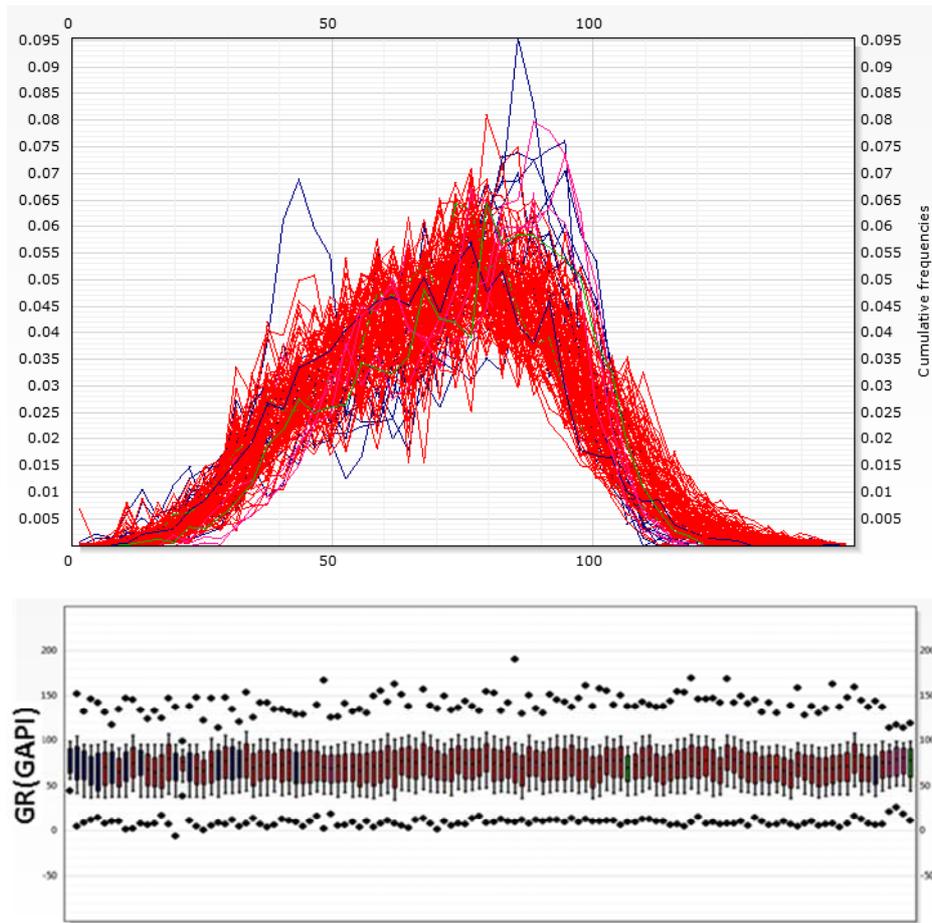


Figure 17. Frequency and box diagram for GR after normalization.

Delta GR can be positive and negative, maximum delta GR is 31.2GAPI, minimum delta GR is -30.7GAPI, averaging delta GR is -0.639GAPI, 90% of delta GR ranging from -15 to 15GAPI (Figure 15).

## 7. Conclusion

DEN and GR logs from the Triassic coal bearing formation are study object in this article. After finish logs resample, merge and split after logs collection and collation. Type well plus histogram method is used for normalization of subject well according to the applicability of the different normalization methods. Because of the existence of casing in some wells, different methods are used in the selection of type well. DEN and GR logs are normalized by the linear transformation according to their frequency distribution. The results show that the distribution of the all DEN and GR logs are more consistent than before and more correspond to actual geological conditions.

- (1) Logs preprocessing before normalized can be useful, and also reducing some unnecessary troubles.
- (2) Although there are many logs normalization methods, specific application conditions for each method are not the same, only through the correct normalization method can accurately complete logs normalization research.

- (3) Selection of the type well is very important in the logs normalization; type well selection should consider selection criteria and block's actual situation.

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