Fuel 134 (2014) 63–73

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Designing of plug-in for estimation of coal proximate parameters using statistical analysis and coal seam correlation

Sayan Ghosh [a], Rima Chatterjee [b,*], Suman Paul [c], Prabhat Shanker [a]

[a] Central Mine Planning and Design Institute Limited, Bilaspur, India
[b] Department of Applied Geophysics, Indian School of Mines, Dhanbad, India
[c] Department of Petroleum Engineering, Al Habeeb College of Engineering and Technology, Hyderabad, India

HIGHLIGHTS

- Statistical models for prediction of coal proximate parameters.
- The proximate results are validated with the laboratory data.
- Software code for coal seam correlation.
- The code is explained with the data for two coalfields.

ARTICLE INFO

Article history:
Received 10 September 2013
Received in revised form 26 March 2014
Accepted 8 May 2014
Available online 2 June 2014

Keywords:
Software design
Coal proximate parameters
Well log
Multiple regression analysis
MATLAB

ABSTRACT

This paper aims to design plug-in at matrix laboratory (MATLAB) for estimation of coal proximate parameters and coal seam correlation from well logs. Five major sub-functions such as: normalisation of single point resistance log, shifting of logs for depth matching, lithology marking, calibration for estimation of coal proximate parameters and coal seam correlation are included with graphical user interfaces. The geophysical log data of Jharia and Bishrampur coalfields, India are calibrated visually with the laboratory analysed data where recovery is considerable for a certain number of scattered boreholes designated as master boreholes. Multiple linear regression relationships are obtained between geophysical logging parameters: density, natural gamma ray, normalised single point resistance and coal proximate parameters: ash, moisture content and fixed carbon. The software then proceeds towards the estimation of ash, moisture and fixed carbon (band by band) for the other boreholes except master boreholes. In the present study the coal seams are correlated from total 5 and 15 numbers of exploratory wells in Jharia and Bishrampur coalfields respectively. The correlation is made and accordingly correlation table is prepared using graphic display mode of the software by matching the lithology of all the boreholes and correlation plot is generated during the process.

1. Introduction

Due to limitations of drilling and low recovery of soft coal, the estimation of coal quality cannot be obtained solely from testing of coal samples. The physical and chemical properties of coal vary significantly from seam to seam as well as within same seam. Coal chemical properties can be determined by proximate and ultimate analyses. A proximate analysis provides the percentages of fixed carbon, volatile matter, moisture and ash yield of coal. An ultimate analysis gives the chemical makeup of the coal as percentages of carbon, oxygen, hydrogen, nitrogen and sulfur, often corrected to a dry, ash-free basis. Gross calorific value of coal can be obtained from these analyses [11,10]. One of the major challenges faced by the coal mining industries in the field of exploration is to utilize the raw geophysical logging data for coal exploration. In coal applications, the most common geophysical measurements are the electrical resistivity, natural gamma, acoustic velocity, neutron porosity and density. By combining this information, it is possible to differentiate the coal beds from the surrounding lithotypes, normally associated with coal seams, such as siltstones and sandstones [7,8,18].

Coal characteristics from well logs of the Jharia and Bishrampur coalfields are chosen for statistical analysis for coal quality estimation and to design software for predictions of coal quality based on the statistical analysis and then correlate the seams based on the

* Corresponding author. Tel.: +91 3262235593; fax: +91 3262296563.
E-mail address: rima_c_99@yahoo.com (R. Chatterjee).

http://dx.doi.org/10.1016/j.fuel.2014.05.023
0016-2361/

log signatures. The designing of software code in MATLAB environment for estimation of coal proximate parameters band by band or overall will be useful for any coalfield.

2. Study area

The present study is focussed on two Gondwana coalfields, i.e. Jharia coalfield of eastern India and Bishrampur coalfield of central India. The coals of both the coalfields belong to Barakar Formation but there are differences in their physical and chemical properties. Indian coals generally are of high ash content [5]. The coals of Jharia coalfield are having low moisture content in comparison to coals of Bishrampur coalfield. It is observed that the coal seams in Jharia coalfield are not so banded whereas the seams of Bishrampur coalfields are highly banded. Details of both the coalfields are given below.

2.1. Jharia coalfield

Jharia coalfield (JCF) covers an area of about 456 km^2 and extends to about 38 km in E–W direction whereas about 18 km in the N–S direction (Fig. 1). The formations are striking towards E–W and NW–SE directions and dipping towards the centre of the coalfield [12]. The sedimentary succession, unconformably overlying the Archaean gneissic basement, starts with the Talchir Formation followed upward successively by the Barakar Formation, Barren Measures and Raniganj Formation [4], deposited within an intra-cratonic extensional setting [6]. The seams do not exhibit any major tectonic disturbances but some minor and major gravity faults are encountered with throws ranging from 10 m to more than 100 m [16,6].

In Jharia coalfield total 18 major coal seams, viz. A (bottom seam), B, C, D, E/F/G (combined seam), H, I, J, K, L, M, N, O, P, Q and R (top seam) along with few local seams belonging to Barakar Formation of Lower Permian age are present [12,13]. The thickness of Barakar Formation is more than 1250 m [2]. The core samples and well logs from 5 exploratory wells, viz. S4, S5, K10, K16, and K19, located in the central part of Jharia coalfield, are considered for the present study. Out of the 5 exploratory wells, S4 and S5 are located in Singra block and wells K10, K16 and K19 are located in Kapuria block (Fig. 1). The coal seams located under the study area are varying from a depth of 291.95 m to 1230.50 m. The range of well log parameters: density, gamma ray, single point resistance and coal proximate parameters of the major seams are listed in Table 1.

The volatile matter on dry ash free basis estimated by Rudra and Hazra [14] indicates that the Barakar coals of Jharia are high volatile ‘A’ bituminous to low volatile bituminous in rank. The volume of vitrinite, semi-vitrinite, inertinite, mineral matter and vitrinite reflectance (VRo) ranges from 16.1% to 65.5%, 1.1% to 6.4%, 24.4% to 69.7%, 2.3% to 13.1% and 1.21% to 1.75% respectively in this study area [3].

2.2. Bishrampur coalfield

Bishrampur coalfield (BCF) is located in the Sarguja district of Chhattisgarh, India covering an area of about 1036 km^2 (Fig. 2). The coalfield belongs to Lower Gondwana including Talchir, Kaharbari, Barakar and Kamthi formations. The trend of the beds forms this basin shows a gentle dip of 2–3° [1]. The well logs and core samples from three major coal seams: Dhejagir, Masan and Pasang of Barakar Formation ageing Lower Permian [1] are chosen for the statistical analysis and designing of software. The coal seams of 15 exploratory wells (B1 through B15), occurring within depth intervals 34.46 m and 300.78 m are considered for the present study. The layout of wells is shown in Fig. 2. The geophysical logs (viz, density, natural gamma and single point resistance) are used to identify the coal seams. Table 1 lists the log responses and proximate parameters for these seams in BCF.

3. Methodology

3.1. Data input

The geophysical logs like density (g/cc), Single Point Resistance or SPR (Ω), as well as Natural Gamma or NG (cps) are used widely in many aspects of coal exploration involving coal analysis, lithology identification [8]. The Relative Density or RD (g/cc) determined

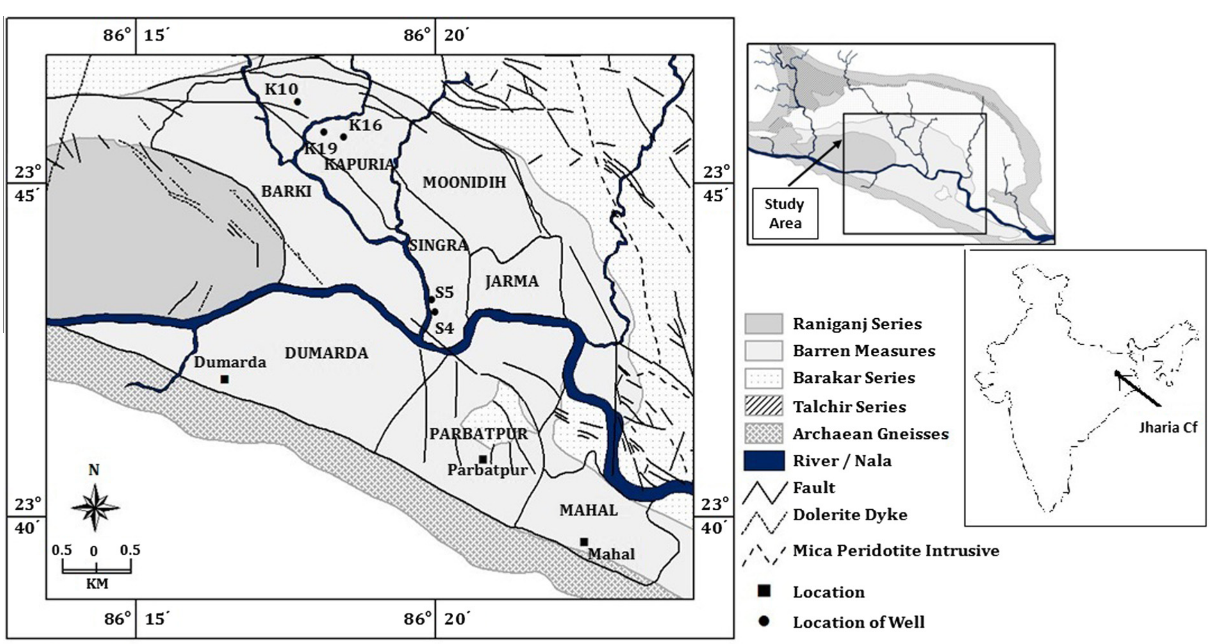

Fig. 1. Borehole location of under the study area of Jharia coalfield. Inset is showing the location of Jharia in India.