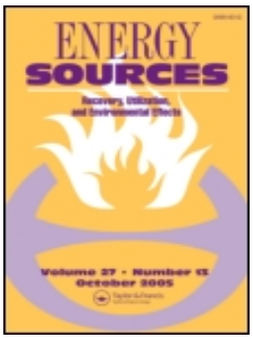

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An Investigation of Cutoff Calorific Grade in a Coal Deposit: A Case Study

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Assessment of cutoff calorific grade is an important parameter for production, planning, and making decisions in coal deposits. Cutoff calorific grade is defined as the value that discriminates between ore and waste within a given deposit. The normal statistical distribution model will serve as an important tool for examination of cutoff calorific grade. In this article, the Seyitomer coal deposit in Kutahya (Turkey) cutoff calorific grade was measured by a normal statistical distribution model. Through the results from the model, it was determined that there are tonnage rate and mean of calorific grades involving the identification of cutoff calorific grades. Finally, the model shows that a normal statistical distribution model can be applied successfully to the mining design and make it possible to manage a future coal deposit.

Keywords: coal, coal deposit, cutoff calorific grade, normal statistical distribution model, Turkey

1. INTRODUCTION

Clean, domestic, and renewable energy is commonly accepted as the key for future life, not only for Turkey but also for the world (Ediger and Kentel, 1999). Turkey's geographic location has several advantages for extensive use of most of the coal and renewable energy sources. The development level of a country is directly related to its economical and social level. One of the most important factors that take an active role in achieving such development level is energy. Energy, which is the requirement of sustainable development, can only be an impulsive force in industrialization and overall development of societies if it is supplied on time, with sufficient quantity and under reliable economic conditions, and considering the environmental impacts. The demand for energy increases rapidly in parallel with the population increase, industrialization, and technological development in Turkey and the other developing countries in the world (Yilmaz, 2008).

Coal is one of the most important energy resources in the world and its importance as an energy source is increasing as petroleum and gas resources decline. The two most important attributes of coal as an energy resource are quality and quantity (Heriawan and Koike, 2008). Coal quality parameters have crucial importance in the production of energy in power plants, and thus estimating these parameters are useful in making decisions and in planning future production of operating plants. Specifically, the quick and reliable prediction of coal quality parameters is a complicated problem (Kolovos, 2003; Tutmez, 2007). The calorific grade of coal is an important

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quality characteristic for energy production from operating plants (Tutmez et al., 2010). The calculation of tonnage rate and mean of calorific grade involves the determination of cutoff calorific grade. These calculations are useful in making decision about opening up new deposits or in planning future investments for coal mines.

In this study, a normal statistical distribution model was used to determine the tonnage rate and mean of calorific grade in the coal deposit. The objectives of this study were organized as follows. Section 2 presents the methodology of normal statistical distribution model, definition of the Seyitomer coal deposit, and dataset. Section 3 shows the result and discussion. Section 4 concludes the article.

2. METHODOLOGY

2.1. Normal Statistical Distribution Model

A positive random variable, g, is said to be normally distributed with mean ($\overline{g}$) and standard deviation (s). The distribution of the random variable, g, can be derived as Eq. (1):

$$\phi(z) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{c-\overline{g}}{s}\right)^2\right] \qquad g > 0. \tag{1}$$

The tonnage rate (P) of the distribution that is above the cutoff is given by:

$$P = Pr\{g > c\}, \tag{2}$$

where g donates the grade in general, and c the cutoff grade. Tables are widely available for the standard normal distribution, which lies below a given value z. For any other normal distribution, the z value is determined by taking the value of interest, subtracting the mean of the distribution, and dividing by the standard deviation. This equation is given by Eq. (3):

$$z = \frac{c-\overline{g}}{s}. \tag{3}$$

The normal table will give us $\Phi(z)$, which is the probability of lying below the cutoff and this can be derived using the following formula:

$$P = 1 - \Phi(z). \tag{4}$$

For the normal distribution, the grade above cutoff is given by the following formula:

$$\overline{g_c} = \overline{g} + \frac{s}{P}\phi(z), \tag{5}$$

where $\overline{g_c}$ denotes the grade above cutoff, and $\phi(z)$ is the height of the standard normal curve at the value z (Clark, 2001).

2.2. Definition of the Seyitomer Coal Deposit

A generalized stratigraphic sequence of the Seyitomer Basin is presented in Figure 1. The figure shows that the metamorphic and ophiolitic rocks and granites of Pre-Neogene age form the basement of the basin. The Miocene-Pliocene aged basin fill rests unconformably on the

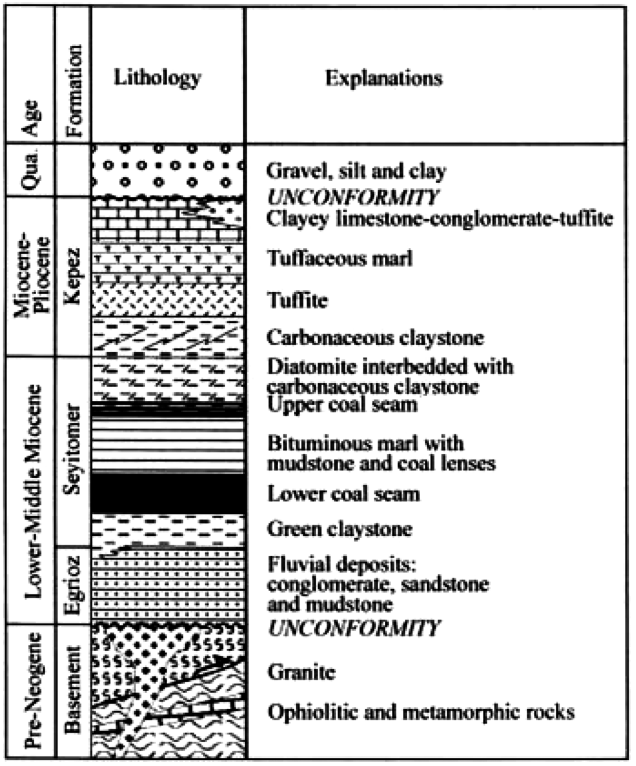

FIGURE 1 Generalized stratigraphic sequence of the basin.

basement rocks, and the first sedimentary system in the basin begins with fluvial regime of the Egrioz Formation, which consists of conglomerate, trough cross-bedded conglomerate, sandstone, mudstone, and thin coal seam. The conglomerate, trough cross-bedded conglomerate, and pebbly sandstone units are channel deposits, which incised into a floodplain and horizontally bedded siltstone and mudstone and are interpreted as overbank deposits.

The coal-bearing Seyitomer Formation in the basin was conformably underlain by fluvial deposits of the Egrioz Formation and was conformably overlain by the Kepez Formation. The coal-bearing Seyitomer Formation in a lateral-vertical direction was developed in lacustrine facies, and is represented from the base to the upwards by green claystone, lower coal seam, bituminous marl with mudstone and sapropelic coal lenses, upper coal seam, diatomite interbedded with carbonaceous claystone, and fossiliferous marl. The Kepez Formation that developed in the lacustrine-partly fluvial environment, from the base to the upwards, consists mainly of carbonaceous claystone, tuffite, tuffaceous marl, clayey limestone, and conglomera-tetuffite. The facies units of the Kepez Formation are interpreted as freshwater carbonates, volcanic fall deposits, and river deposits (Celik and Karayigit, 2004).

2.3. Dataset Description

The study area is located to the northwest of the Seyitomer Basin in Kutahya (Turkey). In the planning of coal deposit, cutoff calorific grade has the most important parameter. The calculation

of tonnage rate and mean of calorific grade involves the determination of cutoff calorific grade. The calorific grade parameter was obtained from 128 borehole coal samples. The parameter was evaluated by using the normal statistical distribution model.

3. RESULTS AND DISCUSSION

Constrained by geology, mining engineering, and environmental aspects, mine design and planning is usually an exercise that seeks an economic outcome. One of the most important aspects of mining engineering is deciding which material in a deposit is worth mining and processing and which should be considered as waste. This decision is summarized by the cutoff grade policy, which affects the size and the life of deposits (Camus, 2002). Ores in general are defined operationally by a cutoff grade. Material with a mineral content above the cutoff grade is scheduled for further processing. Another material is left or dumped as waste (Osanloo et al., 2008).

As discussed, cutoff grade policy is the criterion used in a mining operation to discriminate between ore and waste within a coal deposit. The coal tonnage rate and mean of calorific grade estimates can be used in mine planning. The calculation of the values involves the determination of cutoff calorific grade. One of the fastest models to calculate the tonnage rate and mean of calorific grade is the normal statistical distribution model. In the first step of this model the determination of the dataset is normally distributed. For the next step, tonnage rate and mean of calorific grade will be calculated.

In this article, tonnage rate and mean of calorific grade with the Seyitomer coal deposit in Turkey have been calculated by using the normal statistical distribution model. Considering that cutoff calorific grade was measuring normal statistical distribution model, tonnage rate of the coal deposit was calculated by using Eq. (4). Afterward, these calculations were graphed and shown in Figure 2. The figure shows that the cutoff calorific grade increases as the tonnage rate decreases.

The mean of calorific grade was calculated by using Eq. (5), and the calculations were graphed. The graph is shown in Figure 3. The figure indicates that cutoff calorific grade increase as the mean of calorific grade also increases. Thus, tonnage rate is decreased and mean of calorific grade is increased, the quality of the coal deposit is increased. For this reason, the normal statistical distribution model can provide useful information for the quality of the coal deposit and helping the mining management.

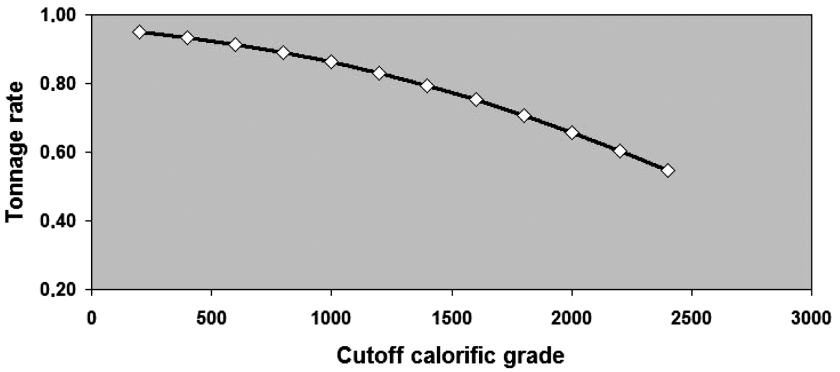

FIGURE 2 Cutoff calorific grade versus tonnage rate.

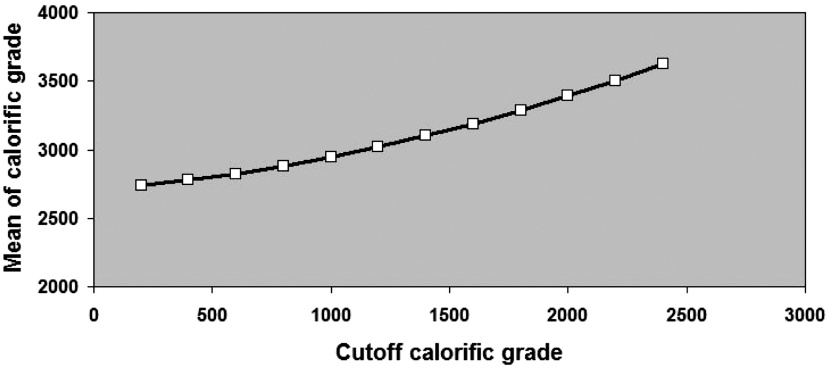

FIGURE 3 Cutoff calorific grade versus mean of calorific grade.

4. CONCLUSIONS

This study indicates that one of the most significant parameters of a coal deposit is the calorific grade. The determination of tonnage rate and mean of calorific grade involves the determination of cutoff calorific grade. In the coal deposit, as the cutoff calorific grade increases, tonnage rate of the coal deposit also decreases. But, cutoff calorific grade is increased as the mean of calorific grade is increased. Thus, with tonnage rate decrease and the mean of calorific grade increase, the quality of the coal deposit is increased.

This study presented that the normal statistical distribution model provides useful information for the tonnage rate and mean of calorific grades in helping them manage their deposit. This model is believed to assist decision makers assessing cutoff grade in order to improve the efficiency of mining planning.

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