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Evaluation of Coal by Rank: An Example from Pakistan

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ABSTRACT

Classification of coals from Katas Nasir Gali, District Chakwal, Pakistan has been carried out according to ASTM method. Besides proximate analysis, calorific values, chlorine and sulphur contents have also been determined. Calorific value of these coals ranges from 5,000 to 6,000 Btu/lb; sulphur contents are not high and chlorine contents are as high as 2,500 ppm. The Katas Nasir Gali coals can be classified as subbituminous A to high volatile C bituminous.

INTRODUCTION

Coal is defined as "a readily combustible rock formed from compaction or induration of variously altered plant remains similar to those of peaty deposits". Difference in the kinds of plant materials (type), degree of metamorphism (rank) and range of impurity (grade) determine the characteristics of coals (Schopf, 1956). The classification of coal by rank is the most commonly used system in the U.S.A. as well as in many industrialised countries (Schopf, 1966).

The coal deposits of Pakistan differ from most of the major coalfields of the world. The Pakistani coals are relatively poorer in grade becuase of the short span of putrefaction. Consequently they fall into the poor grade - low rank cateogory. The coalfields of economic importance in Pakistan are located in three areas, termed as coal provinces. These are Hyderabad and Thar (Sind), Quetta - Kalat (Baluchistan) and Salt range - Makerwal (Punjab).

Some organisations in Pakistan have categorised or classified coal resources by using different techniques. Geological Survey of Pakistan (G.S.P.) has done the classification of some areas by evolving its own model in keeping with the geological realities of Pakistan's coalfields (Ahmed, 1986). Fuel Research Centre (F.R.C.), Karachi has studied the major coalfields of Sind and Punjab (Basit et al, 1990). No data is available about the chemical characteristics of Katas Nasir Gali coal.

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Laboratory tests to determine the chemical and physical characteristics of coal are recommended by National and International organisations to assure buyers of coal a fair value for their money and sellers a fair price for their products. The chemical tests are used to evaluate economic and environmental impacts of a coal resource on power, cement, steel and fuel industries. Coal quality studies are important in plant design and in reduction of plant downtime due to fouling, stagging, erosion and corrosion.

The objective of coal classification is the prediction of the behaviour of the coal. The purpose of the present study is to examine the coals obtained from the different seams of Katas Nasir Gali, district Chakwal (Figure I) and to classify them on the basis of "moist" according to the ASTM system (Annual Book of ASTM, 1988).

EXPERIMENTAL

Materials and Reagents

The following materials and reagents were used in the present study.

Oxygen gas._ Commercially available compressed oxygen gas supplied by Malik Welders, Rawalpindi.

Benzoic acid._ AR grade benzoic acid was employed in the standardization of the calorimeter. Its heat of combustion is reported to be 6,320 cals per gram

Other reagents._ 0.0725 N Sodium carbonate, conc. hydrochloric acid, 10% barium chloride, 10% ammonium carbonate, 0.01M silver nitrate, methyl orange indicator, 5% potassium chromate indicator etc. All the solutions were made from AR grade chemicals.

Methods

i) *Calorific value.*_The instrument used for the present study was an adiabatic bomb calorimeter, manufactured by Parr Instruments Company, Inc. Illionois, U.S.A. with oxygen bomb model 1108. In this investigation, the calorimetric procedure adopted was in

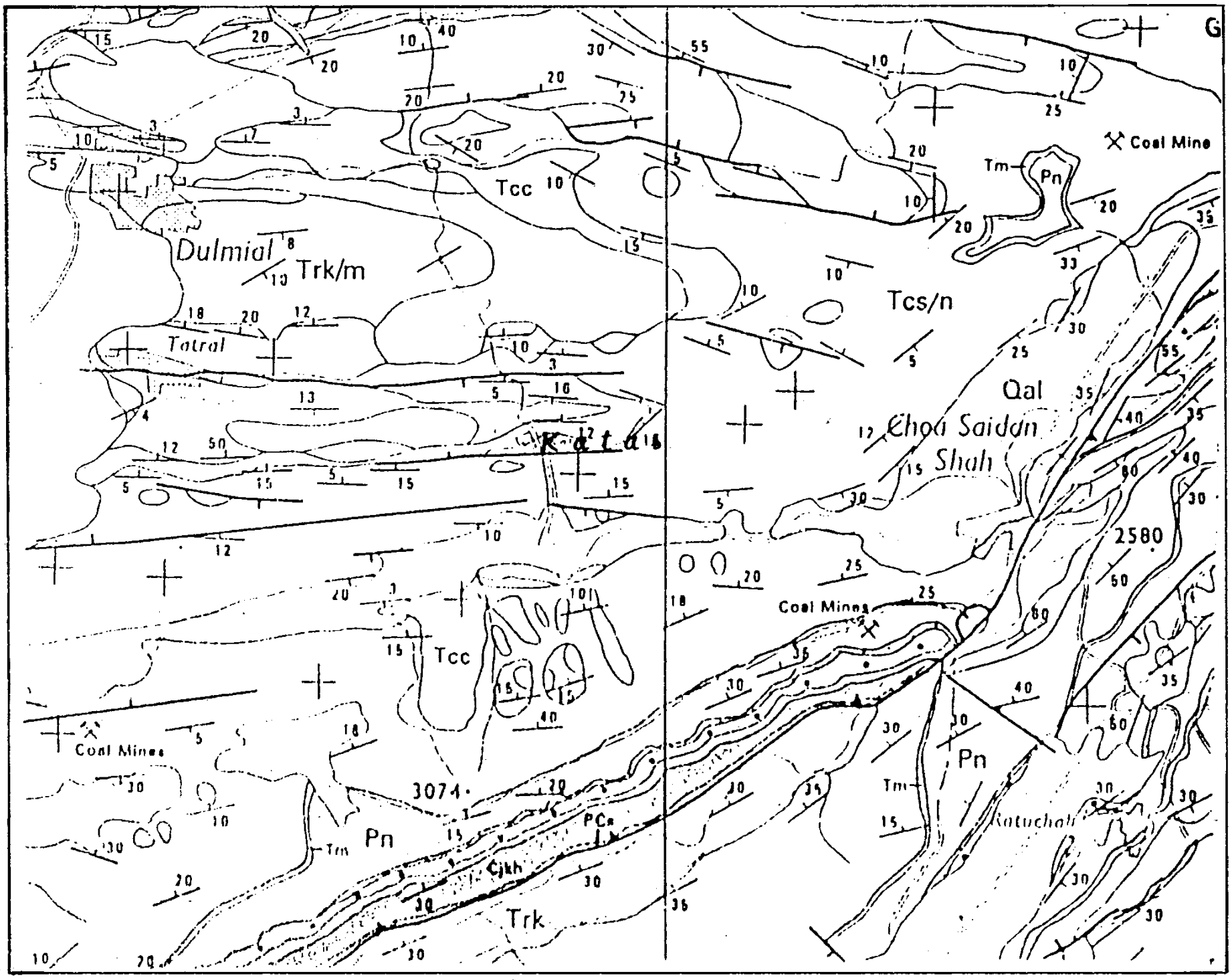

Figure 1- Location map of Katas Nasir Gali

accordance with the ASTM method and the same has been described previously (Zaheeruddin and Lodhi, 1991).

ii) *Total chlorine*._ Total chlorine was determined using oxygen bomb method (Basit, et al, 1990). The bomb washing has been titrated against the standard o.o 1M silver nitrate solution using 5% potassium chromate as indicator. The chlorine contents were calculated as follows:

1 ml of o.o1 M silver nitrate solution = 0.0003545 gm Chloride.

iii) *Total sulphur*._Total sulphur was also determined using bomb washing method (Manual for Bomb Calorimeter). By adopting the procedure as reported in the literature, 10% barium chloride solution was added. After ignition at 925°C in electric muffle furnace, the percentage of sulphur is determined by the following formula:

$$\text{Sulphur \%} = \frac{\text{wt.of } BaSO_4 \times 13.734}{\text{wt. of Sample}}$$

iv) *Proximate analysis*._ ASTM established procedures were used for the determination of moisture, volatile matter and ash and the calculation of fixed carbon by using the following formula:

Fixed Carbon % = 100 -(Moisture % +ash%+volatile matter %)

Table 1. Chemical and proximate analysis of various samples from Katas Nasir Gali coal mines.

Mine No.	Depth of Coal Seam (foot) (ppm)	Total Chlorine Contents	Moisture %	Ash %	Volatile matter %	Fixed Carbon %	Total Carbon	Sulphur %	Gross Calorific Value (Btu/1b
1.	1.0	1614	3.73	44.77	35.76	15.74		2.93	5246
2.	1.5	1702	4.29	53.14	21.85	20.72		1.71	5026
3.	1.5	1710	3.43	39.75	37.93	18.89		4.38	6046
4.	1.5	2009	4.14	42.82	31.21	21.76		1.57	5290
5.	3.0	2549	3.37	42.78	26.86	26.99		5.18	5275
6.	1.5	1610	4.49	47.23	24.62	23.66		0.87	5786
7.	1.0	1219	5.11	46.08	38.85	9.96		1.54	6118

RESULTS AND DISCUSSION

The two most generally used systems for classifying coal are the ASTM classification of coal by rank and the ISO system. The National Coal Board (United Kingdom) coal classification system is similar to the ISO system. Most classification systems throughout the world use calorific value, fixed carbon or volatile matter. In some systems additional tests further classify the coal by utilizing free (crucible) swelling index, dilatometery. The ASTM system utilizes calorific value (moist, mineral-matter free) and fixed carbon (dry, mineral-matter free). Higher rank coals are classified according to fixed carbon and lower rank coals according to calorific value.

Chemical and proximate analysis of various seams of coal from the study area were conducted. The results are shown in Table 1. Besides proximate analysis, total chlorine, total sulphur and calorific values of each sample were determined. Results show high ash contents, which means "extraneous ash", i.e., free mineral matter consisting of calcium, magnesium and ferrous carbonates, pyrites, clays, sand and gypsum, is high.

The chlorine content in different coal samples varies from 1,200 to 2,500 ppm (Table 1), which shows higher chlorine content as compared to other Punjab coals. The higher values of chlorides in the Katas Nasir Gali Coal indicate that it is not suitable for use in power station because it is liable to cause appreciable corrosion. By using the data as shown in Table 1, classification according to rank on mineral-matter free basis can be carried out by applying the Parr formulas which are as under:

Dry ,Mm-fee FC

$$= (FC-O.15\ S)/[100-(M+1.08A+0.55S)]x100 \quad (1)$$

$$\text{Dry Mm-Free VM} = 100-\text{Dry, Mm-Free FC} \quad (2)$$

$$\text{Moist, Mm-Free Btu} = \text{Btu}/[100-(1.1A + 0.1S)]x\ 100 \quad (3)$$

Mm=Mineral matter,
Btu=British thermal units per pound (gross calorific value),
Fc= Percentage of fixed carbon,
VM= percentage of volatile matter,
M = Percentage of moisture,
A = Percentage of ash and
S = Percentage of sulphur.

By using the above three formulas and the required data from Table 1, the results calculated are shown in Table 2, which clearly indicate that first two formulas are not appropriate for clasifying these coals. According to Formula 1 for classification the value should be equal or greater than 69 (Annual Book of ASTM, 1988). Similarly for classification according to formula (2), the percentage of volatile matter should be less than 31 (Annual Book of ASTM, 1988).

Table 2. Calculated values of Katas Nasir Gali coals according to Parr Formulas.

Fixed Carbon (%) Dry, Mineral-matter free basis.	Voltalie Matter (%), Dry, Mineral-matter free basis	Gross Calorific value (Btu/1b) Moist, Mm-Free basis
33	67	10396
55	45	12147
36	64	10827
44	56	10045
55	45	10062
53	47	12064
22	78	12446

The only formula (3), which is on moist, mineral-matter free Btu is suitable for classifying this type of coal. The results shown in Table 2 are between 10,000 to 12,000 Btu/1b. These values fall within range given in the table of ASTM standard classification of coal (Annual Book of ASTM, 1988). It is found out that the coal of Katas Nasir Gali is low ranking coal, which can be placed according to ASTM classification in class bituminous and group submituminous A coal to high voltile C bituminous coal.

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