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Delineation of High Quality Coking Coal by Concentration-Number Fractal Model in B_2 Seam of East Parvadeh Coal Deposit, Central Iran

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Abstract This study aims to identify proper parts of B_2coking coal seam in the North block of East-Parvadeh coal deposit (Central Iran) using the C-N fractal models based on sulfur and ash values. Based on the C-N log-log plots, there are five different geochemical populations for both sulfur and ash data. First population for sulfur has ranged from 0-1.58%namely “very low sulfur population” which has best quality for coking coal and this has situated in the northern and western parts of the area. However, first and second populations for ash with ash values between 0 and 30% namely “very low ash population” and “low ash population” have suitable quality for coking coal in B_2 seam which have situated mostly in the western part of the North Block. Moreover, proper parts of the B_2coking coal seam are situated in the northern and western parts of the North Block.

Keywords Concentration-Number (C-N) Fractal Model; Ash; Sulfur; East-Parvadeh Coal Deposit

1. Introduction

Recognition of coking coal parts in the bituminous coal seams is necessary for mine planning and equipment selection of these zones. Ash and sulfur values are important for determination of proper coal zones and seams for coke production. However, the materials are important for environmental control of coal mining [1].Iranian coking coal resources and reserves are estimated to be about 7-10 Gt where most occurs in two main basins consisting of the northern and Central Iran, which are namely as the Alborz and the Central basins respectively. The Tabas coalfield provides a high percent of Irans coking coal for metallurgical applications, because its reserve is estimated to be 3-4 Gt [2,3].Spatial distribution of geochemical data is significant for separation of geochemical populations but it is not taken into consideration for conventional statistical methods. Furthermore, these methods are based on quantities such as mean, median and standard deviation cannot identify difference between geochemical populations, e.g. ore zones or anomalies,in many cases. because the methods defined based on data distribution.[4-7] Fractal/multifractal modeling has been established by Mandelbrot [8]are widely used in geosciences since 1980s .[4,7,9-16].Cheng et al[4] and Cheng[17] proposed concentration-area (C-A) and concentration-perimeter (C-P) fractal models for distinguish of geochemical anomalies from background and calculation of elemental thresholds values for different geochemical data. Moreover, other fractal models were developed and applied in geochemical exploration such as power spectrum-area (S-A) by Cheng et al[18], concentration-distance (C–D) by Li et al[12], concentration-volume (C-V) by Afzal et al[15]and concentration-number (C–N) by Hassanpour and Afzal[19].In this paper, C-N fractal model was applied for separation of ash and sulfur populations based on drillcore data from the B2 seam of the North block of East-Parvadeh coal deposit, Central Iran,for identification of proper parts of coking coal.

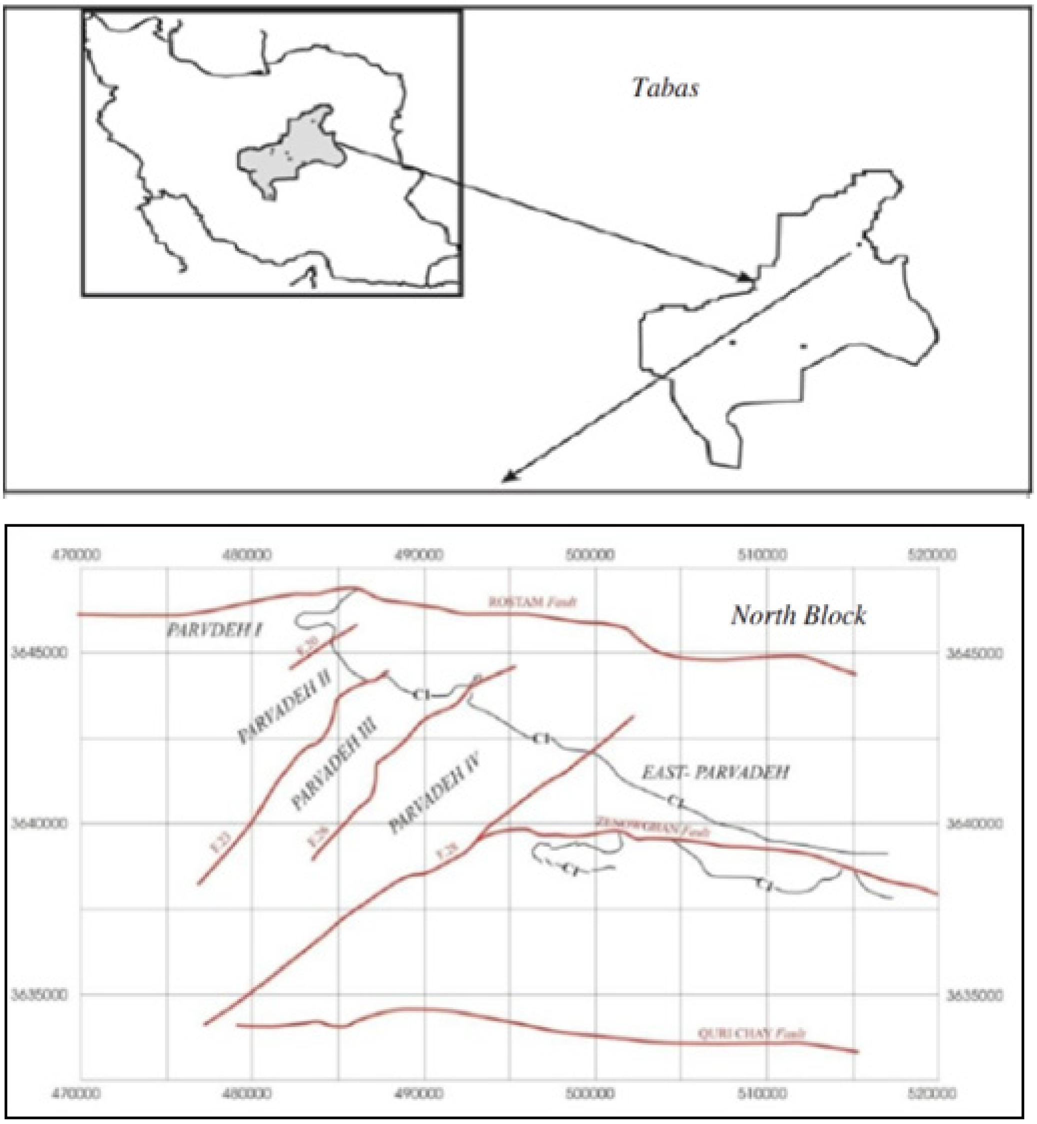

Figure 1. Parvadeh deposits locations and East-Parvadeh blocks in Tabas coalfield

2. Geological Setting of the Case Study

The East-Parvadeh coal deposit is located about 80 Km south of the Tabas region, Central Iran (Fig. 1). Tabas coalfield district is a part of Central Iran's structural zone which is divided into different sub-zones namely Parvadeh, Nayband and Mazinu[3,20,2].The Parvadeh area includes six parts divided by Major faults and East-Parvadeh is depicted in Fig. 1. The East-Parvadeh coal deposit is divided by Zenoughan fault to the North and South blocks. According to dip, depth and structural effects in the North block are generally accepted to be better than coal seams in the South block [20].The coal bearing strata of the Tabas coalfield consists mainly of sediments of the Upper Triassic, Middle Jurassic age namely the Nayband formation and Ghadir member. Their rock unitsinclude siltstone, sandstone, shale,sandy siltstone and small amounts of limestone and ash coal. Coal seams in the Parvadeh region are named A, B , C , D , E and F that the B and C coal seams are minable based on their quality and quantity especially C1 and B2[3].

3. Methodology

The number-size (N-S) model, which was originally proposed by Mandelbrot [8], can be utilized to identify different geochemical populations without any pre-processing of data. The model shows that there is a relationship between desirable attributes (e.g., depositsulfur and ash content in this paper) and their cumulative numbers of samples. Based on the model, Agterberg [21] proposed a multifractal model named size-grade for determination of the spatial distributions of giant and super-giant mineral deposits. Monecke et al [22] used the N-S fractal model to characterize element enrichments associated with metasomatic processes during the formation of hydrothermal ores in the Waterloo massive sulfide deposit, Australia. A power-law frequency model has been proposed to describe the N-S relationship according to the frequency distribution of element concentrations and cumulative number of samples with those attributes[14,23-26].Hassanpour and Afzal[19]intended the elemental concentration–number (C-N) model as a branch of N-S model which is used to define the geochemical background and anomaly threshold values. The model has the following form:

$$N(\geq\rho) \infty \rho\text{-}\beta \tag{1}$$

Where $N(\geq\rho)$ indicates the sample number with concentration values greater than the ρ value and ρ is concentration of element and β is the fractal dimension. In this model, any primary process and evaluation have not accomplished on the geochemical data [27,19].

4. Results and Discussion

For this study, 54 samples were collected from 87 boreholes in the B_2coal seam and also chemical analysis for evaluation of sulfur and ash content in these samples were carried out. The resource database consists of the information based on and developed from the interpretation of surface and subsurface data consisting of collar, orientation, stratigraphy and sulfur and ash values. The selection of project dimensions for computerized 3D seam model is an exercise which is fundamentally significant according to the area and the boreholes coordinates (collar) and project dimensions which were calculated as 14500 m, 5500m and 820 m for X, Y and Z respectively.The3D models consisting of stratigraphy model (Fig. 2) and sulfur and ash distribution in the B_2 seam were created by RockWorks[15] software package. The Inverse distance squared (IDS)interpolation algorithm used for generating of sulfur and ash distribution models in the studied area.

The analyzed grades in all samples were sorted based on decreasing grades and cumulative numbers were calculated for grades. C-Nlog-log plots generated for ash and sulfur in the B_2 seam. The breakpoints between straight-line segments in those fully logarithmical plots show threshold values separating different populations of sulfur and ash values in B_2 seam (Fig. 3.1,3.2). Based on the C–N log-log plots, there are five different geochemical populations for both sulfur and ash data (Tables 1 and 2). First population for sulfur has ranged between 0 and 1.58% namely "very low sulfur population" which can be introduced as best population for coking coal due to Russian standards (Table 3)[3]. This population has located in the northern and western parts of the area, as depicted in Fig. 4.1.Two another populations for sulfurare namely "low and moderate sulfur populations" which they have sulfur values 1.58%-2.81% and 2.81%-3.38% respectively (Fig. 4.2, 4.3) (Table 1). Low sulfur population has a NE-SW trend which has largest population among another populations (Fig. 4.2). Populations with lowest qualities for coking coal which they were ranged from 3.38% to 4.07% and higher than 4.07%determined as high and very high sulfur populations respectively. (Fig. 4.4 , 4.5) Very high sulfur population is smallest population and it is relatively sparse population which most of voxels are located in the eastern part(Fig. 4.5).Moreover,there are five populations (Table 2) for ash which first population has ranged 0-6.91% show "very low ash population" that this population has best quality for coking coal whichis located in the western parts of the area (Fig. 5.1). The second population has values between 6.91% and 30.19% which are coking coal with proper quality based on Russian standard (Fig. 5.2) (Table 3)[3].This population for ash is the largest population among other populations which has an E-Wextension in the area. The third population has ranged 30.19%–39.81 % ash which is coal with moderate ash (Fig 5.3) .High ash population has ash values 39.81-57.54 % ash and the last population has ash values higher than 57.54%whichwas called "ash coal" or "argilliccoal" (Fig.5.4 , 5.5).

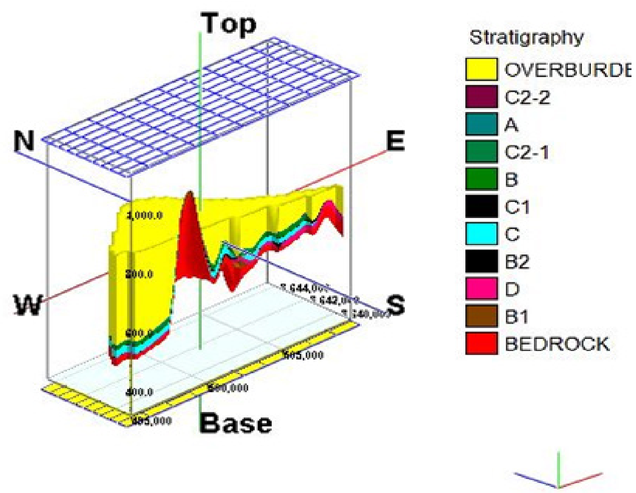

Figure 2. Stratigraphy model for North block of East-Parvadeh coal deposit, Central Iran

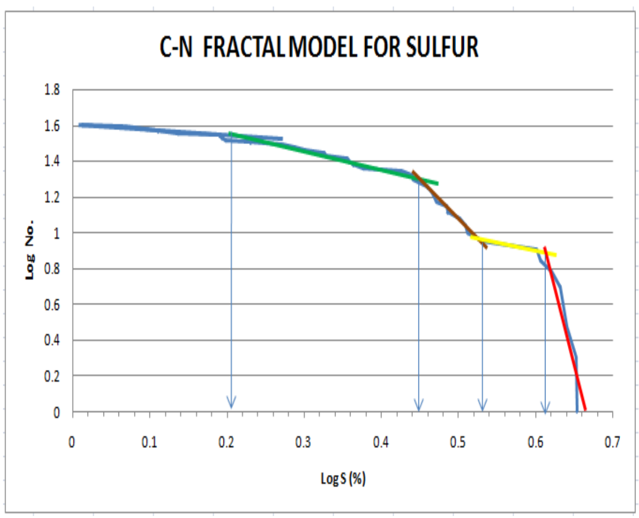

Figure 3-1. C-N log-log plotof sulfur for B2seam in the North Block of East-Parvadeh deposit.

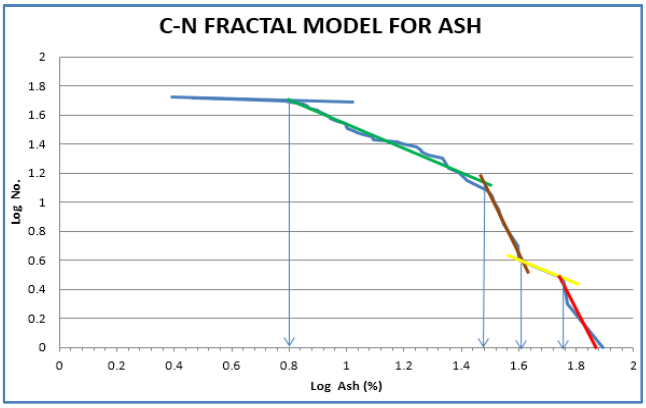

Figure 3-2. C-N log-log plot of ash for B2seam in the North Block of East-Parvadeh deposit

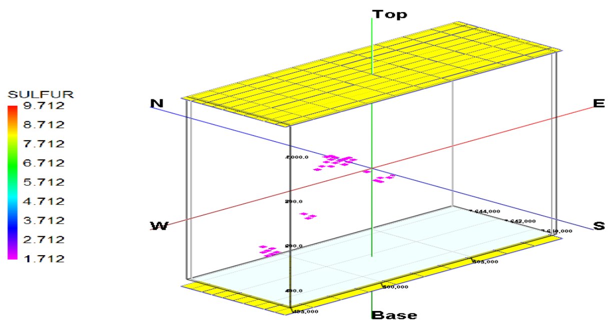

Figure 4-1. Very low sulfur population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

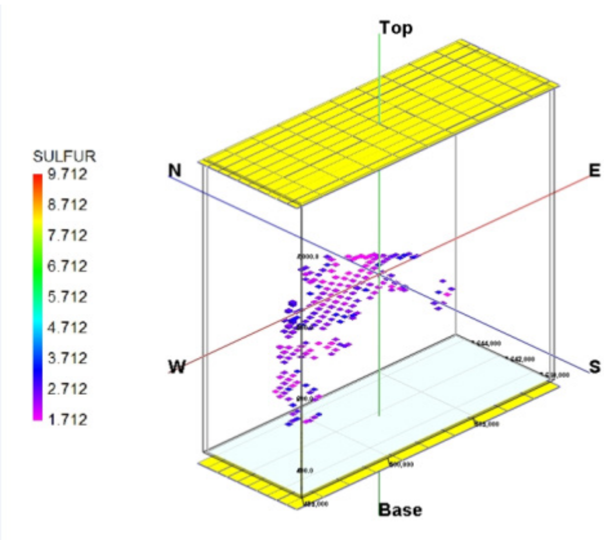

Figure 4-2. Low sulfur population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

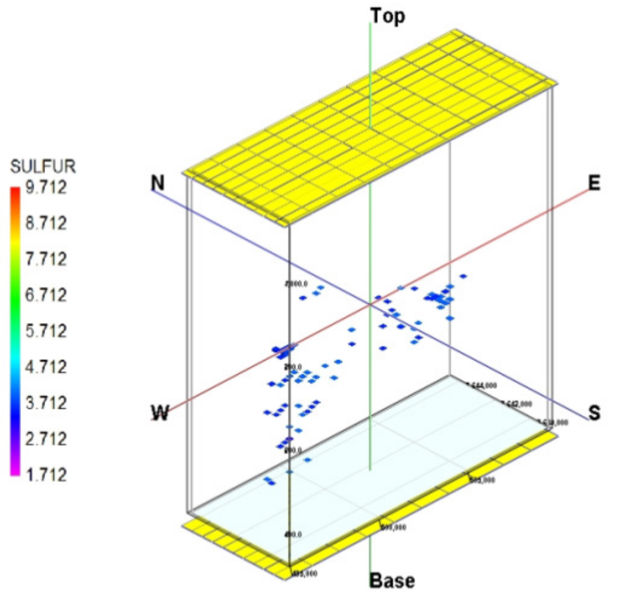

Figure 4-3. Moderate sulfur population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

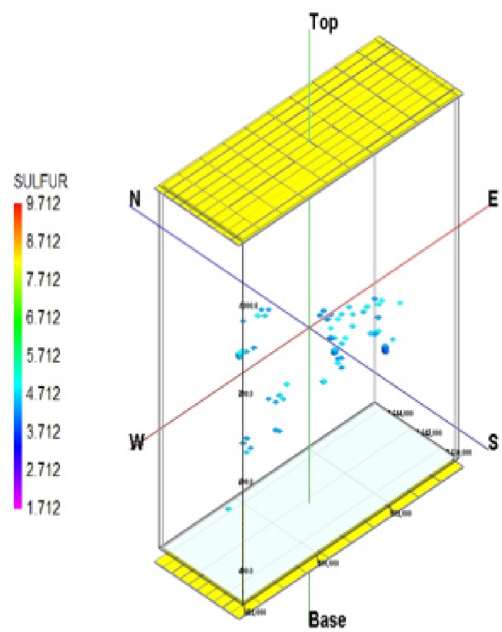

Figure 4-4. High sulfur population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

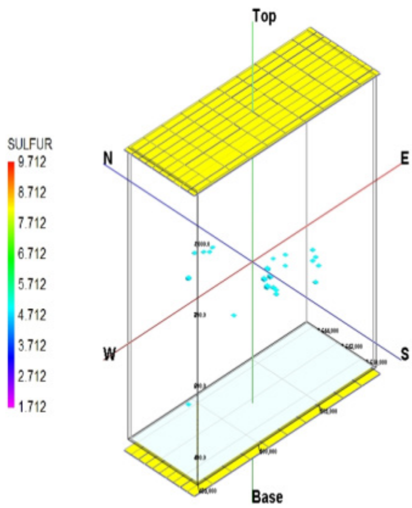

Figure 4-5. Very high sulfur population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

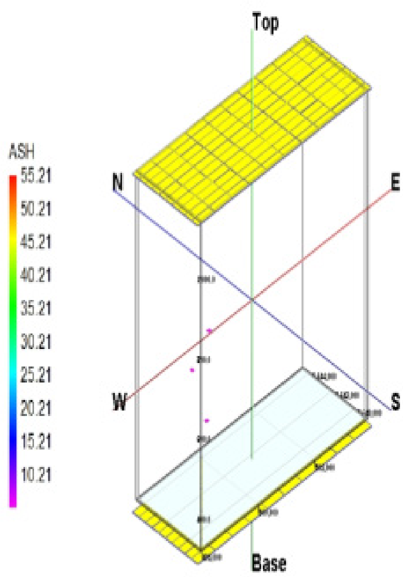

Figure 5-1. Very low ash population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

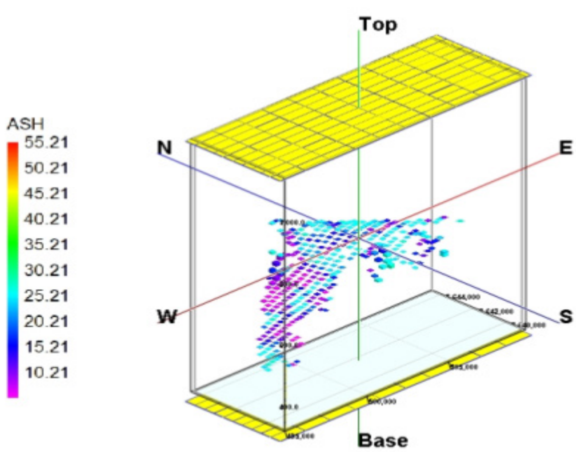

Figure 5-2. Low ash population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

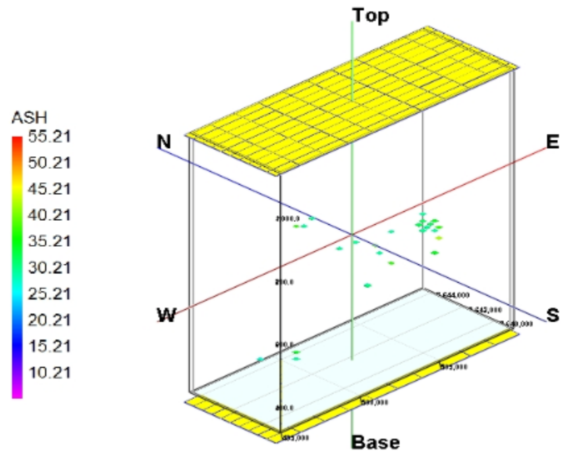

Figure 5-3. Moderate ash population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

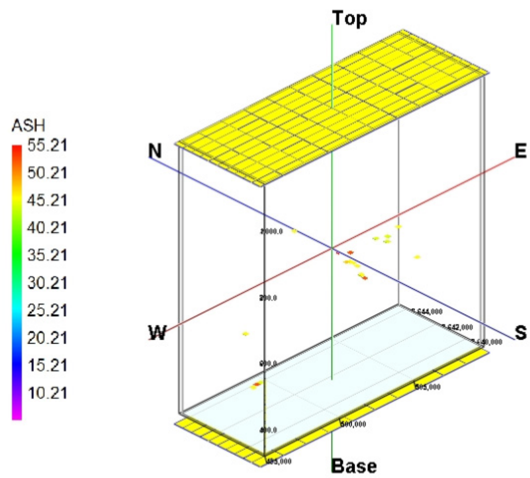

Figure 5-4. High ash population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

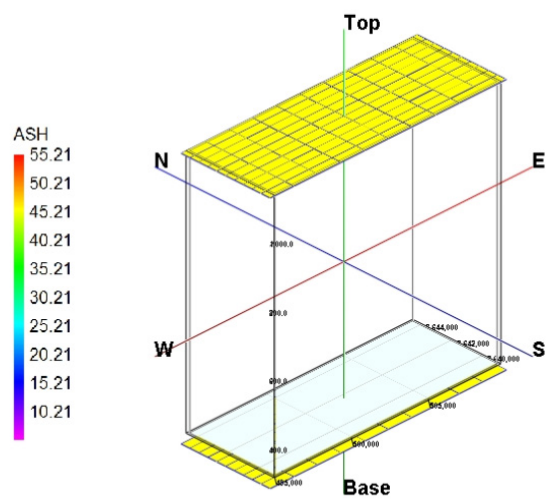

Figure 5-5. Very high ash population in B_2 seam of the North block in the East-Parvadeh coal deposit by the C-N Fractal model

Table 1. Different geochemical populations for sulfur in B2seam based on C-N Fractal model

Category	Very low	Low	Moderate	High	Very high
Sulfur(%)	0-1.58	1.58-2.81	2.81-3.38	3.38-4.07	4.07-4.5

Table 2. Different geochemical populations for ash in B_2seam based on C-N Fractal model

Category	Very low	Low	Moderate	High	Very high
Ash(%	0-6.91	6.91-30.19	30.19-39.81	39.81-57.54	57.54-78

Table 3. Coking coal categorization based On the Russian Standards (10583-72) and(7059-75)

Category	Very low Ash	Low Ash	Medium Ash	Relatively High Ash	High Ash	very high Ash
Ash (%)	0-10	10-15	15-25	25-31	31-40	> 40
Category	Very low Sulfur	Low Sulfur	MediumSulfur	Relatively High Sulfur	High Sulfur	very high Sulfur
Sulfur (%)	0-1	1-1.5	1.5-2.5	2.5-3.5	3.5-5	> 5

By the comparison between results obtained by C-N fractal modeling for sulfur and ash values and available geological information, it has revealed which there is strong correlation between multifractal models and geological features. Based on the geological evidences there are some pyrite veins in the eastern and southern parts of B_2 coal seam in the North Block which it correlated with high sulfur parts due to the C-N fractal model in the eastern and southern parts of the B_2 coal seam.

By comparison between C-N Fractal modeling for sulfur and ash data in B_2 seam and Russian standard categorization for coking coal, it has revealed which there are five geochemical populations for both sulfur and ash data in C-N Fractal modeling Tables(Tables 1 and 2), but Russian standard Table for coking coal has 6 populations. This additionally population has named “relatively high population” which has accounted for both sulfur and ash data in this table.(Table 3).also it has revealed which limits of populations in the C-N Fractal modeling tables(Tables 1 and 2) for both sulfur and ash data have significant differences with these limits in Russian standard table, however these limits for ash data have more differences than those in sulfur data, e.g, first population for ash values which obtained from C-N fractal modeling has ranged between 0 and 6.91% ash , but this population in Russian standard table with same name has ranged between 0 and 10 % ash. A severe difference has seen in high ash population. Lower limit in this population in C-N fractal modeling table for ash data is about near to upper limit of the population in Russian standard table .also second population for ash data in table 2 contains four populations for ash values in Russian standard table alone.

5. Conclusion

Based on the C-N multifractal modeling, there are five geochemical populations for sulfur and ash data in B_2 seam of North block. First populations for sulfur and ash data have highest quality for coking coal which have lower than 1.58 % and 6.91% sulfur and ash respectively which located in western part of the area. Moreover, low values for sulfur (<2.81%) and ash (<30.19%) are situated mostly in the northern and western parts of the North block. Low quality coals with high and very high ash content (>39.81%) have called “ash coal”, and high and very high populations for sulfur(> 3.38%) are located in the eastern part of the area and there is several pyrite veins which is validated results from the C-N fractal modeling.

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