

## Abstract

Three coal deposits in the eastern regions of Mongolia, Khavtgai deposit in Bayankhutag sum in Khentii province, Khulmannuur deposit in Erdenetsagaan sum in Sukhbaatar province and Aduunchuluu deposit located 6-8 km north of Choibalsan city in Dornod province, were selected for the comparative study. Upon XRF spectroscopy analysis result, it can be seen that Khulmannuur coal ash has the highest silica content compared to Khavtgai coal ash with 33.33% and Aduunchuluu coal ash with 34.88% SiO<sub>2</sub>. Furthermore Aduunchuluu coal ash has the lowest alumina content of 9.22% whereas Khulmannuur and Khavtgai coal ash have approximately 20% of alumina. According to the ASTM classification, Khulmannuur coal ash is classified as F type while Khavtgai and Aduunchuluu coal ash are classified as C type.

## Introduction

Coal contains a mixture of minerals that compose their mineral mass. Coal minerals and elements are formed in two ways. Coal minerals inherited from the original plant, and mineral components that are transported externally in various ways. The main mineral components of coal are silicon, aluminum, calcium, magnesium, sodium, potassium and titanium and can be found in the following forms: clay minerals, oxides, hydroxides, aluminosilicates, carbonates, sulfides, sulfates, phosphates, and chlorides. The predominant types of coals in Mongolia are as follows: lignite in eastern and Khangai regions, transitory stage of brown to coking coal in central regions, and hard rock and coking coal in the western and Gobi regions.

Three lignite deposits in the eastern part of Mongolia were selected for this study; Khavtgai in Bayankhutag sum in Khentii province, Khulmannuur in Erdenetsagaan sum in Sukhbaatar province, and Aduunchuluu in Dornod province.

It is important to conduct detailed proximate analysis to help identify the mineral and elemental contents of the coal to determine their use. In this study, we performed proximate analysis (moisture, ash, volatiles, calories), elemental analysis (carbon, hydrogen, oxygen, sulfur), and identified the mineral compositions of the coal samples from the deposits.

## Research objectives

The Khavtgai deposit is located in the territory of Tsantiin Am, 15 km southwest of the center of Bayankhutag sum in Khentii province. The Khulmannuur deposit is located in Erdenetsagaan sum, Sukhbaatar province. The Aduunchuluu coal deposit is located 6-8 km north of Choibalsan, the capital of Dornod province. The deposit's reserves are estimated at 423.8 million tons.

## Results

According to the X-ray fluorescence spectroscopy analysis, the coal samples have highest mineral contents of SiO<sub>2</sub>(33.33-65.49%) and Al<sub>2</sub>O<sub>3</sub>(9.22-22.84%). CaO content is highest in Aduunchuluu and Khavtgai coal (17.7-19.07%) and 2.3% in Khulman Nuur's coal. Fe<sub>2</sub>O<sub>3</sub>(3.3-7.96%) and MgO (4.48-6.294%) are moderate, while other elements are less than 1%. In general, the coal ash from the samples have high silica content.

Coal ash is classified by its macroelement contents. Through this classification, it can be considered as a siliceous ash due to its' high contents of silica and alumina, and contents less than 20% of calcium and iron oxides.

Composition of a lignite is generally: C 59-75%, H 4.6-6.0%, and O 20-30%. According to the elemental analysis results of the samples, the content percentages are C<sup>daf</sup>: 69.80-77.20% and N<sup>daf</sup> + O<sup>daf</sup> + H<sup>daf</sup>: 22.58-28.8%. This indicates that the sample is lignite. Sulfur content in coal varies between 0.2-10%. Sulfur contents less than 1.5% is considered low; when sulfur contents are low, organic sulfur predominate. In terms of sulfur contents, the coal of Khavtgai deposit has a very low content of 0.22%, whereas the coal of Khulman Nuur and Aduunchuluu deposits have sulfur contents of approximately 1.1-1.4%. Sulfur content is low in the coals of the deposits. The sulfur contents of coal have to be determined prior to using the coal for energy purposes due to its' harmful effects.

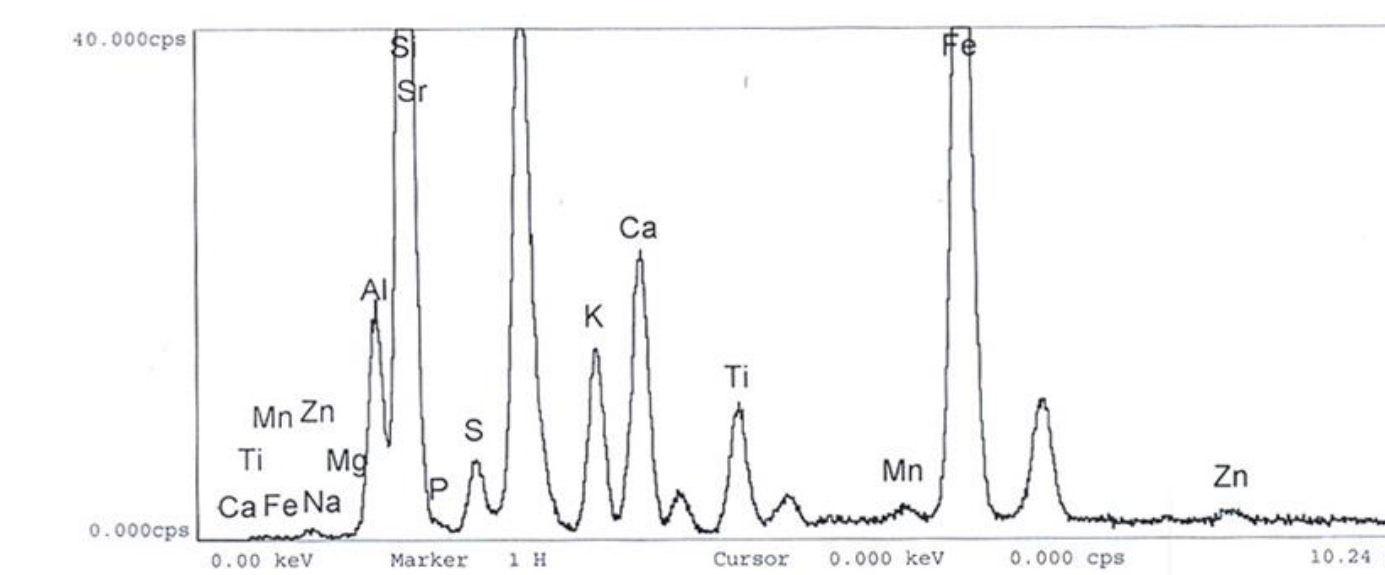


Figure 1. XRF spectrum of Khulmannuur coal ash.

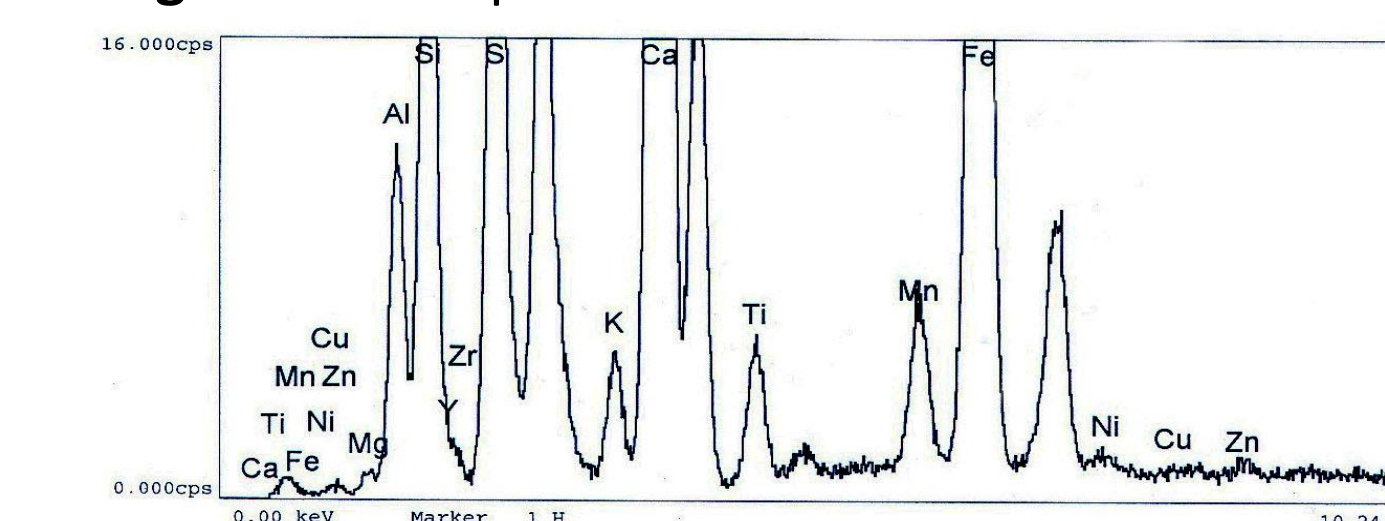


Figure 2. XRF spectrum of Khavtgai coal ash.

Table 1. Elemental composition of coal, %.

Deposits	C <sup>daf</sup> , %	S <sub>total</sub> , %	N <sup>daf</sup> + O <sup>daf</sup> + H <sup>daf</sup> , %
Khulmannuur	73.1	1.1	25.7
Khavtgai	77.20	0.22	22.58
Aduunchuluu	69.80	1.4	28.8

Table 2. Results of proximate analysis of the coal deposits, %.

Deposits	Sample	Moisture, %	Ash, %		Volatile substances, %		Calories, kcal / kg
		W <sup>a</sup>	A <sup>a</sup>	A <sup>daf</sup>	V <sup>a</sup>	V <sup>daf</sup>	Q <sup>daf</sup>
Khavtgai	1	10.78	9.11	10.22	37.26	46.99	5442
	2	10.80	9.99	11.20	37.50	47.08	
	average	10.80	9.55	10.71	37.38	47.03	
Khulmannuur	1	6.02	33.9	36.07	33.98	56.56	4398
	2	5.98	34.1	36.29	35.35	59.01	
	average	6.3	33.3	35.50	38.60	63.83	
Aduunchuluu	1	9.94	-	17.2	-	47.6	6361
	2	9.92	-	18.7	-	48.9	
	average	9.93	-	17.9	-	48.25	

Table 3. Mineral composition of coal deposits, %.

OxideA	Khavtgai	Khulmannuur	Aduunchuluu
CuO	0.005	0.00	0.00
MgO	6.294	0.791	4.48
Al <sub>2</sub> O <sub>3</sub>	21.76	22.84	9.22
SiO <sub>2</sub>	33.33	65.49	34.88
Y <sub>2</sub> O <sub>3</sub>	0.038	0.759	0.00
SO <sub>3</sub>	12.29	1.590	0.00
K <sub>2</sub> O	0.765	1.706	4.48
CaO	19.07	2.307	17.7
TiO <sub>2</sub>	0.798	0.970	0.41
Mn <sub>2</sub> O <sub>3</sub>	0.470	0.052	0.26
Fe <sub>2</sub> O <sub>3</sub>	5.032	3.330	7.96
ZnO	0.025	0.039	0.00
Na <sub>2</sub> O	0.00	0.00	1.69

## Discussion

Khulmannuur coal ash has the highest and Khavtgai coal ash has the lowest silicate modulus. As for the hydraulic modulus which are considered as low, Khulmannuur coal ash has the lowest of 0.05 while Khavtgai and Aduunchuluu have about 0.5. Moreover pyroxene modulus of the samples are approximately 1.0 which is also considered low. These types of ash can be used as a hydraulic mixture for construction materials. However, due to the low modulus of pyroxene, it cannot be used in a foundry. The ratio of base oxide to acid oxide is less than 1, which indicates that the coal ash from the deposits are acidic.

## Conclusions

1. According to the proximate and elemental analysis results, the coal of the eastern regional deposits have C<sup>daf</sup> of 69.80-77.20% and V<sup>daf</sup> of 47.03-63.83% meaning that the coals belong to the lignite type. It can be observed that Khavtgai coal has the highest carbon content and lowest volatiles while Aduunchuluu has the lowest carbon content and Khulmannuur has the highest volatile matter of 63.83%.
2. According to the X-ray fluorescence spectral analysis of the mineral composition of the coal ash from Khavtgai, Khulmannuur and Aduunchuluu deposits can be categorized as siliceous ash, due to its high content of silica and aluminum oxides, and less than 20% calcium and iron oxides.
3. Khulmannuur coal ash has the highest silica content compared to Khavtgai coal ash with 33.33% and Aduunchuluu coal ash with 34.88% SiO<sub>2</sub>. Aduunchuluu coal ash has 9.22% Al<sub>2</sub>O<sub>3</sub> whereas Khulmannuur and Khavtgai coal ash have approximately 20% of alumina. The coal ash from these deposits have high silica contents, thus they can be used to produce cement, concrete, bricks and construction materials.
4. Khulmannuur coal ash has the highest and Khavtgai coal ash has the lowest silicate modulus. For hydraulic modulus, Khulmannuur coal ash has the lowest of 0.05 while Khavtgai and Aduunchuluu have about 0.5. Moreover pyroxene modulus of the samples are approximately 1.0 which is also considered low. Consequently the ash from these deposits can be used as an additive in construction materials, but not in the foundry, due to the low hydraulic and pyroxene modulus values of the coal ash from the deposits.

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