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Study of rare earth elements in coal ash from Khartarvagatai coal deposit

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Abstract: Have been investigated the mineral matter and chemical composition of ash from the Khartarvagatai coal deposite by X-ray fluorescence (XRF) and atomic absorption spectroscopy (AAS) methods. In the ash of this coal have revealed trace elements like Ce, Th, Be, La, Nd, Y, As. These elements come from mineral gasparite that present in raw coal. All diffraction patterns were analyzed by full-profile Rietveld refinements, using the software package WinPLOTR

Keywords: Khartarvagatai deposit, coal ash, rare earth elements, gasparite,

Introduction

Coal serves as source of energy resources and as source of organic compounds of 21th century. Nowadays more than 90 percent of Mongolian power electricity and heat energy are produced by using of coal resources and coal is the main and reliable source of energy throughout in all aimags and soums of Mongolia.

Mongolia has a huge amount of coal resources and coal is cheaper in comparison with petroleum and natural gas. Demand of coal is increasing year by year. Unfortunately coal also may serve as source of pollutant of nature.

At the same time coal ash is reliable source of rare earth and dispersal elements. Recently coal deposits are beginning to evaluated by their contents of rare earth and dispersal elements because of their needs in modern industrial branches.

Therefore investigation of coal mineral matter, chemical composition and trace elements in ash is important task. Moreover, beneficiation of coal might give possibility to use coal completely without risk for nature damage.

Experimental

Coal samples from deposit Khartarvagatai located in western Mongolia were used in the study. Khartarvagatai coal deposit is located in Mongol Altai mountains region. According to coal area this deposit belongs to Kharhiraa coal basin.

The coal samples were ground and sieved to particle sizes 0.074 mm and subjected to combustion in a muffle furnace at 600^{o}C temperature to obtain ash samples. The contents of trace elements were determined by PANalytical AXIOS Advanced sequential X-ray spectrometer installed in Central geological laboratory of Mongolia. The glass disks are used for trace element determination are prepared by using mixtures of lithium tetraborate and lithium metaborate, Spectromelt A12, Merck. For the dilution 4200 mg of this flux and 700 mg of the sample are weighed in platinum-gold crucibles and fused for 15 min at 1100^{o}C. The melt is poured into pre-heated, polished 32 mm-diameter moulds. For trace element determinations the standard deviations of consecutive analyses are in the

range of 2 to 5% relative at the level of 20 to 30 ppm. Detection limits vary from 3 to 0.5ppm for the majority of the measured elements.

Phase analysis and determination of cell parameters at room temperature were carried out using X-ray powder diffraction (XPD) with Advanced D8 diffractometer (Cu-Kα_1-radiation) in transmission mode. All diffraction patterns were analyzed by full-profile Rietveld refinements, using the software package WinPLOTR [1].

Results and Discussion

Mineral matter decreases the ability of heat releasing and has negative effect on coal processing. Therefore, it is important to determine content of the mineral matter and its chemical and mineralogical compositions of coal as well as ash.

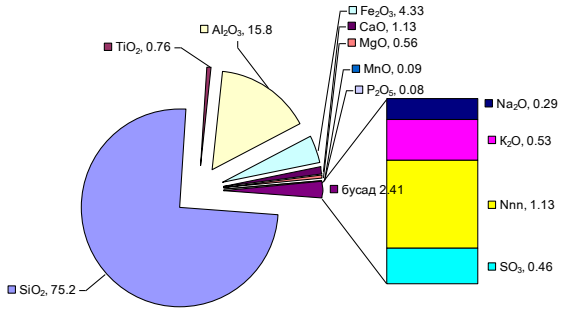

Figure 1. Chemical composition of coal ash in the Khartarvagatai coal deposit (%)

As seen at figure 1 the content of silicon oxide and aluminum oxide prevailed otherwise the content of alkaline and alkaline earth metal's oxide are comparatively less. It is because of coal layer location of this deposit (1800 m below sea level) and consists of conglomerate, clay and quartz minerals [2].

Coal ash of Khartarvagatai deposit shows ratio $(Fe_2O_3+CaO+MgO+Na_2O+K_2O)/(SiO_2+Al_2O_3+ Ti_2O) = 0{,}079$, therefore has an acidic character [3]. Also $CaO+MgO < Fe_2O_3$ an indication of bitumous character of this ash, and $(SiO_2 + Al_2O_3 + Fe_2O_3)$ –sum is more than 70 % , therefore by ASTM C618 classification ash belongs to F class of ash [3].

X-ray difractogram of coal ash from Khartarvagatai deposit is shown at picture 2 and table 1.

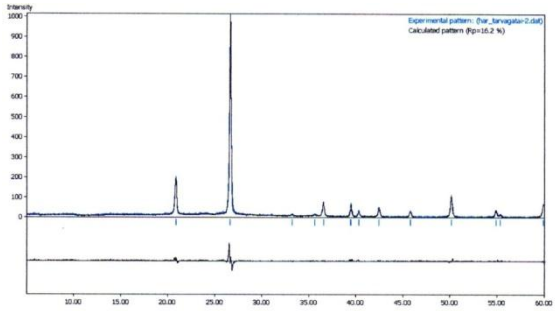

Figure 2. X-ray diffractogram of coal ash from Khartarvagatai coal deposit

At X-ray diffractogram of Khartarvagatai coal ash (picture 2, table 1) we saw d=4.25, 3.34, 2.45, 2.27, 2.12, 1.97, 1.81, 1.67, 1.54 A^o quartz analytical line, d=1.65 A^o muscovite line, d=2.69, 2.51, 1.90, 1.79 A^0 gasparite analytical line, consequently.

Table 1.X-ray parameters of the coal ash from Khartarvagatai deposit

№	d,E	Name of minerals	Chemical formula	Symmetry of crystal grid, parameters of grid (E)
1	4.25	Quartz	α-SiO_2	trigonal, $P3_12_1$ a=4.9180, c=5.4070
2	3.34		α-SiO_2	
3	2.69	Gasparite	(Ce, Th, Be, La, Y, Nd)[$As_{0.71}P_{0.29}O_4$]	betta-monoclin, $P2_1/n$ a=6.9290, b=7.1290, c=6.6970
4	2.51		(Ce, Th, Be, La,Y, Nd)[$As_{0.71}P_{0.29}O_4$]	
5	2.45		α-SiO_2	
6	2.27		α-SiO_2	
7	2.12		α-SiO_2	
8	1.97		α-SiO_2	
9	1.90		(Ce, Th, Be, La, Y, Nd)[$As_{0.71}P_{0.29}O_4$]	
10	1.81		α-SiO_2	
11	1.79		(Ce, Th, Be, La, Y, Nd)[$As_{0.71}P_{0.29}O_4$]	
12	1.67		α-SiO_2	
13	1.65		$KAl[Si_3AlO_{10}](OH)_2$	
14	1.54		α-SiO_2	

The content of rare earth and dispersal elements in coal ash of Khartarvagatai deposit more than Clark of clay minerals, also the content of Y, Yb more than the industrial content in coal ash. (table 2).

Table 2. Average content of rare earth elements in coal ash from Khartarvagatai deposit (g/ton)

Earth rare elements	K_1-clark in clay minerals	Khartarvagatai	Industrial content*
Y	26	**122**	75
Yb	2.2	**8**	7.5
La	90	95.84	750
Ce	50	174.8	-
Nd	26	75	-
Sm	4.5	29.47	-
Pr	7.1	30	-

*- Yudovich Ya.E. 1989

The results show that most of rare earth elements in the ash samples have contents lying in the ranges for most coals. The content of Y in coal ash of Khartarvagatai deposit was 122 g/t (the highest content is 150 g/t, the lowest content is 94 g/t). It is known that the industrially applicable content of Y and Yb in coal ash are 75 g/t and 7.5 g/t, consequently (Yudovich Ya. E.,1989). From above mentioned results we have made conclusion that the contents of Y and Yb in coal ash of Khartarvagatai deposit prevailed the industrial content [5,6].

From figure 2, and table 1 we see that coal ash contain mineral gasparite which consist of following rare earth and dispersal elements like Ce, Th, Be, La, Nd, Y, As.

Conclusions

Ash from Khartarvagatai coal deposit contains quartz, muscovite and gasparite as mineral matters. Coal ash from this deposit belongs to acidic, bitumic, low calcium F class type coal ash by ASTM C618 classification. Y and Yb in Hartarvagatai coal ash have contents, allowing their industrial productions from coal ash. Khartarvagatai's coal ash contain mineral gasparite which consist of following rare earth and dispersal elements like Ce, Th, Be, La, Nd, Y, As.

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