Study Of Chemical And Mineralogical Composition Of Low-Grade Phosphorites And Carbons Of Tajikistan Using Modern Physico-Chemical Analysis Methods

Fakerov Gurezxon Murodovich, Sharipova Khabiba Teshaevna, Mirzoev Boxodur, Erkaev Actam Ulashevich

Abstract : The article studies the physicochemical properties of coals from the Fan-Yagnob deposit and phosphorites from the Gissar deposit in order to use them for the production of humic compounds, phosphorus, and organomineral fertilizers. The possibility of obtaining phosphorus-containing organomineral fertilizers containing the assimilable form of P2O5 and humic acids from different fractions of phosphorites from the Gissar deposit and coals from the Fan-Yagnob deposit is shown.The aim of the work is to study the chemical composition of the coals of the Fan-Yagnob deposit and the phosphorites of the Gissar deposit with the establishment of the suitability of their processing into humic compounds, as well as phosphorus and organo-mineral fertilizers.

Keywords : coal, component, liquid and solid phase, balance, microelement, humic acids, moisture, organomineral fertilizer, phosphorite, fertilizers, element.

1 INTRODUCTION

The process of obtaining phosphorus fertilizers consists of converting indigestible forms of phosphorus into raw materials into forms assimilable for plants. Usually, this transfer is carried out by acidic methods. But acidic methods are good for rich phosphate raw materials and not suitable for poor ones. Therefore, it is almost impossible to obtain highly concentrated water-soluble phosphorus fertilizers from poor phosphorites with acceptable technical and economic indicators. We made an attempt to develop an alternative to an acidic method for processing phosphorites from the Gissar deposit, the so-called method of activating phosphate raw materials to convert the form of P2O5, which is indigestible for plants, into raw materials into digestible. The industry is trying to carry out this translation mechanically [1], chemically [2], mechanochemically [3], thermally [4], complexometric [5], and microbiologically [6]. Chemical and mechanochemical activation are one of the simple and promising methods for processing lean phosphate raw materials. These methods make it possible to use phosphate raw materials of any quality and obtain fertilizers with the required ratio of nutrient components, as well as solve issues related to the saving of an acid reagent, in particular, with its complete replacement with acid salts. Mechanochemical technology does not require large capital investments to organize the production of fertilizers. It is environmentally friendly due to the absence of effluents and emissions into the atmosphere. However, there is no information in the literature on the study of the processing of phosphorites from the Gissar deposit into phosphorus-containing fertilizers. There are absolutely no data on the production of organomineral fertilizer mixtures from phosphorites of the Gissar deposit and organic salts.

• *Fakerov Gurezkhon Murodovich - art. teacher in Institute of Energy in Tajikistan.*
•*Sharipova Khabiba Teshavna - associate professor in Tashkent Institute of Chemical Technology, Uzbekistan*
•*Mirzoev Bohodur- professor in Branch of the Moscow University. M.V. Lomonosov in Tajikistan*
•*Erkaev Aktam Ulashevich – professor in Tashkent Institute of Chemical Technology, Uzbekistan*

An important advantage of organic substances is that, in addition to increasing the assimilation of phosphorus in phosphate raw materials, they help to supply plants with the necessary nutrients, while improving the physical, physicomechanical, chemical, and biological properties of soils. Such an effective reagent for the activation of phosphate raw materials can be attributed brown coal, which contains a large number of humic acids. But ordinary brown coal from the Angren deposit and the Fan-Yagnob coal with a humic acid content of 4,1% is unsuitable for obtaining organomineral fertilizers on its basis. This requires oxidized coal containing more than 45% humic acids [7]. Therefore, the authors of [8] first studied the oxidation process of brown coal from the Angren deposit with a mixture of nitric and sulfuric acids. The industrial potential of the Tajik coal basin is great. It contains the unique Nazar-Ailok deposit with low-ash and low-sulfur anthracites, the Fan-Yagnob deposit, a large coking coal deposit in Central Asia, and a whole group of small coal objects - energy and chemical raw materials. In terms of coal reserves, all the deposits of the republic belong to the group of small (up to 50 million tons), except for the Fan-Yagnob deposit, which belongs to the group of medium deposits [10-13]. On the territory of Tajikistan, 4 regions of the development of coal-bearing deposits are distinguished, each of which differs in a number of characteristic features in terms of geological zoning:

1. Zarafshan-Gissar
2. South Gissar
3. Pamir-Darvaz
4. South Fergana.

The largest, vast in area, coal-bearing region, which is represented by the maximum number of coal seams, is Zarafshan-Gissar. The coal-bearing strata stretch in an almost continuous strip from Penjikent to the headwaters of the Zarafshan River. The Republic of Tajikistan is rich in coal located in various parts of its territory. According to the Ministry of Industry and New Technologies, coal reserves are sufficient not only to provide the fuel and energy complex for decades but also to create a chemical industry. Of the 40 deposits and occurrences of coal known on the territory of Tajikistan, only two have been studied in detail: Shurab and Fan-Yagnob. The main share of production falls on the following state and private enterprises: Unitary Enterprise “Mine Fan-Yagnob” (57.7%), LLC “Talko-Resource” (13.1%), Unitary Enterprise “Koni Angishti Ziddi” (11.2%), Angisht OJSC (5.6%), Nazar-Aylok Unitary Enterprise (5%), Sayyod LLC (3.2%) and 4.2% for other enterprises [10-14]. As shown above, Tajikistan's coal is used primarily as fuel. There is no information in the literature on the use of coal from Tajikistan as humate-containing preparations used in agriculture. Therefore, the study of the physicochemical properties of the coals of the Fan Yagnob deposit and the phosphorite of the Gissar deposit in order to use them for the production of organo-mineral fertilizers is urgent. But in the literature, there is no data on the use of coals of the Fan Yagnob deposit for the production of organic fertilizers. For research, samples of coals were taken from various depths of the Fan Yagnob deposit of the Dzhidikrut site.

2 RESEARCH METHODS.

The identification of samples was carried out on the basis of diffraction patterns, which were recorded on an XRD-6100 apparatus (Shimadzu, Japan) controlled by a computer. We used CuKα-radiation (β-filter, Ni, 1.54178 modes of current and tube voltage 30 mA, 30 kV) and a constant detector rotation speed of 4 deg/min with a step of 0.02 deg. (ω / 20-cohesion), the scanning angle varied from 4 to 80° C. The morphology and size of the particles were studied using a Jeol JSM-6510LV scanning electron microscope (Japan). The spectral analysis of the ash of all the studied coal samples was carried out on a Rigaku high-performance energy dispersive X-ray fluorescence spectrometer EDRF. The spectrometer is used for the daily determination of trace elements in complex sample types. Up to five secondary targets cover the full range of elements (Na – U) with optimum sensitivity. Excitation is provided by a 50 W X-ray tube with a Pd anode. On a derivatograph of the Paulik-Paulik-Erdey system, when heated to 900^0C at a rate of 10 deg/min, thermal analysis of the initial phosphate raw material, as well as fractions № 1, № 2, № 3 was performed. The sensitivity of the galvanometer was DTA, DTG - 1/10, TG - 200. Samples were placed in a corundum crucible with a diameter of 10 mm without a lid. Al_2O_3 served as the reference. Heating was carried out under atmospheric conditions. General technical studies of coals were carried out using generally accepted methods. The analytical moisture content of coal was determined according to GOST 11014-81. The ash content of the samples was determined according to GOST 11022-75. The number of humic acids in coal was determined by extracting humic acids with a 0.1 N alkali solution upon heating, precipitating them with an excess of hydrochloric acid, and determining the mass of the resulting precipitate according to GOST 9517-76.

3 RESULTS.

The research results are shown in Table 1.

Table 1.
Results of analyzes of coal samples from the Fan-Yagnob deposit

№	Humidity,%	Ash content,%	Organic mass of coal,%	HA,% in OM
1	2,67	25,2	72,13	2,38
2	3,03	9,76	87,21	5,68
3	3,78	13,21	83,01	3,58
4	2,06	28,01	69,93	2,06

As can be seen from Table 1, the ash content of the coals varies widely from 9,76% to 28,01%. Samples № 2 and №3 have ash content of 9,76% and 13,21%, respectively. Samples № 1 and № 4 are distinguished by a high content of minerals. The ash content in them ranges from 25,2-28,01%.The results of analyzes of the coals of the Dzhidikrut site show that they contain a small amount of humic acids 2,06-5,68%, moreover, coals with high ash content (samples 1 and 4) have a lower amount of humic acids: 2,38% and 2,06, respectively. However, as shown by prospecting experiments in the oxidation of the coal of Tajikistan under certain technological conditions with sulfuric and nitric acids, the amount of humic acids increases to 60%.With the aim of a detailed study of the mineral part of the coals of the Fan Yagnob deposit by the method of X-ray fluorescence, spectral analysis of the ash of all studied coal samples was carried out on a high-performance energy dispersive X-ray fluorescence spectrometer EDRF of the Rigaku company. The spectrometer is used for the daily determination of trace elements in complex sample types. Up to five secondary targets cover the full range of elements (Na – U) with optimum sensitivity. Excitation is provided by a 50 W X-ray tube with a Pd anode. The results of analyzes of the mineral part of the Fan coals of the Yagnob deposit of the Dzhidikrut site are presented in Table 2.

Table 2.
Spectral analysis of coal ash from the Dzhidikrut site

The elements	sample №1	sample №2	sample №3	sample №4
Si	20,0	25,0	25,0	25,0
Al	10,0	15,0	10,0	10,0
Ca	1,0	1,0	1,0	0,3
Na	0,3	0,2	0,4	0,4
K	0,6	1,0	1,0	1,5
Fe	10,0	3,0	4,0	4,0
Mg	3,0	3,0	3,0	3,0

P	0,5	0,1	0,4	0,1
Ba	0,03	0,04	0,04	0,04
Sr	0,02	0,02	0,03	0,02
B	0,02	0,01	0,01	0,01
Mn	0,1	0,02	0,03	0,03
V	0,06	0,03	0,03	0,03
Ti	0,2	0,2	0,2	0,2
Cr	0,01	0,006	0,015	0,02
Ag	0,0003	0,00004	0,0001	0,00004
Cu	0,02	0,006	0,01	0,008
Pb	0,01	0,006	0,01	0,01
Zn	0,02	0,006	0,01	0,01
Ni	0,02	0,003	0,004	0,003
Co	0,005	-	0,001	-
Mo	0,003	0,001	0,004	0,0006
Sn	0,0005	0,0004	0,0004	0,0004
Be	0,003	0,0003	0,001	0,0004
Li	0,03	0,04	0,06	0,04
La	-	0,02	0,02	-
Sc	-	0,002	0,001	-

As can be seen from Table 2, the coals of the Fan Yagnob deposit of the Dzhidikrut area contain a wide range of elements. They are rich in compounds of silicon, aluminum, iron. Their number reaches 20-25%, 10-15%, and 3-10%, respectively, and sample №1 contains 10% iron, and samples №2, №3, № 4 have a reduced amount of iron (3; 4%). The analyzed samples contain 0,1-0,5% phosphorus, and the amount of calcium reaches 0,3-1,0%.The research results show that the studied coal samples contain such trace elements as boron (0.01-0.02%), manganese (0.03-0.1%), copper (0.006-0.02%), nickel (0,003-0,02%), which can be used in agriculture as trace elements. As noted above, there are no data in the literature on the use of phosphorite from the Gissar deposit for the production of phosphorus and organo-mineral fertilizers [13-15].

In order to use the phosphorites of the Gissar deposit for the production of organomineral fertilizers, the chemical, elemental, and oxide composition of the phosphate raw material was studied. The results of the spectral analysis of phosphorite from the Gissar deposit are confirmed by the spectrograms shown in Fig. 1 and in Table 3. As can be seen from Table 3, the phosphorites of the Gissar deposit contain a wide variety of oxides. The phosphate raw material of this deposit contains a large amount of silicon oxide 64,5%. The number of oxides of magnesium, aluminum, calcium reaches 2,44; 7,32; 12,0% respectively. The content of the main nutrient for plants P_2O_5 is 8,15%.

Table 3.

Spectral analysis of phosphorites of the Gissar deposit (oxides)

№	component	Resalt	Unit	Stat.err.	LLD	LLQ
1	MgO	2,44	Mass%	0,0252	0,0322	0,0965
2	Al_2O_3	7,32	Mass%	0,0217	0,0147	0,0440
3	SiO_2	64,5	Mass%	0,086	0,0029	0,0087
4	P_2O_5	8,15	Mass%	0,0135	0,0054	0,0162
5	SO_3	0,867	Mass%	0,0035	0,0009	0,0026
6	K_2O	0,979	Mass%	0,0070	0,0038	0,0115
7	CaO	12,0	Mass%	0,0197	0,0039	0,0117
8	TiO_2	0,13	Mass%	0,0017	0,0017	0,0050
9	V_2O_5	0,0151	Mass%	0,0007	0,0016	0,0047
10	Cr_2O_3	0,0077	Mass%	0,0003	0,0006	0,0017
11	MnO	0,0326	Mass%	0,0009	0,0012	0,0036
12	Fe_2O_3	1,08	Mass%	0,0037	0,0011	0,0033
13	NiO	0,0016	Mass%	0,0001	0,0003	0,0009
14	CuO	0,0019	Mass%	0,0001	0,0002	0,0006
15	ZnO	0,0031	Mass%	0,0001	0,0001	0,0004
16	Ga_2O_3	0,0005	Mass%	<0,0001	0,0001	0,0004
17	As_2O_3	0,0015	Mass%	<0,0001	0,0001	0,0003
18	Rb_2O	0,0036	Mass%	<0,0001	0,0001	0,0001
19	SrO	0,0443	Mass%	0,0002	<0,0001	0,0001

20	Y_2O_3	0,0036	Mass%	<0,0001	<0,0001	0,0002
21	Ag_2O	0,0009	Mass%	<0,0001	0,0002	0,0005
22	SnO_2	0,0030	Mass%	0,0002	0,0003	0,0009
23	BaO	0,0111	Mass%	0,0006	0,0014	0,0042
24	Ta_2O_5	0,0017	Mass%	0,0002	0,0006	0,0018
25	PbO	0,0013	Mass%	<0,0001	0,0002	0,0007
26	ThO_2	0,0007	Mass%	<0,0001	0,0001	0,0003
27	U_3O_8	0,0027	Mass%	<0,0001	0,0002	0,0005
28	Na_2O	2,18	Mass%	0,105	0,249	0,746
29	NO_3	<0,0001	Mass%			
30	CO_2	<0,0001	Mass%			
31	Se_2O_3	ND	Mass%	0,0052	0,0153	0,0459
32	ZrO_2	0,153	Mass%	0,0012	0,0004	0,0012
33	Eu_2O_3	0,0142	Mass%	0,0017	0,0048	0,0144
34	Tb_4O_7	ND	Mass%	0,0040	0,0131	0,0392
35	Dy_2O_3	0,0178	Mass%	0,0033	0,0092	0,0275
36	Er_2O_3	ND	Mass%	0,0051	0,0163	0,0489
37	Tm_2O_3	ND	Mass%	0,0012	0,0035	0,0105
38	YbO_3	ND	Mass%	0,0003	0,0010	0,0029
39	PuO_2	<0,0001	Mass%			

In the phosphate raw materials of the Gissar deposit, alkaline earth metals are in the amount,%: Fe_2O_3 -1,08; Na_2O -2,18; K_2O-0,979. The investigated samples of phosphorite contain trace elements in the following amount,%: MnO – 0,0326; NiO 0,0016; CuO 0,0019; ZnO – 0,0031. The chemical composition of phosphate raw materials and its fractions was studied according to a well-known technique. CaO, P_2O_5 and CO_2 were determined [16,17]. For this purpose, phosphorite was washed with ordinary water at S: W = 1: 3 and divided into three fractions:

Sample №1 - initial phosphorite from the Gissar deposit

Sample №2 - heavy first fraction — isolated after repulpation in 30 seconds.

Sample №3 - the second fraction - isolated after repulpation after 120 seconds.

Sample № 4 - the third light fraction - isolated after repulpation in 300 seconds.

The first fraction was 55,93%, the second fraction was 35,81%, and the third fraction was 8,2%.As can be seen from Table 4, the phosphorites of the Gissar deposit are classified as poor. The content of P_2O_5 total in it is 7,93%, CaO -14,19%. It was found that the fractions of phosphate raw materials contain CaO in the range of 12,23-12,95%. The amount of P_2O_5 in them varies in the amount of 3,92-6,60%. Moreover, fraction № 3 contains the largest amount of P_2O_5 – 6,60%.The digestible form of phosphoric anhydride was determined by dissolving the phosphate raw material in citric acid. It was found that in the phosphorite fractions 78,13 – 82,73% P_2O_5 total. goes into an assimilable form.

Table 4.

Chemical composition of phosphate raw materials and its fractions

№	Samples	Component content, wt. %					$\frac{P_2O_{5усв}}{P_2O_{5общ}}$ citric acid,%	Fraction share,%
		Hydrochloric acid soluble part			Lemon soluble part			
		CaO	P_2O_5	CO_2	CaO	P_2O_5		
1	Phosphorite original	14,19	7,93	2,46	8,00	4,51	56,87	
2	1 -faction	12,45	4,94	1,96	7,92	3,86	78,13	55,93
3	2 -fraction	12,23	3,92	4,99	7,88	3,16	80,62	35,81
4	3 -fraction	12,95	6,60	2,89	7,64	5,46	82,73	8,20

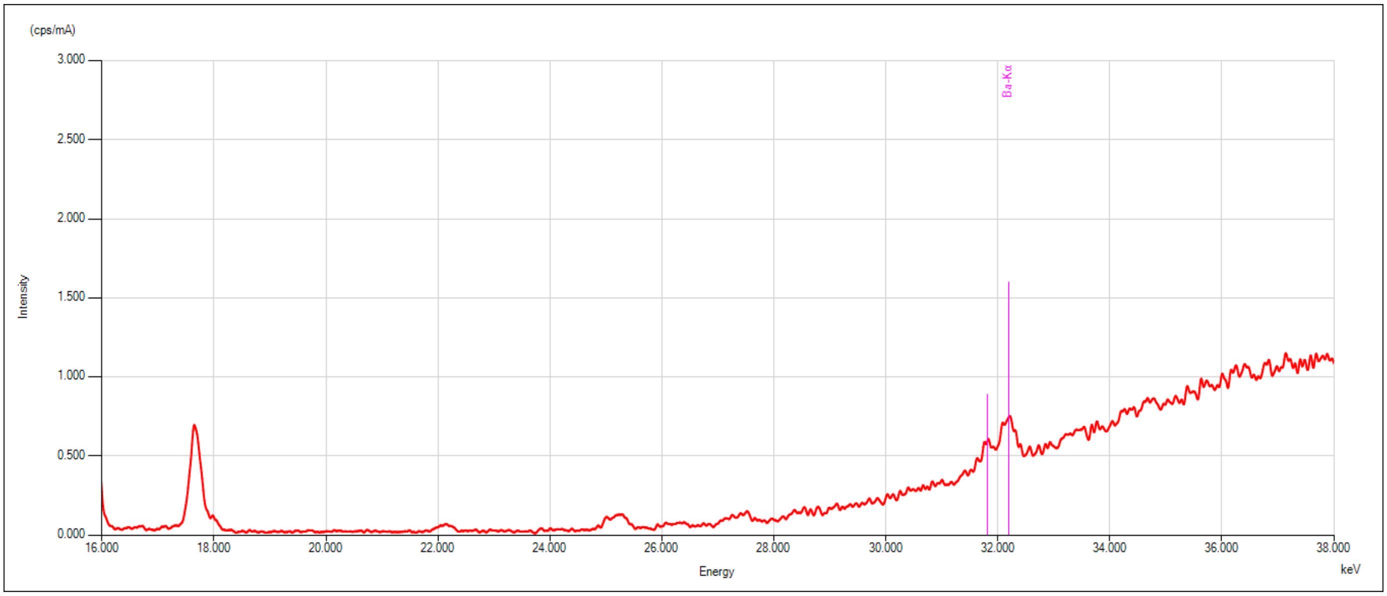


***Figure 1**. Spectrum of phosphorite of the Gissar deposit (oxides)*

Samples of phosphate raw materials in order to study their mineralogical composition were analyzed by thermal and X-ray analysis methods. The results are shown in Figure 2-3. From the analysis of the tree diagram, the following follows: The heating curve for sample № 1 (initial phosphorite) shows the first two endothermic effects at temperatures of 100^0C and 150^0C, respectively. In these endo-effects, there is a decrease in mass by 0,67 and 1,06%, respectively. At the same time, sorbed and crystalline hydrate moisture is lost, dehydration of free moisture and dehydration of bound moisture occurs, respectively. At a temperature of 405 °C, one exo effect is manifested, which is accompanied by a weight loss of 1,59%. In this case, the destruction of aluminosilicate materials occurs. Endoeffects at 650 and 850°C with a decrease in mass by 10,64% and 19,945%, respectively, indicate the release of crystallization moisture in aluminosilicates, as well as the beginning of the decomposition of magnesium carbonates.

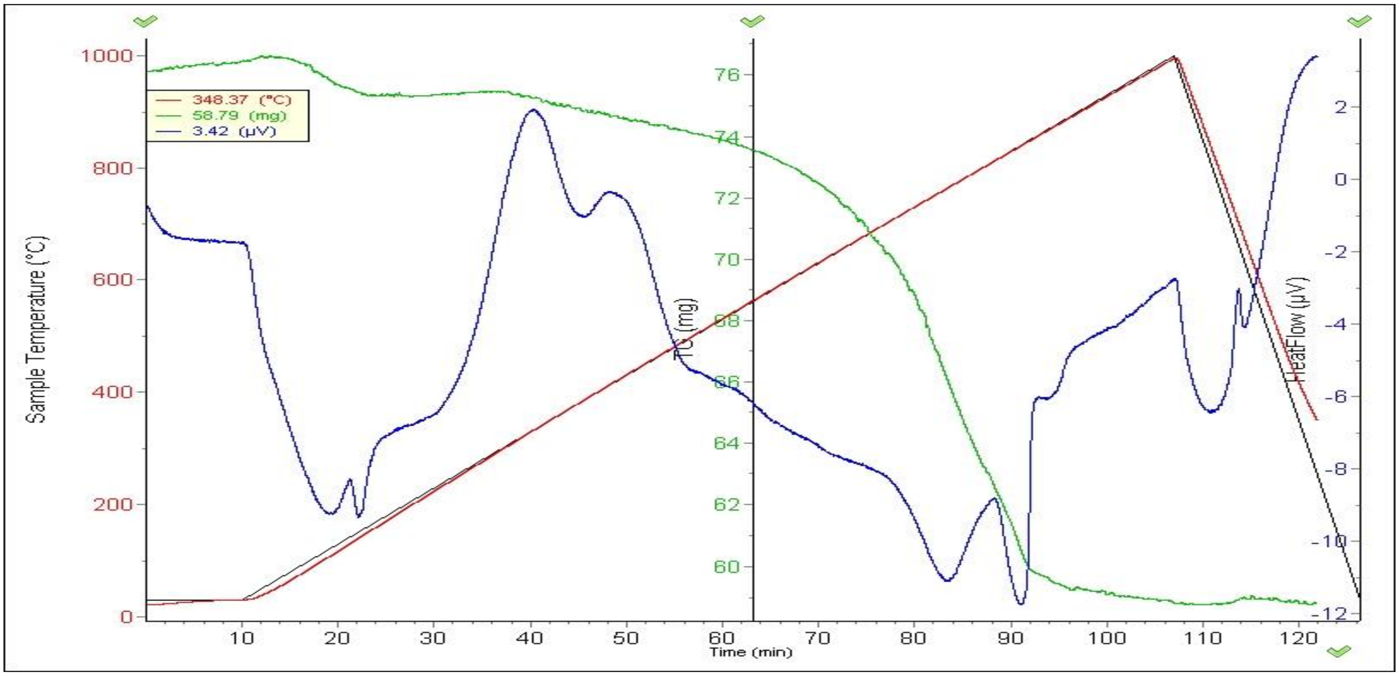
The total weight loss is 22,87% (table 5.).

The heating curve of sample № 2 (washed phosphorite fraction №1) is characterized by endothermic effects at temperatures: 105^0C, 340^0C, 580^0C and 800 ° C, which corresponds to a decrease in weight by 0,74%, 1,29% and 2,49%, 4,41%, respectively . These endoeffects indicate dehydration of free moisture, dehydration of bound water, dehydration and destruction of aluminosilicate materials, and decomposition of carbonate materials, respectively. The total weight loss is 4,41%. The same picture is observed on the derivatograms of the 3-sample (2-fraction) where the total weight loss is 4,86%.In Fig. 2, the derivatogram of the fourth sample (fraction 3), a picture is observed that differs from the derivatogram of 1 and 2-fractions. Here the endo effect is due to the dehydration and destruction of aluminosilicate materials and the total weight loss is -14,26% (table 5.) To determine the approximate mineralogical composition of the samples, the X-ray analysis method was used Fig. 4. Practically all diffraction patterns of the samples under study have clear interplanar spacings typical of quartz, fluorocarbonate apatite, calcite, dolamite, and aluminosilicate compounds. Thus, the obtained data show that the coals of the Fan Yagnob deposit contain a small amount of humic acids 2,06-5,68%. When oxidized with sulfuric and nitric acids, the amount of humic acids in them increases to 60%. The phosphorites of the Gissar deposit contain a large amount of silicon oxide 64,5%. The number of oxides of magnesium, aluminum, calcium reaches 2,44; 7,32; 12,0% respectively. The content of the main nutrient for plants P_2O_5 is 8,15%.Samples of phosphate raw materials in order to study their mineralogical composition were analyzed by thermal and X-ray analysis methods. The results are shown in Figure 2-3.

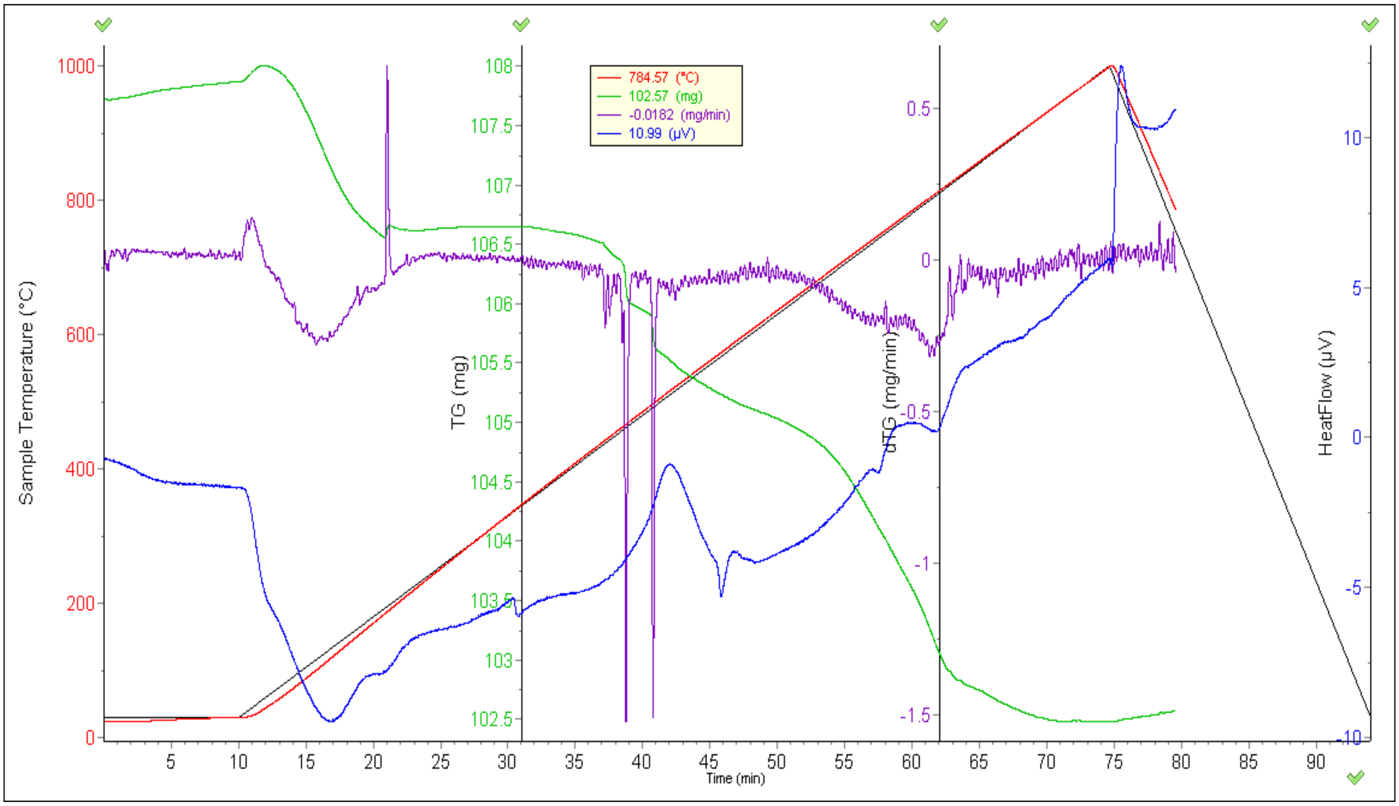
From the analysis of the tree diagram, the following follows:

The heating curve for sample № 1 (initial phosphorite) shows the first two endothermic effects at temperatures of 100^0C and 150^0C, respectively. In these endo-effects, there is a decrease in mass by 0,67 and 1,06%, respectively. At the same time, sorbed and crystalline hydrate moisture is lost, dehydration of free moisture and dehydration of bound moisture occurs, respectively. At a temperature of 405 °C, one exo effect is manifested, which is accompanied by a weight loss of 1,59%. In this case, the destruction of aluminosilicate materials occurs. Endoeffects at 650 and 850°C with a decrease in mass by 10,64% and 19,945%, respectively, indicate the release of crystallization moisture in aluminosilicates, as well as the beginning of the decomposition of magnesium carbonates. The total weight loss is 22,87% (table 5.). The heating curve of sample № 2 (washed phosphorite fraction №1) is characterized by endothermic effects at temperatures: 105^0C, 340^0C, 580^0C and 800 ° C, which corresponds to a decrease in weight by 0,74%, 1,29% and 2,49%, 4,41%, respectively . These endoeffects indicate dehydration of free moisture, dehydration of bound water, dehydration and destruction of aluminosilicate materials, and decomposition of carbonate materials, respectively. The total weight loss is 4,41%. The same picture is observed on the derivatograms of the 3-sample (2-fraction) where the total weight loss is 4,86%.In Fig. 2, the derivatogram of the fourth sample (fraction 3), a picture is observed that differs from the derivatogram of 1 and 2-fractions. Here the endo effect is due to the dehydration and destruction of aluminosilicate materials

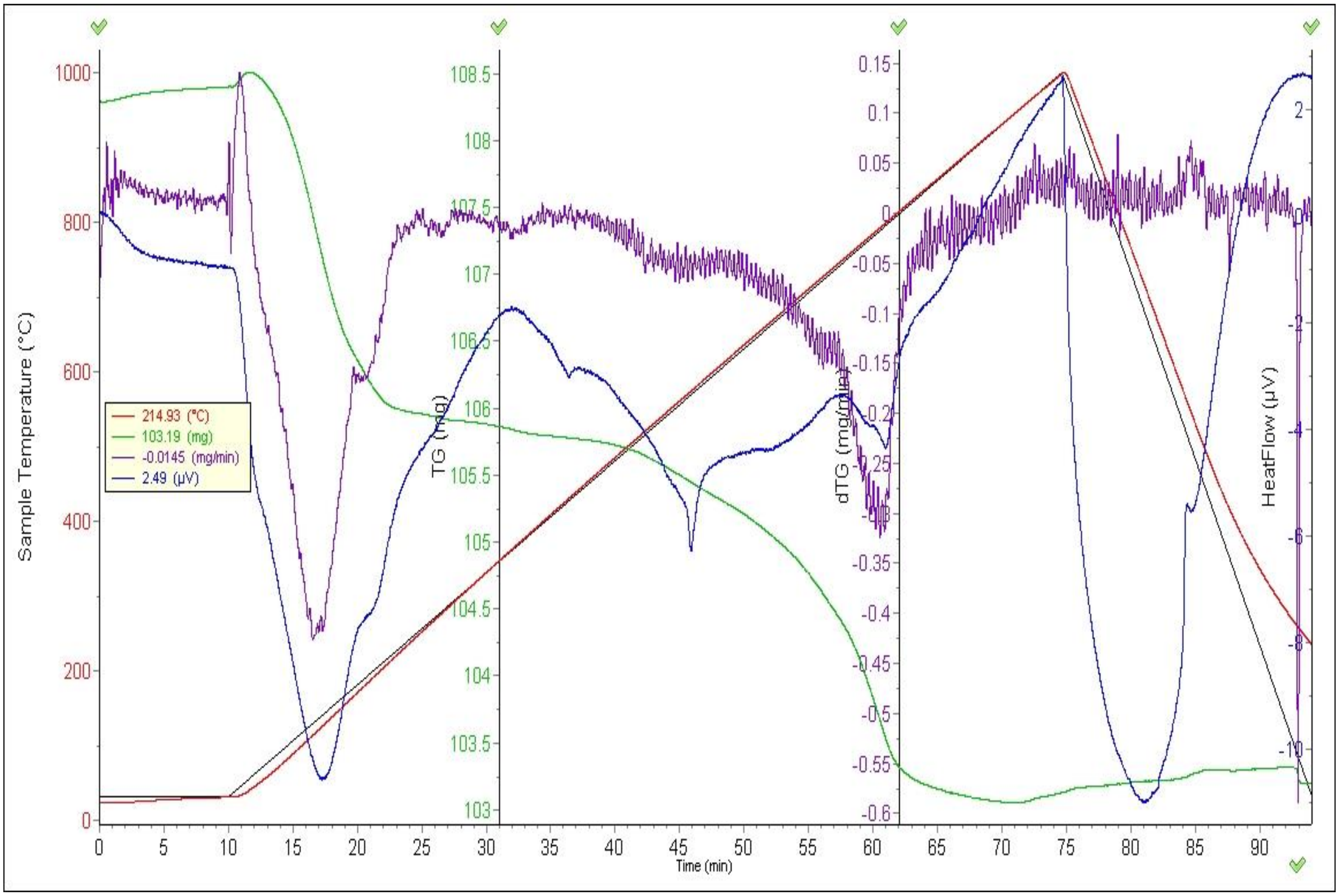
and the total weight loss is -14,26% (table 5.) To determine the approximate mineralogical composition of the samples, the X-ray analysis method was used Fig. 4. Practically all diffraction patterns of the samples under study have clear interplanar spacings typical of quartz, fluorocarbonate apatite, calcite, dolamite, and aluminosilicate compounds. Thus, the obtained data show that the coals of the Fan Yagnob deposit contain a small amount of humic acids 2,06-5,68%. When oxidized with sulfuric and nitric acids, the amount of humic acids in them increases to 60%. The phosphorites of the Gissar deposit contain a large amount of silicon oxide 64,5%. The number of oxides of magnesium, aluminum, calcium reaches 2,44; 7,32; 12,0% respectively. The content of the main nutrient for plants P_2O_5 is 8,15%.



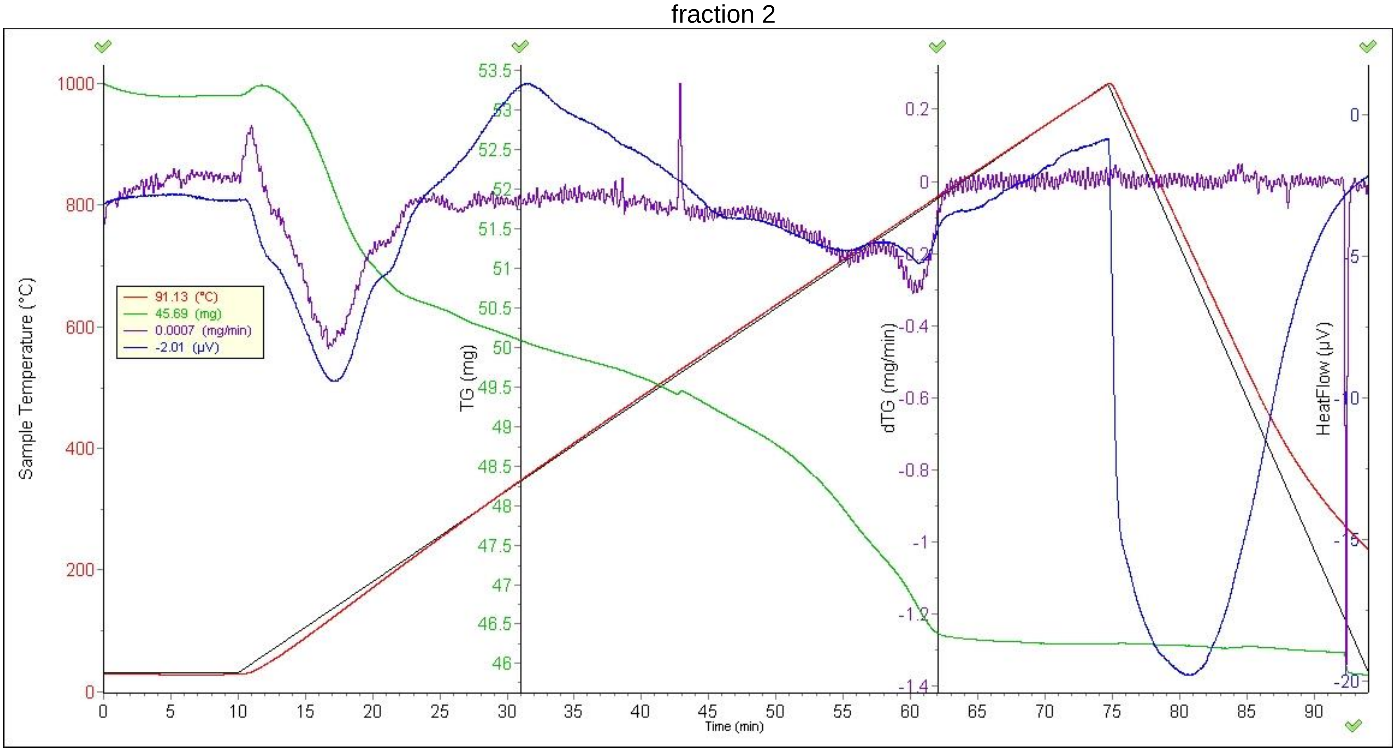
phosphorite



fraction 1



fraction 2



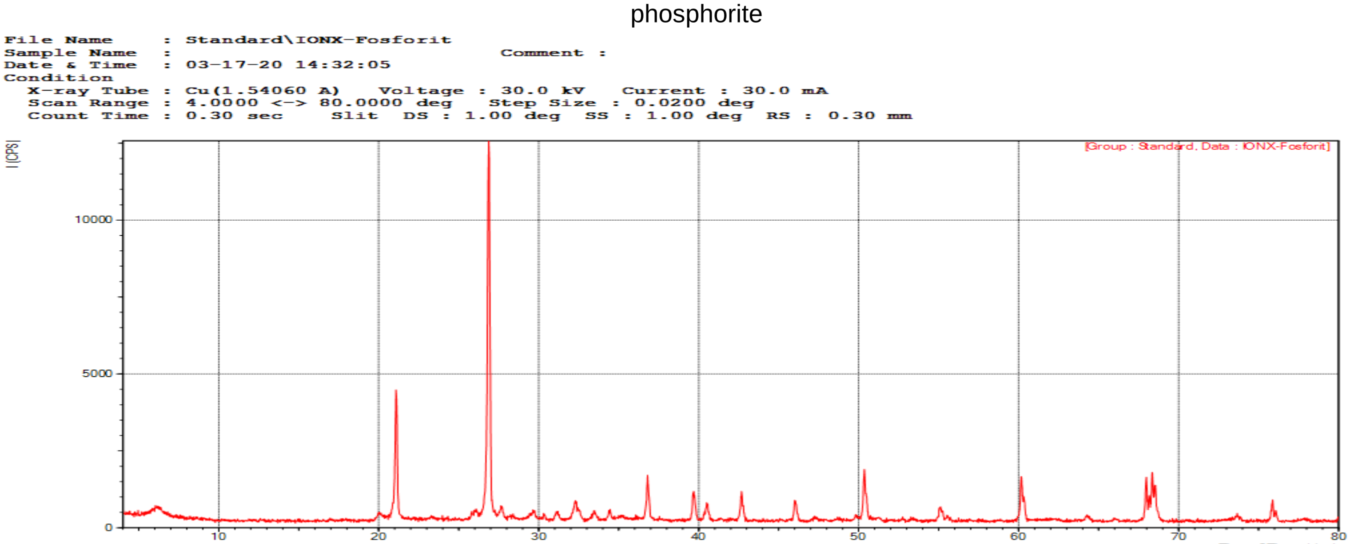
fraction 3

***Figure 2**. Derevatograms of phosphorite and its fractions*

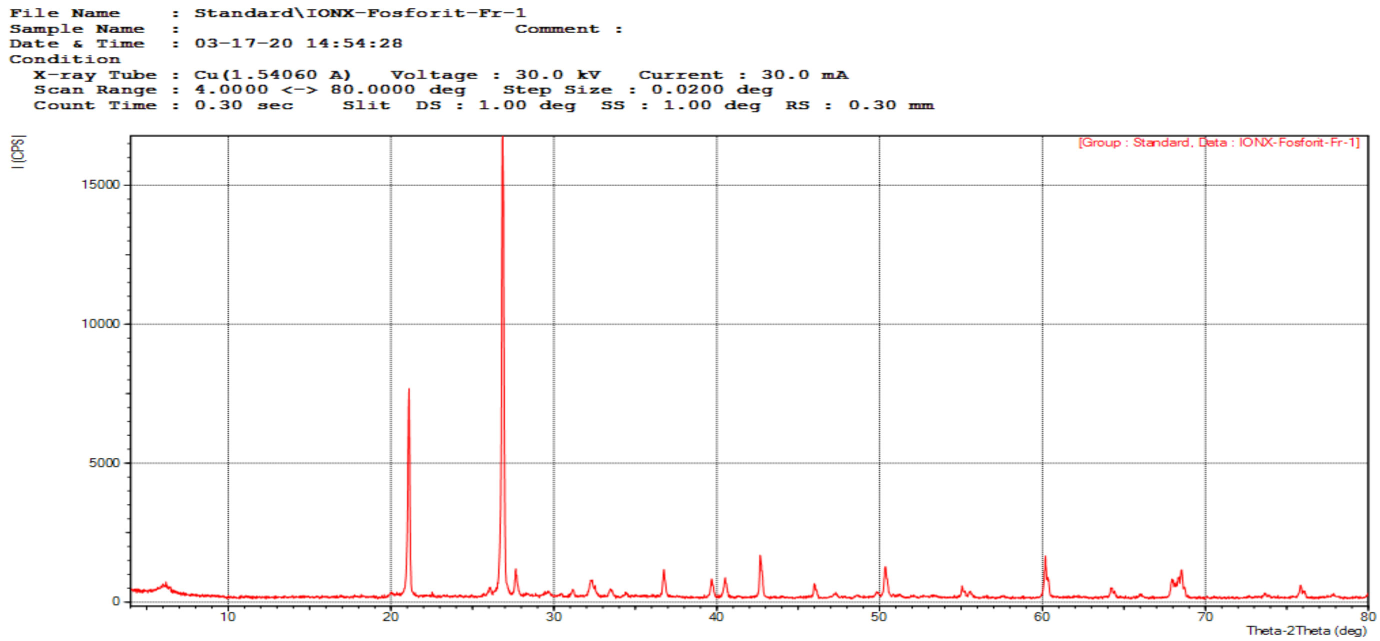
Table 5.
Analysis of derivatograms of phosphorite samples from the Gissar deposit

№	Effect	Temperature	Mass change,%	Notes
initial phosphorite				
1	endo	100	0,67	dehydration of free moisture
2	endo	150	1,06	dehydration of bound water
3	exo	310	1,59	destruction of aluminosilicate materials
4	exo	405	1,59	
5	endo	650	10,64	release of crystallization moisture in aluminosilicates
6	endo	850	19,945	beginning of decomposition of magnesium carbonates
7	exo	999	22,87	decomposition of calcium carbonates
fraction 1				
1	endo	105	0,74	dehydration of free moisture
2	endo	340	1,29	dehydration of bound water
3	endo	580	2,49	dehydration and destruction of aluminosilicate materials
4	exo	750	3,51	decomposition of magnesium carbonates
fraction 2				
1	endo	110	1,35	dehydration of free water
2	exo	360	2,81	dehydration and destruction of aluminosilicate materials
3	exo	560	2,91	
4	exo	560	4,05	decomposition of magnesium carbonates
5	endo	500	4,86	
fraction 3				
1	endo	130	2,25	dehydration of free moisture
2	endo	380	6,38	dehydration of bound water
3	endo	580-780	12,95	dehydration and destruction of aluminosilicate materials
5	exo	710	14,26	decomposition of magnesium carbonates

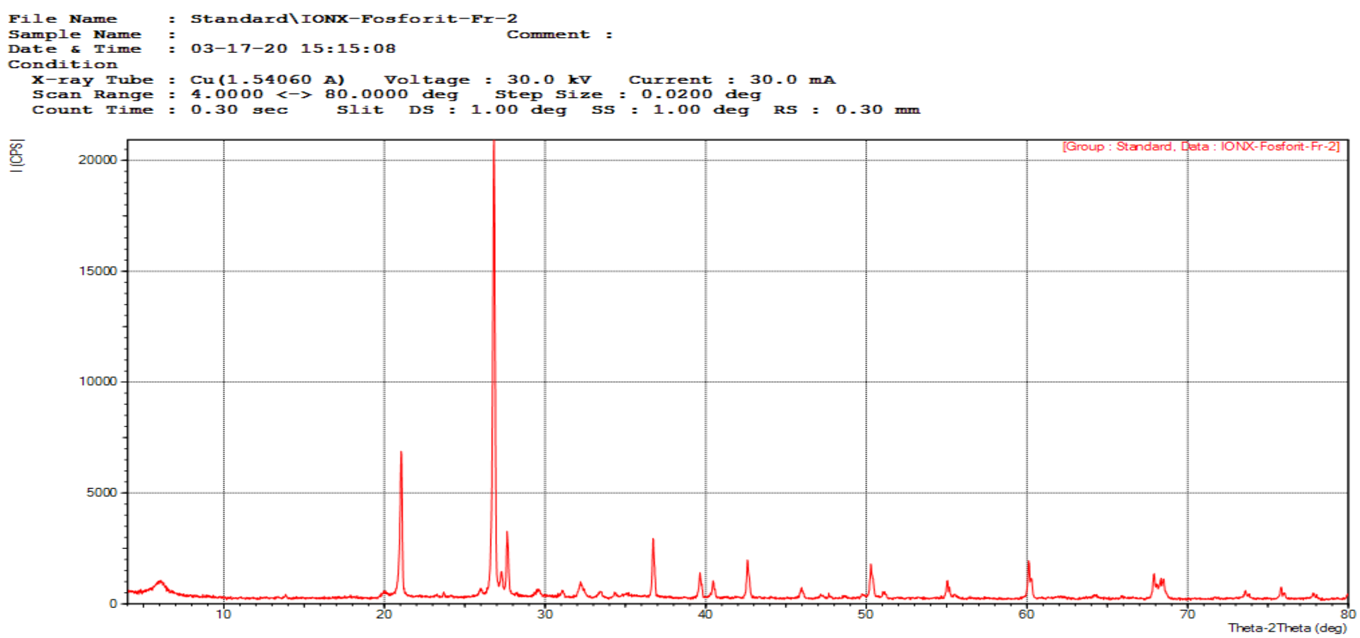
phosphorite



fraction 1



fraction 2



fraction 3

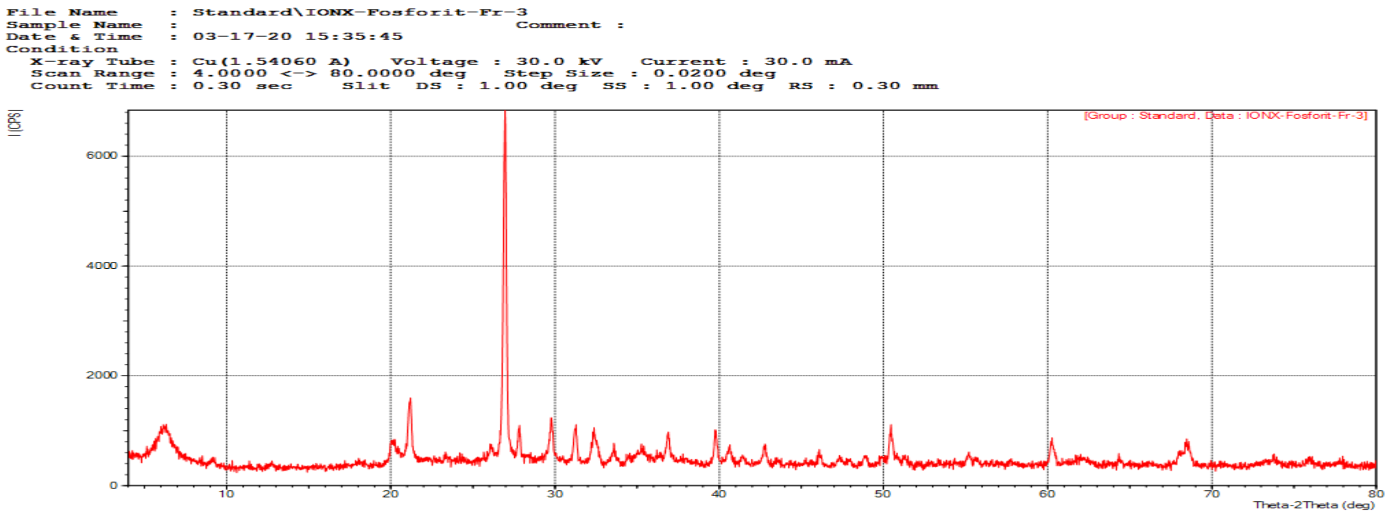


Figure 3. *X-ray diffraction patterns of phosphorite and its fractions*

4 CONCLUSIONS.

It was found that the studied coal samples contain such trace elements as: iron, boron, manganese, copper, nickel, which can be used in agriculture as a source of trace elements, and it was also found that in the phosphorite fractions 78,13 – 82,73% of P_2O_5 total is in an assimilable form that can be used in agriculture as a phosphorus-containing fertilizer without chemical treatment and even without activation. Based on the above, it follows that the coals of the Fan-Yagnob and phosphorites of the Gissar deposits are suitable for the production of humic acids and / or phosphorus-containing organo-mineral fertilizers with the organization of a simple mechanically processing technological line.

REFERENCES.

[1] Authorship certificate 712407 USSR. MKI S 05V11 / 02. Method of obtaining phosphorus fertilizers. / A.S. Kolosov, V.V.Boldyrev, M.V. Chaikina, E.E. Pomoschnikov, G.I. Gordeeva, Roman Powdert, Heinz Harentz, Gerhard Heinicke, Lothar Dunkel, Rosemaria Pettig .- Bulletin of inventions, 1980, No. 4.

[2] Dinku I. Increasing the efficiency of phosphate rock by processing it with small amounts of acids: Abstract of the thesis ... cand. agricultural sciences. M., 1958.-17p.

[3] Authorship certificate 697486 USSR. MKI S 05V11 / 00. Method of obtaining phosphorus fertilizers. / S.P. Kochetkov. N.N. Malakhova. S. V. Khryashchev, V. N. Filin, Z. A. Zorikhina, V. A. Zarubina.- Bulletin of inventions, 1979, No. 42.

[4] Kadushkina L.A. A water-soluble form of phosphoric acid in thermophosphates: Abstract of the thesis. ... Cand. chem. Sciences. - Alma-Ata, 1951.-10p.

[5] Pathak D.N. Solubility of some Indian phosphate ores in the presence of complexing agents. // J.Inst.Chem. (India) .- No. 4, v.52. - 1980.- S. 138-140.

[6] Ilyaletdinov A.N. Biological mobilization of mineral compounds. - Alma-Ata: Science, 1966.-332p.

[7] Pokul T.V., Larina V.A. Raw materials sources of the Irkutsk region for the production of coal-humic fertilizers and plant growth stimulants // Chemistry and processing of solid fuel. - Irkutsk, 1973, P. 3-14.

[8] Zhumanova M.O., Usanboev N.Kh., Namazov Sh.S., Beglov B.M. Oxidation of brown coal of the Angren deposit with a mixture of nitric and sulfuric acids // Chemical industry. - No. 5, v. 86, 2009. - p. 217-226.

[9] Methods of analysis of phosphate raw materials, phosphoric and complex fertilizers, feed phosphates / MM Vinnik, LN Erbanova, PM Zaitsev et al. - M .: Chemistry, 1975, 218 p.

[10] Abdurakhimov BA, Okhunov RV The coal industry of Tajikistan: raw materials base, state and development prospects. Dushanbe: Nedra, 2011–248 p.

[11] Mikhailov V.V. The main areas of coal accumulation in Central Asia // Geology of coal and oil shale deposits in the USSR, vol. 6. Moscow: Nedra, 1968.

[12] "Regulations on the Ministry of Industry and New Technologies of the Republic of Tajikistan" approved by the Government of the Republic of Tajikistan dated March 3, 2014, No. 147 (as amended by the Resolution of the Government of the Republic of Tajikistan dated March 13, 2015 No. 149)

[13] Sieve A.N. Research report. Section 7. Study of the coals of Central Asia. Nazar-Ailokskoye anthracite deposit. VUKHIN. Yekaterinburg. 1987.

[14] Classification of deposits and inferred mineral resources (Resolution of the Government of the Republic of Tatarstan. 2009, No. 429).

[15] 15.Mining magazine, special issue 2016.25 years of state independence of the Republic of Tatarstan

[16] Methods of analysis of phosphate raw materials, phosphoric and complex fertilizers, fodder phosphates / M.M. Vinnik, L.N. Erbanova, P.M. Zaitsev and others - M .: Chemistry, 1975, 218 p.

[17] GOST 21560.2-82. Mineral fertilizers. Test methods. - M .: Gosstandart, 1982, 30 p.