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Research Article

FEATURES OF THE GEOLOGICAL STRUCTURE OF PALEOGENE DEPOSITS OF SOUTHERN UZBEKISTAN AND THEIR RELATIONSHIP WITH PHOSPHORITES (ON THE EXAMPLE OF THE AKTAU REGION)

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ABSTRACT
Phosphorites are one of the raw materials for the production of phosphate fertilizers. Recently, Uzbekistan has sharply intensified work aimed at creating a local raw material base for the production of phosphate fertilizers. The result of the work carried out in the republic was the identification of large deposits, new, granular type of phosphorites in the Central Kyzylkum. However, the existing raw material base does not sufficiently ensure the development of the production of phosphate fertilizers, therefore, further strengthening of geological exploration is required in order to expand the reserves of phosphate raw materials.
Southern part of Uzbekistan, with its developing economy, favorable natural conditions, with an excess of labor resources and numerous manifestations of phosphorites, is one of the most profitable regions for the development of the phosphate industry. The Aktau area on the southern slopes of the Machetli Mountains, which are part of the system of the southwestern spurs of the Gissar Range, is one of the promising areas for the distribution and content of phosphorite ores. The productive strata are confined to the Middle Eocene of the Paleogene, in the section of which there are 5 phosphorite-bearing strata with a thickness of 0.8 to 6.20 m with a P_2O_5 content of 2.82% to 9.5%.
The conducted studies show the agricultural suitability of phosphorite-containing sandstones of the Aktau area as a cheap local raw material that helps to preserve fertility, increase the productivity of cotton, wheat and other crops and partially replace mineral fertilizers with good profitability. At the same time, the mining and technical conditions of the study area are favorable for the development of phosphorite-containing rocks in an open way.

Keywords: *Phosphorite, Paleogene, Aktau, Deposit, Rock, Section, Mineral, Facies, Area*

INTRODUCTION
A chemical industry development plan is being successfully implemented in Uzbekistan. In recent years, the work aimed at creating a local raw material base for the production of phosphate fertilizers has been sharply intensified. The result of the work carried out in the republic was the identification of large deposits of granular phosphorites new to Uzbekistan in the Central Kyzylkums (deposits of Jeroy-Sardar phosphorites). However, the existing raw material base does not sufficiently ensure the development of phosphate fertilizer production, therefore, further strengthening of geological prospecting works is required in order to expand the reserves of phosphate raw materials.
Southern Uzbekistan, with its developing economy, favorable natural conditions, an abundance of labor resources and numerous manifestations of phosphorites, is one of the most profitable areas for the development of phosphorous ores.

Aktau phosphorite-bearing area is located on the southern slopes of the Machetli Mountains, which are part of the Southwestern spurs of the Gissar Ridge (SWSGR), within the Aktau – Shargun interfluve, occupying a strip of 6.0 km, belongs to the Saryasi district of Surkhandarya region.

MATERIALS AND METHODS

Studies of phosphorites of the promising Aktau area were carried out according to methodological guidelines. The main types of work included: driving of trenches, pits, drilling of boreholes, deep exploration of boreholes, selection of furrow, core, geochemical and laboratory technological samples, selection of monoliths for radiation and hygienic assessment in accordance with the requirements of SanPiN 0029-94 (Kasykov, 1984; Kiperman, 1981).

The main method of the work carried out was the study of the qualitative properties of phosphorite-containing rocks for use in agriculture. Since there are no generally accepted GOST and OST standards for phosphorite-containing rocks as non-traditional agricultural ores for agricultural use in Uzbekistan, therefore, the assessment of the quality of phosphorite-containing sandstones in Aktau was based on the materials of the UzNIIH report on the agricultural suitability of phosphorite rocks.

RESULTS AND DISCUSSION

In the early 1930s, N.P.Kheraskov carried out work on the study of the phosphorite content of the area west of the Kafirnigan River, where he noted scattered nodules of phosphorites in the Suzak layers. In the Aktau region, in the Eocene sandstones, he discovered a layer of gravel with granular phosphorite.

Since 1953, the Uzbek Geological Department has carried out systematic prospecting of phosphorites on the territory of Southern Uzbekistan (V.Ya.Ilyashenko et al. (1954, 1957), N.P.Petrov (1957), R.B.Baratov et al. (1967). During this period, occurences including geological units with granular phosphorites were isolated in the Eocene sediments in the Aktau-sai area (Ilyashenko, 1984).

In 1987-91, Kashkadarya geological prospecting expedition conducted prospecting for phosphorites and other minerals in the sediments of the Alai formation of the Eocene (Kondakov I.V., Shoimurotov T.H., Pirnazarov T.P., etc.). As a result of studies of samples by flotation, a concentrate with a phosphoric anhydrite content – 26.2% – was obtained, upon extraction – 74.3%; during the secondary extraction operation, a concentrate with a P_2O_5 content of 28.33% was obtained, but with low extraction degree. According to the study, the burnt concentrate corresponds to TU 113-12-81-87 and TU 113-25-62-83 in terms of the content of the main components. Concentrate yield is 31.0%, extraction of P_2O_5 is 68.3% (Pirnazarov *et al.*, 1991).

The geological structure of the work area includes Paleozoic metamorphic formations (Carboniferous), Meso-Cenozoic sedimentary formations (Jurassic, Cretaceous, Paleogene, Neogene and Quaternary), as well as igneous rocks of intrusive complexes of Pre-Mesozoic age of acidic, intermediate, basic and ultrabasic compositions.

Paleogene formations in the area, with relatively small thickness, are characterized by good facies stability over long distances and are divided into Paleocene and Eocene tiers (sedimentation time); there are no Oligocene deposits in the area.

Paleogene sediments transgressingly lie on Cretaceous sediments and are mainly represented by a stratum of marine sediments – limestones with layers of dolomites, sandstones, siltstones, clays and gypsum anhydrites. Sediment thickness up to 856 m.

Tectonically, the area is confined to the junction zone of the SWSGR meganticline and the Surkhandarya meganticline. Aktau area is located in the southern wing of the large Machetli anticline and belongs to the South Hissar phosphorite-bearing region. The extension of the fold axis is close to latitudinal with a dip to the west. The occurrence of Meso-Cenozoic layers is monoclinal. The angle of incidence of the layers increases along the stretch from east to west, from the marginal to the core part along the fall. The change in the fall of rocks occurs within the range of 26-65°.

Disjunctive tectonics in the Aktau area is expressed by single throw cracks. The displacement amplitude does not exceed 5 m. Discontinuous tectonics is less pronounced than such phenomena as landslides and gravitational displacement of rocks. Thus, disjunctive tectonics in Paleogene sediments manifested itself very weakly and is caused by gravitational movements of rocks (Bezuglov *et al.*, 1969).
Structurally, the work area is confined to the southern wing of the Machetli anticline, which has a chest shape. The fold is asymmetrical, its northern wing is steep. The sandy, silty-sandy strata of the Alai formation, extending from west to east up to 6 km and with a total sediment thickness of up to 40-50 m, is productive for phosphorites (Fig. 1).
As a result of studying the actual geological materials in the section of the Alai formation, 5 phosphorite-bearing strata with a thickness of 0.8 to 6.20 m with a P_2O_5 content of 2.82% to 8.32% are identified. The characteristics of the stratum are given below (Bezuglov, 1967):
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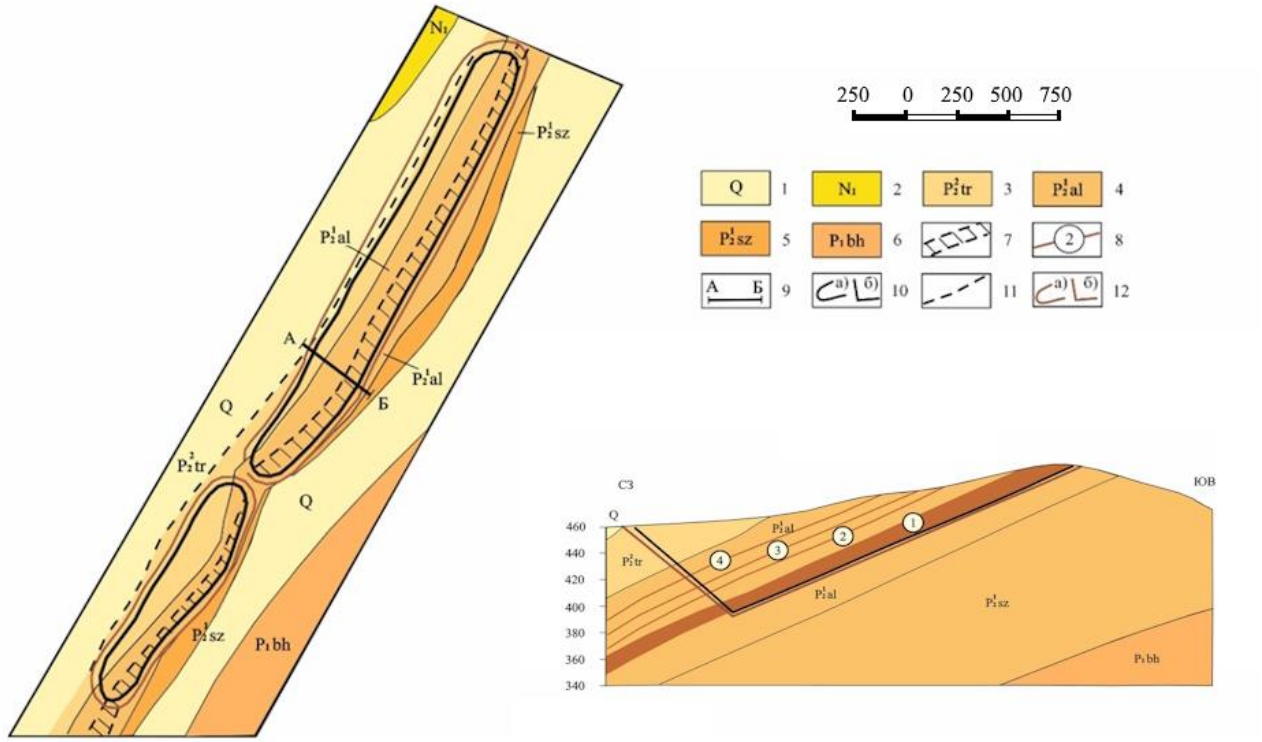

Figure 1: Schematic geological map of the Aktau phosphorite agro-ore deposit. (compiled by Sh.Akhmedov based on the materials of Kashkadarya GEE)
Quaternary deposits: 1-loams, sandy loams; Neogene system, Miocene: 2-sandstones, clays, siltstones; Paleogene system, Middle Eocene; Turkestan formation: 3-clay, sandstones, siltstones, limestones; Alai formation: 4-clays, sandstones, organogenic limestones, marls, phosphorites (mineral); late Eocene, Suzak formation: 5-marl clays with layers of shell rocks and lenses of siltstones; Paleocene, Bukhara formation: 6-limestones, bituminous limestones, marls, gypsum; 7-phosphorite-containing rocks; 8-phosphorite beds and their numbers; 9-section line; 10-contour of calculation of reserves of category C2: a) on the plan, b) on the section; 11-contour of calculation of forecast resources of category P1; 12-contour of the quarry: a) on the plan, b) on the section.

Layer 1. Phosphorite-containing fine- and medium-grained sandstones with oyster shells and shark teeth. The cement is carbonate-clay. There are interlayers of clay-siltstone rocks with a thickness of up to 0.9 m. Phosphorite secretions are observed in the rock, mainly in the form of phosphate grains, less often,

coprolites, oolites, nodules, fragments of shells and fish bones remains. The thickness of phosphorite-bearing sandstones of Layer 1 is from 3.5 to 8.67 m. The content of P_2O_5 in the formation is extremely uneven and ranges from 2.4 to 9.4%.

Layer 2 is separated from the lower Layer 1 by clays and a layer of organogenic limestones up to 5.30 m thick, which is composed of gray medium-fine-grained sandstones with inclusions of shell detritus, shark teeth and fish bone remains. Phosphate secretions are mainly represented by coprolites. The content of P_2O_5 is 8.32%. The thickness of the layer is 0.96 m.

Layer 3 is composed of multi-grained sandstones with numerous organic residues. It is separated from the Layer 2 by an interlayer of siltstones. Phosphate secretions are mainly represented by coprolites. The content of P_2O_5 ranges from 1.8% to 4.85%. The thickness of the layer is varying from 0.87 to 1.14 m.

Layer 4 is separated from Layer 3 by siltstones up to 19.0 m thick. The layer is composed of gray fine-grained sandstones with layers of clays and organic residues. The content of P_2O_5 ranges from 2.30% to 11.84%. The thickness of the layer is varying from 1.26 to 4.73 m.

Layer 5 is separated from Layer 4 by a layer of siltstones with a thickness of up to 19.0 m and is composed of fine-grained sandstones of greenish-gray color, interlayers with remnants of fauna. The content of P_2O_5 ranges from 2.4% to 4.4%. The thickness of the layer is 2.15 m. The layer is overlain by thin-layered gray mudstones, with separate layers of siltstones and sandstones, some of which are weakly phosphoritized.

The chemical composition of phosphorite-bearing rocks is the main factor determining their suitability for agricultural farming. Therefore, much attention was paid to the study of the chemical composition of the rocks of the studied area.

After analyzing the results of spectral analysis of phosphorite-containing sandstones, it can be concluded that the rocks of the sites are characterized by a high (0.7-1%) content of silicon, iron, potassium, magnesium and aluminum. Titanium, vanadium, potassium, chromium, zinc, cerium, helium, beryllium are present in hundredths of a percent (0.01-0.02%). Nickel, copper, tin, cobalt, and manganese are present in insignificant amounts (0.003% or less). Biologically active trace elements (copper, zinc, molybdenum, cobalt) are present in acceptable concentrations. The content of harmful elements in the phosphorite-bearing rocks of the site is significantly lower than their maximum permissible concentrations (Ivanov *et al.*, 1990).

The data obtained indicate that phosphorite-containing sandstones of the studied area can be a significant source of micro- and macroelements for agricultural crops and contribute to an increase in soil fertility.

The agrophysical properties of phosphorite-bearing rocks were studied using 9 laboratory and technological samples characterizing the productive stratum of the Aktau area studied in laboratories and at experimental testing grounds of UZNIIH.

The research was conducted under the guidance of candidate of agricultural sciences L.N.Slesareva (UzNIIH) in laboratory, lysimetric and field experiments. The following properties of phosphorite-containing rocks were studied in laboratory experiments:

- the content of elements by spectral analysis; the content of water-soluble salts by water extraction method 1:5; exchange capacity according to the Pfeffer method; carbon content according to the Tyurin method; the content of gross and mobile forms of potassium trace elements according to the UzNIIH method; the content of 0-30, 30-40 cm layers of mobile forms of nutrients (nitrogen, phosphorus, potassium) in the soil according to the main phases of development, as well as their removal from the harvest at the end of the growing season according to the UzNIIH method on the options of experiment (Slesareva, 1992).

Established by spectral analysis of the content of micro- and macroelements in phosphorite-containing rocks of this area indicate that the studied rocks are a significant nutrient source for agricultural crops (cotton, wheat, corn) and contribute to an increase in soil fertility.

The study of the content of water-soluble salts and the content of 0-30 (arable layer), 30-40 cm (sub-arable layer) layers of absorbed bases in the soil shows that the exchange capacity of soils of all variants

ranges from 10-12 mg-eq. per 100 g of soil in the upper layers and 8-9.5 mg-eq. per 100 g of soil in the lower ones, which indicates that irrigated gray-earth soils are characterized by a low absorption capacity, close to, slightly higher than, the control variant. The analyses carried out showed that potassium and magnesium predominate in the composition of the absorbed bases with a low content of exchangeable potassium and sodium, which indicates that the studied phosphorite-containing sandstones introduced into the soil do not worsen the composition of the absorbed soil bases.

In lysimetric experiments, the influence of various types, norms and technologies of agricultural ore application on the growth, development, yield of cotton and cotton complex crops in conditions of irrigated typical gray soils and meadow-takyr soils was studied. In the experiments, observations were made on the dynamics of accounting for the growth, development and accumulation of mass and yield of agricultural crops. At the end of the growing season, the technological qualities of cotton fiber and seeds were determined.

According to the conducted experiments, the positive effect of phosphorite-containing sandstones of the Aktau area on the fertility of irrigated soils and the effect on germination, growth, development and yield of cotton was established. The studied breeds improved the growth conditions and the development of cotton from the first phases of its development and throughout the growing season. It was found that already on the first background of mineral nutrition by introducing Aktau phosphorite-containing rocks, the height of the main stem and the number of real leaflets increased, their increase is even more significant on an increased background of mineral nutrition. The calculations carried out during the budding and fruiting phase also indicate an improvement in the growth and development of cotton throughout the growing season, which is realized in its productivity (Slesareva, 1998).

As a result, the yield of cotton on the first background of mineral nutrition increases by 9-14.1% with the introduction of Aktau phosphorite-containing rocks. With an increased background of mineral nutrition, the yield of cotton increases within the same limits and amounts to 0.7-4.2 c/ha in variants with Aktau phosphorite-bearing rocks and 5.6-5.8 c/ha (Table 1).

Table 1: The effect of the use of phosphorite-bearing rocks of the Aktau area as fertilizers-meliorants of complex action on the growth and development of cotton (according to UZNIIH)

No.	Test variants and name of site	The rate of application of agricultural ore, kg/ha	Maturation		Harvest				
			Height of the main stem, cm	Number of boxes, pcs..	Number of boxes, pcs..	Weight of one box, g	Raw cotton, c/ha	Addition	
								c/ha	%
1	2	3	4	5	6	7	8	9	10
1.	Control	-	68,1	7,2	8,2	5,28	39,8	-	100
2.	Aktau	0,75	70,4	8,6	9,8	4,72	45,41	+4,5	114,1
3.	Aktau	1,5	69,9	8,2	8,9	5,31	43,69	+3,9	109,8
4.	Control	-	69,6	7,9	9,1	4,78	41,49	+	100
5.	Aktau	0,75	74,6	8,6	10,0	5,0	45,7	+4,2	110,1
6.	Aktau	1,5	69,6	7,8	9,0	5,1	42,2	+0,7	101,7

Note: in variants 1 - 3, the background of mineral nutrition N is 150 kg/ha, P2O5 - 0, K2O – 0; in variants 4 – 6, the background of mineral nutrition N is 150 kg /ha, P_2O_5 – 60, K_2O -50 kg/ha.

The positive role of the studied phosphorite-containing sandstones was also shown by the study of the content of gross forms of nitrogen, phosphorus and humus in improving the nutritional regime not only in arable, but also in sub-arable layers.

Thus, against the first background of mineral nutrition, the content of gross nitrogen in the arable layer increases from 0.119 in the control to 0.134-0.128% when introducing phosphorite-containing rocks. The

total phosphorus content increases from 0.108 to 0.129-0.172% when the Aktau rocks are introduced. Against the increased background of mineral nutrition, the increase in soil reserves of nitrogen and phosphorus increases somewhat. There is also an increase in humus reserves from 0.95% in the control to 1.015-1.036%.

Thus, the Paleogene deposits in the studied area, with relatively small thickness, are characterized by good facies average size over long distances and are divided into Paleocene and Eocene tiers. The phosphorite-bearing deposits are the Middle Eocene deposits of the Alai formation, which is represented by limestones and sandstones with interlayers of dolomites, siltstones and clays of marine genesis. In the section of the Alai formation, 5 phosphorite-bearing strata with a thickness of 0.8 to 6.20 m with a P_2O_5 content of 2.82 % to 9.5% are distinguished. The radiation-hygienic properties of phosphorite-containing rocks of Aktau area were estimated by the content of natural radioactive elements in samples studied in the central analytical laboratory of the State Enterprise “Nisyltepageology". The total specific activity of phosphorite–containing rocks according to the samples ranged from 38 to 301 Bq/kg, with the maximum permissible for rocks intended for use as agricultural ore - 1650 Bq/kg.

The results of lysimetric experiments conducted by the Institute of Cotton Growing show that the use of phosphorite-containing rocks in the Aktau area as fertilizers improves the nutrient regime of the soil, conditions for the growth and development of cotton and increases its productivity by 9-14% or by 3.9-5.8 c/ha. In the conditions of the shortage of phosphorus fertilizers in the republic, the use of Aktau area as an agricultural ore will contribute to improving the fertility of irrigated gray soils and increasing the yield of cotton and related crops.

According to the conducted field experiments, it was found that the hay harvest increases by 15-23%, and the grain harvest by 8-10% or by 3.9-5.0 kg/ha. At the same time, it should be noted that an increase in the rate of application of phosphorite-bearing rock four times, from 0.5 to 2.0 t/ha, increases wheat yield by only 2%. The most economical are the phosphorite application rates of 0.5-0.7 t/ha, which are recommended at this stage of development.

Sowing corn for grain as a repeat crop after harvesting wheat also showed an improvement in growth, development and an increase in yield according to options with the introduction of phosphorite-bearing rock as an aftereffect.

Thus, the corn grain yield in the control amounted to 36.4 c/ha, and when 0.5 t/ha of phosphorite–bearing rock was introduced into the soil - 40.3 t/ha. With an increase in the rate of application of nutrient rock to 1-2 t/ha, the grain yield increased to 44.7-49.6 c/ha, and the total yield from 323.0 in the control to 347.1-363.6 c/ha in the experimental versions.

Industrial studies were also conducted on the influence of phosphorite-containing sandstones of Aktau area on the growth, development, and yield of cotton in irrigated meadow-takyr medium-saline soils of Surkhandarya region. Observations during the growing season were carried out on cotton of the Namangan-77 variety according to the variants of the experiment.

The observations have established that, other things being equal, the introduction of phosphorite-containing sandstones into the soil of Aktau area increases the yield of cotton by 0.9-5.2 c/ha (3-15%). At the same time, the increase in yield is noted due to the first harvest, where the increase ranges from 6.3 to 22.6 % (Slesareva, 1998).

CONCLUSION

Thus, the analysis of the geological development of the Southern Gissar district in the Paleogene showed that the main stratigraphic levels are the age intervals of the Paleocene and Eocene (there are no Oligocene). The Middle Eocene deposits of the studied area are productive for phosphorites, the thickness of which reaches 0.8-6.20 m with a P_2O_5 content from 2.82% to 9.5 %. The conducted research shows the agricultural suitability of phosphorite-containing sandstones in Aktau area as a cheap local raw material that helps preserve fertility, increase the productivity of cotton, wheat and other crops and partially replace mineral fertilizers with good profitability (18%).

For all the samples presented, the rocks confidently meet the requirements for radiation purity. The estimated geological reserves in category C_2 for the Aktau area are 5461 thousand tons (208818 tons of phosphorus pentoxide); projected resources in category P_1 amounted to 4041 thousand tons (154308 tons of P_2O_5).

At the same time, it should be noted that the mining and hydrogeological conditions of the studied area are favorable for the development of phosphorite-containing rocks by an open method.

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