УДК 553.04 (477.43/44)
DOI 10.25128/2225-3165.20.01.17

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ІСТОРІЯ ВИВЧЕННЯ ФОСФОРИТОВИХ ПОКЛАДІВ ПОДІЛЛЯ

Анотація. У статті проаналізовано історичні особливості вивчення фосфоритових покладів Подільського регіону. Перші публікації з висвітлення даної проблематики з'являються ще в першій половині XIX ст., коли почалися описи фосфоритових конкрецій в теперішніх Хмельницькій та Вінницькій областях (тоді – Подільська губернія Росії). Поклади були зосереджені у Подністров'ї. Інтенсивні геологічні дослідження подільських фосфоритів, вивчення їхнього складу та властивостей спричинили початок їх інтенсивної експлуатації для потреб сільського господарства (виробництво суперфосфату). Розробка родовищ почалася у середині XIX ст. і продовжувалась до його кінця, коли основні запаси відомих родовищ були фактично вичерпані. Вивчення фосфоритів однак продовжувалось й триває з окремими перервами та різною інтенсивністю до наших днів. З 80-их років XIX ст. почались дослідження фосфоритових покладів в австро-угорській, а пізніше – польській частині Поділля й стосувались вони також покладів, зосереджених в басейні Дністра та його лівих допливів (територія теперішніх Івано-Франківської та Тернопільської областей).

На даний час зусиллями декількох поколінь польських та вітчизняних дослідників з достатньою детальністю вивчена фосфоритоносність Подільського регіону, складені карти їхнього поширення, вивчено хімічний, мінералогічний та петрографічний склад, визначено області та можливості їхнього застосування як сировини для виробництва мінеральних добрив та меліорантів, встановлено промислову цінність окремих родовищ та проявів, виявлено нові площі поширення фосфоритоносних відкладів та нові фосфороносні породи. Грунтуючись на аналізі здійснених досліджень фосфоритоносності Поділля, в статті подано рекомендації щодо напрямків подальших науково-дослідних робіт в регіоні та геологічних розвідок перспективних у промисловому відношення ділянок, вивчення окремих нетрадиційних видів фосфорної сировини (зернисті фосфорити, крейдоподібні фосфатвмісні вапняки, фосфат-глауконітові руди та ін.).

Ключові слова: фосфоритоносність, фосфоритові поклади, родовища, промислові запаси, прогнозні ресурси, геологічні дослідження, області застосування.

PODILLIA PHOSPHORITE DEPOSITS HISTORY OF STUDYING

Summary. The article analyzes the historical features of the study of phosphorite deposits of the Podillia region. The first publications on the coverage of this problem appeared in the first half of the 19th century, when descriptions of phosphorite nodules in the current Khmelnytskyi and Vinnytsia regions (then - Podillia province of Russia) began. Deposits were concentrated in Transdnister. Intensive geological studies of Podillia phosphorites, the study of their composition and properties caused the

beginning of their intensive exploitation for agricultural needs (production of superphosphate). Deposits development began in the middle of the 19th century and continued until its end, when the main reserves of known deposits were actually exhausted. The study of phosphorites, however, continues with separate interruptions and varying intensities to the present day. From the eighties of the 19th century, studies of phosphorite deposits in the Austro-Hungarian Empire, and later the Polish part of Podillia began and they also dealt with deposits concentrated in the Dnister basin and its left tributary (the territory of the present Ivano-Frankivsk and Ternopil regions). At present, the efforts of several generations of Polish and domestic researchers have studied phosphorite bearing in the Podillia region with sufficient detail. Maps of phosphorite distribution have been drawn up, chemical, mineralogical and petrographic composition have been studied, areas and possibilities of their application as raw materials for the production of mineral fertilizers and ameliorants have been identified. The industrial value of individual deposits and occurrences has been established, new promising areas of distribution of phosphorite-bearing deposits and new phosphorus-bearing rocks have been identified. Based on the studies analysis of the Podillia phosphorite content, the article gives recommendations on the directions of further research in the region and geological studies of industrially promising areas, the study of certain non-traditional types of phosphorus raw materials (granular phosphorites, chalky phosphate-containing limestones, phosphate-glauconite ores, etc.).

Keywords: phosphorite potential, phosphorite deposits, mineral assets, industrial reserves, forecast resources, geological studies, application areas.

Introduction. Within the southwestern margin of the East European Platform, three phosphorite-bearing basins are distinguished: Podillia Vendian, Volyn-Podillia Cretaceous and Polissia Paleogene [Senkovskii J., Hlushko, Senkovskii A., 1989]. The history of their research reaches its origins in the first decades of the 19th century. The issue was studied by scientists from Austro-Hungarian Empire, Poland, Soviet and Ukrainian researchers [Alth, 1869; Barbot-de-Marni, 1869; Bienjasz, 1879; Dunikovski, 1882–1921; Melnykov,1884; Sniegocki, 1887; Tokarski, 1923, 1925, 1931, 1938; Palij, 1925, 1930; Morawiecki, 1931, 1933; Tschirwinski, 1908, 1911, 1919; Vyrshykovskyi, 1926-1936; Kovalenko, 1964; Chernikova, 1969; Senkovskii, 1984; Brahin, 2000; Bardas, 2002 et al.]. The historical excursus offered to readers is *aimed* at: to trace the change in ideas about the genesis, location features, qualitative composition and possibilities of using the phosphorite deposits of the region; to establish unresolved issues of the problem for the formation of a holistic view of the region's prospects in using this type of agrochemical raw material strategic for the country.

Research methods. The methodological basis of the study was based on the basic principles of modern historical science – historicize and objectivity. The investigated historical events were considered in their interconnection and development, based on a comprehensive analysis and reliable assessment of historical facts. The methods of bibliographic and source study analysis were used, which contributed to the search and systematization of primary information. The systemic method allowed thoroughly and comprehensively analyzing and generalizing the results of many years of research on phosphorite deposits and ore occurrences in the Podillia region (within the Ternopil, Khmelnytsky, Vinnytsia and, in part, Ivano-Frankivsk administrative regions of Ukraine).

Results and discussion. The first publications concerning the geological structure of Podillia and Volyn appeared in the 16th century. However, more or less systematized studies of the region should be attributed to the beginning of the 19th century. They are associated with the Severgin's works [Severgin, 1803, 1804, 1807, 1809] and Staszic's works [Staszic, 1805, 1806]. In the twenties and thirties of the 19th century, the geological structure of the region was studied by H. Jakovicki [Jakovicki, 1827, 1828, 1830] and E. Eichwald [Eichwald, 1830]. The first gave an overview of the minerals of Podillia and Volyn, the second one studied the crystalline rocks of the region, transitional formations (Silurian, Devonian), chalk and for the first time described the Podillia phosphorites found at the base of Cretaceous deposits in the Po-Dniester region (near the Liadova village, Vinnytsia region). Phosphorites are described by them as marl balls, which can be

recognized as metallic by their weight. In 1834, A. Schneider [Schneider, 1834], who carried out work in the neighborhood of the Dunaievtsi city, Khmelnytskyi region, describes Podillia phosphorites like shales with balls spherosiderite. The first special, albeit small in volume, publications devoted to the Podillia phosphorites appeared in Austrian and Russian editions in 1869. They are served almost at the same time A. Alth, M. Barbot-de-Marni, E. Glassel [Alth, 1969; Barbot-de-Marni, 1869; Glassel, 1869]. M. Barbot-de-Marni describes phosphorites near the Liadova village and gives a general description of the phosphorites of the Podillia province. E. Glassel supplies the chemical composition of Cretaceous phosphorite concretions. A. Alth for the first time characterizes the microscopic structure and chemical composition of oraginal Podillia phosphorites, paying attention to the presence inside concretions of such minerals as calcite, galena, iron oxides, manganese, etc.

In addition to the authors mentioned, in the second half of the 19th century, Podillia phosphorites are described F. Schwackhofer, R. Prendel, M. Gunn, M. Neruzhev, F. Bienjasz, E. Dolinskiy, E. Dunikowski, F. Roemer, O'Reily [Schwackhofer, 1872; Prendel,1878; Gunn,1876; Neruzhev, 1883; Bienjasz, 1879; Dolinskiy, 1883; Dunikowski, 1884; Roemer, 1885; O'Reily, 1886] et al.

Special attention should be paid to the publications of F. Schwackhofer [Schwackhofer, 1871, 1872], in which the geological structure of the region of phosphorite occurrence is presented, the structure and composition of phosphorites are examined in detail, and an attempt is made to explain their genesis. The author, in particular, is of the opinion that phosphorites were formed from calcareous spheres, then impregnated with phosphate solutions. R. Prendel [Prendel, 1878] expresses the idea of the phosphorites formation from apatite crystalline massifs.

Geological studies of Podillia phosphorites, the study of their composition and properties caused the beginning of their intensive use for agriculture (production of superphosphate). Field development began in the middle of the 19th century and continued until its end, when the main reserves of known deposits were actually exhausted H. Denysyk [Denysyk, 1998] presents data according to which 175 adits were developed only in the mines of Zhuravsk, Karpachivsk, Hryhorivsk and Bernashivsk mines. In total, at that time there were 77 mines and many small delfs. All deposits were located in the basins of the left tributary of the Dnister – Ushytsa, Kaliusa, Zhvana, Liadova. Since 1881, part of the extracted phosphorites was exported outside of Russia.

In the 1980 s, Russian periodicals published the results of fundamental research on Podillia phosphorites by M. Melnikov [Melnikov, 1883, 1884]. The works of this author synthesize information on phosphorites obtained during the 19th century. In the articles "Phosphorites of Podillia and Bessarabia", "Geological Investigations of the Transdnister Phosphorites", etc. M. Melnykov presents a historical essay on the study of the phosphorites of Podillia and Bessarabia, describes the geological structure of the phosphorite distribution area, the conditions of their occurrence, and physical properties. Autochthonous and secondary deposits are distinguished. The author associates the autochthonous phosphorite deposits with clay shales of the Upper Silurian, and the secondary (redeposited) deposits with Cretaceous glauconite sands and alluvial deposits. The composition and origin of phosphorites are also considered, the reserves of individual deposits are indicated.

Toward the end of the century, works of V. Jakovlev, A. Ginken, P. Tutkovskiy, M. Myshenkov, and H. Klien, also insignificant in volume, were published [Jakovlev, 1884; Ginken, 1888; Tutkovskiy, 1894; Myshenkov, 1883; Klien, 1895] and others, which consider the use of phosphorites in agriculture,

the development of their deposits and the conditions of occurrence of the productive stratum.

Particularly noteworthy are the works of the famous Ukrainian geologist V. Tschirwinski [Tschirwinski, 1907, 1908, 1911, 1919], which discusses the chemical and mineralogical composition of Podillia phosphorites. In particular, in the area of the river Ushytsia, he found small yellow crystals of a new mineral called *podolite* ($3Ca_3(PO_4)_2 \cdot CaCO_3$). In addition, V. Tschirwinski identified two distribution areas of phosphorite deposits: the northern – along the river Ushytsia and the tributary of the Dnister, in which redeposited phosphorites predominate and the southern one along the Dniester, where autochthonous deposits are predominantly developed. It was shown that the bulk of redeposited phosphorites from the northern region is composed of podolite, and fluorapatite predominates in the deposits of the southern region.

Some interruptions in the systematic research of Podillia phosphorites and, in this regard, the lack of publications related to the events of the First World War and the 1917 Revolution, which covered the territory of Podillia. Only in 1921 the newly formed Southwestern Industrial Research Administration resume work on the study of phosphorites. The studies were conducted under the general supervision of V. Luchitsky. In Transdnister, the work was supervised by R. Virshikovski, in the basin of the Ushytsia the work was supervised by R. Palij and H. Burenin. The results of these studies were published in 1923–1926 [Vyrshikovskii, 1926; Palij, 1925; Burenin, 1924]. R. Vyrshykovskyi described the geological structure of the environs of the Liadova village, R. Palij described the Dzhurzhivsk deposits. In addition, R. Vyrshykovskyi expresses his view on the problem of the formation of primary phosphorites. The origin of phosphorites is considered at this time by A. Krasivskyi [Krasivskyi, 1923], who allowed the presence of a grooved depression on the surface of the Paleozoic sediments, where the concentration of secondary phosphorites occurred in the chalk.

In 1882–1921 phosphorites from the Buchach and Nezvisko regions were studied in detail by prof. E. Dunikowski [Dunikowski, 1884], who found that sandy marls that contain phosphorite nodules containing up to 5.9% P_2O_5. It was estimated that in the Nezvisko region on an area of 1 ha, a phosphorite-bearing layer with a thickness of 0.5 m contains 5000 tons of raw materials. Phosphorite nodules contain 20–30% P_2O_5. The question was raised about the production of superphosphate based on the Po-Dnister phosphate deposits. According to estimates, the reserves of phosphorus raw materials near Nezvysko, Horodenka and Buchach are 15.9 million tons [Bobrovski, 1922].

In 1922–1927, certain aspects of phosphorite deposits in the Buchach, Horodenka, Luka and Nezvisko area were studied by J. Morozevich, V. Jacek and Yu. Nowak [Morozevich, 1922; Jacek, 1922; Nowak, 1927].

In 1922–1923, phosphorites attracted the attention of the famous Polish geologist J. Tokarski, who publishes a number of articles mainly in relation to the Nezvisko deposit [Tokarski, 1923]. The geological structure of the deposit is considered, mineralogical and petrographic features of phosphorites in thin rock sections are studied. In particular, it was indicated that important components of phosphorites are calcite, quartz, glauconite, less commonly plagioclase, amphibole, muscovite, and chlorite. Chemical composition of phosphorites of Nezvisko deposit, in%: P_2O_5 – 30,47; CaO – 51,41; Al_2O_3+Fe_2O_3 – 2.23%; SiO_2 – 3–13, others – 12,34. In 1926–1928, A. Morawiecki studied Nezvisko phosphorites [Morawiecki, 1926, 1928].

In 1925, R. Vyrshykovskyi continued to study phosphorite deposits in the Ushytsia river basin, and in 1926 summarized the results in a report at the II

Congress on the Study of the Productive Forces and the National Economy of Ukraine. A number of publications by this author concerning the description of individual deposits of phosphorites (Kucha village, Hlybochok village) were published in 1930 and 1936 [Vyrshykovskyi, 1930, 1936].

The agronomic significance of Podillia phosphorites was studied by S. Rozen [Rozen, 1927].

S. Olszevski [Olszevski, 1928] presents the history of the study of Transdnister phosphorites from 1869 to 1928. Recommendations on mining and geological conditions of field development, estimated reserves of phosphorite nodules in the vicinity of Horodenka (up to 6 million tons) are offered.

In 1929, studies of Podillia phosphorites by A. Morawiecki were restored. The thermoluminescence and phosphorescence of phosphorites are studied. Microscopic studies are carried out, according to which in phosphorites from Nyzhniv, Nezvysko, Horodenka, Rakovets, Semenivka, Chernelytsi, Repuzhyntsi, apart from phosphorite nodules, fragments of a phosphatized tree, mammalian bones, teeth, shells, pseudomorphs along sponges, sea urchins, belemnites, etc. are noted. The mineralogical composition of phosphorites is also served [Morawiecki, 1929]. In 1931, the author reached the outskirts of Melnytsia-Podilska, Ustia, Borshchiv and Zalishchyky. Significant accumulations of phosphorites were observed on the sides of the Nichlava River near the Pylypche village. Single manifestations of phosphorites are described in the Cenomanian of the Seret River Valley between the villages of Horodok and Bilche-Zolote, as well as on the left bank of the Dnister near the Dobrivliany village. Two years later, the author publishes a short article describing the finds of phosphorites in the valley of the Stripa River near the villages of Nahirianka, Pidzamochok, Rukomysh, Zaryvyntsi, Perevoloka, Stari Petlykivtsi, Bobulyntsi, Zarvanytsia, etc. Podillia phosphorites are divided into 4 types: nyzhniv, nezvysko-horodenka, khudykivets and buchach. The chemical composition of each type is indicated. It has been ascertained that the nezvysko-horodenka, khudykivets and buchach types belong to crystalline phosphorites, and the nyzhniv amorphous ones. In 1932, A. Morawiecki studied phosphorite displays in the valley of the river Strypa near human settlements Nahirianka, Pidzamochok, Rukomysh, Zaryvyntsi, Perevoloka, Stari Petlykivtsi, Bobulyntsi, Zarvanytsia , etc. The age of phosphorite displays is defined as Cenomanian, a conclusion is drawn about the unpromisingness of their industrial development [Morawiecki, 1931, 1932].

In 1931, Yu. Tokarski published a generalizing work on the phosphorites of the Nezvyske deposit. Their confinement to marls of Albian-Cenomanian is indicated, where phosphorites are 37%. Based on the chemical analysis, the content of phosphoric acid was calculated – in the nodules of the upper layers an average of 25%, the lower layers – about 20%. Emphasis is placed on the important economic sense of Nezvyske phosphorites as sources of phosphorus [Tokarski, 1931].

S. Pasternak in the Shevchenko Scientific Society Collection in 1932 notes that phosphorite deposits with a band width of 10–15 km extend along the Dnister from Bukivnia near Nyzhniv to Okopy on Zbruch. The thickness of the reservoir is 30-110 cm, reserves – up to 20 million tons. The amount of phosphoric acid in nodules ranges from 1.8 to 15% [Pasternak, 1932].

In 1936, Yu. Samsonovicz reported on the findings of phosphorite nodules in Cenomanian brown-black sandstones with phosphorite cement on the Horyn riverside near Khotyn. Phosphorites are in a redeposited state, in composition (fluorine-apatite) and the structure is compared with the Ordovician phosphorites of Transdnister, spread from the river Ushytsia to the Mohyliv-

Podilskyi city. Outcrops of the Ordovician phosphoriferous rocks should be located in the Horyn river basin, within a radius of several km from Khotyn, under the Cretaceous and Permian deposits [Samsonovicz, 1936].

M. Lobanov in 1938 reports on the possibility of using Podillia phosphorites in the production of superphosphate [Lobanov, 1938]. Local raw materials with a low concentration of P_2O_5 (12–18%) can be used as an additive to strong imported phosphorites; concentrated phosphorites (25–26% P_2O_5) are quite suitable for the production of 14% superphosphate.

At the end of the twenties, such employees as N. Zonov, I. Kurman and N. Larin of the Fertilizers Institute conducted work in Transdnister. A stratigraphic diagram of the Paleozoic sediments of the Ushytsia river basin was compiled, and later – the entire phosphorite-bearing area. Considerable attention was paid to the formation of phosphorite deposits [Zonov, Kurman, Larin, 1932].

In 1941, after the occupation of Western Ukraine by Soviet troops, Russian geologists M. Bychover and A. Matveev publish generalizations on the Podillia phosphates, which is based on field studies of Polish and Ukrainian scientists in the 20-30s. [Bychover, Matveev, 1941]. Phosphorite deposits are confined to the Cenomanian stage, they are found in the middle of Transdnister and in Volyn (village Khotyn). The formation of phosphorites is associated with the transgression of the Cenomanian Sea. Phosphorites are represented by nodules of various sizes, which are the product of the replacement of calcareous skeletal remains of organisms with calcium phosphate. The most explored and richest deposits are Nezvysko, Buchach and Horodenka with phosphorus anhydrite content in nodules of 20–22%. The reserves of the Nezvysko deposit are indicated (9 million tons).

Work related to the study of the phosphorite content of the Podillia region was resumed only in the postwar years and mainly concerned the study of the mineralogical and petrographic composition of phosphorites.

L. Tkachuk in 1944 on the basis of the Transdnister minerals forecast map compiled by him determines the prospective areas of phosphorites distribution.

Phosphorites in the Paleozoic strata were also studied by M. Stashzsuk [Stashzsuk, 1956], who examined the conditions for the occurrence of phosphorites in the productive stratum of Podillia, O. Furman, who divided phosphorites into two types: nodules and concretionary [Furman, 1954], as well as A. Chomenko and E. Kozak (1954) [Chomenko, Kozak, 1954] .

In the sixties, three large monographs were published in which the problem of the phosphorite content of Podillia is thoroughly covered. These are the works of D. Kovalenko, V. Semenov “Phosphates of Ukraine” [Kovalenko, Semenov, 1964], E. Lazarenko and B. Srebrodolskii “Mineralogy of Podillia” [Lazarenko, Srebrodolskii, 1969] and E. Lazarenko and D. Kovalenko “Agronomic ores Ukrain” [Lazarenko, Kovalenko, 1966]. In recent works, in particular, the history of studying the geological structure, mineralogy, and petrography of phosphorite deposits has been analyzed, a map of the distribution of phosphorites in Transdnister has been submitted. The chemical and mineralogical composition of the phosphorites of the two phosphorite bearing regions of Podillia – the south-eastern and south-western identified by the authors, is characterized.

In 1969, Z. Tzhernykova published an interesting article on phosphorites of the Upper Cretaceous of the Middle Transdnister. According to her, phosphorus-bearing deposits within the Middle Transdnister (Khmelnytsk and Vinnytsia regions) are traced on an area of about 350 km^2. In this territory, phosphorus ore geological reserves with a P_2O_5 content of 4–5% amount to about 5 billion tons [Tzhernykova, 1969].

And, finally, the works of J. Senkovskii and A. Senkovskii appeared in the 80s, which set forth modern ideas about the geological structure and the genesis of the Volyn-Podillia phosphorite deposits. First of all, this is A. Senkovskii's dissertation work "Geology of chalk phosphorites of the Volyn-Podillia outskirts of the East European Platform" [Senkovskii A., 1984], as well as the generalizing work by J. Senkovskii, V. Hlushko and A. Senkovskii "The west of Ukraine phosphorites" [Senkovskii J., Hlushko V., Senkovskii A., 1989]. The authors characterize three phosphorite-bearing regions (basins): Podillia Vendian, Volyn-Podillia Cretaceous and Polissia Paleogene. The Podillia Vendian basin of autochthons phosphorites covers the territory of the development of the kali layers of the Vendian between the rivers Ushytsia and Derla. Within the Volyn-Podillia Cretaceous basin industrial deposits are confined to the Podillia region, which includes the Nezvysko deposit of autochthons Cenomanian phosphorites and redeposited Vendian phosphorites, which lie in the bottom of the Cretaceous sediments in Transdnister. The East Podillia group includes autochthons phosphorite deposits of the Cenomanian stage - Tsivkivsk, Bakhtynsk, Matsiorsk, Lomachynsk, Vasylivsk and Kozliv of Albian age. Redeposited Vendian phosphorites occur in the Upper Alba and are represented by deposits Kuchynsk, Hlybovets, Zhvansk, Bernashivsk and Nahiriansk. A number of small phosphorite is also distinguished.

The resources of autochthons Cretaceous phosphorites amount to more than 230 million tons with a content of P_2O_5 in ore 3–6% [Tzhernykova, 1969]. The redeposited Vendian phosphorites in Podillia have long been an object of intensive exploitation. Their industrial development began back in 1870 near Zhmerynka town. By 1934, the main reserves of small deposits were depleted. In addition, rich apatite ores of the Khibiny mountains were discovered in Russia, so the further development of Podillia phosphorites became unprofitable and was stopped. J. Senkovskii et al. [Senkovskii J., Hlushko V., Senkovskii A., 1989] believe that the territory of the watershed plateaus (interfluve) of the left tributary of the Dnister can be considered quite promising for identifying new industrial accumulations of phosphorites of this type. The problem, however, is that the productive layer in such areas lies at a depth of about 100 m and can only be developed by underground mining. In addition, the siliceous rocks presence of a productive horizon can be considered as an unfavorable factor in future operation.

In recent decades, the problem of studying the so-called *granular phosphorites*, which deposits have been discovered in the northern part of the Ternopil and Khmelnytskyi regions, has become urgent. We are talking about phosphorites of the Cenomanian age, which are glauconite-phosphate-quartz sandstones on carbonate, finely similar cement. There are many options for replacing carbonates with a phosphate substance (the content of P_2O_5 is from 6 to 30%), while phosphorus oxide is in a form that is easily absorbed by plants.

The main deposits of granular phosphorites of the *Volyn-Podillia phosphorite-bearing basin* are localized within the Manevyts-Klevan and Zdolbuniv-Ternopil promising areas. The phosphorite resources are found in glauconite-quartz and limestone sands and sandstones of the Cenomanian. The total thickness of deposits is up to 6 m at a depth of up to 250 m in the presence of P_2O_5 up to 15%. The phosphorite bearing of the deposits is due to the presence of granular formations, among which phosphatization of the prism from the inocerium valves is dominant [Bardas, 2002; Brahin, 2000 et. al.]. Predicted resources (P_2) of granular phosphorites of the areas are estimated at 100 and 73.6 million, respectively.

Conclusions. At present, the long-lasting efforts of several generations of Polish and domestic researchers have studied the phosphorite bearing of the Podillia region with sufficient detail. Maps of phosphorite distribution have

been drawn up, chemical, mineralogical and petrographic composition have been studied, areas and possibilities of their application as raw materials for the production of mineral fertilizers and ameliorants have been identified. The industrial value of individual deposits and occurrences has been established, new promising areas of distribution of phosphorite-bearing deposits and new phosphorus-bearing rocks have been identified.

Research work should be continued aimed at reproducing the paleogeographic conditions for the formation and establishment of an industrial perspective of mid-Albian phosphorites (Khudykivetsk-Pylypchansk phosphorite), as well as granular phosphorites of the Lower Cenomanian, discovered and intensively studied in recent decades in the northwestern part of the region.

Today, the question of the possibility of developing complex phosphate-glauconite ores of the Zhvansk deposit requires study. Phosphorite-glauconite flour from ore deposits is successfully used in agricultural chemistry. Similar in composition to the Zhvansk deposit, ore are known in many places of the Yampil district. Their value has not been investigated.

In relation to the traditional phosphate raw materials - Vendian concretionary phosphorites (raw materials for superphosphate), certain prospects can be associated only with future prospecting works in the watershed areas of the left tributary of the Dnister: Studenytsia-Ushytsia-Derlo at depths of about 100 m.

Upper Cenomanian Cretaceous phosphate-containing limestones also remain virtually unexplored. The latter are considered promising ameliorants of complex action and could become in the future an alternative to phosphorite flour, which until recently was supplied to Ukraine from the Russian Federation. Deposits of such rocks are known in the Murovano-Kurylovetskyi and Mohyliv-Podilskyi regions, respectively, of the Khmelnytskyi and Vinnytsia regions.

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