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FRACTIONAL STRUCTURE AND MINERALOGICAL FEATURES OF PSEPHYTIC DEPOSITS – POTENTIAL RESERVOIRS OF DIAMOND IN THE NORTH-WESTERN PART OF THE UKRAINIAN SHIELD. Part 1. PRYPIATSKA AREA

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Due to the thematic and prospecting works for diamonds in the North-Western part of the Ukrainian shield, the areas of psephytic rocks development have been allocated which could be the reservoirs of diamonds and, therefore, – the promising areas of diamond placers localization. The paper deals with the investigations in the Prypiatska area which is located in the far south part of the Prypiatska depression. Palaeogene and Neogene coarse-grained deposits have been studied, especially their lithologic and facial features (gravel component and heavy fraction of –1.0+0.2 mm), and paragenetic satellites of diamond – pyrope, ilmenite, chrome-spinellids etc.

The conclusion has been made that in this case mentioned minerals cannot be used as search signs nor on the identification of alkali-ultramafic magmatic bodies, nor to identify the diamond placer because of such facts: small size of detected grains of pyrope and chrome-spihellids; quite high degree of their roundness and the character of their surface testify to a long stay of these grains away from the primary sources; the content of both minerals in the sediments is low; ilmenite grains with "kimberlitic" values of thermoelectric power are extremely rare.

Key words: diamond, placer, kimberlitic minerals-satellites of diamond, psephytic rocks, Palaeogene, Neogene, Prypiatska depression.

In 1980–1990-ies, the geologists of Zhytomyrska Geological Exploration Expedition (Suprunenko et al., 1984; Vysotsky et al., 1985, etc.) performed the thematic and prospecting works for diamonds in the North-Western part of the Ukrainian shield. Due to these investigations, the areas of psephytic rocks have been allocated which could be the reservoirs of diamonds and, therefore, – the promising areas of diamond placers localization. These works were joined by the scientists of the Lviv University (U. Fenoshyna, Ye. Slyvko, O. Lytvynovych, N. Razumieieva, O. Bura).

It is known that the material composition of reservoirs, usually represented by terrigenous deposits, is essential for a proper understanding of placer-forming process. Associations of material components of these collectors bear the imprint not as much the petrographic composition of sources of load, as the processes of material differentiation during all the way from the indigenous source to the placer. Therefore, the main characteristics of material composition of the collector are the data about its factional structure and mineralogy.

In the case of terrigenous deposits study, especially during prospecting for the discovery of placers, scientists pay great attention to clastogene accessory minerals. Paragenetic associations of these minerals (as typomorphic features of each mineral) particularly "sensitive" react to the duration of stay outside the original source. Hence you have the possibility of solving the inverse geological problem – to determine the genetic type of the near or far sources of load of clastogene accessory minerals and/or their associations, ways of their migration, and accumulation conditions on the basis of minerals and mineral associations, identified in terrigenous sediments.

Therefore, the main task of our research was to identify the character of clastogene minerals distribution in psephytic sediments, and to determine the lithologic and facies features of localization of diamond and its paragenetic and gravitational minerals-satellites in these sediments.

Five prospecting areas have been allocated in the North-Western part of the Ukrainian shield: (1) Bilokorovytska* (three places – within the southern closure of Bilokorovytska structure, on the edge of its eastern side and in the northern part of the structure); (2) South-Western (Pivdenno-Zakhidna) (in the south-western part of Ovruchska structure) – to search for ancient metamorphosed placers in conglomerates and other psephitic rocks; (3) Mezhyritska (psephitic alluvium in the interfluve Uzh–Zherev) – to search for placer deposits of Meso-zoic-Cenozoic age; (4) Prypiatska (the extreme southern part of the Prypiatska depression) – to search for Meso-Cenozoic diamond placers, confined to Palaeogene and Neogene gravel-pebble horizons; (5) Usivska (Usivske uplift) – for the exploration of indigenous sources of diamond – the bodies of alkaline-ultrabasic composition.

The results of the study in the Prypiatska area are given below.

Prypiatska area is located in the far south part of the Prypiatska depression, between the Studenytskyi fault (for the west) and north-eastern continuation of Ubortsko-Sushchanskyi fault. Here, directly on Palaeozoic bedrock, the *MZ–KZ* boulder-pebble deposits are superposed. Actually they have been the object of search for deposits and auspicious collectors for paragenetic and gravitational satellites of diamond.

Gravel-pebble deposits have been striped by prospecting boreholes on the four profiles. Four small-volume samples have been picked out from the boreholes of the three profiles. In these samples, we studied the composition and lithologic-facial features of the potentially productive psephitic rocks of the cover, as well as the composition and fractional structure of their heavy fractions.

We investigated Palaeogene sediments in the western and central parts of the Prypiatska area. In the first case, they are represented by five-meter horizon of the boulder-pebble rocks, which are deposited on the Jurassic (?) clays. The filling material is coarse-grained glauconite sand in which the content of psephitic material is 40–60 %, and it is distributed unevenly. In composition it is mainly pebbles and boulders of pink quartzite-sandstones of Tovkachivska suite and pebbles of quartz. There are numerous fragments of quartz gritstone with entire sulphide cement in the lower part of the horizon. Size of these fragments varies from 2–3 to 5–7 cm and more, they are well rounded. In the central part of the area, various-grained to coarse-grained feldspathic-quartz sand directly overlaps the granites of the crystalline basement. The sand contains 30–40 % of quartz fragments, as well as the gruss of quartzite-sandstones and granites; size of this material is 0.8–2.5 cm.

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*The results of studies of paragenetic and gravitational minerals-satellites of diamond from conglomerates and the other rocks of Bilokorovytska structure and its framing have been described in numerous scientific works [1, 2, 5–8 etc.].

Neogene deposits have been striped by boreholes at depths of 25 to 34 m. They are represented by pinkish-gray sand with admixture of gravel, composed of quartz and pink quartzite-sandstone. The sands are predominantly medium- to fine-grained, contain a small quantity of large and gravel-size grains. The interlayer of gravel-pebble sediments with the content of psephitic material from 15–20 to 20–30 % has been discovered in the lower part of the Neogene sands strata. The composition of the pebbles is the same as gravel. There are some interlayers of grey clay and numerous remains of charred wood.

The study of the material composition of psephitic rocks in the jigging concentrates (–8+1 mm) and their heavy fractions (grades –1.0+0.5; –0.5+0.2; –0.2 mm) showed the following.

The **gravel component** of Palaeogene and Neogene sediments is represented mostly by gravel of colourless, white and grey quartz, rarely – pink quartzite-sandstone and intensely weathered feldspar. The composition of the gravel-size heavy fraction is unstable. In the Palaeogene deposits of the Prypiatska area western part, there are peculiar septarian nodules of microbreccias type, which are composed of different size clastogene material (quartz, occasionally quartzite-sandstone, feldspar, ilmenite, garnet). This clastogene material is cemented by autigenic pyrite – entire and fine-grained, at least of oölitic and crystalline structure. In the Palaeogene sediments of the Central part of the area, the gravel heavy fraction contains the grains of iron hydroxides which have brown colour, different shape (irregular, rod-like, tabular) and different degree of roundness. The mass of fine-dispersed iron hydroxides contains fine-grained and aleuritic clastogene material.

In the heavy fraction of the Neogene sediments of the gravel size, already mentioned “microbreccias” dominate. However, their cementing mass, in addition to authigenic pyrite, contains iron hydroxides of brownish-red colour; in rare cases, cement is the substance of black colour with strong pitch glance (similar to hisingerite). In addition, the heavy fraction more than 1 mm contains the fragments of pyritized charred wood.

Without a doubt, the presence of authigenic pyrite in the studied Palaeogene and Neogene sediments indicates that these sediments have been formed in reducing conditions and, obviously, during diagenetic stage, when the segregation of sulphide substance in peculiar septarian nodules of gravel and coarse-sand size – “microbreccias” – took place. Pyrite cemented clastogene various-grained material, and this resulted in the formation of deposits with a microporous texture. In turn, this contributed to the formation of microscopic septarian nodules and crystals of pyrite not only in the intergranular space of sediments, but also on the surface of individual grains of clastogene quartz. Here, looking ahead, we note that in the heavy fractions of the size of –1.0+0.5 mm we discovered a sufficient amount of pyrite in the form of separate grains, nodules and small crystals, as well as its intergrowths with the grains of clastogene minerals, and in such intergrowths, pyrite plays the role of cementing substance.

Therefore, we discovered in the studied sediments (1) the pyrite, which fell in the heavy fractions due to crushing of the fragments of gritstone with entire pyritic cement and (2) authigenic pyrite that cements various-grained clastogene material of the sediments and has been isolated in them in the form of nodules and crystals.

Investigations of the **heavy fraction of –1.0+0.2 mm** showed the following. Its content in the samples varies due to different quantity of the main clastogene minerals (ilmenite, garnet, staurolite etc.) and authigenic pyrite. In particular, the pyrite content in the Palaeogene deposits ranges from 57.2 to 91.8 g/t, and in Neogene – from 241.6 to 1557.8 g/t, at that the grains of –0.5+0.2 mm dominate. The heavy fractions are predominantly medium-grained: the grade of –0.5+0.2 mm forms more than 98 % of their mass.

Resistant terrigenous minerals are represented in the heavy fractions by ilmenite, garnet, staurolite, kyanite (their content in the samples is much interchangeable), tourmaline, topaz, zircon (their content varies less) and other minerals.

Ilmenite grains are represented by four types, the contents of which depend on the grain size. In particular, in the Neogene sediments the ilmenite-1 dominates (the so-called fragmented ilmenite) in the form of poorly rounded grains of table-like and rod-like shape, dull black, sometimes with brownish powdery coatings of iron hydroxides; the surface of grains is rough, with pits and potholes, often scalariform. The mass of such ilmenite contains a small number of angular grains of irregular shape, which have a intense black colour and strong submetallic lustre (ilmenite-2 – “shiny”). Unrounded grains of ilmenite-3, dull and intensely changed (so have a look of spongy-skeletal aggregates), have been found in the heavy fraction of the Palaeogene sediments (so-called leached ilmenite). Ilmenite-4 is represented by well-rounded grains of different shape: in the class of –1.0+0.5 mm – tabular grains, slightly leucoxenized, therefore, painted in dark gray with a brown tinge colour; in the class –0.5+0.2 mm – grains of irregular-isometric, rarely tabular shape, size mostly < 0.3 mm, black, dark grey and dark brown.

Leucoxene is represented by single porcelaneous grains with the size of 0.5–1.0 mm and the visible relics of tabular form; smaller grains are rounded, oval, have different tinges of brown colour.

Garnet grains are diverse in appearance. In the fraction –1.0+0.5 mm, unrounded grains dominate, among which there are the following varieties: (1) monolithic transparent orange-red grains, irregular, often angular in shape, with smooth shiny surface; (2) opaque fragments of aggregate structure and pinkish-red colour; (3) grains of irregular shape with jagged, like pitted boundaries and the same surface. Well rolled grains are less common, they have spheroidal, irregular-rounded, sometimes oval form and various tinges of reddish-pink colour. Their surface is smooth, fine-rough or lusterless, with separate hollows and mechanical chips. Single grains are represented by perfect and slightly deformed poor rounded crystals of rhombododecahedral habit. In the class –0.5+0.2 mm, there are rounded and angular (with aggregate structure) garnet grains of pink and orange-red colour.

Other terrigenous minerals have been found only in the class –0.5+0.2 mm. In particular, ***zircon*** is represented by such subidiomorphic crystals: (1) short-prismatic pink individuals, water-transparent, without inclusions; (2) elongate-prismatic crystals of yellow colour and different degrees of transparency; (3) elongate-prismatic black crystals, etc. ***Kyanite*** is found in the form of subrounded colourless, sometimes grey, yellowish grains of sliced form. Grains of tourmaline, topaz, sillimanite, and some grains of staurolite are well rounded. And also there are poor rounded fragments of tourmaline crystals.

The performed studies allow distinguishing two distinctly different mineral associations among terrigenous minerals that have different information about their sources:

1) coarse-grained leucoxene-garnet-ilmenite association – sources of these minerals (with the exception of well rounded garnet grains), probably, are located at a relatively short distance from the place of their burial;

2) medium-grained topaz-garnet-staurolite-ilmenite association with zircon, sillimanite, kyanite is a characteristic association of many terrigenous deposits which have undergone not only continuous transportation but also repeated redeposition from more ancient sediments.

Paragenetic satellites of diamond in the studied Palaeogene and Neogene sediments of the extreme southern part of the Prypiatskyi trough have been identified in very small quantity: there are single grains of pyrope and chrome-spinellid per one small-volume sample (20 litres).

We identified 94 grains of ***pyrope*** in four small-volume samples, 68 of them – in coarse-grained sediments of the Palaeogene, 26 – in the Neogenic sediments; among them 84 grains have size from 0.50 to 0.25 mm, and the rest – 0.20–0.25 mm. Four varieties of pyrope have been distinguished by optical properties: (1) pink grains with index of refraction n = 1,746–1,748 (47 grains); (2) grains of purple colour of varying intensity (25 grains), the value of n is quite variable, but 15 grains have n = 1,752; (3) red grains with n = 1,373–1,748 (17 grains); (4) orange grains with n = 1,754 (four grains).

Shape of grains in general is irregular, slightly elongated; individual grains have a rectangular or triangular cross-section. The surface usually is lusterless, with separate hollows. Grains are poorly rounded and semi-rounded, some of them are well rounded; the degree of preservation of grains is good.

Eleven pyrope grains have been investigated (see Table) using a partial microprobe analysis (three components). It follows from the diagram Cr_2O_3–CaO (Fig. 1), that all the grains correspond to pyrope of lherzolite paragenesis. For comparison, we have put on the diagram the figurative points of composition of pyrope from the conglomerates of Bilokorovytska structure, products of their destruction and phyllite-like schists [1].

The results of partial microprobe analysis of pyrope grains

The number of analysis	Colour of pyrope grains	Content, mass %		
		CaO	FeO	Cr_2O_3
Neogene deposits				
1608/5	Red	4,90	7,35	3,59
1608/6	Violet-red	4,43	8,71	1,81
1608/7	The same	4,35	8,83	2,15
1609/3	Violet	4,72	7,39	1,76
1609/4	Orange	4,72	7,45	0,67
Palaeogene deposits				
1628/8	Orange	4,51	8,80	1,88
1628/10	Red-violet	4,58	9,41	1,71
1628/12	The same	4,92	7,83	1,53
1628/14	– " –	5,06	8,37	1,75
1628/17	Violet-red	4,77	7,65	2,88
1628/19	Red-violet	4,58	8,33	1,63

N o t e. Analyses have been performed at the Institute of Geology of Yakut branch of the Siberian branch of the Russian Academy of Sciences (IG YaB SB RAS).

Chrome-spinellids are represented by single grains in the class of –0.5+0.2 mm, and only in one sample of psephytic Neogene sediments their content is 0.39 g/t. Grains have an irregular or rounded shape, rough surface, are black, opaque, in thin fragments shine brown.

Partial microprobe analysis (IG YaB SB RAS) of the four grains showed the following. Two grains from the Palaeogene deposits are the ferruginous ferrichromite, mass % (average): Cr_2O_3 – 54.45; TiO_2 – 0.13; Al_2O_3 – 11.12; they are comparable with the accessory chrome-spinellids of stratificated ultrabasites (Fig. 2). Two grains from the Neogene deposits are the chrome hercynite: Cr_2O_3 – 31.74; TiO_2 – 0.11; Al_2O_3 – 32.16 mass % (are not in the chart in Fig. 2 due to low chromium); they are comparable with the accessory chrome-spinellids from ultrabasic rocks of ophiolitic formation. According to N. Sobolev et al. [4], chrome-spinellids of similar composition have been found in the concentrates of the Yakut kimberlite pipes. We note in passing that quite a lot of grains of the same composition (58 and 92, respectively, of the 414 analyzed) were discovered in terrigenous rocks of Bilokorovytska structure (see Fig. 2) and in Albian and Quaternary sediments of North-Western Volyn region [1].

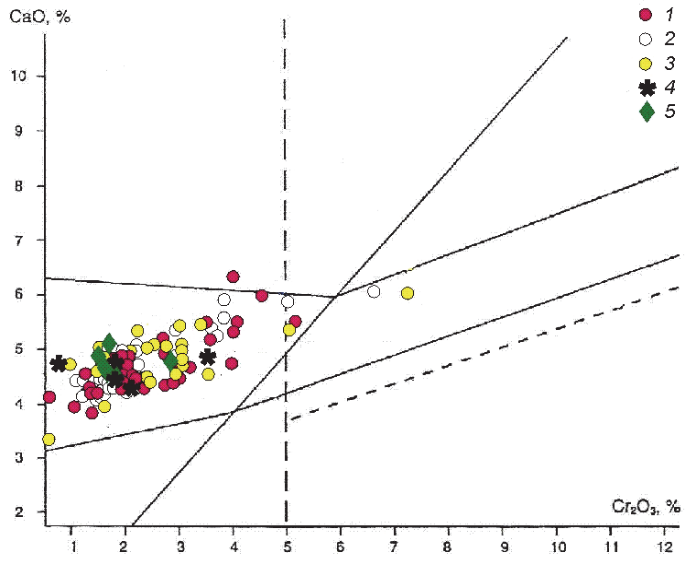

Fig. 1. The position of the figurative points of pyrope composition from the Bilokorovytska structure rocks (*1* – conglomerates, *2* – products of their destruction, *3* – phyllite-like schists) [1] and Prypiatska area (*4* – Neogene rocks, *5* – Palaeogene rocks) on the diagram Cr_2O_3–CaO.

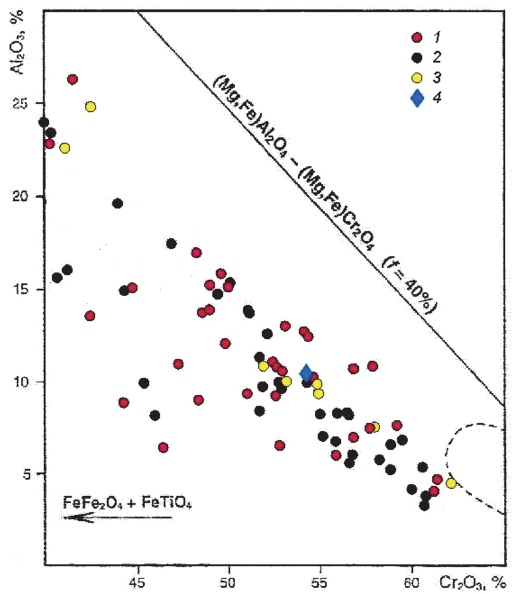

Fig. 2. The position of the figurative points of chrome-spinellids composition from the Bilokorovytska structure rocks (*1* – conglomerates, *2* – products of their destruction, *3* – phyllite-like schists) [1] and Prypiatska area (*4* – Palaeogene rocks) on the diagram Cr_2O_3–Al_2O. Dashed line limits the field of composition of chrome-spinellids associated with diamonds.

For the study of ***picroilmenite*** by the method of thermoelectric power, we have selected 170 grains of ilmenite from the grade of –2.0+0.5 mm, among them 95 grains – "fragmented" ilmenite, 72 – "leached", three grains – "shiny". It turned out that the vast majority of the grains have a value of thermoelectric power as in ilmenite from the basic rocks – from +180 to +400 mV/°C. And only two grains have these values as in picroilmenite: +77 ("shiny") and –166 mV/°C ("leached").

Therefore, small size of detected grains of pyrope and chrome-spihellids, quite high degree of their roundness and the character of their surface testify to a long stay of these grains away from the primary source. The content of both minerals in the sediments is low. Ilmenite grains with "kimberlitic" values of thermoelectric power are extremely rare. On this basis, we can conclude that in this case, these minerals cannot be used as search signs nor on the identification of alkali-ultramafic magmatic bodies, nor to identify the diamond placer.

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ФРАКЦІЙНА СТРУКТУРА І МІНЕРАЛОГІЧНІ ОСОБЛИВОСТІ ГРУБОУЛАМКОВИХ ВІДКЛАДІВ – МОЖЛИВИХ КОЛЕКТОРІВ АЛМАЗУ В ПІВНІЧНО-ЗАХІДНІЙ ЧАСТИНІ УКРАЇНСЬКОГО ЩИТА. Ч. 1. ПРИП'ЯТСЬКА ДІЛЯНКА

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Речовинний склад колекторів має важливе значення для розуміння розсипоутворювального процесу, особливо це стосується фракційної структури відкладів та різноманітних мінералогічних особливостей. Під час тематичних і розшукових робіт на алмази геологи Житомирської ГРЕ виділили п'ять ділянок розвитку грубоуламкових порід, які могли бути колекторами алмазу і, отже, перспективними на виявлення в них відповідних розсипищ: Білокоровицьку, Південно-Західну, Межиріцьку, Прип'ятську та Усівську.

Наведено дані про результати досліджень, виконаних науковцями Львівського університету, на Прип'ятській ділянці. Ділянка розташована у крайній південній частині Прип'ятської западини, між Студеницьким розломом на заході й північно-східним продовженням Убортсько-Сущанського розлому. Тут безпосередньо на палеозойському плотику залягають валунно-гальково-гравійні утворення мезо-кайнозою, які розкрито свердловинами за чотирма профілями. У західній і центральній частинах ділянки досліджено палеогенові відклади, представлені п'ятиметровим горизонтом валунно-галькових порід, що залягають на глинах юри (?). Відклади неогену (інтервал 25–34 м) представлені середньо-дрібнозернистим піском з домішкою гравію.

Речовинний склад грубоуламкових порід вивчали за концентратами відсадження розміром –8+1 мм та їхньою важкою фракцією (класи –1,0+0,5; –0,5+0,2; –0,2 мм). Стійкі теригенні мінерали представлені ільменітом, гранатом, ставролітом, кіанітом (вміст яких значно змінний), турмаліном, топазом, цирконом (кількість яких варіює менше) та ін. Наявні дві чітко відмінні мінеральні асоціації: 1) крупнозерниста лейкоксен-гранат-ільменітова (джерела цих мінералів розташовані на порівняно невеликій відстані від місця їхнього захоронення); 2) середньозерниста топаз-гранат-ставроліт-ільменітова з цирконом, силіманітом, кіанітом (характерна асоціація багатьох теригенних утворень, які не тільки зазнали тривалого транспортування, а й неодноразового перевідкладання з давніших відкладів).

Серед парагенетичних супутників алмазу в досліджених відкладах виявлено рідкісні зерна піропу (відповідають піропам лерцолітового парагенезису) та поодинокі зерна хромшпінелідів (залізистий ферихроміт і хромовий герциніт) і пікроільменту (зі значеннями термо-е.р.с. +77 і –166 мкВ/град).

Малий розмір виявлених зерен піропу і хромшпінелідів, достатній ступінь їхньої обкатаності та характер їхньої поверхні свідчать про тривале перебування цих зерен далеко від першоджерел. Якщо додати до цього низький вміст обох мінералів та надзвичайну рідкість зерен ільменіту з "кімберлітовими" значеннями термо-е.р.с., то можна зробити висновок, що в нашому випадку ці мінерали не можна використовувати як розшукові ознаки на виявлення ані лужно-ультраосновних магматичних тіл, ані розсипищ алмазу.

Ключові слова: алмаз, розсипище, кімберлітові мінерали-супутники алмазу, грубоуламкові породи, палеоген, неоген, Прип'ятська западина.