UDC 551.8: 903.23: 691.4
DOI: https://doi.org/10.15407/ugz2021.01.015

Zh.M. Matviishyna, S.P. Doroshkevych, A.S. Kushnir
Institute of Geography of the National Academy of Sciences of Ukraine, Kyiv

ASSESSMENT OF INFLUENCE OF PALEOGEOGRAPHICAL CONDITIONS ON THE FORMATION OF MINERAL RAW MATERIALS FOR THE MANUFACTURE OF CERAMIC PRODUCTS (ON THE EXAMPLE OF OPISHNYANSKE DEPOSIT OF CLAY ROCKS)*

The main properties and features of clay rocks, which are the basic raw materials for the manufacture of ceramic products are outlined. The main morphogenetic, physicochemical and geochronological characteristics of clay rocks of the Opishnyanske deposits (Poltava region) are covered, the natural conditions of this mineral raw material formation in the late Miocene, Pliocene and Pleistocene are reconstructed, the role of paleogeographic conditions in their formation and accumulation is estimated. Perspective locations of their place position are marked out basing on paleogeographical data.

Keywords: *clay rocks; Neogene; Miocene; Pliocene; Pleistocene; paleogeographical conditions; mineral resources; ceramics.*

Ж.М. Матвіїшина, С.П. Дорошкевич, А.С. Кушнір
Інститут географії Національної академії наук України, Київ

ОЦІНКА ВПЛИВУ ПАЛЕОГЕОГРАФІЧНИХ УМОВ НА ФОРМУВАННЯ МІНЕРАЛЬНОЇ СИРОВИНИ ДЛЯ ВИГОТОВЛЕННЯ КЕРАМІЧНИХ ВИРОБІВ (НА ПРИКЛАДІ ОПІШНЯНСЬКОГО РОДОВИЩА ГЛИН)

Мета дослідження – розглянути палеогеографічні особливості умов формування й накопичення глинистих порід з пізнього міоцену до голоцену та оцінити вплив змін палеогеографічних обстановок на умови й специфіку осадконагромадження, фізико-механічні властивості відкладів та їх локалізацію. На основі польових досліджень глинистих відкладів в межах ключової ділянки (селище Опішня, Полтавська обл.) та палеогеографічних інтерпретацій аналітичних літературних матеріалів схарактеризовано фізико-хімічні, механічні, генетичні властивості й особливості різновікових глинистих порід та встановлено геохронологічну належність продуктивних шарів. Оцінено вплив змін палеогеографічних умов на утворення мінеральної сировини для виготовлення керамічних виробів й окреслено перспективні ділянки місцезнаходжень цих корисних копалин. Встановлено, що сировиною для керамічної промисловості в околицях селища Опішня є глинисті відклади пізнього міоцену (строкаті глини), пліоцену (червоно-бурі глини) та плейстоцену (суглинки). Утворенню глинистих порід сприяли інтенсивні процеси вивітрювання в умовах вологого й теплого (іноді жаркого) клімату, з активним розвитком флори і фауни, що значно активізують елювіальні процеси. Якісні зміни природних умов також яскраво зафіксовані у фізико-хімічних та мінералогічних особливостях різновікових відкладів за наявністю керівних груп вторинних глинистих мінералів (каолініту, монтморилоніту, гідрослюд тощо). Відклади середнього-пізнього плейстоцену, які формувались у більш сухих та холодних умовах, у порівнянні з відкладами міоцену-раннього плейстоцену, мають значно нижчі показники пластичності й вогнетривкості та підвищені показники водопоглинання. Найперспективнішими ділянками місцезнаходжень глинистих відкладів (строкаті й червоно-бурі глини міоцену-пліоцену та плейстоценові суглинки) є площі в межах всього неогенового плато на захід від населених пунктів Опішня й Попівка.

Ключові слова: *глинисті породи; неоген; міоцен; пліоцен; плейстоцен; палеогеографічні умови; мінеральна сировина; кераміка.*

Relevance of the research topic

It is well known that paleogeographic reconstructions play an important role in basic research to establish trends in the development nature in the past, help to explain the specific natural and physicochemical features inherent in certain geological bodies, which are due to the influence of natural factors of their accumulation time and allow to search for new deposits of minerals, including minerals for the manufacture of various ceramic products.

*The research was carried out within the framework of the departmental fundamental research topic of the paleogeography sector of the Institute of Geography of the NAS of Ukraine «Paleogeographic factors and methods of research of formation and accumulation of mineral resources in the context of expanding prospects for mineral reserves in Ukraine» (State registration number 0117U004908).

It should be noted that ceramics are materials and products obtained by sintering clay and its mixtures with mineral impurities, oxide powders and other inorganic compounds [1, P. 598-599]. As key location for research of paleogeographic condition for mineral raw materials manufacture have been choosed the territory of main concentration of the modern Ukrainian «pottery capital of Ukraine» village Opishnya (Poltava region) ***(Fig. 1 A).***

The aim of the study - to consider paleogeographic features of conditions of formation and accumulation of clay rocks from the late Miocene to the Holocene and to estimate the influence of paleogeographic environment changes on conditions and specifics of sedimentation, physical and mechanical properties of sediments and their localization.

Research methods

The work is based on the results of field paleopedological studies of clay deposits of different ages (morphogenetic description of sediments and stratigraphic dissection based on the specifics of individual features of the structure of different age horizons) and paleogeographic interpretations of various analytical data (from literature sources).

The state of study of the issue

Ceramics plays a very important role in the retrospective research (archaeological, paleogeographic, etc.), as it serves as a kind of marker of a certain cultural and historical period of human society. On the territory of modern Ukraine, pottery begins to appear with the tribes of the Neolithic era (VI - V millennium before Crystmas), which are identified primarily by the style and type of ceramic wares. For example, on the territory of the modern Left-bank Dnieper forest-steppe region there are cultural and historical communities of the Dnipro-Donetsk and Sursko-Dnipro as well as later pit-comb ceramics. The tribes of the Trypillya culture (IV-III millennium BC), which were widespread mainly on the right bank of the Dnipro, had a significant influence on the further development and formation of the manufacture of ceramic products. Later, ceramics were used by the population of the Bronze and Iron ages, etc. [2]. Archaeological evidence confirms that ceramics is a kind of marker of a certain historical period, which in the future development of earthlings will characterize the present (now ceramics are architectural and construction (bricks, tiles, chimneys, etc.) and technical materials (insulators, refractories, thermal insulation products, pipes, parts for the electrical and radio engineering industry, nuclear energy, rocket production, automotive, quantum optics, etc).

In the pre last century, geographers and geologists have tried to identify and delineate the location of clays suitable for the manufacture of ceramic products. For example, in the territory of the former Poltava province, Oleksandr Gurov managed to do this. He described the outcrops of Quaternary sediments, described their properties and referred them to a certain group of mineral raw materials[3]. Among the scientists who studied clay rocks within Ukraine and adjacent territories should be mentioned M.F. Veklych, V.I. Vernadsky, I.I. Ginzburg, S.W. Goshovsky, P.K. Zamoriy, I.D. Zhusa, N.V. Rengarten, L.B. Rukhina, N.M. Straknova, O.E. Fersman and others. An important contribution to the study of Neogene and Quaternary clay deposits was made by P.Ya. Armashevsky, M.P. Barbot de Marni, V.G. Bondarchuk, O.V. Gurov, V.Ya. Didkovsky, M.I. Dmitriev, V.Yu. Zosymovych, M.M. Klyushnikov, I.F. Levakovsky, K.M. Feofilaktov and others. The study of individual components of clay substances of the Opishnyanske deposit are also devoted to the work of V.S. Levitsky, G.D. Semchenko, O.B. Skorodumova, N.S. Chopenko, G.P. Shishatsky and others.

Presenting of the main material

The main mineral raw materials used for the manufacture of bricks and ceramics are a variety of clay rocks, mainly low- and refractory clays, rarely loesses, argillites, argillaceous schist's (preliminary crushed) and kaolin [4, P. 308-330]. A striking feature of clay rocks is the ability to form a viscous body with water, suitable for formation and preservation during drying of the form given to it and after firing to acquire stone hardness and strength [5, P. 421-422].

According to the definition from the geological dictionary [6, P. 108-110] clays are non-cemented polydisperse (fine-grained) sedimentary rocks, consisting mainly of clay minerals and containing more than 50% of particles with a size of <0.01 mm and 25-30% of particles size <0.001 mm. The main chemical components of clays are: SiO_2 (30-70%), Al_2O_3 (10-40%), H_2O (5-10%); also present Fe_2O_3 (FeO), CaO, MgO, Na_2O and others. Clays are different in composition and genesis. The main types of clay rocks are: kaolin, montmorillonite, chlorite, hydromica and polyminerals. By origin, eluvial and redeposited rocks are distinguished. Among the latter

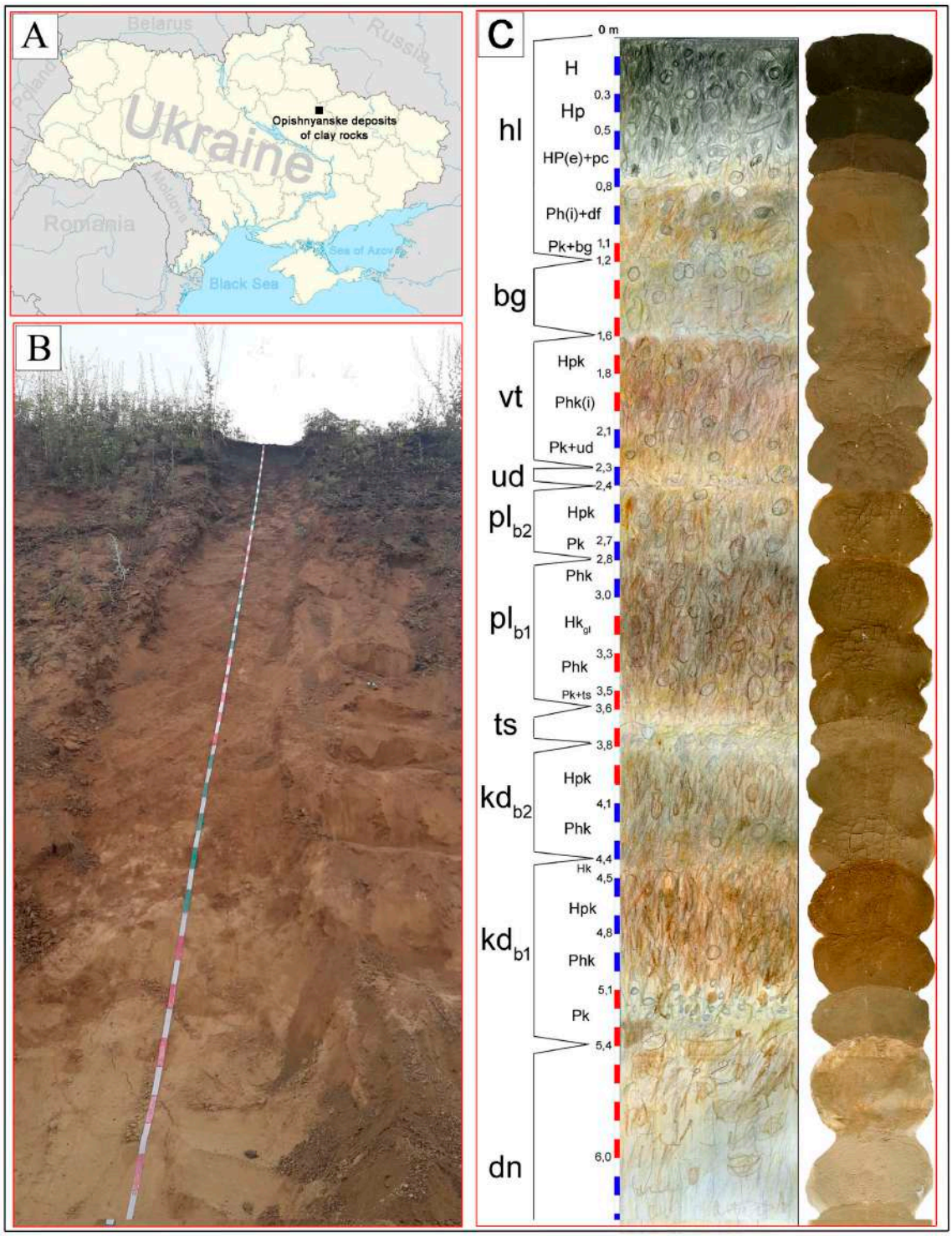

Fig. 1. **A** – Location of Opishnyanske deposits of clay rocks. **B** – Photo of part of the profile of Quaternary deposits of the Opishnyanske-2 section. **C** – Stratigraphic dissection and color drawing of Quaternary deposits of the Opishnya-2 section with smears of natural material (according to Zh.M. Matviishyna)

Indices of paleogeographic stages: *hl – Holocene; pc – Prychornomorya; df – Dofinivka; bg – Bug; vt – Vytachiv; ud – Uday; pl – Pryluky; ts – Tyasmyn; kd – Kaydaky; dn – Dnipro. Indices of staged soils:* pl_{b1} *– Pryluky soil of early optimum;* pl_{b2} *– Pryluky soil of late optimum;* kd_{b1} *– Kaydaky soil of early optimum;* kd_{b2} *– Kaydaky soil of the late optimum. Indices of soil genetic horizons: H – humus; Hk (gl) – humus, carbonate, with hidden signs of gleying; Hp – humus-transitional; HP (e) – humus-transitional with signs of eluvial processes; Ph (i) – transient with signs of illuvial processes; Hpk – humus-transitional, carbonate; Phk – transitional, carbonate; Phk (i) – transient, carbonate, with hidden signs of illuvial processes; Pk – carbonate parent rock*

there are sea, river, glacial (water-glacial).

Within the territory of Ukraine, clays rocks are widespread in almost all geostructural regions [5, p.425]. Thus, in the Dnieper-Donetsk basin, deposits of clays are associated with deposits of Carbonian, Permian, Jurassic, Paleogene, Neogene and Quaternary systems. On the Ukrainian Shield and its slopes, clay rocks are represented by deposits of the Paleogene, Neogene and Quaternary systems. Within the Chernomorian basin, Volyn-Podilska plate, Lviv depression and Carpathian folded region, clay rocks are confined to the deposits of the Neogene and Quaternary systems.

In the vicinity of the village of Opishnya, according to geological research [7], there are three deposits of clay rocks: 1) Opishnyanske deposit [8] (is not developed) - the main minerals are refractory clays (raw materials for fine ceramics), sands and loam (brick and tile raw materials); 2) Opishnyanske deposit-2 [9] (is developed) - loams are mined; 3) Opishnyanske deposit (Suslyak) [10] (is not developed) - the main raw material is loam. Geochronological these minerals are deposits of the Late Miocene, Pliocene and Pleistocene.

According to geomorphological zoning, the study area belongs to the Poltava-Karlivska alluvial (ancient terrace) hilly, moderately dissected plain of Prydniprovsk region of formation-accumulative plains on Paleogene and Neogene deposits [11, P.162]. In the area of the Opishne village, Neogene plateau and the Pliocene (Ivankivska) terrace of the Dnieper stand out [12, P. 26]. A series of Quaternary deposits, which are underlain by Late Miocene-Pliocene clays and Miocene sands of the Poltava suite, take part in the geological structure of the plateau. Absolute marks of the plateau surface exceed 175 m (maximum 212,9 m). The plateau is divided by ravines and gullies overlooking the valleys of the Vorskla and Govtva rivers.

To the south and southwest of the plateau is the surface of the Pliocene terrace of the Dnieper (Ivankivska) [12, P. 27]. Its width in some places reaches 40 km. The surface of the terrace is similar to a plateau but has a lower degree of relief. Absolute surface marks range from 150-170 m. The foot of alluvial deposits can be traced at the level of + 110… + 140 m. The transition from the plateau to the terrace is gradual, without visible ledge. Landslides are common on the terrace surface, especially in the Vorskla river valley. They are small in size (within a few tens of meters), the foot of the landslides is the surface of Pliocene clays.

According to geological mapping [12, P. 19], the clays used for the manufacture of ceramics within this area are represented by continental Neogene deposits (N_{1-2}), namely the strata of variegated clays of the late Miocene - Pliocene. These are rather inhomogeneous in color – yellowish-green, brownish-gray, black, fatty, weakly carbonate clays of montmorillonite-kaolinite composition. Remains of flora and fauna within the horizon have not been identified. According to its genesis, the horizon of variegated clays belongs to the continental sediments of watersheds.

In general, variegated clays are characterized by a certain sequence in the stratification [13, P. 130]. The lower layer of variegated clays is composed of ash-gray or light gray clays, which are sandy in the lower part and clean, plastic in the upper part, without foreign inclusions and impurities. Above is a layer of plastic clay of dark gray, sometimes almost black, with glandular spots and inclusions. The black color is due to the presence of dispersed carbonaceous matter, which is sometimes accumulated in the form of small layers and lenses. Even higher is the light gray clay with yellowish, greenish or blue hues, with ocher-yellow or reddish-yellow spots. This clay is generally plastic in some layers sandy.

Quaternary sediments overlay all older geological formations with an almost continuous cover and are represented by formations of various genesis. Early Pleistocene sediments are represented by heavy loamy and clay deposits of brown and red-brown color with small carbonate and manganese nodules, which are often interbedded with fine quartz sands. According to the genesis, these are lake and eluvial-deluvial deposits of the plain, which stretched on the left bank of the Dnieper before the onset of the Dnieper Glacier. In places, Early Pleistocene sediments are completely absent as they were destroyed in subsequent periods [12, P. 20]. Middle Quaternary sediments are represented by alluvial sands in river valleys and aeolian-deluvial losses and losses-like loams.

According to the passports of deposits [8-10] in the vicinity of Opishne, among the types of minerals deposits there are refractory clays (raw materials for fine ceramics) and loams (raw materials for the brick and tile industry). The body of a layer of refractory clay (Opishnyanske deposit) lies horizontally, is covered with loams sands. The length of the industrial body varies between 500-660 m (average - 580 m), width - from 100 to 220 m (average - 160 m), power - from 0.6 m to 4.7 m (average - 2,2 m.). The

total industrial reserves of refractory clays of the Opishnyanske deposit are estimated at 748 thousand tons (categories A + B + C1 + C2) [8]. Industrial reserves of loam for the brick and tile industry range from 560 thousand m^3 (Opishnyanske-2 deposit) [9] and 325 thousand m^3 (Opishnyanske deposit (Suslyak) [10].

According to the DNVP «Geoinform of Ukraine» [8], the following chemical composition (content in %) is characteristic for the refractory clays of the Opishnyanske deposit: SiO_2 - 55.2 - 70.1; Al_2O_3 - 8.96 - 16.8; Fe_2O_3 - 1.47 - 4.85; CaO - 0.5 - 1.38; TiO_2 - 0.28 - 1.34; MgO - 0.21 - 1.48; SO_3 - up to 1.35; K_2O - 0.07 - 0.26; Na_2O - 0.04 - 0.12 and others. They have the following physical and mechanical properties: the number of plasticity – from 4.37 to 34.87, fire resistance – from 1480ºC to 1660ºC, air shrinkage – from 2 to 14%, complete shrinkage – from 6 to 18%, water absorption – from 4.74 to 17.8%, bending strength – from 1.67 to 2.95 kg / cm^2.

At the same time, the qualitative indicators of the chemical composition of loams (content in %) in the Opishnyanske-2 and Opishnyanske (Suslyak) deposits are as follows [9, 10]: SiO_2 - 60.6 - 72.9; Al_2O_3 - 8.5 - 13.75; Fe_2O_3 - 2.3 - 4.3; CaO - 5.8 - 9.2; TiO_2 - 0.5 - 0.8; MgO - 0.15 - 1.2; SO_3 –0.1 - 0.3; K_2O - 1.3 - 2.5; Na_2O - 0.7 - 2.0, etc. The number of plasticity – from 3.2 to 20.1, fire resistance – from 1140ºC to 1300ºC, air shrinkage – from 6.3 to 12.4%, complete shrinkage – from 6.7 to 14.0%, water absorption – from 9.6 to 16.7%.

Data of chemical analysis and mineral composition in relation to seven horizons of clays of the Opishnyanske deposit are given in the work of N.S. Chopenko [14, P. 5-6]. Unfortunately, in this work the author limited himself to digital identification of horizons, without reference to geological age *(Table 1)*. Interpretation of data N.S. Chopenko regarding the depth of horizons bedding, chemical analysis, mineralogical composition, as well own field stratigraphic observations within the key area, allow to suggest that 1-st from the top horizon is the Late Pleistocene loesses (Bug horizon) (Q_3, bg), 2 – Middle-Late Pleistocene loesses and loams (Q_{2-3}, kd-vt), 3 – Middle Pleistocene loesses (Dnipro horizon) (Q_2, dn), 4 – Early Middle Pleistocene deposits (Q_{1-2}), 5 – Red-brown Pliocene clays (N_2), 6-7 – variegated Miocene clays (N_1).

As a result of own field work it was investigated section of Pleistocene sediments ***(Fig. 1 B)***, located in the quarry of a brick factory at a distance of 600 m from the western outskirts of the village of Opishnya, 300 m on both sides of the highway P 42 road Lubny-Myrhorod-Opishnya. The geographical coordinates are as follows: 49° 959 N; 34° 569 E. Altitude above sea level - 180 m. The size of the quarry is about 110 by 190 m. The study location is part of the Opishnyanske-2 deposit (its northern part), which is being developed in connection with the extraction of brick and tile raw materials (owner (until January 13, 2031) LLC «Budservice», Poltava) [9].

In the course of authoring own researches a detailed morphogenetic description of sediments and stratigraphic dissection was performed based on the specifics of individual features of the structure of Quaternary sediments of different ages (according to the Scheme of dissection of Quaternary sediments of 1993). It is established that the brick-tile raw materials here are medium-loamy Pleistocene deposits, which are represented by horizons from Holocene to the Dnipro ***(Fig. 1 C)***. Sediments lie almost horizontally with a barely noticeable angle of inclination in the south-western direction. At the bottom of the quarry there is a thick layer of the Dnipro (dn) aeolian-deluvial deposits (dusty-loamy well-sorted loesses, visible thickness about 3 m). Above the Dnipro horizon lies a subaerial layer of sediments, which is represented from top to bottom by the following stratigraphic horizons.

Holocene deposits are represented by modern zonal soil - podzolic chernozem, which was formed as a result of active biogenic-accumulative soil-forming processes in the conditions of the washing regime. The processes of Holocene soil formation strongly changed the underlying sediments of the Prychornomorya and Dofinivka horizons, which are distinguished rather conditionally by latent signs of color (traced in the soil profile in the form of individual fragments of material not transformed by soil fauna).

Below are whitish-pale aeolian-deluvial loess deposits of the Bug horizon. Sediments are loose, carbonate, lumpy-crumbly, light loamy, with some mole holes. In the lower part the content of floury and micellar forms of carbonates increases, the limit is fine-wavy, the transition is clear by the change in granulometric composition and browning of color.

Under the Bug loess deposits lies the thickness of fossil soil horizons of the Middle-Late Pleistocene age (Vytachiv, Pryluky, Kaydaky), which are separated by the remnants of loess horizons (Uday and Tyasmyn). Vytachiv soils have pale brown shades of color, specific, combine features of steppe (short profile, weak differentiation into genetic horizons,

Table 1.

Data of mineralogical analysis of clay deposits of the Opishnyanske deposit [14]

№ clay layer (stratigraphic interpretation)	The ratio of components, %												
	β - quazt	Kaolinite	Potassium feldspar	Plagioklaze	Mica and hidromica	Montrnorillonite	Fe hydroxides and Hematite	Carbonate	Accessory minerals	Carbonic substance	Beydelite	Hydrargilite	Zeolites
1 (Q_3, bg)	44-55	12-17	3-5	5-7	15-20	<1	~1	1-3	1-3	2-4	-	-	-
2 (Q_{2-3}, kd-vt)	50-60	10-15	4-6	5-7	9-14	<1	2-4	5-7	1-3	1-3	-	-	-
3 (Q_2, dn)	33-43	18-23	3-5	4-6	17-22	<1	~1	5-10	1-3	2-4	-	-	-
4 (Q_{1-2})	28-38	30-40	1-3	1-3	8-13	<1	4-8	5-10	1-3	1-3	-	-	-
5 (N_2)	20-30	5-7	-	-	2-4	8-13	2-4	4-6	~1	1-3	35-45	1-3	1-3
6 (N_1)	43-53	31-41	-	2-4	2-4	4-6	1-3	-	1-3	<1	-	-	-
7 (N_1)	30-35		-	-	6-10	13-18	1-3	-	>1	1-3	32-42	-	2-4

carbonate) and forest (compaction of material in the middle part of the profile, clay, iron) soil formation. Pryluky deposits are represented by the soil suite, which consists of grayish-brown soil of late optimum (pl_{b2}) and brownish-gray chernozem with signs of gleying of early optimum (plb_1). Kaydaky soils (kd_{b2}, kd_{b1}) are light-medium loamy, have yellowish-brown, brown, dark brown color, carbonate, with moleholes; in the middle part of the soil (kd_{b1} (Hpk and Phk)) there are signs of oxidation of ferrum and gleying of the material, and in the lower part (kd_{b1} Pk) there is an accumulation of silicon-carbonate concretions up to 3 cm in diameter. Sediments of the Udai and Tyasmin ages are strongly transformed by active soil formation processes, so they are traced only in the form of individual spots and are diagnosed by accumulations of visible forms of carbonates at the boundary between soil horizons. In the lower part of the section there is a thick layer (more than 3 m) of dusty, vertically columnar, carbonate, well-sorted loesses of the Dnipro horizon. Sediments of the Uday and Tyasmyn ages are strongly transformed by active soil formation processes, so they are traced only in the form of individual spots and are diagnosed by accumulations of visible forms of carbonates at the boundary between soil horizons. In the lower part of the section there is a thick layer (more than 3 m) of dusty, vertically-columnar, carbonate, well-sorted forests of the Dnipro horizon. Sediments of the Uday and Tyasmyn ages are strongly transformed by active soil formation processes, so they are traced only in the form of individual spots and are diagnosed by accumulations of visible forms of carbonates at the boundary between soil horizons. In the lower part of the section there is a thick layer (more than 3 m) of dusty, vertically columnar, carbonate, well-sorted loesses of the Dnipro horizon.

The described section of Quaternary sediments has a structure characteristic of elevated areas within the Neogene plateau on which the village of Opishnya is located. A feature of such sections is a thick layer of subaerial sediments, represented mainly by eluvial horizons of pedosedimentary soils (Holocene, Dofinivka, Vytachiv, Pryluky, Kaydaky), which lie almost on top of each other and transform weak loess layers by active soil formation processes. This structure of the stratum, where the section is dominated by soil deposits of eluvial genesis, is favorable for the extraction of loam, which is a raw material for the brick and tile industry. It should be noted that soil deposits, compared to loess, are less carbonate, which also has a positive effect on the properties of clay for the production of quality bricks.

Paleogeographical conditions and their influence on the formation of clay deposits of the Opishnyanske deposit

Analysis of changes in granulometric composition of typical horizons of variegated clays of the late Miocene, red-brown clays of the Pliocene and early Pleistocene heavy loam sediments indicates their belonging to the eluvial type (primary clays).

Deluvial and aeolian processes (secondary clays) played a significant role in the formation and accumulation of Middle and Late Pleistocene loams, along with eluvial ones.

Interpretation of literature data on the chemical composition of Late Miocene and Early Pliocene clays, as well as Pleistocene loams of the Opishnyanske deposit [8-10, 14] indicates that sediments were formed in continental conditions under active chemical weathering processes (the main components of the content are the stable SiO_2 and significant part of aluminum and ferrum oxides). The low content of carbonates and the absence of gypsum indicate wet conditions for the formation of horizons of variegated clays of the late Miocene. The absence of visible remains of living organisms also confirms the assumption of continental conditions for the formation of these sediments, which did not contribute to the preservation of organic remains. The increased concentration of titanium oxides in the variegated clays indicates the proximity of the basic deposit of ilmenite placers, which were redeposited, probably from the sands of the Poltava series. Natural conditions in some stages of the Pliocene were more arid than in the Miocene. The argument in favor of this is the increased content of carbonates in red-brown clays compared to variegated clays, as well as a much higher proportion of iron oxides. Data on the chemical composition of Pleistocene sediments, compared with Pliocene and Miocene, indicate even more arid conditions of their formation (much higher content of carbonates, relatively lower content of aluminum and iron oxides), especially since the Middle Pleistocene. The increased content of sodium and potassium oxides indicates an increase in the role of steppe sedimentation.

Analysis of the distribution of clay minerals allows to establish the climatic, tectonic and hydrochemical natural conditions of the geological past [15, P. 199]. Thus, the leading role in the formation of clay mineral complexes of continental sediments, both humid and arid zones, belongs to climate. The peculiarities of the last are manifested through the varying degrees of intensity of the processes of gradual transformation of minerals, which determines, in the case of a humid climate, the dominance of kaolinite among clay minerals. In the arid zone as rule, weathering usually reaches only the montmorillonite stage. The least resistant to weathering are hydromica, which characterizes the cold arid conditions or the initial stage of clay formation [16, P. 53-54]. To zonal clay minerals of arid areas, except montmorillonite, include other minerals of the smectite group (nontronite, beidelite). Minerals of the kaolinite group are perceived as an indicator of hot humid climate, intensive weathering, washing regime, which is typical for the tropics and humid subtropics.

Data on the mineralogical composition of the clays of the Opishnyanske deposit obtained by N.S. Chopenko [14, P. 5] indicate on the formation of the upper pack of variegated clays of Miocene (content of kaolinite – 31-41%) in the condition of warm and wet climate, but of the low pack (content of beydelite – 32-42%, montorillonite – 13-18%) and red-brown Pliocene clays (beydelite 35-45%, montmorillonite 8-13%, kaolinite 5-7%) - in more arid conditions. Compared with the Pliocene, the Early Pleistocene climate became wetter again, as the content of kaolinite in the Early Pleistocene loams increased to 30-40% and the content of carbonates increased too (5-10%); in the some horizons there are whole horizons of carbonate and concretions inclusions, that indicate on more arid conditions in separate stages. The highest relatively indexes of micas and hydromicas content in the Dnipro sediments (17-22%) and Bug (15-20%) horizons are the indicators of cold and arid conditions of their accumulation time.

For M.F. Veklych [17], the general paleogeographic pattern of formation of rocks of red formation is the intensification of their formation in geocratic epochs (during planetary regressions). In general, Late Miocene rocks formed on the sands of the Poltava suite are considered as sandy-clay carbonate-free soils with a well-developed profile up to 3 m thick. In the Pliocene and partly in the early Pleistocene, thick soils pedosedimentes of red, brown, brownish shades of color were formed on the territory of the study, which are identified as pedosedimentary soils close to subtropical [16]. After the Dnipro glaciation on the territory of Ukraine, in the warm interglacial epochs, soils close to modern genetic types began to form. In particular, if now the modern zonal varieties of soil cover, within the key area, are chernozems podzolic and dark gray podzolic soils [11], which reflect the situation of the forest-steppe zone, then studied in the context of Opishnyanske-2 deposit indicate the predominance of the conditions of the steppe regime of sedimentation (carbonate mass, a significant number of moleholes, gradual transitions between genetic horizons). Although, in the soil of the early optimum of the Kaydaky time there are

signs of forest soil formation (gleying, ferrafication, carbonate illuvium in the lower part of the profile). Hidden signs of glaciation were also found in the Pryluky soil of the early optimum.

Literature data on paleogeographic reconstructions of the territory of Ukraine in the late Miocene - Early Pliocene indicate that the study area was within the continental regime in the form of an accumulative plain with clay-sandy sediments [13, 18]. Within this plain, in addition to river valleys (sandy alluvial deposits), lakes (clay lake deposits, sapropel-humus shales, layers of brown coal) were widespread. The climate of the late Miocene was warm and relatively humid. The amount of precipitation in some time intervals could reach 1100 mm/year, and the average annual temperature did not exceed 15-16ºC. Paleontological data indicate that in the early Pliocene period the climate was drier and warmer than today [17, P. 212-233].

In the Pleistocene there were periodic rhythmic alternations of glacial epochs with interglacial ones. In the glacial stage subaerial eolian-deluvial loess deposits accumulated in the study area [19]. In the interglacial stages, when natural conditions were similar to modern or even warmer, fossil soil horizons were formed under favorable conditions for soil formation processes [20]. Periods of development and degradation of cover continental glaciations in the Pleistocene caused the displacement and migration of the boundaries of natural areas with their inherent features of flora and fauna [11, 16]. By the end of the Pleistocene, much of the flora and fauna became extinct. After the last cold Pleistocene stage (Prychernomorya), which ended about 10 thousand years ago, the modern stage of nature is started (Holocene) which paleogeographic reconstructions are often performed on the basis of geoarchaeological approach [21]. The Holocene is associated with the active development of cultural and historical communities, who began to actively use ceramic products.

Conclusions

The paleogeographic conditions of sediment accumulation time within the key area of Opishnya (Poltava region) are characterized on the basis of the complex analysis of properties and features of clay rocks of different ages, which are the basic raw materials for the production of the clayear the wares. This allowed us to assess the impact of paleogeographic conditions on the formation of mineral raw materials for the manufacture of ceramic products.

1. It is established that the raw materials for the ceramic industry in the vicinity of the village of Opishnya are clay deposits of the Late Miocene, Pliocene and Pleistocene. Schistose and reddish-brown clays (raw materials for fine ceramics) are common within the Neogene plateau. Pleistocene loams (brick and tile raw materials) practically cover more old geological formations with almost a continuous cover.

2. The accumulation of mineral raw materials for the manufacture of ceramic products is directly related to the natural conditions of the time of their formation. It is established that the formation of clay rocks is facilitated by intensive weathering processes in a humid and warm (sometimes hot) climate, with the active development of flora and fauna, which significantly activates the processes of soil formation.

An important aspect is the geomorphological position, which on the one hand contributes to the accumulation of raw materials, and on the other - prevents its destruction in the next paleogeographical stages. In leveled elevated areas, sedimentation is characterized mainly by eluvial genesis with the formation of primary clay deposits (in situ).

3. Data of physicochemical and mineralogical researches clearly indicate specific natural conditions of formation of different ages clay deposits. Humid and hot weather conditions for the times formation of Late Miocene sediments contributed to the high content of kaolinite and oxides of iron and aluminum. Zonal clay minerals of more arid areas include montmorillonite, as well as other minerals of the smectite group (nontronite, beidelite), the increased values of which are recorded in Miocene and Pliocene deposits. The significant content of carbonates in the sediments is evidence of the aridity of sedimentation conditions. The high content of kaolinite, along with the increase in carbonates content, indicates the alternation of the influence of warm and humid conditions with cool and arid ones in the early Pleistocene. Relatively high indicators of carbonate content were recorded in Pleistocene loess deposits and late Pleistocene loams. Cold arid conditions reflect hydromica, the high content of which is characteristic for the loess horizons of the Pleistocene.

4. The results of field research recorded a typical structure of Quaternary sediments characteristic of elevated areas within the Neogene plateau on which the vast majority of the village of Opishnya

is located. The peculiarity of such sections is a thick layer of subaerial Pleistocene sediments, represented mainly by eluvial formations with fossil soils, which practically transform the underlying aeolian-deluvial formations (loess sediments) by active soil formation processes. This structure of the stratum, where the section is dominated by soil deposits of eluvial genesis, is favorable for the extraction of loam, which is a raw material for the brick and tile industry. The formation of eluvial loams is associated with the interglacial stages of the Pleistocene, when natural conditions contributed to the active processes of soil formation, which formed thick horizons of the soil suite. In the cold and arid stages of the Pleistocene, the processes of sedimentogenesis played a crucial role, which led to the aeolian accumulation of dusty carbonate loess deposits. Due to the sparse vegetation, forest sediments actively accumulated in depressions, on elevated relief elements their capacities are insignificant.

5. Natural conditions had a direct impact on the formation of physico-chemical and physico-mechanical properties of different ages clay rocks. In particular, the Middle-Late Pleistocene sediments, which were formed in drier and colder conditions, in comparison with the Miocene – Early Pleistocene sediments, have significantly lower plasticity and fire resistance and increased water absorption (especially for loess sediments), which causes significant differences quality of raw materials for the ceramic industry.

6. Paleogeographic data allowed to outline the most promising areas of clay deposits. Thus, we assume that the deposits of schistose Miocene clays and red-brown Pliocene lie within the whole Neogene plateau, but their extraction is complicated by the increase in the thickness of the overlying rocks, the surface of which, moreover, is actively built up and used in agriculture. Pleistocene loams cover ancient deposits with a continuous cover, have sustained capacities within the Neogene plateau, which allows to extract them on almost all elevated and undeveloped areas. Areas west of the settlements of Opishnya and Popivka are especially promising.

The novelty of the research. Based on field studies of clay deposits within the key area (Opishnya village, Poltava region) and paleogeographic interpretations of analytical literature, the physicochemical, mechanical, genetic properties and features of different ages of clay rocks are characterized and geochronological characteristics are established. The influence of changes in paleogeographic conditions on the formation of mineral raw materials for the manufacture of ceramic products is estimated and promising areas of locations of these minerals are outlined.

References [Література]

1. *Encyclopedia of Modern Ukraine, Vol. 12* (2012). Kyiv, 712 p. [In Ukrainian].
   [Енциклопедія Сучасної України. Т. 12. Київ, 2012. 712 с.]
2. Krutenko N.G. (1998). Ceramics: an art view of the evolution of things. *Sights of Ukraine, 3,* 65–75. [In Ukrainian].
   [Крутенко Н.Г. Кераміка: мистецтвознавчий погляд на еволюцію створення речей // Пам'ятки України. 1998. №3. С. 65–75.]
3. Gurov A.V. (1889). *Geological description of the Poltava province. Report to Poltava Provincial Zemstvo* (preprint). 217 p . [In Russian].
   [Гуров А.В. Геологическое описание Полтавской губрении. Отчет Полтавському губернскому Земству. 1889 (препринт). 217 с.]
4. Mykhailov V.A., Vynogradov G.F., Kurylo M.V., Mykhailova M.S., Shunko V.V., Shevchenko V.I., Grinchenko O.V., Geleta O.L., Shcherbak D.M. (2008). *Non-metallic minerals of Ukraine.* Textbook. Edition 2. Kyiv, 494 p. [In Ukrainian].
   [Михайлов В.А., Виноградов Г.Ф., Курило М.В., Михайлова М.С., Шунько В.В., Шевченко В.І., Грінченко О.В., Гелета О.Л., Щербак Д.М. Неметалічні корисні копалини України: Підручник. Видання 2. Київ, 2008. 494 с.]
5. Gurskyi D.S., Yesypchuk K.Y., Kalinin V.I., Kulish V.O., Chumak D.M., Shumlyanskyi V.O. (2006). *Metallic and non-metallic minerals of Ukraine. Vol. 2. Non-metallic minerals.* Kyiv-Lviv, 552 p. [In Ukrainian].
   [Гурський Д.С., Єсипчук К.Ю., Калінін В.І., Куліш В.О., Чумак Д.М., Шумлянський В.О. Металічні і неметалічні корисні копалини України. Т. 2. Неметалічні корисні копалини. Київ-Львів, 2006. 552 с.]
6. Vovk V.M. (2012). *Geological dictionary: for students of higher educational institutions*. Kirovograd, 504 p. [In Ukrainian].
   [Вовк В.М. Геологічний словник: для студентів вищих навчальних закладів. Кіровоград, 2012. 504 с.]
7. Map of non-metallic minerals. Mineral resources of Ukraine. URL: http://minerals-ua.info/mapviewer/nemetali.php [In Ukrainian].
   [Карта неметалічних корисних копалин / Мінеральні ресурси України. URL: http://minerals-ua.info/mapviewer/nemetali.php]
8. Passport № 200. Opishnyanske deposit. State Research And Production Enterprise Geoinform of Ukraine. URL: http://geoinf.kiev.ua/wp/zviti-map.php?rep=pasp_30&pasport=200 [In Ukrainian].

[Паспорт № 200. Родовище Опішнянське. ДНВП «Геоінформ України». URL: http://geoinf.kiev.ua/wp/zviti-map.php?rep=pasp_30&pasport=200]

9. Passport № 3308. Opishnyanske deposit 2. Mineral resources of Ukraine: Information on the object of accounting from the state cadastre and balance. URL: http://minerals-ua.info/zviti-map.php?rep=mpasp_30&pasport=3308 [In Ukrainian].
[Паспорт № 3308. Родовище Опішнянське 2. Мінеральні ресурси України: Інформація про об'єкт обліку з державного кадастру та балансу. URL: http://minerals-ua.info/zviti-map.php?rep=mpasp_30&pasport=3308]
10. Passport № 2605. Opishnyanske deposit (Suslyak). Mineral resources of Ukraine: Information on the object of accounting from the state cadastre and balance. URL: http://minerals-ua.info/zviti-map.php?rep=mpasp_30&pasport=2605 [In Ukrainian].
[Паспорт № 2605. Родовище Опішнянське (Сусляк). Мінеральні ресурси України: Інформація про об'єкт обліку з державного кадастру та балансу. URL: http://minerals-ua.info/zviti-map.php?rep=mpasp_30&pasport=2605]
11. *National Atlas of Ukraine* (2007). Kyiv, 440 p. [In Ukrainian].
[Національний атлас України. Київ: ДНВП «Картографія», 2007. 440 с.]
12. Geological map of the USSR on a scale of 1: 200,000. Dneprovsko-Donetskaya series. Sheet M-36-XXIII. Explanatory letter / G.D. Lepigov, B.S. Kovalev (1971). Moscow, 52 p. [In Russian].
[Геологическая карта СССР масштаба 1:200 000. Серия Днепровско-Донецкая. Лист М-36-XXIII. Объяснительная записка / сост. Г.Д. Лепигов, ред. Б.С. Ковалев. Москва, 1971. 52 с.]
13. *Stratigraphy of the USSR. Volume 10. Neogene* (1975). Kyiv, 272 p. [In Ukrainian].
[Стратиграфія УРСР. Том 10: Неоген. Київ: Наукова думка, 1975. 272 с.]
14. Chopenko N.S. (2012). *Technology of large artistic ceramic products using clays of the Opishnyansky deposit*. Abstract of the dissertation for the degree of Candidate of Technical Sciences. Kharkiv, 23 p.
[Чопенко Н.С. Технологія художніх великогабаритних керамічних виробів з використанням глин Опішнянського родовища: автореф. дис…. канд. тех. наук. Харків, 2012. 23 с.]
15. Zkhus I.D. (1966). *Clay minerals and their paleogeographic significance (on the example of oil and gas bearing regions in the south of the USSR*. Moscow, 280 p. [In Russian].
[Зхус И.Д. Глинистые минералы и их палеогеографическое значение (на примере нефтегазоносных районов юга СССР). Москва, 1966. 280 с.]
16. Matviishyna Zh.M., Gerasymenko N.P., Perederiy V.I., Bragin A.M., Ivchenko A.S., Karmazynenko S.P., Nahirnyi V.M., Parkhomenko O.G. (2010). *Spatial-temporal correlation of paleogeographic conditions of the Quaternary period on the territory of Ukraine*. Kyiv, 192 p. [In Ukrainian].
[Матвіїшина Ж.М., Герасименко Н.П., Передерій В.І., Брагін А.М., Івченко А.С., Кармазиненко С.П., Нагірний В.М., Пархоменко О.Г. Просторово-часова кореляція палеогеографічних умов четвертинного періоду на території України. Київ, 2010. 192 с.]
17. Veklych M.F. (1982). *Paleostage and stratotypes of soil formations of the Upper Cenozoic*. Kyiv, 202 p. [In Russian].
[Веклич М.Ф. Палеоэтапность и стратотипы почвенных формаций верхнего кайнозоя. Киев, 1982. 202 с.]
18. Pasechnyi G.V. (1986). *Paleogeographical stages (on the example of the Neogene of Ukraine*). Abstract for the degree of Doctor of Geographical Sciences. Kyiv, 44 p. [In Russian].
[Пасечный Г.В. Палеогеографическая этапность (на примере неогена Украины). Автореф. … докт. геогр/ наук. Киев, 1986. 44 с.]
19. Matviishyna Zh. M., Karmazynenko S. P., Doroshkevych S. P., Matsibora O. V., Kushnir A. S., Perederii V. I. (2017). Paleogeographical preconditions and factors of the changes of human's living environment on territory of Ukraine in Pleistocene and Holocene. *Ukrainian geographical journal, 1,* 19–29. DOI: https://doi.org/10.15407/ugz2017.01.019 [In Ukrainian].
[Матвіїшина Ж.М., Кармазиненко С.П., Дорошкевич С.П., Маціbора О.В., Кушнір А.С., Передерій В.І. Палеогеографічні передумови та чинники змін умов проживання людини на території України у плейстоцені та голоцені // Укр. геогр. журн. 2017. № 1. С. 19-29. DOI: https://doi.org/10.15407/ugz2017.01.019]
20. Doroshkevych S.P. (2018). *The nature of the Middle Pobuzhzhya in Pleistocene according to the study of fossil soils*. Kyiv, 175 p. [In Ukrainian].
[Дорошкевич С.П. Природа Середнього Побужжя у плейстоцені за даними вивчення викопних ґрунтів. Київ, 2018. 175 с.]
21. Matviishyna Zh. M., Kushnir A.S. (2018). Geoarchaeological approach in paleosoil research of archaeological sites. *Ukrainian geographical journal, 4,* 10-15. DOI: https://doi.org/10.15407/ugz2018.04.010 [In Ukrainian].
[Матвіїшина Ж.М., Кушнір А.С. Геоархеологічний підхід у палеоґрунтознавчих дослідженнях археологічних пам'яток. Укр. геогр. журн. 2018. №4. С.10-15.]

The article received 22.09.2021