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ON THE EARLIEST EVIDENCE OF THE MIDDLE DNIPRO AREA NON-FLINT ROCKS USE

Purpose. To determine the rock composition and origin of raw materials of non-flint stone products found during the study on the Mira Upper Palaeolithic archaeological site in the Middle Dnipro area.

Methodology. The research on the artefacts was carried out using the mineralogical and petrographic methods. The rocks were studied in transparent thin sections using a polarized microscope. To verify the accuracy of the petrographic analysis of some specimens, the XRD and XRF methods were applied. Establishing the provenance of the rocks was performed using comparative mineralogical and petrographic analysis, for which the specimens of samples from the outcrops were used, as well as geological survey and literary data.

Findings. To conduct petrographic research, seven specimens of stones with traces of processing, found during archaeological excavations of the Upper Palaeolithic Mira site, were taken. As a result of the petrographic analysis, it was established that the stones with traces of processing are represented by the aplitoid two-feldspar granites, altered dolerite, quartz arenite, quartz rock, amphibolite and actinolitite. All the mentioned rocks are typical for the Middle Dnipro area. The specimens of the granites, dolerite, and arenite, by their petrographic features, have analogues among the rocks of the region and, more likely, are of the local provenance. Most likely, a quartz sample comes from the territory of the Ukrainian Shield. The types of amphibolite and actinolitite, which are analogues to the studied artefacts by their petrographic and chemical features, do not occur today among the rocks that form natural outcrops in the Middle Dnipro area. Thus, the specimens of the amphibolite and actinolitite may have both local and other origin. More accurate determination of the provenance of the amphibolite and actinolitite samples requires further study involving sample collections from other regions, wherefrom these rocks could have been carried.

Originality. For the first time, the Upper Palaeolithic Mira archaeological site stone artefacts were studied in thin sections and with the application of XRD and XRF analyses, which made it possible to make more precise findings on their petrographic properties and origin. The studied samples are of great importance because, today, they are the earliest non-flint stone artefacts from the Middle Dnipro area to be studied by means of petrography, particularly those made from crystalline rocks of the Ukrainian Shield.

Practical value. The results obtained can be used in performing studies on archaeology and the history of mining, as well as in popular science works.

Keywords: *stone artefacts, petroarchaeology, Early Upper Palaeolithic, Mira, Ukraine*

Introduction. The history of the use of rocks in the Middle Dnipro area dates back many millennia. It is known that the main type of stone raw material used by man at the very beginning of history, particularly, in the specified region, was flint. However, this type of stone raw material is almost absent here. On the other hand, the Middle Dnipro area has always been a centre of extraction of other types of stone raw materials, primarily, crystalline rocks of the Ukrainian Shield. In the scientific literature, the issue of determining the time of the beginning of the Middle Dnipro area rocks use has not yet been raised. Today, the earliest petrographically proven fact of the use of rocks in this region dates to the Neolithic Age [1]; however, modern-looking people lived on the territory of the studied area for a much longer time, namely from the beginning of the Upper Palaeolithic Period, and could not have been unaware of local stone raw materials. Although, it should be admitted that the basis of their toolkit at that time consisted of flint products coming from other territories, including distant ones.

Archaeological petrography allows us to answer the question of when the use of this or that stone raw material began. The name, mineral composition, microstructural features, and most importantly, the provenance of the rock can be most accurately established based on the results of the petrographic study. Today, petrographic research methods are widely used in the study on stone artefacts, in particular, in the study on the Palaeolithic stone industry. There should be noted petroarchaeological studies, in particular, devoted to the identification of rocks and the description of stone artefacts in thin sections [2, 3], the study on mobility strategies of the Palaeolithic population in connection with the necessity to fill their own needs with stone raw materials [4], and the determination of the origin of stone products raw materials supplied from other regions [5, 6], as well as the features of the use of flint raw materials [7]. The beginning of petroarchaeological direction development in Ukraine is closely linked to the name of V. F. Petrougne, who carried out research into archeological sites materials of different epochs: from the Stone Age to the Middle Ages. V. F. Petrougne repeatedly referred to the topic of archeological petrography of the Upper Palaeolithic (Petrougne, V. F., 1969; Stanko, V. N., Petrougne, V. F., 1998). An important work by V. F. Petrougne published together with V. N. Stepanchuk is petrographic research on the Mira Upper Palaeolithic site near the city of Zaporizhzhia [8]. The importance of the work is that, unlike most petroarchaeological studies devoted to the Palaeolithic, much attention was paid to rocks other than flint. Particularly, V. F. Petrougne considered the origin of tools made from flint together with other rocks as one complex.

The open-air site of Mira is located in the very centre of continental Ukraine, in the middle flow of the Dnipro River, immediately in its valley (Fig. 1). The site is dated to ca. 32,000–31,000 calibrated years before the present and contains three archaeological layers. Environmentally, during its functioning at the end of Marine isotope stage 3, associated with Bryansk or Vitachiv interstadial [9], the site was located in a low and vast, often flooded river terrace [10, 11]. The surrounding area was rich in various kinds of plant resources, as it is typical for the shallow and swampy edge zones of large continental rivers of the temperate belt and was highly attractive for ungulates during droughts and winters, and, consequently, for the ancient hunters.

The uppermost layer I of Mira is the richest in various evidence of human activity and contains a big number of lithic products, bone industry, charcoals, ashes, and faunal remains. The layer is represented by a well-recognizable, structured area that contains remains of the oldest Upper Palaeolithic surface-dwelling construction in Eastern Europe [12], various pits, and areas of specialized activity. Available archeozoological data are indicative comparatively short seasonal late autumn-winter existence. Mira layer I lithic assemblage enumerates ca. 54,000 pieces. The vast majority of them are represented by flints, besides there is a series of specimens of non-flint rocks, as well. Layer I industry demonstrates the technological and morphological features of local Middle and Upper Palaeolithic. The nearest Middle Palaeolithic analogies are seen in the materials of local and Crimean sites with bifacial tools, while the nearest Upper Palaeolithic analogies are seen in Gorodtsovskaya culture of the Middle Don.

The question of the origin of lithic raw materials used at the site is important for recognizing the features of the economy profile and behavioural pattern of people that left the uppermost layer of Mira. The issue is of special interest because Mira is localized in the area where flint deposits are unknown. The Middle Dnipro area is a region, which is very poor in this material, so flint was mainly brought here for thousands of years (Berezanskaya, S. S., Tsvek, Ye. V., Klochko, V. I., Lyashko, S. N., 1994). The only exception could be alluvial deposits in the Dnipro valley, which are of a primary moraine origin.

Due to the lack of repeatable access to flint raw materials in the nearest area, the site residents had to look for ways to overcome its shortage. This manifested itself in many aspects of lithic assemblage, in particular the intense fragmentation and further splitting of the resulting fragments, the likely use of microflakes as inserts, in the application of the bipolar method, in the exploitation of bifaces as situational cores, etc. [12].

Fig. 1. Mira archaeological site location

For the majority of flint products of Mira, the remote origin is identified. The series of 300 samples of flint and stone artefacts were subjected by V. F. Petrougne to analysing by means of studying immersion samples under a polarising microscope. The examination had allowed stating that the main portion of flint artefacts was made on mostly tabular smoky, greyish smoky, and grey Upper Cretaceous chalcedonoliths of likely Eastern Carpathian origins, their state of preservation suggests collecting on fresh primary outcrops. The next groups of flints, far less significant in number, were defined as Lower Cenomanian apospiculae chalcedonoliths collected in the river Prut valley; as Upper Cenomanian spiculae-inoceramic flints picked up in the river Dniester valley; and as residual-infiltrated Sarmatian flints and opoka-like rocks from the area of river Bakshala mouth in the river South Bug valley [8]. The less fresh state of preservation of the natural surface of these flints points to the likely redeposited nature of outcrops and generally to the random nature of these findings.

Thus, the quantitatively predominant series of flints from the Eastern Carpathian deposits are supplemented by small series of random flint finds from the flint-bearing areas of river valleys between the territory of modern Romania and the river Dnipro. This allows for a presumption of targeted movement of the UP group in a latitudinal direction from west to east, to the valley of a large continental river with rich and predictable biological resources [8].

In V. F. Petrougne's opinion [8], data on the origin of non-flint rocks from layer I of Mira correspond to this scenario. The assemblage contains both local and remote rocks. The paragenetic association of zeolitized tuffs and effusives points to the Carpathian origins of some exotic varieties of non-flint rocks. Sandstone, quartz mylonite-ultramylonite, migmatite or gneiss, and probably quartz diabase, mentioned in the work, are of local provenance.

The problem of the research, performed by V. F. Petrougne, was that the analysis was carried out using an immersion method without producing thin sections or using other laboratory analyses. In view of this, it was decided to re-examine the materials of the Mira site, namely non-flint stone products, which are characteristic of the Middle Dnipro area, in order to clarify the petrographic features and the origin of the stone raw materials that were used.

Purpose. The main goal of the work is to determine the rock composition and origin of raw materials of non-flint stone products found during the study of the Mira Upper Palaeolithic archaeological site in the Middle Dnipro area.

Materials and methods. To conduct petrographic research, seven specimens of stones with traces of processing, found during archaeological excavations of the Mira site, were taken (M1–M7).

From an archaeological point of view, M1 and M2 samples constitute platy stone pieces with clear signs of splitting in free-hand or possibly bipolar techniques. Damages from using it as an anvil are present on the surface of a massive M1 rock fragment. The specimen itself also seems to have been fragmented on an anvil, all its side edges are removed. Platy sample M4 is similar to the abovementioned, and also demonstrates features of intentional knapping and shows recurrent hammerstone damages, as well. M3 is a fragment of a stone with signs of purposeful fragmentation, and sample M5 is also most similar to the product of intentional fragmentation. Sample M6 is likely the product of anthropic modification of an elongated, barely flattened pebble. Most likely, the pebble was fragmented on purpose, as evidenced by specific areas of damage to one of the flat surfaces near the edge of the fragmentation. Impact damages were found on the narrowed end of the original pebble. One of the fragments was used as a hammerstone. The edges of some fragments are polished. Sample M7 is one of the pieces of purposely broken pebble, whose fragments were found in different parts of the site. When the pebble was intact, it was probably used as a hammerstone and retoucher. Some of its fragments, after fragmentation, were also used as tools for retouching and breaking.

The specimens under study were represented by fragments of igneous, metamorphic, and sedimentary rocks, except flint. The transparent thin sections were produced from all the available specimens and the petrographic research using the polarizing microscope POLAM R-312 was performed. The provenance of the rocks was ascertained by comparing them with the thin sections of similar rocks from natural outcrops, the materials of geological survey reports and literary data.

Taking into account the variability of the composition and textural features of the metabasites, a chemical study on the amphibolite sample (M6) was also conducted to compare it with similar rocks of different structures of the Ukrainian Shield. Since the volume of the studied item was small, an X-ray fluorescence analyser (XRF) was used to study its chemical composition. The analysis was carried out in powder, using an ElvaX Plus spectrometer of Analytical Research Laboratory of Dnipro University of Technology, by analyst PhD Geol. Ye. S. Perkov.

To verify the accuracy of the actinolitite (M7) mineral composition determination, the XRD analysis was performed. The research was carried out in the Laboratory of Crystal Chemistry and Structural Analysis of the Institute of Geochemistry, Mineralogy and Ore Formation named after M. P. Semenenko of the National Academy of Sciences of Ukraine, by analyst PhD Geol. O. Ye. Hrechanovska. XRD analysis was carried out using the diffractometer DRON-2 on copper radiation ($CuK\alpha$ = 1.54178 Å). The acquisition was performed in the interval of angles $4 - 65^\circ\ 2\theta$, with a scan step of 0.5 deg/s. For the diagnosis of minerals, a standard file catalogue of the PDF-2 database of the International Center for Diffraction Data (ICDD) 2003 was applied using PCPDF-WIN software. The positions of the diffraction maxima on the X-ray diffraction pattern were compared with the given reference values of the minerals of this database.

Results. As a result of the petrographic analysis of the specimens in thin sections, their raw materials were determined.

Granite. Two specimens of the studied collection were attributed to granites (M1 and M5). Both were identified as two-feldspar aplitoid granites. The mineral composition of the rocks (vol.%) is as follows: plagioclase – 40, microcline – 32, quartz – 27. The texture of the rocks is characterized by the irregular shape of all the main rock-forming minerals, which is why it was identified as allotriomorphic granular (Fig. 2).

The provenance of granites. The veins of similar aplitoid leucocratic granites are found among migmatites of the Middle Dnipro area. Particularly, the rocks are exposed in the valley of the river Dnipro from Kremenchuk to Zaporizhzhia. The vein granites are regarded today as a part of the Paleoarchean Dnipropetrovskyi granitoid complex, but earlier they were considered as a discrete Dniprovskyi complex [13, 14]. Accordingly, these rocks most likely originate from the area of Dnipro rapids, where the Mira site is located.

Dolerite. Specimen M2 was identified as a quartz-containing altered dolerite (diabase). The mineral composition of the rock (vol.%) is as follows: plagioclase – 55, clinopyroxene – 40, ore mineral – 5, micropegmatite (coalescence of feldspar with quartz) – 1, goethite – 1, hornblende – 1, sericite – 1, biotite – <1, chlorite – <1. The texture of the rock is ophitic.

The plagioclase is represented by prismatic crystals with twins. Twins were also found in sporadic grains of clinopyroxene. The pyroxene is slightly altered to hornblende. There are spots of oxidation with a significant admixture of goethite in the centre of many crystals of pyroxene. Plagioclase is moderately altered to sericite and chlorite. Micropegmatite is represented by the intergrowths of feldspar and quartz (Fig. 3).

The provenance of dolerite. Dolerites and their altered species – diabases are quite common rocks in the territory of the Ukrainian Shield. The specific feature of the studied rock is the presence of micropegmatite. The natural outcrops of diabases that contain coalescences of feldspar with quartz were mentioned by I. S. Usenko along the rivers of Mokra Sura and Bazavluk (Usenko, I. S., 1952). Also, according to the data provided by P. H. Verbytskyi (Verbytskyi, P. H., 1952) and the geological survey report by V. M. Gladkiy (1950–1952), the diabase that comprises micropegmatite cropped out in an abandoned quarry in the northwest of Chapli village, on the left bank of the Dnipro River (now residential community Prydniprovskyi of Dnipro city). According to the description, the mineral composition of the rock is as follows: plagioclase, pyroxene, micropegmatite (quartz + potassium feldspar), ore mineral; secondary minerals are sericite, chlorite, biotite, epidote, amphibole, leucoxene, carbonate. Thus, the raw material of the analysed sample may well come from the area of Dnipro rapids.

Arenite (sandstone). In the studied collection, specimen M3 was identified as a fine-grained quartz arenite. 99 vol.% of its framework is composed of quartz. In addition, among clastic grains, less than 1 vol.% of chert, occasional grains of feldspars and individual flakes of muscovite are present. The framework is represented by the grains of angular to rounded shape (the degree of roundness increases with the size of the grains). The size of grains is 0.1–0.8 mm, the great bulk – 0.2–0.3 mm.

There are several types of cement present in the rock, which differ in mineral composition and the type of cementation: contact argillaceous cement (thin layers of hydro-mica scales between the framework grains); porous siliceous cement (chalcedony cement, coloured with an opaque dispersive substance that fills individual pores); regeneration quartz cement (thin rims around clastic grains). The texture of the rock is fine-grained psammitic (Fig. 4).

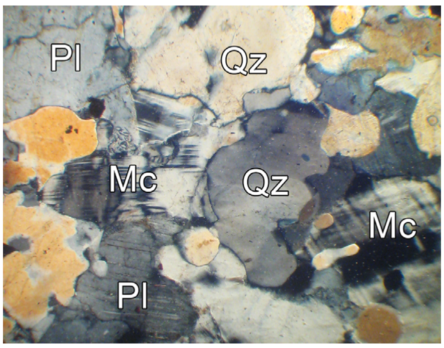

Fig. 2. Granite (M1):

Pl – plagioclase; Qz – quartz; Mc – microcline. Transmitted light, nicols (+), zoom 47ˣ

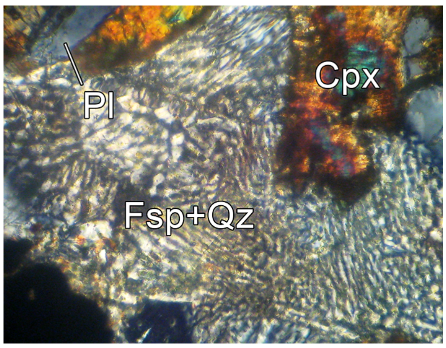

Fig. 3. Micropegmatite in dolerite (M2):

Pl – plagioclase; Cpx – clinopyroxene; Fsp – feldspar; Qz – quartz. Transmitted light, nicols (+), zoom 210ˣ

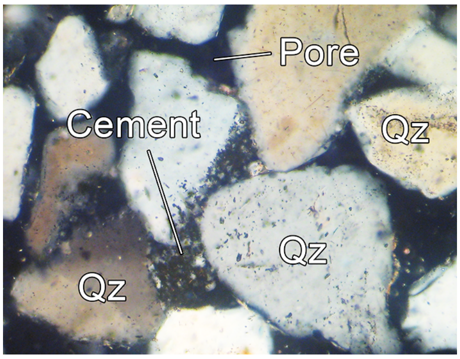

Fig. 4. Quartz arenite (M3):

Qz – quartz. Transmitted light, nicols (+), zoom 210^x

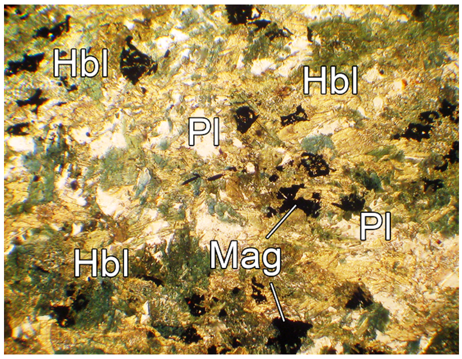

Fig. 5. Amphibolite (M6):

Pl – plagioclase; Hbl – hornblende; Mag – magnetite. Transmitted light, nicols (–), zoom 47^x

The provenance of arenite. Similar rocks are widespread in many regions. The studied specimen is represented by a quartz arenite with argillaceous and siliceous cement. Such sandstones in the Middle Dnipro area belong to the Neogene Poltavska series and are distributed among the sands of the respective series in the form of lenses and boulders in the left bank and south-west parts of Dnipropetrovsk Oblast, as well as in the north-east and central parts of Zaporizhzhia Oblast. The same formations are typical for the Sarmatian sandstones found in the Lower Dnipro area, particularly, in the south of Zaporizhzhia Oblast (Tkachuk, L. G., et al., 1981; Vidergauz, L. M., et al., 1964).

Quartz. Specimen M4 of the studied collection was identified as a quartz rock. It consists of fine- and medium-grained crystals of quartz and has a granoblastic texture.

The provenance of quartz. The quartz most likely belongs to hydrothermal formations that are ubiquitous in the granitoids of the Ukrainian Shield. The nearest big deposit of quartz is a vein in the village of Sholokhove, Nikipol Raion of Dnipropetrovsk Oblast, in the valley of the Bazavluk River that is mentioned in the monograph "Geological Landmarks of Ukraine" (Kalinin, V. I., Hurskyi, D. S., 2007). Besides, quartz can originate from pegmatites that are common both in the Middle Dnipro area and in the Azov Sea area.

Amphibolite. In the studied collection, amphibolite is represented by specimen M6. Based on the structural features, the rock was identified as an apodolerite amphibolite. Mineral composition of the amphibolite (vol.%) is as follows: hornblende – 70, plagioclase – 27, ore mineral – 3, epidote – < 1. The hornblende forms tabular crystals that split at the edges, often fragmented into small columnar crystals. The pleochroism of the mineral is from greenish yellow to bluish green. The hornblende contains inclusions of plagioclase. Often crystals have a sieve-like microstructure, which is characteristic of apogabbro and apodiabase amphibolites. Plagioclase is represented by two species. Tabular and prismatic crystals with twins belong to the first one, and isometric crystals of irregular shape without twins, which include prismatic crystals of hornblende, belong to the second one. Plagioclase with polysynthetic twins is sometimes altered to the aggregate of epidote. The ore mineral forms grains of irregular and angular shape as well as dendrites. Most likely, it is represented by magnetite. The texture of the rock is nematogranoblastic (Fig. 5).

The provenance of amphibolite. In the Middle Dnipro area, amphibolites are quite common, both among the rocks of greenstone structures and migmatites, where they form xenoliths and make up about 10 vol.% of the volume of rocks of the most widespread Paleoarchean Aulska series, in some areas up to 50 vol.% [13, 14]. The amphibolites of xenoliths in granitoids petrographically differ from the studied specimen by sharp margins of hornblende crystals and granulated granoblastic texture. The examined specimen is more similar to the rocks of greenstone formations.

In order to find such varieties, a comparison with the amphibolites from the natural exposures of the Middle Dnipro area was performed, since in ancient times only rocks located near the surface could be used. This was done using a collection of rocks gathered by one of the authors, as well as geological published works and survey reports of the middle of the *20th* century when great attention was paid to the description of natural outcrops.

Usenko I. S., who performed a comparison of the Ukrainian Shield amphibolites that form natural exposures, ascertained that the rocks of different geological structures belong to several stages of magmatism, whose products differ by their chemical features. Thus, he divided all the metabasites of the Ukrainian Shield into two main groups by the total iron, calcium, and magnesium oxides ratio. In the first group, which is less common, the content of iron is approximately equal to the amount of magnesium and calcium; in the second group, which is the most common, the oxides of these elements are contained in a ratio of nearly 1 : 1 : 1 (Usenko, I. S., 1953).

According to the XRF analysis of the amphibolite specimen, the following results were obtained: SiO_2 – 50.86 ± 0.13 %; Fe_2O_3 – 23.99 ± 0.05 %; CaO – 9.73 ± 0.06 %; Al_2O_3 – 8.81 ± ± 0.08 %; TiO – 1.96 ± 0,02 %; Cl – 1.81 ± 0.03 %; MgO – 1.10 ± 0.05 %; Na – 0.8 ± 0.3 %; BaO – 0.39 ± 0.07 %; MnO – 0.30 ± 0.01 %; P_2O_5 – 0.20 ± 0.01 %; K_2O – 0.04 ± 0.00 %; S – < 0.01 %.

Though the XRF analysis does not allow obtaining separate rates for divalent and trivalent iron, the high rate of Fe_2O_3, registered in the rock, even converted to FeO (multiplied by the coefficient of 0.9), surpasses the total content of magnesium and calcium.

According to the data provided by I. S. Usenko, metabasites with such chemical characteristics are the metadolerites (epidiabases) of the river Saksahan, amphibolites of the river Inhulets, albitised amphibolites of the Mokra Sura River, orthoamphibolites of the rivers Hiskyi Tikych and Hnylyi Tikych (Cherkasy Oblast), amphibolites of the Azov Sea area that expose along the river Berda in the zone where the river Karatysh flows into it.

As a result of the direct comparison of chemical analyses, it was ascertained that the most similar to the studied sample are amphibolites of the Kryvyi Rih Basin, among which there exist the species with a high content of iron and minimal percent of magnesium. However, among these rocks, epidiabases of Saksahan differ from the studied specimen by their blastoophitic texture, and amphibolites of the Inhulets River, despite some similarities in thin sections, have recrystallized and granulated plagioclase. Orthoamphibolites of the rivers Hirskyi Tikych and Hnylyi Tikych differ from the examined sample by their texture and pyroxene content. Amphibolites that expose along the Berda River in the Azov Sea area and have similar features of chemical composition are chloritized species that contain a high rate of magnetite. According to the data provided by I. S. Usenko, the only rocks from the Mokra Sura River, namely amphibolites occurring near the village

Novomykolaivka, are somewhat similar to the studied amphibolite specimen by their petrographic features (Usenko, I.S., 1953).

However, as a result of the comparison of the specimen with the collection of the Middle Dnipro area amphibolites, including rocks from the village Novomykolaivka, it was ascertained that the most similar were the amphibolites of the middle stream of the Bazavluk River. Nevertheless, these rocks also have differences: their hornblende is actinolitized; these are spotty white and black rocks in contrast to the studied sample, which is almost black and fine-grained. Moreover, the main thing is that the rocks have different features of chemical composition.

Thus, there are amphibolites similar to specimen M6 in the region where it was found, primarily amphibolites from the Mokra Sura River. However, we currently do not have any evidence that could entirely prove the local origin of the specimen. The analysis is greatly complicated by the fact that the studied artefact is more than 30,000 years old, since even in half that time, any natural exposure of rocks can turn into eluvium as a result of weathering.

Actinolitite. Specimen M7 was identified as an actinolitite. The mineral composition of the rock (vol.%) is as follows: actinolite – 75–80, chlorite – 15–20, plagioclase – 3–5, sphene – 1, ore mineral – < 1, epidote (clinozoisite) – < 1, quartz – singular grains. The texture of the rock is nematolepidogranoblastic, apodoleritic. Actinolite forms tabular and elongated crystals that split at the edges. It is of a light green colour and pleochroism. Most likely, actinolite belongs to the weakly ferruginous variety. It is possible that tremolite is present in the composition of the rock, in admixture with actinolite. There are grid-like aggregates of actinolite and chlorite, which can be the pseudomorphs formed as a result of altering the tabular crystals of pyroxene. Chlorite (clinochlore) is represented by the aggregates of scaly crystals with anomalous brownish colours of interference under crossed nicols. Plagioclase forms relict prismatic crystals, which in many cases are altered to chlorite and epidote (Fig. 6). The sphene is found in the form of irregular-shaped grains, surrounded by margins of secondary alteration. Quartz is represented by singular grains of isometric shape.

As a result of the XRD analysis, the following phases were detected: chlorite – clinochlore, amphibole – actinolite and plagioclase – albite (Fig. 7).

The provenance of actinolitite. Actinolitites are common enough rocks in the area of the Ukrainian Shield. They are also widespread in younger structures where they are formed as a result of the metamorphism of ultrabasic magma products.

The Middle Dnipro area and the Azov Sea area are the regions of the highest abundance of ultramafic rocks in the Ukrainian Shield. Usually, actinolitites form geological bodies simultaneously with other products of ultramafic rocks alteration, such as tremolitites, talc, chlorite and amphibole schists, as well as transitional varieties.

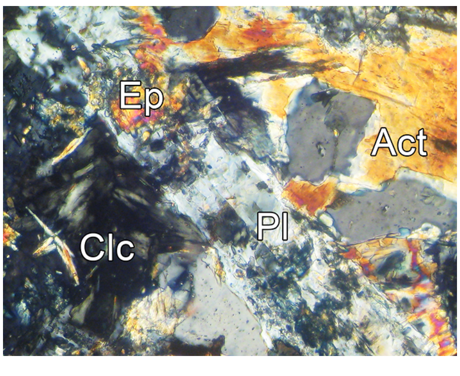

Fig. 6. Actinolitite (M7):

Pl – plagioclase; *Act – actinolite*; *Clc – clinochlore*; *Ep – epidote*. *Transmitted light*, *nicols* (+), *zoom 210*^{x}

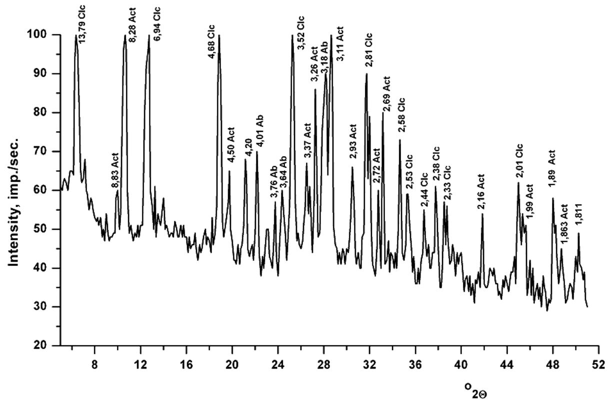

Fig. 7. X-ray diffraction pattern of actinolitite (M7):

Act – actinolite; *Clc – clinochlore* (*chlorite*); *Ab – albite* (*plagioclase*)

In the area of the artefact find (south of Dnipropetrovsk Oblast, north of Zaporizhzhia Oblast), outcrops of actinolitites were recorded in numerous materials of geological surveys led by A.G. Vinogorodskiy (1960), A.V. Tymoshenko (1962), A.A. Zaitsev (1968), V.F. Kiktenko (1968), M.V. Kushinov (1983), V.V. Sukach (2006). In addition, the petrographic features of exposed actinolitites are described in the literature.

Today, in the south of Dnipropetrovsk Oblast the most preserved among occurrences of actinolitites are the dikes of meta-ultrabasites of the river Bazavluchok. According to the data of geological survey led by A.G. Vinogorodskiy during the field research, dikes were met in the vicinity of the place, where the Bazavluchok River flows into the Bazavluk River. The content of amphibole in meta-ultrabasites (actinolite or tremolite) can be up to 95 vol.%. Also, they comprise talc, antigorite, biotite, carbonates, quartz, plagioclase, sphene, pyrite and magnetite. The texture of both actinolite and tremolite rocks is nematoblastic. Today, most of the mentioned outcrops are flooded due to the construction of a reservoir on the Bazavluchok River. We found only the actinolite vein that was mentioned in the report and is located in the gully that flows into the Bazavluchok River on the left side near the village of Novoivanivka. But the specified rock is represented by coarse-grained variety with tabular amphibole and almost unchanged plagioclase, which does not correspond to the studied sample.

Outcrops of actinolitites along the Chortomlyk River were recorded by I.S. Usenko in the middle of the *20*th century. In their composition, the share of actinolite accounted for more than 98 vol.%, secondary minerals were carbonates, ilmenite, intensively altered into titanite, as well as chlorite formed as a result of actinolite alteration. The texture of the rock is fan-shaped, porphyroblastic (Usenko, I.S., 1953). To date, the outcrops have not been preserved.

According to M.V. Kushinov's report, which was based on the drilling data, actinolite rocks are found in the Chortomlyk greenstone structure in the valley of the Bazavluk River. Mineral composition of the rocks (vol.%) is as follows: actinolite – 70, chlorite-plagioclase mass – 30, magnetite, accessory minerals: tourmaline, ilmenite, rutile, sphene, leucoxene, garnet, apatite et al. The texture of the rocks is nematoblastic, nematogranoblastic, and lepidogranoblastic.

According to the survey data by V.F. Kiktenko, meta-ultrabasites, including actinolitites, were found in the valley of the Mokra Moskovka River in the Peredatochne granite quarry in Zaporizhzhia city. The body of ultrabasites is represented by peridotite, serpentinite, talc-anthophyllite rock, tremolitite, and actinolitite. Mineral composition of actinolitite is as follows: actinolite – 97–100 vol.%, biotite, magnetite.

The nearest occurrence of actinolitite to the place of the archaeological excavations (15 km to the north) is the body of ultrabasites that lies close to the surface in the gully of Serednia Khortytsia on the right bank of the Dnipro River near the city of Zaporizhzhia. Actinolitites consist of actinolite (85–98 vol.%), carbonate, biotite, chlorite, epidote and ore mineral. The texture of the rocks is nematoblastic.

Except for the Middle Dnipro area, actinolitites are common in the Azov Sea area. Here, chlorite actinolitites expose in many meta-ultrabasite occurrences. The main mineral of the rocks is actinolite, partly altered to tremolite and clinochlore. Among ore minerals, magnetite and pyrite are present (Usenko, I. S., 1953).

As it is clear from the foregoing descriptions, the most akin to the studied specimen of actinolitite are the rocks of the Chortomlyk structure described by M. V. Kushinov. Particularly, they contain relict plagioclase altered by chlorite and partly the same minor minerals. However, these rocks were found as a result of drilling, and today they do not expose to the day surface. The rocks of the same structure in outcrops were earlier described by A. G. Vinogorodskiy. The last description is very generalized. Today the mentioned outcrops of the river Bazavluchok are intensively weathered. However, we have specimens of actinolitite from this area taken from local archaeological sites. The specimen with similar mineral composition has textural differences such as granulated plagioclase in contrast to the prismatic blades in the specimen under study. The rest of the actinolitites of the Middle Dnipro and the Azov Sea areas have more significant petrographic differences. Therefore, despite the variability of the composition of such rocks, the outcrops of absolute analogues are not recorded. Besides, since the rock is represented by a pebble, the local origin of the specimen should be considered with caution.

Discussion. Comparing the results obtained in the current research with the findings of the analyses performed by V. F. Petrougne [8], we should note that most of the conclusions coincide. Particularly, it concerns the provenance of the sandstone (M3). The same are the conclusions about the origin of the dolerite (diabase) (M2), which most likely originates from the northern part of the Dnipro Rapids area. However, dolerites with micropegmatite are also common in the valleys of the Bazavluk and Mokra Sura Rivers. Owing to its wide prevalence, the provenance of the quartz rock specimen (M4) can be both local and delivered.

The petrographic analysis allows the authors to correct some conclusions by V. F. Petrougne, who studied rocks without producing thin sections. Concerning granitoids (M1 and M5), V. F. Petrougne provides a description of gneiss or migmatite, most likely the leucosoma of migmatite represented by biotite plagiogranite (trondhjemite). As a result of our analysis, it was ascertained that the specimens are represented by two-feldspar leucogranites. Nevertheless, granitoids in our opinion, as well as in the opinion of V. F. Petrougne, have the same provenance.

We made adjustments to the definition of amphibolite (M6). The amphibolite described by V. F. Petrougne has a heteronematoblastic texture, it is composed of prismatic hornblende crystals, often with micro-inclusions of magnetite, rare scales of biotite, as well as single grains of quartz and plagioclase. In the thin section observed by us, there was no biotite or quartz detected, though, the epidote was present. Probably, it relates to the size of the thin section. V. F. Petrougne ascertained the provenance of the amphibolite as Carpathian, namely from the area of Chyvchynski Mountains, where the rocks of the Maramures crystalline massif, located in the territory of Ukraine and Romania, occur.

It should be noted that the rock described by V. F. Petrougne is very close by its mineralogical and petrographic features to the amphibolites of the Chyvchynski Mountains. These rocks consist of amphibole, plagioclase, quartz, epidote, contain biotite and other secondary and accessory minerals. The texture of the amphibolites is nematoblastic, granonematoblastic, sometimes in combination with a poiciloblastic. According to O. I. Matkovskiy, these rocks were formed as a result of the metamorphism of lenticular bodies or the dikes of basic rocks of a gabbro-diabase or a diabase type (Matkovskiy, O. I., 1971).

According to our data, sample M6 has both common features and differences with the amphibolites typical for the Chyvchynski Mountains. The common features are the genesis of rocks as a result of gabbro or diabase alteration (based on the fine-grained texture, the alteration of dolerite), resulting in similarities of texture features. Among common features are also the high content of hornblende (approx. 70 vol.%), the presence of two plagioclase types and the epidotization of feldspar.

Among the differences, we should mention chemical features, as well as the absence of quartz, biotite, and other secondary and accessory minerals except for epidote. By its petrographic and chemical features, the studied specimen is closer to the amphibolites of the Mokra Sura River in the Dnipro Rapids area. However, today we do not have evidence that would allow us to reject other variants of the origin of this rock. For example, such fine-grained black amphibolites were noted by V. M. Chirvinskiy among the boulders of the glacial moraine (Chirvinskiy, V. M., 1914). Thus, the studied rock can originate both from the area of the Ukrainian Shield and from other regions. By several features, it indeed can be of Carpathian provenance, but, at the same time, because of the abundance of such rocks, this statement cannot be unambiguous.

The studied specimen of actinolitite (M7) was determined by V. F. Petrougne as of Carpathian origin. In particular, he suggested that the rock might come from the Rakhiv massif. However, it should be noted that, according to the literary data, the characteristic ultrabasites of the Rakhiv massif are represented by serpentinites (Tkachuk, L. G., Gurzhiy, D. V., 1957), and among actinolite-containing rocks, only actinolite schists were mentioned (Matkovskiy, O. I., 1971). In the Eastern Carpathians, in the territory of Romania, ultrabasites are represented by hornblendites that form xenoliths in agmatites (Oncescu, N., 1960). It is likely that V.F. Petrougne had a collection of rock specimens from the Carpathians, which enabled him to draw such a conclusion. In our opinion, analogues of actinolitites similar to the sample under study can be found in the territory of the Ukrainian Shield; however, because of the poor exposure of these rocks, and the fact that the studied sample is a pebble, it cannot be explicitly stated that it does not originate from another area.

The location of places in the Middle Dnipro area, where the local stone materials could originate from, including similar but not identical rocks, is shown in Fig. 8.

Conclusions. As a result of the petrographic study, it was established that the stones with traces of processing, found during excavations of the Upper Palaeolithic Mira site, are represented by the aplitoid two-feldspar granites, altered dolerite, quartz arenite, quartz rock, amphibolite and actinolitite. All the mentioned rocks are typical for the Middle Dnipro area. The specimens of the granites, dolerite, and arenite, by

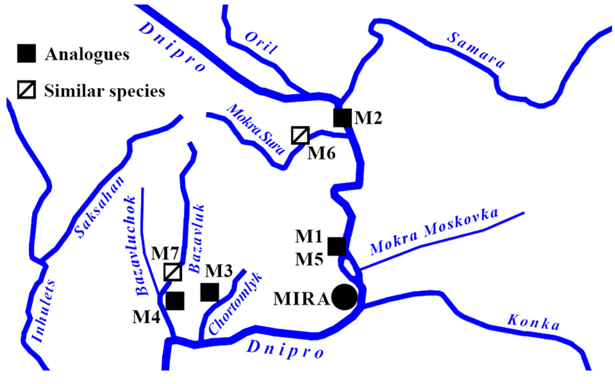

Fig. 8. Probable places of origin of the studied samples

their petrographic features, have analogues among the rocks of the region and, more likely, are of the local provenance. Most likely, the quartz sample comes from the territory of the Ukrainian Shield. The types of amphibolite and actinolitite, which are analogous to the studied artefacts by their petrographic and chemical features, do not occur today among the rocks, which form natural outcrops in the Middle Dnipro area. Thus, the specimens of the amphibolite and actinolitite may have both local and different origins. More accurate determination of the provenance of the amphibolite and actinolite samples requires further study involving sample collections from other regions, wherefrom these rocks could be carried.

The materials of the Mira site are the earliest petrographically proven evidence of the Middle Dnipro area rocks use, primarily the crystalline rocks of the Ukrainian Shield. Thus, today we can state that the beginning of the development of stone raw materials of this region began in the Upper Palaeolithic by ancient hunters, who, in addition to flint, began to collect and process rocks found in the area of their inhabitation, hunting grounds, as well as migration routes.

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Про найдавніше свідчення використання некрем'яних гірських порід Середнього Придніпров'я

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Мета. Визначення породного складу й походження сировини некрем'яних виробів з каменю, що були знайдені при дослідженні верхньопалеолітичної археологічної стоянки Міра в Середньому Придніпров'ї.

Методика. Дослідження артефактів було виконане за допомогою мінералого-петрографічного методу. Гірські породи вивчалися у прозорих шліфах із застосуванням поляризаційного мікроскопу. Для перевірки точності петрографічного аналізу деяких зразків були застосовані методи рентгеноструктурного й рентгенофлуоресцентного аналізів. Визначення походження гірських порід було виконано із застосуванням порівняльного мінералого-петрографічного аналізу, для чого були використані шліфи зразків із природних відслонень, матеріали геологічної зйомки й літературні дані.

Результати. Для виконання петрографічного дослідження було взято сім зразків каменів зі слідами обробки, знайдених під час археологічних розкопок верхньопалеолітичної стоянки Міра. У результаті проведеного петрографічного дослідження встановлено, що каміння зі слідами обробки представлене аплітоподібним двопольовошпатовим гранітом, зміненим долеритом, кварцовим пісковиком, кварцовою породою, амфіболітом і актинолітитом. Усі зазначені породи характерні для Середнього Придніпров'я. Зразки гранітів, долериту й пісковику, за петрографічними особливостями, мають аналоги серед порід регіону і, найвірогідніше, є місцевими. Найімовірніше, із території Українського щита походить зразок кварцу. Відміни амфіболітів та актинолітитів, що є аналогічними сировині досліджених артефактів, за петрографічними й хімічними особливостями, серед порід, що утворюють природні відслонення у Середньому Придніпров'ї, на сьогодні не проявлені. Таким чином, зразки амфіболіту та актинолітиту можуть мати як місцеве, так і інше походження. Для більш точного визначення походження зразків амфіболіту та актинолітиту необхідне проведення додаткового дослідження із залученням колекцій зразків з інших регіонів, звідки ці породи могли бути привезені.

Наукова новизна. Уперше кам'яні артефакти з верхньопалеолітичної стоянки Міра були досліджені у шліфах та із застосуванням рентгеноструктурного й рентгенофлуоресцентного аналізів, що дозволило отримати більш точну інформацію щодо їх петрографічних особливостей і походження. Досліджувані зразки мають велике значення, оскільки на сьогодні вони є найдавнішими некрем'яними кам'яними артефактами з Середнього Придніпров'я, зокрема, зробленими з кристалічних порід Українського щита, що були досліджені за допомогою петрографії.

Практична значимість. Отримані результати можуть бути використані при виконанні досліджень з археології та історії гірництва, а також при написанні науково-популярних праць.

Ключові слова: *кам'яні артефакти, археологічна петрографія, ранній верхній палеоліт, Міра, Україна*

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