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THE MATERIAL PROVENANCE OF POLOVTSIAN STONE STELAE EVACUATED FROM DONETSK REGION

Purpose. Based on the results of mineralogical and petrographic study of the raw materials of Polovtsian stone statues evacuated to Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi from the territory of Donetsk region, to establish the name and origin of this raw materials.

Methodology. The study was conducted using petrographic analysis of the material of stone statues in transparent thin sections with a polarizing microscope. The mineral composition of sandstone cement, if possible, was studied using X-ray structural analysis, for which oriented preparations were made. The results obtained after conducting mineralogical and petrographic analysis were compared with the features of similar rocks from various deposits and occurrences of Donetsk and Dnipropetrovsk regions, using thin sections of rocks from natural outcrops and previously studied Polovtsian stone statues, as well as literary data.

Findings. As a result of the study of 14 stone statues, it was found that 12 of them were made of sandstones with polymineral clastic material and cement, containing a significant part of rock fragments. According to the percentage ratio of quartz fragments and rock fragments, the rocks were defined as quartz, sublithic and lithic arenites. The cement is of a relict nature, most of the clastic grains are connected without cement as a result of dense compressing. Two samples from the studied collection have clastic material completely composed of quartz, cemented by siliceous cement, which has undergone hypergenic processes, and a matrix of smaller quartz grains. Sandstones of the largest group are characteristic of the Carboniferous deposits of the Donets Coal Basin, which form deposits and numerous occurrences in the territory of Donetsk region, from where they were brought. Two samples of quartz sandstones, which differ from the rest of the samples, most likely belong to Neogene sediments that form deposits in the east of Dnipropetrovsk region, as well as in Donetsk region.

Originality. For the first time, a petrographic study in thin sections has been conducted on Polovtsian "stone babas" relocated from the east of Donetsk region to the city of Dnipro.

Practical value. The information obtained is important for further archaeological and art historical research on the stone statues. Information on the mineral composition and preservation of the sandstone cement is important for restoration work.

Keywords: *Polovtsian "stone babas", sandstones, petroarchaeology, Donets Basin, Dnipro-Donets Aulacogen*

Introduction. Mineralogical and petrographic methods are widely used today not only in purely geological research. They are an important way of cognition in many other fields of knowledge, one of which is archaeology. Today, with the help of mineralogical and petrographic research, many important facts from the history of the use of stone raw materials in Ukraine have been clarified: the routes of supply of stone products and the locations of ancient mining centres have been established, the features of the use of various types of rocks from the time of the arrival of the first people to modern era have been determined.

One of the most well-known archaeological objects in Ukraine, particularly in the steppe zone, are the Polovtsian stone statues, the so-called "stone babas". The Polovtsians, also known as the Kipchaks or Cumans, were a Turkic nomadic people who controlled a significant part of the Eurasian steppes during the *11th–13th* centuries CE. Considering their nomadic lifestyle, the Polovtsians did not leave many archaeological immovable monuments (mainly sanctuaries and burial mounds), which is why the "stone babas" are one of the most important sources for studying their material and spiritual culture. In addition, researchers today use the locations of stone sculptures and burial mounds to determine the places of settlement and the routes of nomads' migration [1, 2].

The world's largest collection of Polovtsian monumental stone sculpture is currently stored in Dnipropetrovsk National Historical Museum named after

D. I. Yavornytskyi. The creation of the collection was initiated in the first half of the *20th* century by the then director of the museum, the famous archaeologist D. I. Yavornytskyi, who delivered Polovtsian stone statues from various parts of the then Katerynoslav governorate, which included part of the Donets Coal Basin (Donbas). This allowed preserving many statues that were the subject of collecting at that time [3]. In 2023–2024, a number of stone statues were received by the museum for temporary storage from the combat zone in the Donetsk region. Usually, they had losses and damages of varying degrees, including from modern weapons. Accordingly, the restoration and preservation of the Polovtsian "stone babas" required information about their material, in particular about the mineral composition and degree of weathering of the rocks. In addition, petrographic analysis could provide information about the possible origin of the statues' raw materials, and accordingly, the place where they were made by ancient craftsmen.

This article presents the results of completed mineralogical and petrographic analysis of the collection of Polovtsian stone sculptures, that were evacuated to Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi from the combat zone in Donetsk region.

Literature review. Petrographic methods are widely used today in the study of ancient large-scale sculptures. Among the latest such studies, a number of petroarchaeological works can be noted. So, French researchers P. Bromblet and L. Leroux studied the composition and determined the provenance of the two types of stone raw material that were used in sculpture of the Ancient Roman city of Narbo Martius (Narbonne, France). They turned out to be marine bioclastic Miocene and lacustrine Oligocene limestones. The authors also identified ancient quarries in the area of the city, from which stone blocks could have been supplied [4].

Another study, this time concerning a stone stele of the Eneolithic-Bronze Age, is the work by a team of Hungarian and American authors, devoted to the study of the Kevermes stele from the Pannonian Plain (Hungary). The authors used petrographic and several other research methods, which allowed them to more accurately characterize the rock and determine its origin. The material of the Kevermes stele was determined as a metamorphic rock altered under greenschist facies conditions. The protolith of the stele material was alkaline mafic or intermediate-mafic pyroclastic rock. According to the authors, the most likely region of origin of the stele is the Serbo-Macedonian massif within the Balkan Peninsula [5].

Petrographic analysis was used in the study of the material of sculptural works of the archaeological site of the Mayans – the abandoned city of Calakmul (Mexico). The researchers found that the rocks used are highly recrystallized limestones-biosparudites with the presence of reef and shallow-water bottom fauna, which, in addition to calcite, contains a certain amount of dolomite. The source of stone raw materials was several deposits in the region [6].

The raw material of the Polovtsian "stone babas" was studied by S. O. Pletneva. She examined all known Polovtsian "stone babas" as of the second half of the *20th* century and concluded that the main material for their manufacture was grey fine-grained sandstone. This raw material was actively used throughout the territory of the Polovtsians from the Middle Dnipro region to the Volga River basin, except for Crimea; limestones and granites were used less often (Pletneva, S. O., 1974). J. R. Daszkiewicz and E. Tryjarski conducted the first petrographic research on the material of Polovtsian stone statues in thin sections. They studied statues from the collection of the Biosphere Reserve "Askania-Nova" (Kherson region). A total of 17 samples were examined. According to the results of the study, it was established that the material of the "stone babas" was marl, limestone and granite. The authors suggested that the material for the three granite statues was the granite of Tokivskyi complex in Dnipropetrovsk region, although the use of granites by the Polovtsians is more typical for the Azov Sea region. The remaining materials, according to the authors, came from the Northern Black Sea region, which we can agree with [7].

Also, the material and origin of the Polovtsian stone statues are determined in the works by L. S. Geraskova. According to her, among the stone stelae, the largest group was produced of sandstones of the Carboniferous system. Less often, according to L. S. Geraskova, Devonian, Permian and Neogene sandstones were used. Limestone statues, according to her, were made of rocks of the Carboniferous, Upper Cretaceous, Paleogene and Neogene systems, granite stelae from the Azov Sea region are also noted [8, 9].

The study of Polovtsian "stone babas", in particular from Donetsk region, was carried out by the Polish researcher Aneta Gołębiowska-Tobiasz. The peculiarity of her monograph is that the phenomenon of Turkic anthropomorphic sculptures was considered from the point of view of archeology and restoration. The work considers the issue of the distribution of stelae, the evolution of their canon and attribution. Attention is paid to the latest hypotheses regarding the function of sculptures in relation to beliefs, social and political spheres [10].

Petrographic studies of the raw materials of Polovtsian stone statues were conducted by one of the authors of this article together with colleagues. Almost all the statues from the collections of Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi and Poltava Museum of Local Lore named after V. Krychevskyi were examined [11, 12]. According to the results of both studies, it was determined that most of the statues, the material of which was studied, were made of sandstones of the Carboniferous system of the Donets Basin. The material for the manufacture of some statues from the collection of Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi was ferruginous sandstone of the Permian period from the same region. The raw material for most Polovtsian stone statues made of limestone comes from the Middle Dnipro region. The quartzite-like sandstone from which several "stone babas" found in the Left Bank area of Dnipropetrovsk region were made may come from both the Neogene sandstone deposits in the Left Bank area and from deposits of rocks similar in composition and origin found in the Donets Basin. The only "stone baba" found in situ in the Left Bank area, in Synelnykove raion of Dnipropetrovsk region, was made of difeldspar gran-

ite, similar to those that are exposed along the Vovcha River. This statue can be attributed to the Azov centre, where granite was the main material for making "stone babas" [11].

Actuality. Polovtsian stone statues possess great cultural and historical value and require preservation. No less important is their study, which utilizes all available scientific methods, not limited to art history and typological analysis. Performing a petrographic study of the rocks of stone sculptures makes it possible to establish the provenance of their raw materials, and accordingly, to determine the areas of their production. Additionally, petrographic analysis is crucial for the further restoration of statues and for determining the optimal approaches to their preservation.

Purpose. Based on the results of mineralogical and petrographic study of the raw materials of Polovtsian stone statues, to establish the name and origin of their raw materials.

Methodology. For the study, 14 rock samples were provided, taken from Polovtsian stone statues (Fig. 1).

The sampling was performed from the underground part of the statues ("heel"), that was buried when they were installed, or from the damaged zones. The sample size was minimal to produce transparent thin sections. The study was carried out using a POLAM R-312 polarizing microscope.

To determine the provenance of the raw material of the stone statues, the results obtained were compared with the geological data contained in the materials of the primary geological survey and published works. The studied samples were also compared with thin sections of similar rocks from outcrops and with thin sections of the raw material of other Polovtsian stone statues.

Fig. 1. Anthropomorphic female statue, seated (Polovtsian "stone baba") (sample 2)

For a more accurate determination of clay cement in one of the samples, the XRD analysis was performed. For this, the cement was extracted by grinding the rock and adding distilled water in a proportion of 4 mL per 1 g. After settling for 15 minutes, the upper layer, containing the tiniest particles, was collected using a pipette. Three oriented samples (thermally treated, glycol-impregnated, and conventionally sedimented) were prepared from this substance.

The XRD analysis was performed in the Laboratory of Phase, Structural, Textural and Geochemical Research of the Faculty of Geology, Geophysics and Environmental Protection of the AGH University of Krakow (Poland) on a RIGAKU diffractometer (Cu radiation, 9 kV). The X-ray diffraction patterns were interpreted by the analyst O. Ye. Grechanovska.

Results. As a result of the study of the raw materials of the stone statues, the rocks from which they were made were determined. The Table provides a complete list of the studied statues and the names of the rocks that served as the material for their production.

The material of all the statues studied was sandstone. All the samples studied can be divided into two groups. The first of them includes sandstones with polymineral clastic material, mainly quartz and rocks, and cement of various compositions (1, 4–14) (Fig. 2).

The second group includes the remaining samples (2–3), the clastic material of which is almost entirely composed of quartz. In samples 2 and 3, the cement was almost not preserved due to the weathering of the rocks. It is possible that it had a predominantly siliceous composition (remnants of chalcedony cement are present in sample 3). Also, the sandstones of these two groups differ in that in the first, the connection of clastic grains with each other most often occurs directly, without cement, and the cement, represented by other minerals, usually fills the pores, being relict. Unlike the first group, in the second group quartz grains are also connected directly, but not so densely compressed, have a well-rounded and subrounded shape, in addition, syntaxial overgrowths of quartz are present.

Among the rock fragments in the composition of the detrital material, in samples 1, 4–14, there are fragments of chert and siliceous schists, polycrystalline quartz (microquartzite), volcanic rocks, argillite, quartzite and micaceous quartzite. Among the mineral fragments, in addition to quartz, there are plagioclase, muscovite, microcline, siderite and zircon. The size of the fragments of different rocks of the group is from fine-grained to coarse-grained, mainly medium-grained and medium-coarse-grained. In this group, samples 1 and 13 were identified as quartz sandstones (quartz arenites) due to the quartz content of more than 90 % of the volume of the detrital material. Samples 11 and 14, on the contrary, were identified as polymictic sandstones (lithic arenites) due to the reduced quartz content. The remaining rocks of the group were identified as oligomictic sandstones (sublithic arenites).

In addition to the connection of clastic grains without cement, in the first group of sandstones the cement is mainly porous, more rarely basal. The mineral composition of the cement is as follows: argillaceous-siliceous (illite-chalcedony), porous, rarely basal; argillaceous (kaolinite); siliceous (chalcedony); hydromica

Table

Studied Polovtsian stone statues

No.	Name	Measurements, cm	Place of discovery	Material
1	Anthropomorphic male statue, standing (head missing)	207 × 58 × 40	Velyka Novosilka, Volnovakha raion, Donetsk region	Quartz sandstone with relic argillaceous-siliceous cement
2	Anthropomorphic female statue, seated	120 × 60 × 48	Velyka Novosilka, Volnovakha raion, Donetsk region	Quartz sandstone
3	Anthropomorphic statue, the upper part to the waist	88 × 42 × 24	Velyka Novosilka, Volnovakha raion, Donetsk region	Quartz sandstone
4	Fragment of an anthropomorphic male statue: upper part to buttocks	210 × 70 × 60	Velyka Novosilka, Volnovakha raion, Donetsk region	Oligomictic sandstone with relic argillaceous-siliceous cement
5	Fragment of an anthropomorphic seated male statue: lower part from the waist	91 × 66 × 60	Andriivka, Volnovakha raion, Donetsk region	Oligomictic silty sandstone with relic argillaceous-siliceous cement
6	Anthropomorphic male statue, standing (head of uncharacteristic shape)	167 × 60 × 37	Zolotyi Kolodiaz, Pokrovsk raion, Donetsk region	Oligomictic sandstone with mixed argillaceous and argillaceous-siliceous cement
7	Fragment of an anthropomorphic female statue: upper half	78 × 50 × 40	Zolotyi Kolodiaz, Pokrovsk raion, Donetsk region	Oligomictic sandstone with argillaceous, siliceous, and ferruginous cement
8	Anthropomorphic male statue, seated (head missing)	180 × 53 × 40	Zolotyi Kolodiaz, Pokrovsk raion, Donetsk region	Oligomictic sandstone with fragments of rocks and siliceous-argillaceous cement
9	Anthropomorphic female statue, standing (head missing)	170 × 63 × 46	Konstantynopol, Volnovakha raion, Donetsk region	Oligomictic sandstone with siliceous-argillaceous pore-filling cement
10	Fragment of an anthropomorphic male statue: upper part, bust	80 × 53 × 29	Konstantynopol, Volnovakha raion, Donetsk region	Oligomictic sandstone with mixed cement
11 (13)*	Anthropomorphic male statue, seated	273 × 70 × 41	Shakhivka village council, Pokrovsk raion, Donetsk region, nature reserve Hektova Gully	Polymictic sandstone with polymineral cement and pebble inclusions
12 (11)*	Anthropomorphic female statue, on a flat slab; arms and legs missing, with no traces of their former presence	177 × 65 × 25	Hrodivka settlement council, Pokrovsk raion, Donetsk region	Oligomictic sandstone with argillaceous cement
13 (12)*	Anthropomorphic male statue, seated	298 × 75 × 50	Between the villages of Petrovske and Yuriivka, Kryvorizke community, Pokrovsk raion, Donetsk region	Quartz sandstone with relic siliceous-argillaceous cement
14	Fragment of an anthropomorphic statue, seated: lower part from the pelvis	115 × 60 × 38	Oleksandrivka settlement council, Kramatorsk raion, Donetsk region	Polymictic sandstone with ferruginous-argillaceous cement

* in brackets – number in the museum catalogue of temporary storage

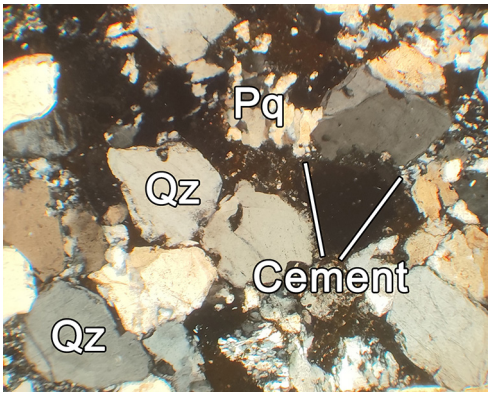

Fig. 2. Oligomictic sandstone with argillaceous, siliceous, and ferruginous cement (sample 7):

Qz – quartz, Pq – polycrystalline quartz (microquartzite). Transmitted light, nicols (+), zoom 47x

(illite); siliceous-ferruginous (chalcedony-goethite); ferruginous (goethite); ferruginous-argillaceous-siliceous (goethite-illite-chalcedony), porous; illite-chalcedony and illite-kaolinite.

For a more accurate determination of the clay component of the cement, an XRD analysis of oriented preparations made from sample 1 was carried out, the size of the collected fragment of which allowed obtaining a sufficient amount of material. Fig. 3 presents the X-ray diffraction patterns of the indicated oriented preparations. The phase composition of the clay fraction is represented by kaolinite $Al_2Si_2O_5(OH)_4$ (reflexes 001 and 002) and palygorskite $Mg_5Si_4O_{10}(OH)_2 \cdot 8H_2O$ (the most intense lines are observed on the roentgenogram).

In samples 2–3, in which almost 100 % of the rock volume is quartz, only in sample 2 about one percent of the rock volume is occupied by quartzite. Both samples were determined as quartz arenites. According to the

size of the clastic grains, they belong to medium-grained.

Cement in samples 2–3 is almost absent due to weathering of rocks. Pores are present in place of cement. In sample 2, thin syntaxial overgrowths are sometimes observed. In sample 3, in some areas between coarser grains, several grains of smaller size are located, being a matrix (Fig. 4).

Provenance of rocks and discussion. Sandstones with polymineral composition of fragments and subangular grains (1, 4–14) are most characteristic of geosynclinal zones. Almost monomineralic sandstones with rounded and subrounded grains (2–3) are most often formed on platforms.

The geosynclinal zone in the area where the stone statues were delivered from is the Donets folded structure. Platform formations in this zone are represented by Cenozoic deposits, distributed to the east and northeast of the Open Donbas in the Dnipro-Donets Aulacogen zone, as well as in the Southern Dnipro region. The Donets folded structure, where Palaeozoic and Mesozoic rocks come to the surface, forms the central part of the Donets Coal Basin. The Donbas is a carboniferous depression that extends for a length of more than 650 km from the Left Bank Area of the Dnipro River to the lower reaches of the Don River. The formation of the Donets Basin strata began in the Palaeozoic. The oldest deposits of the Donets depression are the Middle Devonian terrigenous-carbonate formations. The crystalline basement in the Donbas zone lies at considerable depths, rising towards the Pryazovskyi megablock of the Ukrainian Shield. In the central part of the basin, an effusive-sedimentary formation with basalt covers dating from the Riphaean – Early Palaeozoic is assumed.

The Devonian deposits include carbonate-terrigenous formations of the Upper Devonian with basalt covers near their base. The Carboniferous deposits of the Donets Basin are represented by a complete section of the Carboniferous system. The rocks lie either on Devonian deposits or directly on the rocks of the crystalline basement. The lower part of the section is represented by Tournaisian – Lower Viséan limestones. Above them, to the very border of the Permian deposits, there is a stratum in which sandstones, mudstones and siltstones are interbedded with subordinate layers of lime-

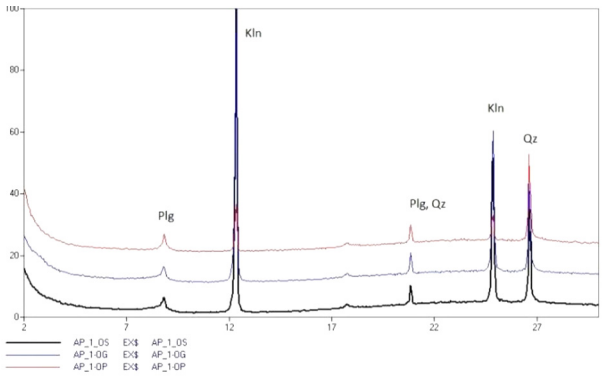

Fig. 3. X-ray diffraction patterns of the oriented argillaceous fraction preparations (samples. AP-1os, AP 1og, AP-1op):

Plg – palygorskite, Kln – kaolinite, Qz – quartz

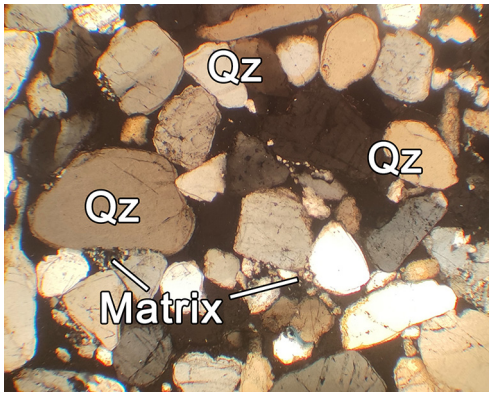

Fig. 4. Quartz sandstone (sample 3):

Qz – quartz, Matrix – cementing mass of smaller quartz fragments. Transmitted light, nicols (+), zoom 47x

stones and coal. The Permian deposits of the Donbas are locally manifested in the west and northeast of the Basin. The deposits of the Lower Permian are generally deposited on rocks of the Upper Carboniferous and are represented by arid formations: red-coloured terrigenous, carbonate-terrigenous and evaporitic. The Upper Permian is represented mainly by brick-red siltstones, as well as red and grey sandstones [13] (Nahornyi, Yu. M., Nahornyi, V. M., Prykhodchenko, V. F., 2005). Sandstones that have undergone varying degrees of influence of catagenesis processes are among the most common rocks of the Donbas Carboniferous System [14, 15].

Mesozoic sediments in the Donbas are not widespread. Triassic sediments are found on the western, northwestern and northern outskirts of the Donets Basin. The lower part of the section is composed of heterogeneous sandstones and red-coloured clays with limestone inclusions, the upper part consists of polymictic sandstones, variegated and grey clays with layers of brown coal. Jurassic sediments are widespread in the north and southwest of the Basin and are represented by sediments of all three series of the system. Marine clays, siltstones and sandstones dominate in the Lower and Middle Jurassic. The Upper Jurassic sediments include thick carbonate formation and continental, red-coloured sediments. The Cretaceous system in the Donets Basin is represented by both sections. Lower Cretaceous sediments are limitedly distributed in the north of the Basin. They are represented by white kaolin sands and sandstones, as well as clays with layers of quartz sandstones. Upper Cretaceous deposits are widespread in most of the territory of the Donbas. The most common rocks in the composition of the Upper Cretaceous stratum are calcareous-glauconite clays, quartz-glauconite sands, sandstones, chalk, conglomerates and siltstones. Paleogene deposits of the Donbas are most widespread in the northwestern part of the Basin and are represented by all three series from the Palaeocene to the Oligocene. They are represented by quartz-glauconite and clayey sandstones, siltstones, clays, glauconite-micaceous and clayey sands, glauconites, siltstone clays, glauconite sands, sandy clays, kaolins, brown coal layers, etc. Neogene deposits of the Donets Basin are developed on its outskirts but are most fully represented in the south. The deposits of this system include clays, sands with sandstone blocks, limestone and brown coal layers. Quater-

nary deposits of the Donets Basin are distributed throughout its territory and are represented by diluvial, alluvial and eluvial formations (Nahornyi, Yu. M., Nahornyi, V. M., Prykhodchenko, V. F., 2005).

Samples with polymineral composition of fragments 4–12 and 14 correspond to oligomictic and polymictic sandstones of the Carboniferous of Donbas in general characteristics. The clastic material is composed of subangular, subrounded and regenerated quartz grains (60–95 %), as well as fragments of feldspars, scales of mica, fragments of siliceous, argillaceous and effusive rocks. In quartz varieties (1, 13) with a similar composition of fragments, the volume content of quartz grains is over 90 %. The cement of the rocks is argillaceous, siliceous, carbonate, often mixed, may contain crushed clastic material (matrix), in many varieties cement is absent due to the high closeness in the quartz grain attachment [16].

We cannot speak about the original location of the Polovtsian stone statues, as over the past centuries the "stone babas" have been moved due to active collecting and economic activities, which is why most of them ended up in museum collections without determining their original location. Nevertheless, some important conclusions can be drawn.

Sandstones of the Carboniferous system form natural outcrops within the Open Donbas, where Paleozoic rocks come to the surface. If we focus on the places from where the "stone babas" were brought for storage to Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi, then seven of them were located in the settlement of Velyka Novosilka and in the villages of Andriivka and Konstantynopol, Volnovakha raion of Donetsk region, located 25 km to the northeast. Six statues were brought from Pokrovsk raion of Donetsk region. Three of them (6, 7, 8) were delivered from the village of Zolotyi Kolodiaz, which is 17 km to the northeast of the city of Dobropillia. "Stone baba" No. 11 (13) comes from the village of Nykanorivka of the Shakhivka village council (15 km east of the city of Dobropillia), No. 12 (11) – from the territory of the Hrodivka village council, and statue No. 13 (12) was discovered between the villages of Petrovske and Yuriivka of the Kryvorizke community of Pokrovsk raion near the border with Dnipropetrovsk region. "Stone baba" No. 14 was brought from the territory of the Oleksandrivka village council of Kramatorsk raion of Donetsk region.

There are no explored sandstone deposits in the Velyka Novosilka area. In Volnovakha raion, the nearest deposit of Carboniferous sandstones is located more than 100 km east of Velyka Novosilka near the village of Starobesheve. The closest to the village of Zolotyi Kolodiaz (6, 7, 8), equidistant at about 25 km, are the Druzhkivske deposit, located within the city of the same name, and the Leontiivske deposit of Lower Carboniferous sandstones near the village of Kamianka east of the city of Pokrovsk. The closest to the villages of Nykanorivka (Hektova Balka) (11) and Oleksandrivka (14) is the aforementioned Druzhkivske deposit of Upper Carboniferous sandstones [17].

Regarding the raw material of "stone baba" No. 11, which is distinguished by its heterogeneous grain size and pebble inclusions, it should be noted that such features are most characteristic of Lower Carboniferous sandstones, which form natural outcrops in the southwestern part of the Donbas, in the basins of the Kalmius, Sukha Volnovakha and Mokra Volnovakha rivers, as well as further to the northeast in the basins of the Krynka, Mius and Naholna rivers. Isolated Lower Carboniferous outcrops are known in the west of the Donbas in the basins of the Solona and Vovcha rivers, in particular, the above-mentioned Leontiivske deposit belongs to the Beshivska Lower Carboniferous suite [16]. Statue No. 13 was discovered in the immediate vicinity of the Leontiivske deposit. In the village of Hrodivka, from the vicinity of which "baba" No. 12 was delivered, there is an occurrence of Carboniferous sandstones. There are also a number of other occurrences of similar sandstones in Pokrovsk raion. The nearest large deposits of Carboniferous sandstones to the places from which the stone statues were delivered are located in Donetsk region. These are the Novoselivske-II, Bohodukhivske and Dolynske deposits. The main concentration of deposits and occurrences of Carboniferous sandstones in the Donbas is located to the northeast and east of Donetsk in Donetsk and Luhansk regions [17, 18]. Since the "stone babas" could be moved during the *19th* – early *20th* centuries, it should not be excluded that they were made from sandstones more distant from the last locations of their installation.

The closest occurrences of Cenozoic sandstones, to which samples 2 and 3 may belong, to the area from which the statues were brought, are located in the east of the Dnipropetrovsk region in the Western Donbas zone, where Paleozoic rocks are covered by a thick cover of Cenozoic age. These sandstones belong to the deposits of the Oligocene-Miocene Poltavska series. The largest deposits of Poltavska series sandstones are located near the villages of Havrylivka, Slovianka and Katerynivka in Synelnykove raion [19]. Cenozoic sandstones are also widespread within other areas of the Greater Donbas as part of sandy deposits that cover rocks of the Donets folded structure [17]. In addition, deposits of similar sandstones have been described in the north-east of Zaporizhzhia region [20]. Sandstones of these deposits occur in the form of blocks and lenses among sands. The fragments are almost entirely represented by quartz grains of varying degrees of rounding. The cement is mainly composed of chalcedony and opal and may contain an admixture of carbonaceous matter. The degree of preservation of the cement in the studied samples does not allow for a full comparison, but it is most likely that the raw material of "stone babas" 2 and 3 does not belong to the typical sandstones of the Carboniferous system, which were most often used in the large stone sculpture of the Polovtsians [11].

Thus, the most likely place of provenance of the raw material of stone statues 1, 4–14 are deposits and occurrences of Carboniferous sandstones, concentrated in the Donetsk region, samples 2 and 3 were most likely made of Neogene sandstones, occurred in the east of modern Dnipropetrovsk region or in Donetsk region. Additional research is required to more accurately determine the place of origin of the raw material of the studied "stone babas".

In general, the data obtained do not contradict the results of the studies carried out by S. O. Pletneva and L. S. Geraskova. The vast majority of the stone statues we studied, most likely, belong to the rocks of the Carboniferous system, which, according to the materials of

the above-mentioned studies, were the most common material of the Polovtsian "stone babas", in particular in the Donets centre. Sandstones of the Neogene system are also noted among the types of raw materials used. Also, the material of the studied "stone babas" corresponds to what was identified by us when studying the collections of Polovtsian stone statues of Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi and Poltava Museum of Local Lore named after V. Krychevskyi [11, 12]. The material of statue 11 (13), which contains inclusions of pebbles from siliceous rocks, has no analogues among the stone sculpture objects in the museum. However, this feature allowed us to more accurately determine the stratigraphic affiliation of the sandstone from which the "stone baba" was made, namely the Lower Carboniferous. Thus, the data we obtained complements the existing idea of the extraction of stone raw materials for the production of stone statues by the Polovtsians with new information and once again confirms their active use of local sandstones of the Carboniferous system, as well as quartz sandstones of the Neogene.

Conclusions. As a result of the study of the raw materials of the collection of Polovtsian "stone babas" delivered to Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi from the territory of Donetsk region, it was found that they are made of sandstones characteristic of the Carboniferous and Neogene systems of the Donets Coal Basin and the Dnipro-Donets Aulacogen. Palaeozoic sandstones with polymineral clastic material and cement are currently exposed within Donetsk and Luhansk regions, in particular, in the eastern part of Donetsk region, from where the stone statues were delivered. Neogene quartz sandstones, closest to the places of the previous location of the "stone babas", form natural outcrops in the eastern part of Dnipropetrovsk region, as well as in Donetsk region. Accordingly, we can state that all the studied statues belong to the Donets centre of the production of "stone babas" by the Polovtsians, although Volnovakha district, from where some of the studied statues were brought, is geographically closer to the Azov centre, where Precambrian granitoids of the Pryazovskyi megablock of the Ukrainian Shield were used as raw materials.

It was determined that the cement of Neogene sandstones (samples 2, 3) underwent greater destruction due to the action of hypergenic processes than the cement of Carboniferous sandstones, which should be considered in the further restoration of stone statues.

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Походження матеріалу евакуйованих із Донецької області половецьких кам'яних стел

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Мета. На основі результатів мінералого-петрографічного вивчення сировини половецьких кам'я-

них статуй, евакуйованих до Дніпропетровського національного історичного музею ім. Д. І. Яворницького з території Донецької області, встановити найменування й походження цієї сировини.

Методика. Дослідження проводилося методом петрографічного аналізу матеріалу кам'яних статуй у прозорих шліфах за допомогою поляризаційного мікроскопу. Мінеральний склад цементу пісковиків, за можливості, вивчався за допомогою рентгеноструктурного аналізу, для чого були виготовлені орієнтовані препарати. Результати, отримані після проведення мінералого-петрографічного аналізу, порівнювалися з особливостями подібних гірських порід із різних родовищ і проявів Донецької й Дніпропетровської областей, використовуючи шліфи гірських порід із природних відслонень і раніше досліджених половецьких кам'яних статуй, а також літературні дані.

Результати. У результаті дослідження 14 кам'яних статуй було встановлено, що 12 із них були виготовлені з пісковиків із полімінеральним уламковим матеріалом і цементом, що містять істотну частину уламків гірських порід. За процентним співвідношенням уламків кварцу й гірських порід пісковики були визначені як кварцові, сублітичні й літичні ареніти. Цемент має реліктовий характер, більшість уламкових зерен поєднані без цементу в результаті щільної упаковки. Два зразки із дослідженої колекції мають уламковий матеріал повністю складений кварцом, зцементований кременистим цементом, що зазнав дії гіпергенних процесів, і матриксом із дрібніших кварцових зерен. Пісковики найбільшої групи характерні для відкладів карбону Донецького кам'яновугільного басейну, що утворюють родовища й численні прояви на території Донецької області, звідки їх було привезено. Два зразки кварцових пісковиків, що значно відрізняються від решти, найвірогідніше належать до неогенових відкладів, які утворюють родовища на сході Дніпропетровської, а також у Донецькій області.

Наукова новизна. Уперше проведено петрографічне дослідження у шліфах половецьких кам'яних баб, релокованих зі сходу Донецької області до м. Дніпро.

Практична значимість. Отримана інформація є важливою для проведення подальших археологічних і мистецтвознавчих досліджень кам'яних статуй. Інформація щодо мінерального складу й збереженості цементу пісковиків є важливою для проведення реставраційних робіт.

Ключові слова: *половецькі кам'яні баби, пісковики, археологічна петрографія, Донецький басейн, Дніпровсько-Донецька западина*

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