МІНЕРАЛОГІЧНИЙ ЖУРНАЛ
MINERALOGICAL JOURNAL
(UKRAINE)

https://doi.org/10.15407/mineraljournal.43.03.104
UDC 552.4 + 904.5

M.N. Daragan, PhD (Archaeology), Research Fellow
Institute of Archaeology of the National Academy of Sciences of Ukraine
12, Heroiv Stalingradu Ave., Kyiv, Ukraine, 04210
E-mail: darmar@ukr.net; https://orcid.org/0000-0003-1019-9407
O.V. Mytrokhyn, DrSc (Geology), Professor
Taras Shevchenko National University of Kyiv, Institute of Geology
90, Vasylkivska Str., Kyiv, Ukraine, 03022
E-mail: mitrokhin.a.v@ukr.net; https://orcid.org/0000-0001-6269-0092

ENIGMATIC STONE SPHEROIDS FROM SCYTHIAN BURIAL AT KRASNYI PODOL OF UKRAINE: PETROGRAPHIC CHARACTERISTIC, PLACE OF MINING AND PROCESSING METHODS

The results of a petrographic investigation of 80 stone spheroids from a Scythian burial near the village of Krasnyi Podol are presented. The results indicate that all the stone spheroids were made from the same type of metamorphic rocks, namely actinolitites. The petrographic characteristics of the actinolitites indicate that the initial raw material was obtained from a single deposit. The Middle-Dnieper Region of the Ukrainian Precambrian Shield is considered as the probable place for their mining. The authors do not exclude that the natural outcrops of actinolitites could initially have had spherical jointing due to the processes of physical weathering. This jointing provided an opportunity to obtain roughly spherical blanks directly at the mining site. But most of the studied stone spheroids have got their spherical shape by artificial firing. The latter manifests itself in the surface desquamation and oxidation of the outer parts of the stone blanks. At least some of the stone blanks were ground to varying degrees after the firing. Stone abrasive materials were used for this purpose. The listed facts allow us to postulate that stone spheroids found in the Krasnyi Podol burial illustrate the successive stages of their processing. The owner of the stone spheroids likely possessed special knowledge regarding their mining, production and use.

Keywords: *archaeological petrography, actinolitite, stone artefacts, Scythian.*

Introduction. Petrography has long ceased to be a purely geological science. Since the second half of the 20th century petrologists began actively to study archaeological artefacts and by now these studies have achieved noticeable success [12, 17]. The traditional objects of research in archaeological petrography are stone buildings, tools, weapons, household items, jewellery and ritual products [8, 10, 13, 14]. A special place is given to stone products of unknown purpose. This category includes spherical stones *ca*. 2-6 cm in diameter, which appear as burial goods in the burials of the Scythians of the Northern Black Sea region in the second half of the 5th-4th centuries BC. The surfaces of the stones can be smooth, giving the impression of grinding or even polishing. The black residue is often visible on their surfaces. It is visually perceived as soot or carbon deposit. The number of such stones in each burial varies from 1 to 10, rarely more, most often 1 or 3-5 items. Only in one case, 80 such stones were recorded: in Burial 1 of Kurgan 2 near Krasnyi Podol, Kherson region [15]. According to the GIS "Kurgans of Ukraine" [6] spheroid stones have been documented in 168 burials, included either as burial goods or used in the process of a burial ritual (finds recovered from a funeral feast, the soil of the mound, the under-kurgan surface or subsoil discharge from the burial). The

Cite: Daragan, M.N. and Mytrokhyn, O.V. (2021), Enigmatic Stone Spheroids From Scythian Burial at Krasnyi Podol of Ukraine: Petrographic Characteristic, Place of Mining and Processing Methods, *Mineral. Journ. (Ukraine),* Vol. 43, No. 3, pp. 104—112. https://doi.org/10.15407/mineraljournal.43.03.104

arrangement of stones in the burials varies: single specimens are found near the body of the buried, while clusters of multiple stones are more often placed together with various tools (kitchen or cosmetic). The social status of those buried with stones ranges from ordinary members of the society [2] to the Scythian elite [1]. The difference in the number of stones in the burials and their location relative to the body of the deceased has led to a wide range of interpretations regarding their purpose. These include among others: 1) they were used as the sling stones; 2) they were used for boiling water and cooking food by heating them in the fire and placing them in a cooking container; 3) they were involved in smoking cannabis or performing some kind of fire rituals [1, 3, 5, 7, 9, 11]. Various scholars based their interpretation of the function of the stones according to their ideas regarding stone hardness. Soft stones (such as sandstone) were supposed to have been used for hemp incense, while "pebbles from hard rocks" were hypothesised to be more functional for heating water or grinding pigments and cosmetic substances [4]. Yet, the petrographical identification of stones and the nature of their spherical shape (natural or obtained as a result of mechanical processing) was never considered. The identifications of stones in publications were suggested by the excavators rather than geologists, and many are incorrect, as the subsequent verification of some of them has demonstrated.

The raw material of the stones is crucial for understanding their function, as well as the methods of their production. In the present study we identify the stones based on their petrographic features; propose the probable place of their extraction; and reconstruct the operational sequence of their processing methods. The origin of stones reveals not only the intricacies of their extraction and processing but also the economic network of their supply, which helps in the reconstruction of the Scythian economy and their way of life.

1. Materials. The study analysed the largest set of spheroids recovered from a Scythian burial: 80 items found in Burial 1 of Kurgan 2, excavated near the village Krasnyi Podol in the Kherson region of Ukraine (Fig. 1). Kurgan 2, central in a group of kurgans, was largely levelled by ploughing. At the time of excavation, it was 1.25 m high and 35 m in diameter. Its initial height was probably about 3 m. The kurgan was constructed at the beginning of the second quarter of the 4th century BC above Burial 1 which consists of an entrance pit and chamber. The burial was partly looted in antiquity, shortly after the burial, by the Scythians themselves, but a sufficiently representative burial inventory was left behind, which suggests that it was occupied by a member of Scythian nobility.

An anthropomorphic stele was found in the entrance pit of the burial. It had previously stood on the top of the kurgan and was thrown into the entrance pit after the robbery. The skeleton of a young man (19-24 years old) lay in the centre of the chamber. The skeleton was stretched out on the back with its head to the west. The bones of the legs and part of the right arm were preserved *in situ*. The skull was found in the fill in the northeast corner of the chamber. A round hole is preserved on its occipital part, likely the mark of a blow with a hammer. The deceased was lying on wooden planks, fastened with iron brackets. The skeleton was placed over the iron armour. An iron scale shield laid at the entrance in the chamber and to the right of the skeleton at the chest level. There was here a lower part of a trapezoidal cuirass that would have been attached to the belt. An iron spearhead, a dart and an axe lay on the shield. There was a lead club near the knee of the right leg. A bronze cauldron with ram bones stood behind the wooden planks, near the eastern wall of the chamber. Next to it, there was a decaying wooden bowl with *75 stone spheroids*. The chamber contained 18 bronze arrowheads, bronze and bone "vorvorka", two bone objects of unknown purpose, as well as a fragment of a Greek grey-clay oinochyes. On the northwestern corner of the chamber, there were animal bones representing burial food offering, a bone knife handle, 15 gold clothing plaques depicting

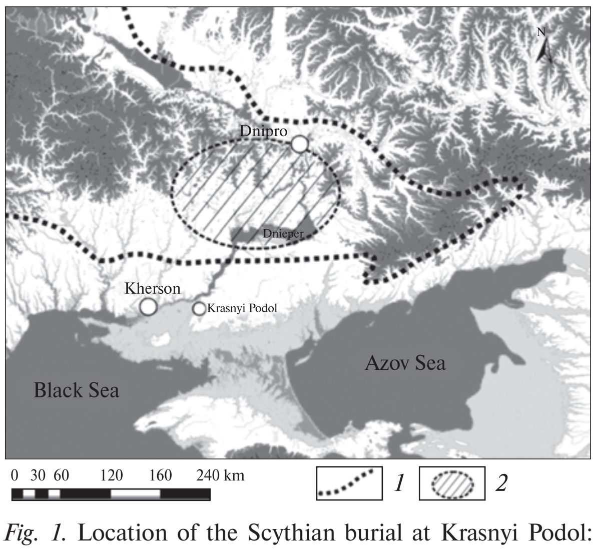

Fig. 1. Location of the Scythian burial at Krasnyi Podol: *1* — borders of the Ukrainian Shield; *2* — probable aria for actinolitites mining

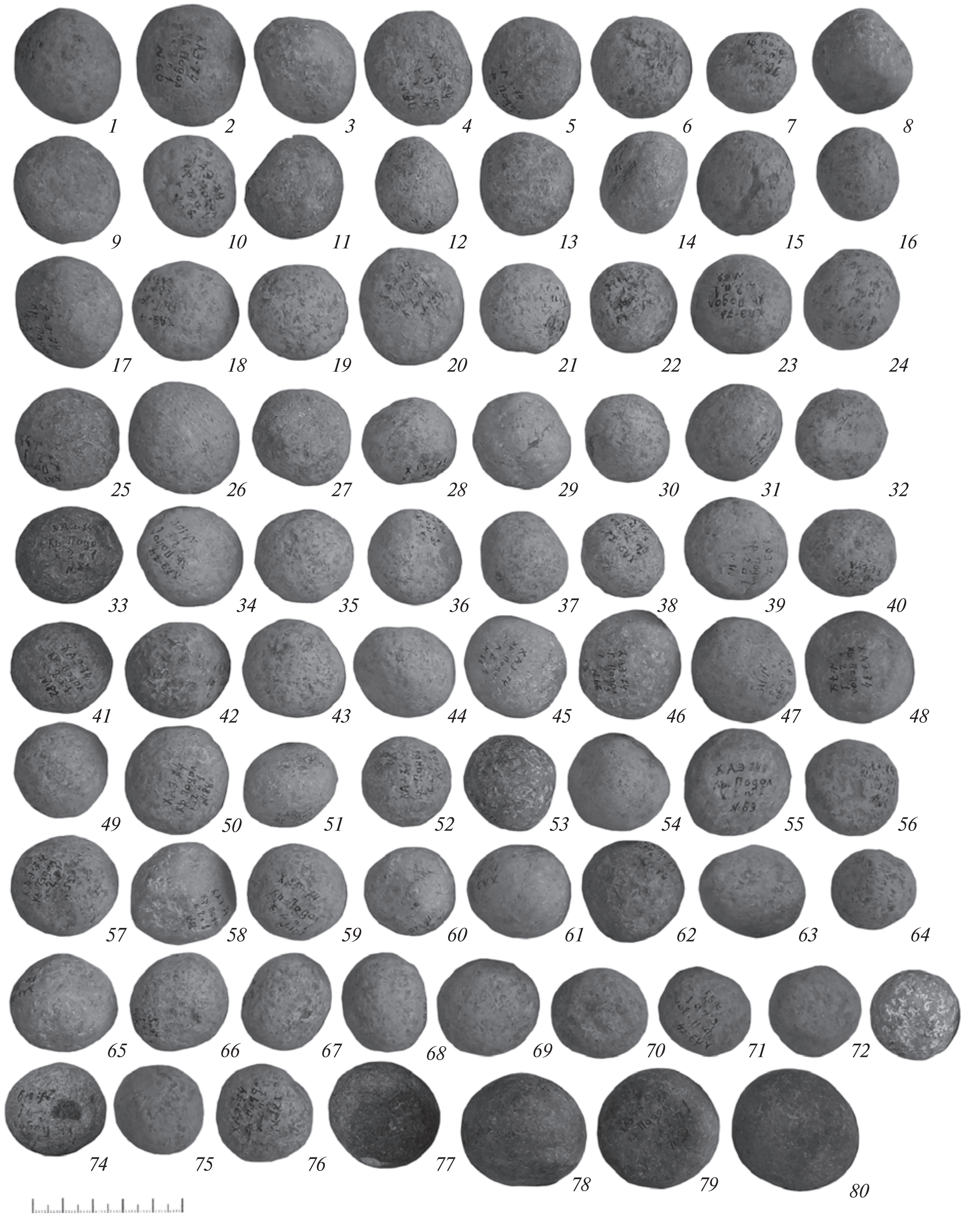

Fig. 2. Stone spheroids from the burial of Krasnyi Podol (Image by M. Daragan)

sphinxes, fragments of a Scythian sword (akinakes) blade and additional *5 stone spheroids*. A hidden cache was also found here. It was a round fossa 12 cm in diameter and 15 cm deep which contained a silver vessel. The fill of the burial produced an iron knife, spear butts and brackets from the planks [15, 16].

All 80 stone spheroids are similar in appearance and light brown. Their size varies from 2 to 4 cm, weight from 30 to 75 g (Fig. 2). A slight black coating was visible on five stone spheroids. In the original publication, stone spheroids from Krasnyi Podol were interpreted as sling stones, based on the theories accepted at that time [15]. It was also noted that this is the largest set ever found. Gavrilyuk (2013) suggested instead that these stones were used to heat water during cooking.

2. Methods. A petrographic study was carried out for 80 samples of stone spheroids. Preliminary visual examination using MBS-1 binocular stereoscopic microscope determined that all studied samples have phaneritic medium-grained texture and more or less homogeneous mineral composition. This made it possible to significantly reduce the number of produced petrographic thin sections, minimizing the mechanical destruction of the samples. The immersion method was used to identify rock-forming minerals. Microscopic chips of mineral grains were crushed on a glass slide, placed in kerosene, and then studied in transmitted light using a MIN-8 polarizing microscope. For 5 control samples, transparent thin sections were made, which were also studied under the polarizing microscope. Final identification of rock-forming minerals was performed using a scanning electron microscope-microanalyzer REMMA-202M equipped with an energy-dispersive X-ray spectrometer.

3. Results. 3.1. Morphology and outer surfaces of the studied stone spheroids. The shapes of all studied samples correspond approximately to a spheroid or slightly flattened ellipsoid of revolution. In many samples, the sphericity is broken by one or two small, more or less flat areas. By the appearance of the external surface, stone spheroids can be divided into two types. The first, more common type, are spheroids with a light brown, finely uneven surface without visible signs of grinding or other mechanical processing. In such stone spheroids, the relief of their surfaces depends exclusively on the grain size of the rocks composing the samples. Sixty-one studied stone spheroids belong to the first type. Less common are stone spheroids of the second type. Their outer surfaces have been smoothed to some extent by artificial grinding and, as a result of this treatment, acquired a lighter yellowish-grey to light grey colour. In some cases, small potholes remain on the abraded surface of such stone spheroids. The potholes are partially filled by dusty grinding products. In other cases, apparently due to more extensive abrading, the outer surfaces of the stone spheroids look quite smooth, without any potholes or bumps visible to the naked eye. Nevertheless, here the quality of abrading is by no means perfect too and no sample can be defined as polished.

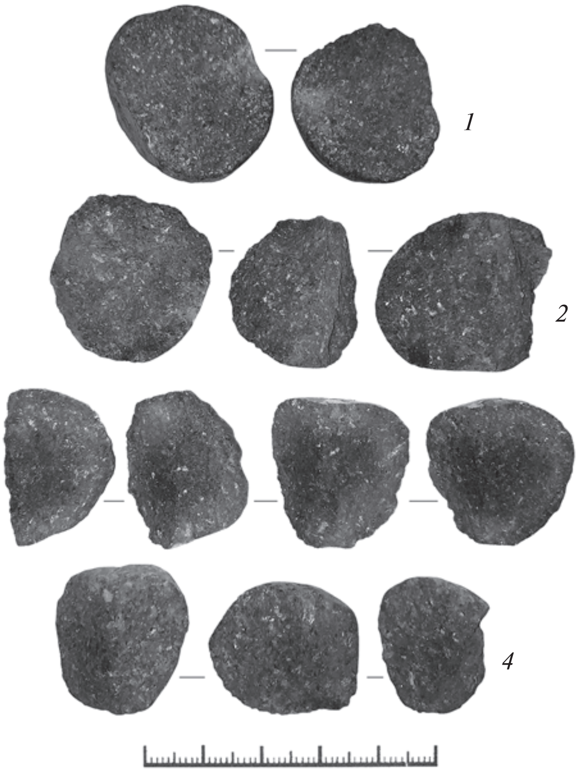

Fig. 3. The internal structure of stone spheroids from Krasnyi Podol. (Image by M. Daragan)

3.2. Internal structure of the studied stone spheroids. Before making the thin sections, six stone spheroids were carefully broken into two or more parts to obtain fresh cleavage and to study their internal structure. Three of them were specimens with a finely uneven surface (first type) and three more ones had surfaces with different level of grinding (second type). In all six studied samples, a concentric-zonal internal structure was established by visual inspection (Fig. 3).

Five stone spheroids had a dark greenish-grey colour on the interior and were composed of rather "fresh" unaltered actinolitites. In one stone spheroid, the internal part was composed of friable yellow-brown actinolitite, significantly altered by weathering processes. The external zones of all six spheroids are rusty brown. Compared to internal zones, the external ones are more crumbly, as a result of which they look altered, most likely oxidized in the process of artificial firing. The thickness of the external zones ranges from 2—3 to 5—7 mm. Moreover, in samples with abraded surfaces, their external zones are thinner and spread asymmetrically for the centre of the stone spheroid. In one abraded stone spheroid, there is a small area where

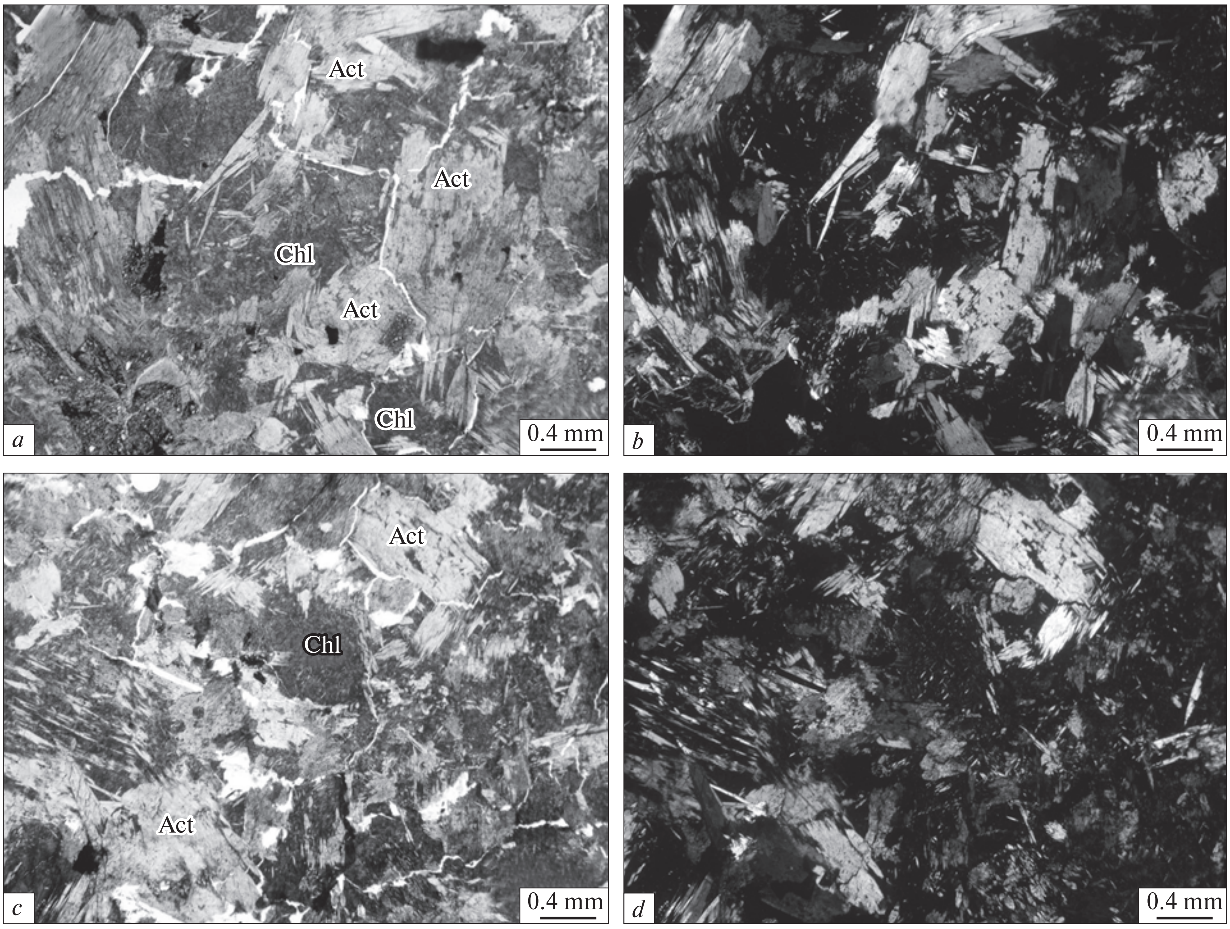

Fig. 4. Petrographic features of actinolitites composing stone spheroids from Krasnyi Podol. Image of transparent thin sections under a polarizing microscope in transmitted light: *a* — the inner part of the spheroid with the analyzer turned off; *b* — the inner part of the spheroid with the analyzer turned on; *c* — outer part of the spheroid with the analyzer turned off, *d* — the outer part of the spheroid with the analyzer turned on. Legend: Act — actinolite, Chl — chlorite (Image by O. Mytrokhyn)

the external zone is absent (most likely, it was removed by excessive abrading) and the dark grey interior of the stone was exposed on the surface of the sample.

3.3. Petrography of the studied stone spheroids. The thin sections made from five of the most typical stones-spheroids demonstrate that the internal most "fresh" zones of the stone spheroids are composed of the same type of metamorphic rock. The latter is identified by authors as actinolitite.

All studied actinolitites have holocrystalline lepidonematoblastic textures (Fig. 4).

They are non-uniform medium-grained. The main rock-forming minerals are actinolitic amphiboles (75-80%) and chlorite (20-25%). The bulk of the rocks are formed by randomly oriented prismatic grains of actinolitic amphibole. Their size is 1-3 mm. Fine-flaked chlorite aggregates are observed in the interstitium between amphiboles.

Amphibole is identified on an electron probe microanalyzer as magnesium actinolite (Table). Actinolite is weakly pleochroic from pale green to colourless in transmitted plane-polarized light. Its short-prismatic grains exhibit block extinction, dividing into lamellar fragments oriented parallel to the total grain elongation in cross-polarized light. In addition to short-prismatic grains, needle-shaped actinolitic individuals are also present. Locally, they collected in parallel and matted fibrous aggregates.

Chlorite is unevenly coloured in pale dirty greenish tones in plane-polarized light. When the analyzer is on, it detects extremely low birefringence without any interference colour anomalies. Fine-flaked chlorite aggregates are often penetrated by thin needle-like microcrystals of actinolite. In some places, relics of light brown biotite are identified within the secondary chlorite aggregate.

Studied actinolitites also contain titanite, rutile, chromite and apatite in accessory quantities (Fig. 5). Particularly noteworthy are the fine-crystalline titanite aggregates 0.2-0.3 mm in size. They retain relict hypidiomorphic outlines and lamellar textures. It can be assumed that these are pseudomorphoses after titanomagnetite. Secondary microcrystalline rutile usually associates with titanite. Chromite quite the contrary is a primary mineral. It forms idiomorphic microcrystals and their aggregates included in the actinolite.

The results of a microscopic study of the external rusty-brown zones of stone spheroids are of particular interest. In these zones, the main rock-forming minerals are distinguished by a rather peculiar colour. For example, actinolite is coloured bright red-brown in reflected light under a stereoscopic binocular microscope. Equally unusual is its colour in thin sections under a polarizing microscope. In transmitted plane-polarized light, it shows pleochroism from orange-brown on Ng to colourless on Np. Chlorite is also unusually coloured in the outer zones of stone spheroids. In plane-polarized light its flakes are rusty-brown. The mentioned changes in the optical characteristics of actinolite and chlorite cannot be attributed to the surface weathering of stone spheroids. The effect of artificial oxidative firing, to which the stone spheroids were subjected during their production process, is more likely.

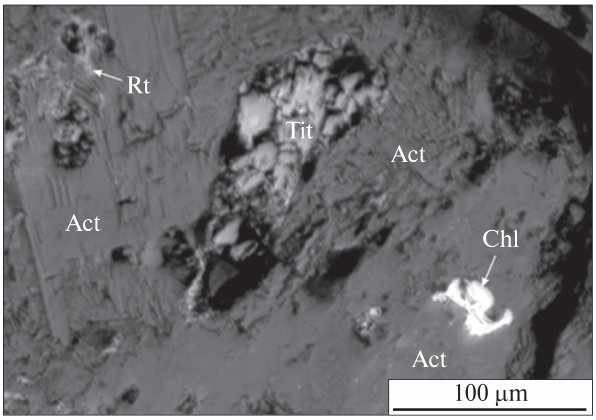

Fig. 5. Accessory mineralization in actinolitite stone spheroid from Krasnyi Podol. Mineral symbols: *Tit* — titanite, *Rt* — rutile, *Chr* — chromite, *Act* — actinolite. Back-scattered electron image on scanning electron microscope REMMA-202M

4. Discussion. **4.1. Origin of raw material for production of stone spheroids.** Actinolitites which the studied stone spheroids were made of belong to the same petrographic type. Most likely, they were mined in the same deposit. Actinolitites take a special place among the metamorphic rocks. They are usually formed during low-temperature metamorphic transformations of some ultramafic igneous rocks, namely pyroxenite, hornblendites, peridotites. Compared to other igneous rocks, for instance basalts or granites, the ultramafites are much less

Selected electron microprobe analyses of the amphiboles in studied stone spheroids from Krasnyi Podol

Component	Point									
	1	2	3	4	5	6	7	8	9	10
Weight percents, %										
SiO_2	54.11	54.32	54.16	54.48	54.25	53.89	54.75	54.18	53.48	54.12
Al_2O_3	1.7	2.22	1.82	1.44	1.65	2.48	1.79	2.01	2.19	2.04
FeO	8.03	8.15	8.18	7.73	8.08	8.87	7.91	8.28	8.08	8.16
MgO	20.39	19.57	20.72	20.84	20.16	20.04	20.54	20.14	20.99	20.25
CaO	13.65	13.66	12.97	13.52	13.85	12.710	13.01	13.2	13.27	12.81
Na_2O	0.12	0.08	0.15	—	—	0.01	—	0.18	—	0.62
Formula units on 8 atoms of oxygen										
Si	7.545	7.599	7.487	7.558	7.583	7.445	7.564	7.533	7.389	7.522
Al	0.279	0.366	0.297	0.235	0.272	0.404	0.291	0.329	0.357	0.334
Fe	0.936	0.953	0.946	0.897	0.944	1.025	0.914	0.963	0.934	0.948
Mg	4.239	4.081	4.270	4.310	4.201	4.127	4.230	4.175	4.323	4.196
Ca	2.039	2.047	1.921	2.010	2.074	1.881	1.926	1.966	1.964	1.908
Na	0.032	0.022	0.040	—	—	0.003	—	0.049	—	0.167
Sum	15.072	15.069	14.961	15.010	15.074	14.884	14.926	15.015	14.966	15.075
#Mg	0.82	0.81	0.82	0.83	0.82	0.80	0.82	0.81	0.82	0.82

widespread in the Earth's crust. This explains the relative rarity of their metamorphic derivatives, including actinolitites. Within Ukraine, such rocks are found exclusively on the territory of the Ukrainian Crystalline Shield. The most probable place for the extraction of raw materials for the production of studied stone spheroids is the Middle Dnieper megablock of the Ukrainian Shield, where metamorphosed ultramafic rocks, including actinolitites, occur within the Archean greenstone structures. Their outcrops on the surface can be found in the banks of the River Dnieper and its tributaries (Fig. 1).

4.2. Production of stone spheroids. Based on detailed study and observed variation in the surface treatment of the stone spheroids from the Krasnyi Podol burial, we suggest that they represent successive stages of processing of the raw material. It is known that some rocks such as diabases, gabbro, amphibolites and others can acquire spherical jointing in natural outcrops due to the processes of physical weathering. Due to this jointing, the rocks can be relatively easily broken into pieces that have a roughly spherical shape with shell-like surfaces. It is likely that the ancient craftspeople gave preference to and selected just such rocks with a naturally spherical shape for the production of stone spheroids. It should be noted that, of the six stone spheroids investigated in detail, only one showed clear signs of natural weathering, while the rest were not weathered. On the other hand, in the process of artificial firing, suggested by the results of performed studies, primary acute-angled stone blanks could acquire spherical outlines due to thermal desquamation. In addition, firing undoubtedly facilitated further grinding of the surface. In particular, 61 stone spheroids with a light-brown finely uneven surface (the first type) are obviously blanks that have not been mechanically abraded. The remaining 19 stone spheroids (second type) were obtained from such blanks in the process of grinding them. Moreover, the grinding process was taking place without metal tool use, as evidenced by the complete absence of characteristic traces of metal on the abraded surfaces. Harder stones such as quartzite, sandstone or ordinary sand were likely used as an abrasive. The quality of grinding on individual stone spheroids varies. Perhaps some of them, for some reason, were not quite finished. *After grinding, none of the studied stone spheroids was fired again*.

4.3. Function of stone spheroids. The spherical shape of the stone spheroids is clearly connected with their function. It is likely that not only the sphericity of stones was important for the Scythians but also specific properties of the raw material and may be the places of its mining. It is noteworthy that actinolitite stone spheroids were identified by the authors not only on Krasnyi Podol but in some other Scythian burials. Specific raw materials, as well as specific production cycle, raises doubts about the use of stone spheroids as sling stones. The fact that the firing of the stone spheroids is concerned with the production process, rather than with their practical application, also allows to exclude the use of spheroid stones from Krasnyi Podol for heating water and cooking food. The above also raises doubts about the version of the using of stone spheroids in smoking cannabis or performing some kind of fire rituals. Moreover, analysis of organic traces on stones found at 5 stones from Krasnyi Podol and 20 specimens from others burials did not identify any traces of cannabinoids, although substances likely deriving from other medicinal and aromatic plants were found. Therefore, most likely the Scythian stone spheroids were used in some rituals, which would also explain the complex process of their extraction and production.

4.4. Status of the "owner" of stone spheroids from Krasnyi Podol. The inventory of the burial, even after looting, suggests that the occupant of the burial was a warrior and a representative of Scythian nobility. The presence of such a large number of spheroid stones in the burial complex is unusual and the stones are likely an attribute indicating a certain symbolic status and social role of the buried. Behind the set of stones, we saw a set of knowledge, both of a handicraft (production cycle), and, most likely, of a ritual (use). This set suggests that the deceased was not only a warrior and a nobleman but also a kind of craftsman-shaman figure, who possessed the (specialised?) knowledge required for mining and processing of stone spheroids used in certain rituals, which he also likely performed.

Conclusions. The research conducted provides a new perspective on Scythian customs and their production activities. Investigation of the raw materials and technology of production of stone spheroids from the Krasnyi Podol burial determined that they were made from the same type of metamorphic rocks, namely actinolitites. Analysis of actinolitites in different samples of stone spheroids demonstrates that initial raw material came from a single deposit, with the Middle-Dnieper megablock of the Ukrainian Precambrian Shield being the most likely place for their mining. A specific concentric zonal structure of the stone spheroids, with the oxidized external zones, indicates artificial firing to which raw stone blanks were subjected before their subsequent grinding. Likely, that the majority of the studied stone spheroids from the Krasnyi Podol gained the spherical shape in the course of firing which caused the desquamation and oxidation of the external zones of stone blanks. Nevertheless, it is impossible to exclude that the natural outcrops of actinolitites obtained their spherical jointing due to the processes of weathering, which would have produced roughly spherical blanks directly at the mining site. After the firing, at least some of the stone blanks were abraded to varying degrees using stone abrasive materials. The results allow us to postulate that stone spheroids found in the Krasnyi Podol burial illustrate the successive stages of their production process.

It is not yet clear to us how, in what form and where the stones were transported: whether some of the specimens were processed at the mining site or were delivered to some kind of workshop. We also do not know whether these stones constituted the articles of trade commodity or if their distribution across Scythia was carried out through some other form of exchange. Nevertheless, their specific origin reflects a certain network of their acquisition, thereby expanding our understanding of the Scythian economy.

Acknowledgements. *We would like to thank Oleg Posil'skiy (Kyiv Scientific Research Institute of Forensic Expertise) for the analysis of organic traces on stones from Krasnyi Podol. We are also grateful to Margarita Gleba and Sergey Polin for discussing and editing the article.*

REFERENCES

1. Bidzilya, V.I. and Polin, S.V. (2012), *Skifskiy tsarskiy kurgan Gaymanova Mogila*. (*Ser. Kurgany Ukrainy*, Vol. 2), Publ. house "Skif", Kyiv, 752 p. [in Russian].
2. Bunyatyan, Ye.P. (1985), *Metodika sotsial'nykh rekonstruktsiy v arkheologii. Na materiale skifskikh mogil'nikov IV-III vv. do n. e.,* Nauk. dumka, Kyiv, 233 p. [in Russian].
3. Gavrilyuk, N.A. (1989), *Domashneye proizvodstvo i byt stepnykh skifov,* Nauk. dumka, Kyiv, 122 p. [in Russian].
4. Gavrilyuk, N.A. (2013), *Ekonomika stepnoy Skifii VI-III vv. do n. e.,* KNT publ., Kyiv, 712 p. [in Russian].
5. Grakov, B.N. (1962), *Materialy i issledovaniya po arkheologii SSSR*, Iss. 115, Publ. house USSR Acad. Sci., Moscow, RU, pp. 56-114 [in Russian].
6. Daragan, M.N. and Polin, S.V. (2017), *Arkheologiya i geoinformatika. Tret'ya Mezhdunar. konf., Tezisy dokl.,* Moskva, IA RAN, pp. 17-19 [in Russian].
7. Dedyul'kin, A.V. (2015), *Materialy Mezhdunar. nauchnoy konf., posvyashchonnoy pamyati A.I. Melyukovoy, Kagal'nik, 26-29 aprelya 2014 g.,* Izd-vo YUNTS RAN, Rostov-na-Donu, RU, pp. 48-51 [in Russian].
8. Kempe, D.C.R. and Horvey, A.P. (eds) (1983), *The petrology of archaeological artefacts,* Oxford Univ. Press, New York, 374 p. https://doi.org/10.1002/gea.3340040408
9. Kovpanenko, G.T., Bessonova, S.S., and Skoryj, S.A. (1989), *Pamyatniki skifskoy epokhi Dneprovskogo Lesostepnogo Pravoberezh'ya,* Nauk. dumka, Kyiv, 336 p. [in Russian].
10. Kulik, N.A. and Postnov, A.V. (eds). (2009), *Geology, petrography and mineralogy in archaeological researches,* Ucheb.-metod. posobie, SO RAN press, Novosibirsk, RU, 102 p. [in Russian].
11. Melyukova, A.I. (1964), *Vooruzheniye skifov, (Arkheologiya SSSR. Svod arkheologicheskikh istochnikov, Vyp. D1-4),* Nauka, Moskva, RU, 113 p. [in Russian].
12. Ostroverkhov, A.C. and Smyrnov, O.I. (2012), *Sci. Bull. Mykolayiv Nat. Univ. V.O. Sukhomlinsky. Ser. Historical Sci.*, Iss. 3(33), Mykolayiv, UA, pp. 38-53 [in Ukrainian].
13. Petrun', V.F. (1967), *Notes Odessa Archaeological Soc.*, Vol. 2 (35), Odessa, UA, pp. 3-11 [in Russian].
14. Petrun', V.F. (2008), *Short reports Odessa Archaeological Soc.,* Favorit publ., Odessa, UA, pp. 147-152 [in Russian].
15. Polin, S.V. (1984), *Vooruzheniye skifov i sarmatov,* Nauk. dumka, Kyiv, pp. 103-119 [in Russian].
16. Polin, S.V. (2014), *Skifskiy Zolotobalkovskiy kurgannyy mogil'nik V-IV vv. do n. e. na Khersonshchine,* (*Ser. Kurgany Ukrainy*, Vol. 3), Vydavets' Oleh Filyuk, Kyiv, UA, 776 p. [in Russian].
17. Shackley, M.S. (2008), *Archaeometry*, Vol. 50, Iss. 2, pp. 194-215. https://doi.org/10.1111/j.1475-4754.2008.00390.x

Received 31.05.2021

М.М. Дараган, канд. археолог. наук, наук. співроб.
Інститут археології НАН України
04210, м. Київ, Україна, пр-т Героїв Сталінграда, 12
E-mail: darmar@ukr.net; https://orcid.org/0000-0003-1019-9407
О.В. Митрохин, д-р геол. наук, проф.
Київський національний університет імені Тараса Шевченка
Навчально-науковий інститут "Інститут геології"
03022, м. Київ, Україна, вул. Васильківська, 90
E-mail: mitrokhin.a.v@ukr.net; https://orcid.org/0000-0001-6269-0092

ЗАГАДКОВІ КАМЕНІ-СФЕРОЇДИ ЗІ СКІФСЬКОГО ЗАХОРОНЕННЯ ЧЕРВОНИЙ ПОДІЛ В УКРАЇНІ: ПЕТРОГРАФІЧНА ХАРАКТЕРИСТИКА, МІСЦЕ ВИДОБУТКУ СИРОВИННОГО МАТЕРІАЛУ, МЕТОД ОБРОБКИ

Наведено результати петрографічного дослідження 80 каменів-сфероїдів зі скіфського захоронення с. Червоний Поділ. З'ясовано, що всі вивчені камені-сфероїди виготовлено з однотипних метаморфічних гірських порід — актинолітитів. Петрографічні особливості актинолітитів свідчать, що кам'яна сировина для їх виготовлення видобувалася на одному "родовищі". Припускається, що найімовірнішим місцем її видобутку є Середньопридніпровський район Українського щита. Цілком можливо, що природні виходи актинолітитів унаслідок процесів фізичного вивітрювання, могли початково мати кульову окремість, яка надавала змогу відокремлювати кам'яні заготівки грубо-сферичної форми безпосередньо на місці видобутку. Хоча вивчені камені-сфероїди с. Червоний Поділ здебільшого отримали свою сферичну форму у процесі штучного випалу, що виявлено у поверхневому "лущенні" та окиснені зовнішніх частин кам'яних заготівок. Частина випалених заготівок після випалу тією чи іншою мірою підлягали шліфуванню з використанням кам'яних абразивних матеріалів. Усі перелічені факти дають змогу дійти висновку, що у захороненні с. Червоний Поділ ми маємо справу з каменями-сфероїдами, які ілюструють послідовні стадії оброблення первинної актинолітитової сировини. Їх власник міг мати спеціальні знання стосовно їх видобутку, виробництва та використання.

Ключові слова: археологічна петрографія, актинолітити, кам'яні артефакти, Скіфи.