ԵՐԵՎԱՆԻ ՊԵՏԱԿԱՆ ՀԱՄԱԼՍԱՐԱՆԻ ԳԻՏԱԿԱՆ ՏԵՂԵԿԱԳԻՐ
УЧЕНЫЕ ЗАПИСКИ ЕРЕВАНСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА

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Geology

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THE PRINCIPLES OF CHOICE OF ARMENIAN OBSIDIAN SOURCES IN BRONZE AGE, OBTAINED BY PXRF ANALYSIS

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In the previous study an analytical database of geological obsidian samples was obtained within the method of portable X-ray fluorescence (pXRF). In this paper 292 obsidian samples from three settlements belonging to the Kura-Araxes culture were studied. Using the pXRF method, the chemical composition of these samples was compared with the results of geological ones to identify their sources. This will give a chance to understand the origin of the raw material.

***Keywords*:** natural resources, obsidian, geochemical analysis, portable X-ray fluorescence, Bronze Age, Kura-Araxes.

Introduction. From the second half of the fourth millennium BC, a number of dramatic changes took place in the Southern Caucasus. These changes are mostly related with the culture, which in literature is mentioned as Kura-Araxes or Shengavit Culture [1]. They are mostly noticeable in areas such as agriculture, livestock and craft. First of all, the sharp increase of population is noticed in the region, which has resulted in unprecedented progress in almost all other spheres of life. During this period all the branches of crafts are evolving, and more and more technically new tools are being developed. According to recent data, nowadays only on the territory of the RA at least 200 monuments belonging to various chronological periods of Kura-Araxes culture are represented [2]. In the Early Bronze Age, the metallurgical industry in the South Caucasus had already reached a relatively high level, which makes it a unique and separate craft [3]. During this period nearly, complete transition to metal tools was applied in all spheres of life. The metal was used not only for making ornaments, but also for tools, especially in the field of weapon production [4]. This development allowed people to understand the overwhelming advantages of metal as a natural resource in comparison to such raw materials as stone, wood and bone.

In spite of these fundamental changes and almost total transition to the metal tools, the use of stone raw materials in the third millennium BC remained an integral part of that culture in a number of spheres. As raw material of stone tools, in the early Bronze Age in the South Caucasus, mostly obsidian and rarely flint, dacite, and jasper were used. Obsidian was used for preparing sickle inserts, scrapers, jewelry, weaponry (arrowheads), as well as obsidian-tempered pottery [5].

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Speaking about the stone industry and its replication, the regional geological settings should be mentioned for a more detailed understanding about sources of raw materials and particularly the obsidian. During his whole history, a number of tectonic acts took place in the Armenian Highland, according to which Armenia is characterized as an active zone of classical young volcanism. Among this number of tectonic processes, the rhyolithic volcanism has its own place. Obsidian flows arose, because of the release of acidic lava consistency [6, 7]. As a result of this type of volcanism only on the territory of Armenia were about 450 volcanic domes and more than 20 volcanoes were presented with obsidian flows. This is why Armenia is considered as one of the richest obsidian regions in the world. So, those local lava flows have served as sources of obsidian for the region and have been actively used by local population.

So, it is not surprising that obsidian is presented in more than 90% of the stone industry of studied Kura-Araxes culture settlements in the region. Taking all this into account, an important issue arises, which is sourcing of stone (obsidian) industry of Kura-Araxes culture. It will allow find out the genesis of artifacts in settlements belonging to the Kura-Araxes culture. Once their genealogy is understood, these will be an opportunity to make judgment about the principles of the use of sources by the local population.

Methodology and Analytical Results. At present, for the studies of volcanic glass (obsidian), a number of modern analytical methods are widely being used, which replaced the previously used optical spectrography [8]. These are methods of neutron activation (INNA), plasma mass spectrometry (LA-ICP-MS) and X-ray fluorescence (XRF) and its modern and practical variation called portable X-ray fluorescence (pXRF) [9, 10].

Within the scope of our previous study with the help of portable Brucker Tracer III SD spectrometer an analytical database was obtained, which included 60 samples from 20 Armenian and 1 Georgian obsidian sources. In this paper the mentioned database will be used to compare the data of geological samples with the archaeological ones to perform obsidian sourcing and to identify the origin of the artifacts [11].

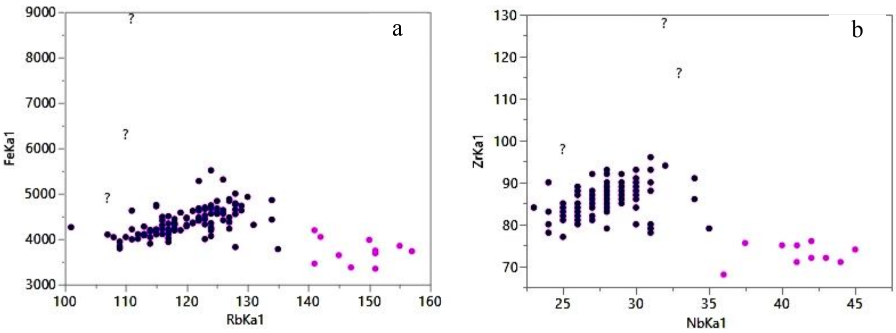
In the paper as archaeological samples are studied 292 archaeological founds from 3 settlements attributed to Kura-Araxes culture. The settlements are located in the different parts of Armenia and belong to various cultural sub-groups and chronological periods of Kura-Araxes.

Tsaghkasar (NL 40°28′ and EL 43°55′) is a one-layered settlement, which was shortly inhabited during the first stage of the Kura-Araxes culture. It is located 2 *km* to the North-East of Tsaghkasar village of Aragatsotn district, near Arteni volcano and occupies territory of about 10 *ha*. Tsaghkasar was excavated in 2005–2008 under the leadership of P. Avetisyan, but the material has not been published yet. More detailed description presented in [12].

Totaly 122 obsidian items were selected for analysis. According to the results samples were mainly divided into two compositional groups, which are presented in the diagrams Fe/Rb, Zr/Nb.

Observing analytical results, it became clear that the two main groups belong to the two domes of the Arteni volcano Pokr and Mets Arteni, which is located 15 *km* South-West from the settlement. So, it was not surprising that the overwhelming majority of the specimens are related to material of this volcanic complex. According to the analytical results, 89% of samples (108 out of 122) were identified as Pokr Arteni and 9% of samples were attributed to obsidian of Mets Arteni. Due to the direction of volcanic flows, obsidian from Pokr Arteni is more abundant then from deposit of Mets Arteni, and it is also higher quality. This is explains why the deposit from Pokr Arteni received such a preference.

Unfortunately, identifying of 2% of samples was failed (Fig. 1).



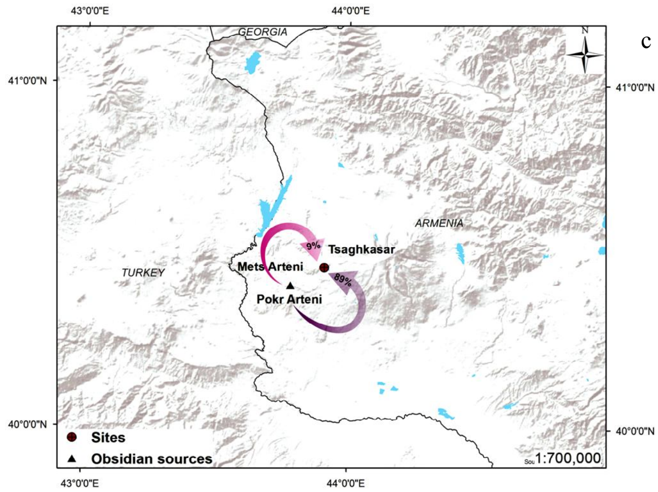
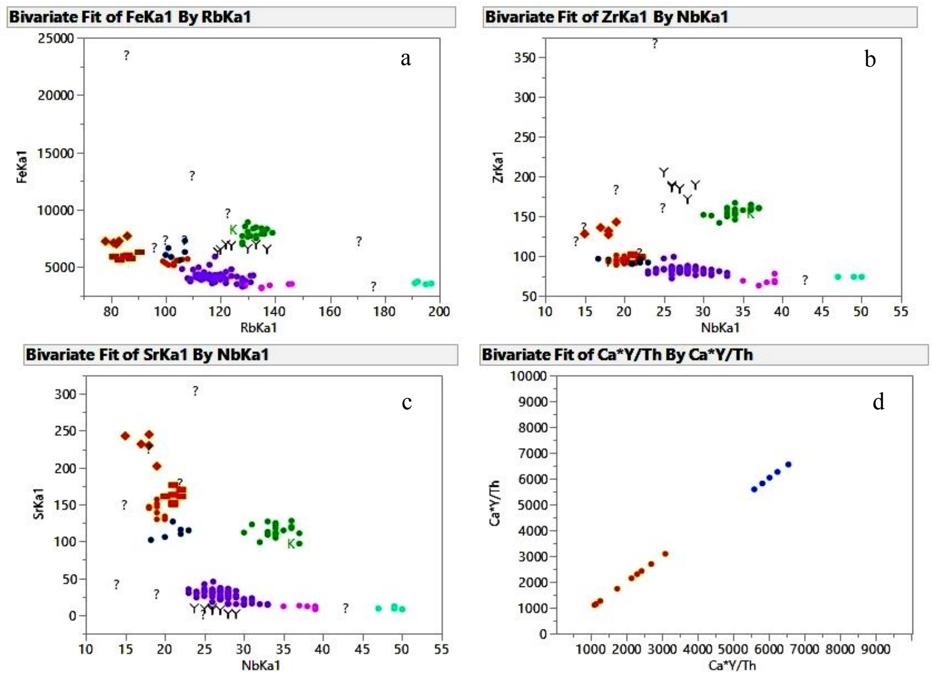


Fig. 1. Tsaghkasar: Fe/Rb (a); Zr/Nb (b) and the utility model map of the settlement Tsaghkasar (c).

Observing the Tsaghkasar utility model, it is clearly defined its relation only to a single source. The geographical location of the settlement is the main reason of this choice (Fig. 1).

Agarak (NL 40°17′ and EL 44°16′) represents 5600 m^2 territory, occupying multilayered settlement, the earliest finds of which are represented by the cultural layer of Kura-Araxes [13, 14]. The settlement is located near Agarak village of Aragatsotn district. The material excavated from the settlement is represented by ceramics, which belong to Shersh-Mokhrablur and Karnut-Shengavit cultural sub-group [2].

There were 130 obsidian specimens available from Agarak. According to results at least six different compositional groups were identified, which included materials from at least 9 different sources. The first two groups belong to two domes of Arteni in total (about 47%), which, as in Tsagkasar, is the absolute majority. Those are clearly separated from others by low Fe and Sr concentration, and are different from each other by Nb and Rb (Fig. 2, a and b). The second group consists of samples of Damlik, Ttvakar and Kamakar from Tsaghkunyats range, which are clearly distinguished on Fig. 2, a. The next group includes 6 samples from Hatis, distinguished on their similarity of (Ca·Y)/Th coefficient (~6000). The next compostitional group is from Gutanasar, samples are presented in 21 artifacts (16%) (see Figs. 2,b and c). Another 4 samples, distinguished by relatively high Rb and Nb and have been attributed to the Geghasar. Finally, 15 more samples were left unclassified, 7 of which are identical and form an unidentified, but homogeneous group called “Y”, which is quite remarkable. The samples included in the group are characterized by low Sr and high Zr content. The other eight samples could not be neither identified nor even grouped (Fig. 2).



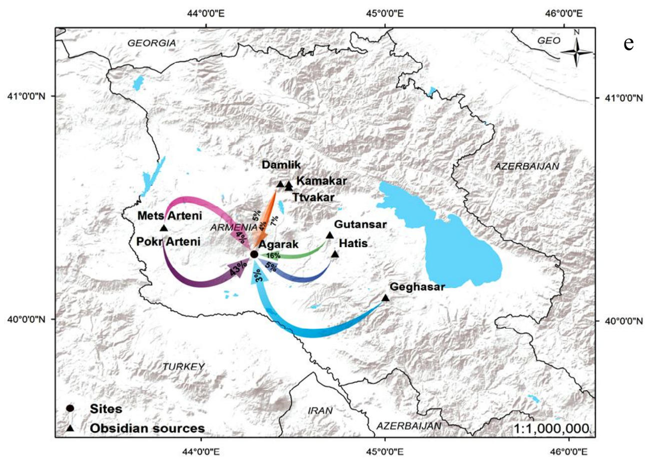
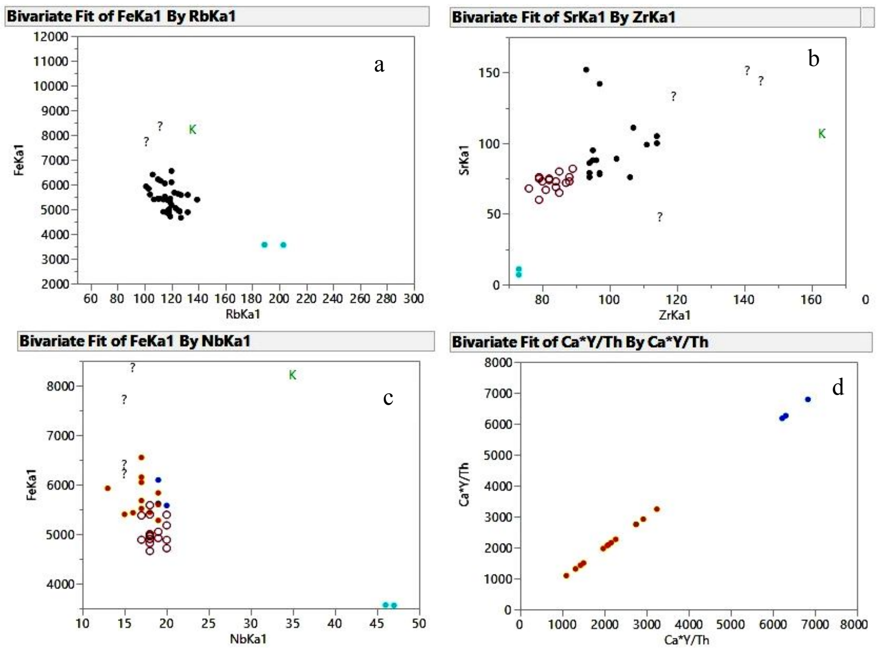


Fig. 2. Agarak: Fe/Rb (a); Zr/Nb (b); Sr/Nb (c); Ca·Y/Th (d) and the utility model map of the settlement Agarak (e).

So, what can be drawn for obsidian utility model of Agarak. The main source is Arteni, which is located about 42 *km* to the North-West (~50%). The next is Gutanasar, which is located 35 *km* to the North-West (16%). About 7.5%, 5% and 4% of the samples are attributed to the Tsaghkunyats range sources Damlik, Ttvakar and Kamakar, located approximately 38 *km* to the North-East. Located 38 *km* to the East Hatis and more than 65 *km* to the South-East, are attributed to 5% and 3% of total samples respectively. More then 5% of obsidian from Agarak remains unidentified (group named “Y”). The origin of this group may be found in the eastern Turkey, which is also rich in obsidian. Thus, the picture drawn in Agarak is totally different. The fact that there are 9 different sources proves multi-source model. In Agarak, no preference is given to single closest source. Instead, several others were used quite intensive (Fig. 2, e).

Teghut (NL 41°07′ and EL 44°50′), there were 20 samples available from two neighbor settlements Kharatanots (2011–2016) and Dzor Gegh (2010–2015), located near village Teghut of Lori District, which were found in the result of the excavations led by S. Obossian.



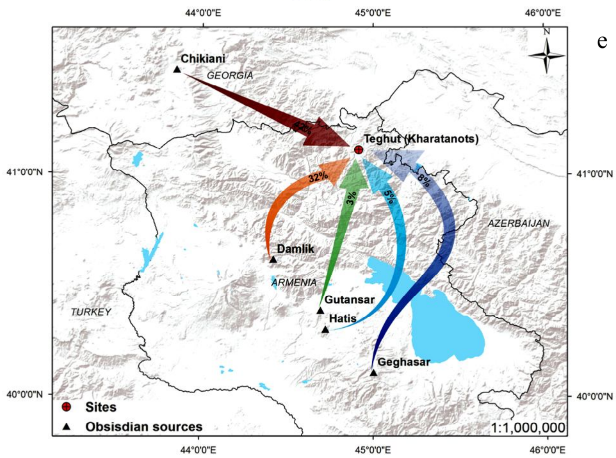


Fig. 3. Teghut: Fe/Rb (a); Sr/Zr (b); Fe/Nb (c); Ca·Y/Th (d) and the Utility model map of the settlement Teghut (e).

The settlements are chronologically synchronized and belong to the second phase of Kura-Araxes culture. According to preliminary results, most of the items were almost identical. First two samples were identified as Geghasar material by its

Nb/Rb ratios. One more sample clearly coincides with the obsidian of Gutanasar, see Fig. 3, a and b. According to Sr/Zr ratio some samples were attributed to Chikiani. Afterward (Ca·Y)/Th diagram was studied (Fig. 3, d). Three samples which value exceeded 6000 point were identified as Hatis, the rest 17 samples were attributed to Damlik. Four more samples unfortunately have not been identified (Fig. 3).

Thus, based on the results obtained, at least 5 compositional groups were distinguished for Teghut. Analyses have shown that Chikiani and Damlik are the primary sources for this settlement. It is remarkable that Chikiani, which is located about 117 *km* North-West far away from Teghut (territory of Georgia), accounts for 42% of the samples. The second source which is rather closer is Damlik accounts only 32% attribution. The remaining identified samples belong to the Gutanasar (3%), Geghasar (5%) and Hatis 8%.

The raw materials from 5 sources in Teghut, as well as in Agarak, proved the existence of a multi-source model. However, unlike Agarak, the main source here is quite far from the settlement, despite the number of closer sources. There was found a similar experience in the study performed by Chataigner and Barge, when quite far located source provided much more material than the closer one [15]. The distribution of this type can be testimony about some kind of relations with the population of the northern regions (Fig. 3).

Conclusion. So what can be drawn from all these? The analyses for 292 obsidian specimen samples were obtained using the pXRF. According to our data, the lithic industry of Tsaghkasar, Agarak and Teghut settlements were examined and compared with the obtained analytical database. As a result, 94.86% of samples were grouped, and 92.50% were identified, which is undoubtedly a good result for this type of study. First of all, these showed the accuracy of the obtained analytical database of the geological samples and allow to study lithic industry of abovementioned Early Bronze age settlements. So, their models were studied and presented in the form of maps. Comparing their results, there are 3 absolutely usage principles of obsidian appears, each of which has their own local motives.

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Ա. Կ. ՋՈՒՀԱՐՅԱՆ

ՀԱՅԱՍՏԱՆԻ ՕԲՍԻԴԻԱՆԻ ԱՂԲՅՈՒՐՆԵՐԻ ԸՆՏՐՈՒԹՅԱՆ ՍԿԶԲՈՒՆՔՆԵՐԸ ԲՐՈՆԶԵ ԴԱՐՈՒՄ PXRF ՎԵՐԼՈՒԾՈՒԹՅԱՄԲ

Ամփոփում

Նախորդ հետազոտության շրջանակներում ռենտգենային ֆլյուորեսցենցիայի եղանակով (pXRF) ստացվել է երկրաբանական օբսիդիայի նմուշների անալիտիկ բազա: Սույն հոդվածում ուսումնասիրվել են Կուր-Արաքսյան մշակույթին պատկանող երեք հուշարձաններից հայտնաբերված ընդհանուր քանակով օբսիդիանի 292 նմուշներ: Վերոնշյալ եղանակով տվյալ նմուշների քիմիական կազմը ուսումնասիրվել և համեմատվել է երկրաբանական նմուշների արդյունքների հետ, ինչը հնարավորություն ստեղծել հումքի ծագումնաբանության մասին պատկերացում կազմելու:

А. К. ДЖУГАРЯН

ПРИНЦИПЫ ВЫБОРА ИСТОЧНИКОВ ОБСИДИАНА НА ТЕРРИТОРИИ АРМЕНИИ В БРОНЗОВОМ ВЕКЕ, ПОЛУЧЕННЫЕ МЕТОДОМ МОБИЛЬНОЙ РЕНТГЕНОФЛУОРЕСЦЕНЦИИ

Резюме

В рамках предыдущих исследований методом мобильной рентгеновской флуоресценции (pXRF) была получена аналитическая база данных геологических образцов обсидиана. В данной статье изучены 292 образца обсидиана из трех поселений, принадлежащих к Кура-Аракской культуре. Методом pXRF химический состав данных артефактов был изучен и сравнен с результатами геологических образцов для определения источников их сырья.