УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ" - ШТИП
ФАКУЛТЕТ ЗА ПРИРОДНИ И ТЕХНИЧКИ НАУКИ

UNIVERSITY GOCE DELCEV - STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES

UDC: 622:55:574:658

ISSN: 1857-6966

Природни ресурси и технологии
Natural resources and technology

Број 2
No 2

Година 15
Volume XV

Декември 2021
December 2021

УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ” – ШТИП
ФАКУЛТЕТ ЗА ПРИРОДНИ И ТЕХНИЧКИ НАУКИ

Природни ресурси и технологии
Natural resources and technologies

декември 2021
December 2021

ГОДИНА 15
БРОЈ 2

VOLUME XV
NO 2

UNIVERSITY “GOCE DELCEV” – STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES

ПРИРОДНИ РЕСУРСИ И ТЕХНОЛОГИИ
NATURAL RESOURCES AND TECHNOLOGIES
За издавачот
Проф. д-р Зоран Десподов

Редакција и администрација	**Address of the editorial office**
Универзитет „Гоце Делчев” - Штип	Goce Delcev University - Stip
Факултет за природни и технички науки	Faculty of Natural and Technical Sciences
ул. „Гоце Делчев“ 89, Штип	Goce Delcev 89, Stip
Република Северна Македонија	Republic of North Macedonia

С о д р ж и н а / C o n t e n t s

UDC: 620.187:546.57-3]:[737.1:903.2(497.715)
DOI:https://www.doi.org/10.46763/NRT21152043b

CHEMICAL COMPOSITION OF THE SILVER TETRADRACHMS FROM THE LOCALITY ISAR MARVINCI DETERMINED WITH THE APPLICATION OF THE SEM-EDS METHOD

Ivan Boev [1]

[1]Faculty of Natural and Technical Sciences, "Goce Delcev" University in Stip,
Blvd. Krste Misirkov 10-A, P.O, Box 210, 2000 Stip, North Macedonia
ivan.boev@ugd.edu.mk

Abstract. This paper presents the research that has been done on the determination of the chemical composition of silver tetradrachms (museum specimens) using the SEM-EDS method. Studies have shown that the chemical composition (Ag, Cl, Fe, Pb) of the tetradrachms from the Isar-Marvinci site is similar to those from Aegean, Pella and Amphipolis. It can be concluded that these are coins that have a very homogeneous chemical composition (Ag; 96.7-98.3 %; Cl; 1.01-1.59 % ; Fe; 0.11-0.31 %; Pb; 0.31-0.58%; Au; 0.16-1.10%)

Kew words: tetradrachms, Alexander, coinc, SEM-EDS method

ХЕМИСКИ СОСТАВ НА СРЕБРЕНИТЕ ТЕТРАДРАХМИ ОД ЛОКАЛИТЕТОТ ИСАР МАРВИНЦИ ОДРЕДЕН СО ПРИМЕНА НА SEM-EDS МЕТОДАТА

Иван Боев [1]

[1]Факултет за природни и технички науки, Универзитет „Гоце Делчев" Штип, ул. 10-А, П.О 210, 2000
Штип, Северна Македонија
ivan.boev@ugd.edu.mk

Апстракт. Во овој труд се прикажни испитувањата кои се направени на одредувањето на хемискиот состав на сребрените тетрадрахми (музејски примероци) со примена на СЕМ-ЕДС методата. Со направените испитувања се доаѓа до заклучок дека хемискиот состав (Ag, Cl, Fe, Pb) на тетрадрахмите од локалитетот Исар-Марвинци е сличен на тетрадрахмите од Еге, Пела и Амфиполис. Може да се заклучи дека станува збор за монети кои имаат многу хомоген хемиски состав (Ag; 96.7-98.3 %; Cl; 1.01-1.59 % ; Fe; 0.11-0.31 %; Pb; 0.31-0.58%; Au; 0.16-1.10%).

Клучни зборови: тетрадрахми, Александар, монети, СЕМ-ЕДС метода

1. Introduction

Silver (chemical symbol Ag, from the Latin word argentum-silver) is a grayish white, easily bent and very soft noble metal. Low hardness of silver is an obstacle for its usage in many applications and products. Some silver alloys with copper, which contain 80 to 90% silver, have been widely confirmed and, as such, they have greater practical application. Just as the alloy of gold with copper is called gold, so the alloy of silver with copper is called silver. When silver or its alloy with copper is exposed to atmospheric influences, it reacts and a dark gray layer of silver sulfide called tarnish forms on the surface.

Silver very rarely appears in nature in its pure form, and therefore its use began later than the use of gold. With the appearance of the amalgamation process (the use of mercury in the extraction of noble metals) begins the process of obtaining silver from sands in which silver appears in fine grains. Most of the silver in nature appears in association with other metals in various mineral, as follows: Argentite (silver sulfide); Horn Silver (silver chloride); Galena (lead sulfide, the main ore of lead and one of the most important sources of silver); Pyrargyrite (silver sulfide-antimony sulfide). In ancient times, silver was used for making ornaments, jewelry, and coins. The use of silver in Mesopotamia began 20-15 centuries B.C.; in Egypt, the use of silver also began in the same period (Hess et al, 1988, Hoey et al, 2000).

The chemical composition of the coins provides important information regarding the techniques used in ancient times in terms of metal production (Cooper, 1988, Oddy, 1980). Basically,the chemical composition of silver coins indicates: 1) the development of metallurgy at the time of making the coin and 2) the origin of silver, i.e. from which ore the silver was obtained.

Basic data about the locality Isar-Marvinci

The archeological site of Isar, the village of Marvinci, Valandovo, is a settlement and a necropolis with a continuity from the VII century BC to the VI century AD. It is located next to the village, on its southwest side, on a very accessible hill with a great view of the Valandovo Valley and the valley of Vardar.

The first information about Isar dates back to World War I, when several findings from ancient Iron Age were discovered. In our professional literature it is registered for the first time with the archeological reconnaissance in (Sokolovska V.,1986). She studied and published a series of random findings (inscriptions, coins), as well as the results from the protective archeological excavation at the place called Porta, performed in 1961 by the Archaeological Museum of Macedonia from Skopje. Since 1977, excavations at the site have been carried out continuously within the project "Vardar Valley in the First Millennium BC." In the period from 2007 to 2010, the archeological site was part of the capital projects of the Government of the Republic of Macedonia.

Fig.1. Part of the archeological site Isar-Marvinci (near Valandovo)

In the earliest period of its existence, the settlement stretched over the area covered by Isar I and Isar II and covered about 5 hectares. Isar I is actually the acropolis of the settlement, erected on a hill spacious enough for survival. The acropolis was reinforced with defensive walls and as such existed throughout the Hellenistic period. At that time, the area of Isar II (sector 5) was also inhabited - the remains of houses found in probe 6, with characteristic material, confirm this. Although no experimental excavations have been carried out, judging by the configuration of the terrain, we can assume that the western terrace of Isar II was protected by a defensive wall. From these two points the settlement gradually expands, so, during the Hellenistic period, the nearest terraces were also inhabited. Conceived in this way, the settlement had the character of an economic, strategic and religious center of this region.

Stratigraphic data indicate three or four living horizons, most of which were destroyed by collapsing. Over a longer period (from the end of V to the middle of the II century BC), the Southern necropolis was used for burial. The discovered graves with rich content give a clear picture of the changes in the way of burial and the burial ritual.

Isar is a significantly large settlement, which developed its economic potential under local conditions, growing from a smaller agglomeration to a city-type settlement. Even during early Hellenism, mining emerged as an important branch of the economy, which was possible due to the presence of mining deposits in the region. The material remains indicate that the ore was processed in the settlement itself. This is not surprising since it is known that mining in Paeonia had a long tradition.

During the period of the early Roman Empire, the settlement developed and expanded. It seems that at this time, the western end of the acropolis was not inhabited, while the northeastern part has traces of life. At that time, the city expanded and it covered the neighboring terraces. Extensive archeological material shows that the city was experiencing a pronounced boom at this time. In I century it was an autonomous municipality - polis, where there was a contingent of immigrant Romans.

Towards the middle of III century, probably during the Gothic invasion in 268, the city was severely damaged. This historical data is confirmed by both archeological research and general impression of the development of the city. It soon recovered and lived with undiminished intensity.

During III and IV century, the Southern necropolis was again used as a burial ground. The burials from this period destroyed many older graves.

It is still not possible to determine for how long and with what intensity the life of the city on Isar existed.

Archaeological research at the site uncovered a number of coins (tetradrachms) dating back to the time of Alexander the Great and some of them (which are museum specimens) are an integral part of the research done in this paper.

2. Methodology

Scanning electron microscopy SEM analyses and electron micro-photographs were performed using a VEGA3LMU scanning electron microscopy (SEM) increasing 2×1000 000, Wwire, voltage up 200 V to 20 kV, infrared camera, maximum sample size 81 mm height, 30 mm width. The study utilized the semi-quantitative analysis using appropriate standards. The standards used are as follows: O: SiO_2; Na: albite; Mg: MgO; Al: Al_2O_3; Si: SiO_2; P: GaP; Ca: wollastonite; Ti: Ti; Fe: Fe; Br: KBr. The results of SEM/EDS analyses of silver coins demonstrated the usefulness of this method for the determination. The silver coins (tetradrachms) that represent museum specimens date from the time of Alexander the Great (Fig. 1) and (Fig. 2). It should be mentioned that there are silver coins of this time in numerous museums in the world (M. J. Price, 1991, G. Le Rider, 1992, 1997).

Fig. 2. Tetradrachm (By Olivera Angelkoska - own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=25737199)

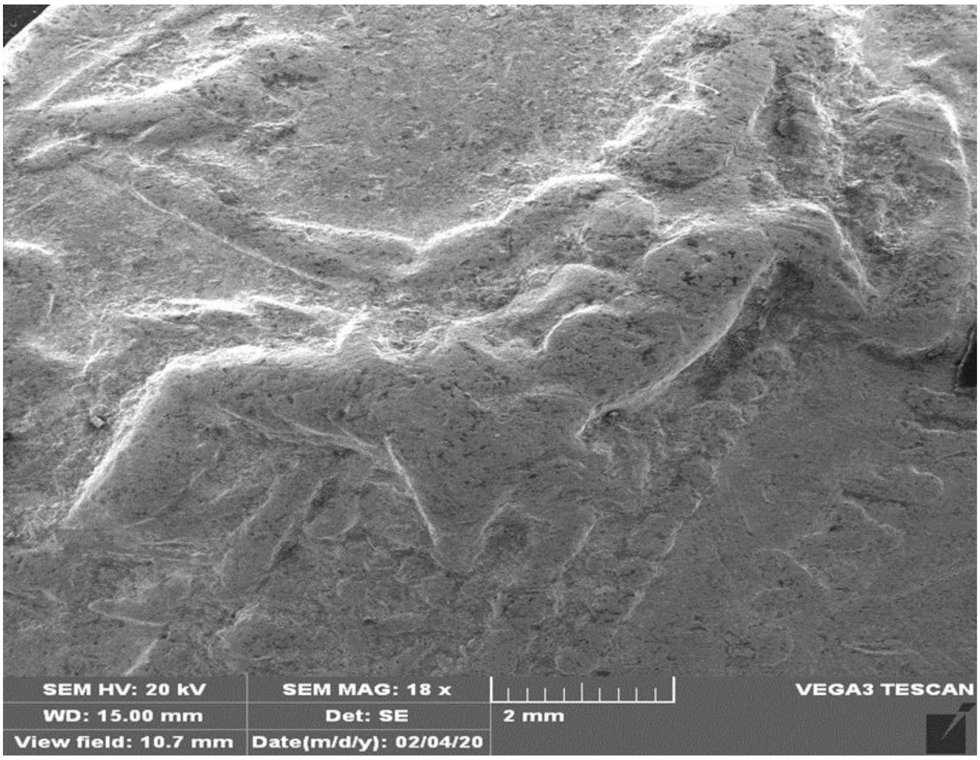

Fig. 3. SEM-EDS photograph of a tetradrachm from the Isar-Marvinci site

3. Results and conclusion

From the research conducted using the SEM-EDS method, the results shown in Table 1 are obtained. From the results shown, it can be concluded that the silver content is very similar and it ranges from 96.7 to 98.3%, which in turn points to the fact that the policy of minting silver coins was at a very high level in the kingdom of the Macedonians. As for the concentration of gold in these silver coins, it can be concluded that it is very low, usually below one percent, which in turn indicates the fact that gold was not added to silver when manufacturing silver coins. In general, it can be concluded that the composition of these coins is very similar to the composition of the coins from Aegean, Pella and Amphipolis (Kallitrhrakas-Kontas et al, 2000) and from Iran (Farhang Khademi Nadooshan et all, 2009). Table 2.

Table 1: Chemical composition of the tetradrachms from the Isar-Marvinci site (SEM-EDS method)

Isar-Marvinci	Ag %	Cl %	Fe %	Pb %	Au %
IS-1	98.3	1.01	0.11	0.13	0,16
IS-2	97.5	1.34	0.15	0.45	0.42
IS-3	96.7	1.59	0.21	0.45	0.87
IS-4	97.1	1.43	0.12	0.31	0.78
IS-5	98.2	1.10	0.11	0.22	0.31
IS-6	96.8	1.12	0.31	0.45	1.10
IS-7	97.4	1.09	0.12	0.58	0.72

Table 2: Chemical composition of the silver coin from National Museum of Teheran (Farhang Khademi Nadooshan et all, 2009) (XRF method)

Coin	Ag	Au	Cu	Pb	Bi	Zn	Fe
Alexander	90.753	0.486					
Alexander	93.074	0.235	0.633	0.33			
Alexander	96.434	0.846				0.163	
Alexander	94.437	0.519	1.089			0.349	
Alexander	93.779	0.9	0.357			1.688	
Alexander	95.,671	0.629	2.095				

References

[1]. Cohen, C., 2008.The Winds of Change: an archaeometallurgical study of silver production in the Porco-Potosíregion, southern BoliviaAD, 1500 to 2000. PhD, University College London.
[2]. Cohen, C., Rehren, T., Van Buren, M., 2009. When the Wind Blows: environmental adaptability in current day silver production within the Bolivian Andes. In: MOREAU, J. F., AUGER, R., CHABOT, J. & HERZOG, A., eds. Proceedings ISA 2006, 36th International Symposium on Archaeometry, Quebec, Canada. 465-475.
[3]. Cohen, C., Van Buren, M., Mills, B., Rehren, T., 2010. Current silver smelting in the Bolivian Andes: a review of the technology employed. Historical Metallurgy,44,153-163.
[4]. Farhang Khademi Nadooshan, Tahereh Azizipoor, Mohammed Taghi Safari, 2009: Seleucid Mintage: A Pattern for Parthian Coinage, Int.J. Humanities, Vol.16 (2), 51-58.
[5]. Hess, K., Hauptmann, H., Wright, H., Whallon, R., 1998. Evidence of fourth millennium BC silver production at Fatmali-Kalecik, East Anatolia. Metallurgica Antiqua8,57-67.
[6]. Hoey, K., Lawrence, S., Tucker, C., 2000. Archaeological Evidence of Ore Processing at the Howqua Hills Goldfield. Artefact: the Journal of the Archaeological and Anthropological Society of Victoria 23,9-2
[7]. Kallithrakas-Kontos, N., Katsanos, A.A., Touratsoglou, J., 2000. Trace element analysis pf Alexander the Great's silver tetradrachms minted in Macedonia, Nuclear Instruments and Methods in Physics Research B 171 (2000) 342-349.
[8]. M.J.Price, 1991. The Coinage in the Name of Alexander the Great and Philip Arrhidaeus, Swiss Numismatic Society, Zurich, 1991.
[9]. G.Le Rider, 1992. Rev. Suisse Numismatique 71, (1992) 214.#
[10]. G.Le Rider, 1997. Le monnayage d'argent et d'or de Philippe II, frappidien Maceodoine de 359-294, Bourgey, Paris, 1997.
[11]. Sokolovska V.,1979. La stele funerary de Marvinci, AIU XIX, Beograd 1979, 42.
[12]. Соколовска В.,1986. Исар-Марвинци и Повардарјето во античко време, Скопје 1986, 57-148.