Journal of Archaeological Science: Reports 9 (2016) 565–576

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Authentication and conservation of corroded archaeological Qatabanian and Himyarite silver coins

Omar Abdel-Kareem [a,*], Awad Al-Zahrani [b], Mounir Arbach [c]

[a] Conservation Department, Faculty of Archaeology, Cairo University, Egypt
[b] Saudi Commission for Tourism & Antiquities, Riyadh, Saudi Arabia
[c] CNRS-French Centre for Archaeology and Social Sciences, Riyadh, Saudi Arabia

ARTICLE INFO

Article history:
Received 5 May 2016
Received in revised form 10 July 2016
Accepted 18 August 2016
Available online xxxx

Keywords:
Saudi Arabia
Najran
South Arabian Kingdoms
Ḥimyarite and Qatabanian coins
Corroded archaeological silver coins
Soiled deposits
Encrustations and corrosion layers
Conservation processes
Mechanical cleaning
Chemical cleaning,
SEM-EDAX
XRD
Bone samples
Radiocarbon dating

ABSTRACT

To help the archaeologists study and date the archaeological silver coins excavated from burial soil, al-Ukhdoud castle, Najran, Saudi Arabia, it was necessary to reveal the impeded decorations and the inscriptions on these coins. For that it was necessary to remove the soiled deposits, encrustations, and corrosion layers covering these coins. To succeed in developing and establishing conservation processes for these coins, various tests were performed on the coins to assess their statement and condition. XRD analysis was used to characterize the coins. Also, scanning Electron Microscope (SEM) attached with energy- dispersive X-ray analyser (EDAX) was used to identify and analyse the corrosion products on the selected coins. Various selected cleaning processes that were suggested to remove the soiled deposits, encrustations, and corrosion layer covering these coins were tested. Mechanical cleaning, alkaline Rochelle salt, alkaline dithionite reduction technique, and electrolytic reduction techniques were tested. To evaluate the suggested cleaning processes used in this study, the coins before, while, and after the cleaning processes were investigated by various methods. SEM with EDAX and XRD techniques were used to characterize the coins before and after the final conservation. The results showed that the most adequate method that can be used safely and successfully for cleaning of the studied coins is as the following. In the beginning, the loosely corrosion layer on the coins has to be removed mechanically. Then, the coins should be treated with alkaline Rochelle salt technique. Finally, after finishing the treatments, the coins should be rinsed, dried, and isolated. The conservation processes used in this study can be applied effectively, safely, and successfully for cleaning and removing the soiled deposits, encrustations, and corrosion layers covering the coins in this treasure and the simulated archaeological coins. The archaeological and historical study of the decorations and inscriptions that appeared on the surface of the coins after their conservation process confirms that these coins belong to kingdoms of Qataban and Ḥimyar. The revealed decorations and inscriptions confirm that a part of the coins belong to Qataban kingdom which returns back to the first century BCE until the middle of the first century CE. The other part of the coins belongs to Ḥimyar kingdom which returns back to the first century BCE until the second century CE. The study confirms that the coins of this hoard date back to the period between last quarter of 1st century BCE-from the ruling time of the Ḥimyarite king, Shamnar Yuhan'im, to the end of the 2nd century CE-from the ruling time of the Himyarite king, Tha'ran Ya'ub. This study can be a guide for the conservators who seek to cleaning processes for simulated coins. Also this study provides archaeologists and historians with very important materials that can help them interpret many questions, mysteries, missing information, a lot of historical facts, and secrets about the economic and technical developments during the ancient times in Najran city.

1. Introduction

Saudi Arabia is located in the middle of the ancient world. So, many trade routes were passing across many regions in Saudi Arabia in ancient times (Abdel-Kareem et al., 2016a, 2016b). These trade routes included sea routes such as the red sea and land routes such as silk road and incense route. Najran was a focal point of the incense road. All routes that left ancient Yemen to the north or west had to meet at Najran (which was known in Islamic time as Al-Ukhdoud), where the routes branched into two general directions, the ones leading north through the Hijaz towards Egypt and the Levant and those leading to the north east towards Gerrha near the Persian Gulf. Najran's oasis with Amir tribe most prosperous trading time seems to the 2nd and 1st centuries BCE up to 2nd century CE (Schiettecatte, 2010).

So, there is a high probability to find coins in the excavations in these areas as a result of trade activities and taxes. Archaeological coins are important excavation findings that could provide to archaeologists

* Corresponding author.
E-mail address: omaa67@yahoo.com (O. Abdel-Kareem).

http://dx.doi.org/10.1016/j.jasrep.2016.08.025
2352-409X/

and historians additional information to ancient writings that come in forms of effigies, short inscriptions, and useful symbols. They are sources of documenting and understanding knowledge of mankind evolution (Reale et al., 2012). Coins are also the most important archaeological and historical findings that can provide us with information about the kings who issued coins in the South Arabian dynasties. More information about analysis of texts on the Qatabanian and Ḥimyaritic coins and classification of numismatic types chronologically are found in the following studies (Davidde, 2003; Munro-Hay, 2003a, 2003b; Huth and Alfen, 2010; Robin, 2010; Al-Zahrani et al., 2012).

Most of silver coins are made from silver-copper alloys (Costa, 2015). Archaeological silver coins (that contain a substantial amount of copper such as our case study, or another alloying element) are easily damaged and corroded (Viljus and Viljus, 2013). These silver coins were subjected to various corrosion processes resulting in different corrosion products that gradually alter their aspect, shape, nature, and resistance (Ioanid et al., 2011; Al-Zahrani and Ghoniem, 2012; Al-Saad and Bani-Hani, 2015). The status of the excavated archaeological coins, the corrosion products, and thickness of their layers depend on many factors such as the chemical composition of the coins, manufacturing technology of the coins, and the environmental factors surrounding the coins in the burial soil such as humidity, salts, pollutants, and microorganisms (Abdel-Kareem et al., 2016a, 2016b).

The most common corrosion products of coins made of silver-copper alloys are silver sulfide Ag_2S and silver chloride AgCl, cuprous and cupric sulfide, Cu_2S and CuS, CuCl (cuprous Chloride), $CuCl_2$ (Cupric Chloride), Cu_2O (Cuprous Oxide), and the aesthetically pleasant green and blue colored cupric carbonates [$Cu_2(OH)_2CO_3$] (Malachite), and [$Cu_3(OH)_2(CO_3)_2$] (Azurite) are the most corrosion products identified on copper objects (Abdel-Kareem, 2015). Many efforts have been done to investigate, understand, and analyse the corrosion products on metals and to explain the mechanisms of the corrosions on the metals (Ingo et al., 2004; MacLeod and Schindelholz, 2004; Campanella et al., 2007; Beck et al., 2008; He et al., 2011; Mousser et al., 2011; Rodrigues et al., 2011; Abdel-Kareem et al., 2011; Wan et al., 2015).

There is no doubt that coins pose challenges to conservators, archaeologists, and historians. From an archaeological perspective, the study of coinage reveals important information related to dating, social structure, economy, and politics (Kotoula and Kyranoudi, 2013). From conservators' perspective, all conservation processes that should be done to reveal the surface morphology of coins in order to be legible, identified, and dated must be safe on coins and preserve them for the next generations. All conservation actions should respect the code of conservation ethics. The main aim of any conservation processes to an object is to improve the long-term preservation of the object by making it safe and pleasing for display (Kotoula and Kyranoudi, 2013; Abdel-Kareem, 2015). The most common conservation processes of a metal object such as a coin include documentation, mechanical cleaning, chemical cleaning, and other cleaning methods such as laser cleaning, stabilization, isolation, restoration, exhibition, and storage (Koh, 2006; Vassiliou et al., 2007; Doménech-Carbó et al., 2009; Viljus and Viljus, 2013; Novakovic et al., 2013; Dillmann et al., 2013; Abdel-Kareem et al., 2016a, 2016b). Any conservation process should be started with a complete examination and documentation of the object (Abdel-Kareem et al., 2011).

Cleaning is usually the first step of many processes in conservation work. It is one of the most difficult operations undertaken when conserving metal artifacts (Novakovic et al., 2013). Any cleaning process must be carried out with great respect and consideration of the original object's form, function, and material (Abdel-Kareem, in press). For this reason, efforts should be done to find and develop new techniques and methods which will be more suitable for cleaning the corroded archaeological silver coins. There are various common methods used in cleaning coins such as mechanical cleaning, chemical cleaning, alkaline dithionite galvanic cleaning, and electrolytic reduction cleaning (Ghoneim and Megahed, 2009; Watkinson, 2010; Costa, 2015). Many methods are developed to conserve metals such as laser cleaning that is now becoming an accepted and important technique in conservation of archaeological coins (Abdel-Kareem et al., 2011; Abdel-Kareem et al., 2016a, 2016b).

However, the new techniques are not always suitable and accepted for conservation of all materials such as coins excavated from soil with thick layers of crust and corrosion products. Also, sometimes the new techniques are not available in the conservation laboratories or in the archaeological sites. So, it is important to select available methods that can be applied easily and safely to conserve these types of archaeological coins. The most important requirement that should be considered is that the selected methods should not damage the surface of the coins and should be applied carefully to prevent any side effect of the misuse of any conservation technique. For example, the mechanical cleaning can be effective and useful in cleaning the thick layers of soiled deposits, encrustations, and corrosion products covering the coin, but this process should be stopped before the appearance of the fresh surface of the coin. If the mechanical cleaning was done until the surface of the decoration of the coin was completely revealed, the surface of the coin, most probably, will be damaged. Also, not all chemical cleaning methods are suitable to clean the coins. Some chemical methods used in cleaning coins can react with the coins and deteriorate them. So, any method that will be suggested to conserve the coin should be justified and applied with controlling all conditions.

The present work aims to determine the best method that can be used safely to remove the soiled deposits, encrustations, and corrosion layers covering the archaeological silver coins excavated from burial soil in the Site of Al-Ukhdoud, Najran area. This is to reveal the surface of the coin with its decorations, inscriptions, and symbols. Also, the study aims to authenticate the conserved coins according to the revealed writings and descriptions on the surface of these coins. The radiocarbon dating for the bone samples excavated from the same area was carried out to compare it with the results of dating the coins according to the revealed writings and descriptions on the surface of these coins. Finally, the study aims to classify the coins chronologically.

2. Experimental

2.1. Description of the studied coins

This study is carried out on corroded archaeological silver coins (Najran Hoard coins). This treasure, a major finding in this excavation, was discovered at Al-Ukhdoud archaeological site, Najran Castel, Najran area. It is a pottery jar filled with silver coins (see Fig. 1); it was found in agricultural burial soil in the middle of a room in the castle building (Al-Zahrani et al., 2012).

2.2. The characterization and status of the studied coins

To characterize and estimate the status of the studied coins and to identify types of the corrosion products covering these coins, various investigation and analysis methods were carried out on the coins. The coins were investigated visually and microscopy. The Scanning Electron Microscope with Energy Dispersive X-ray Analysis (Model JEOL JSM-6510LV, voltage 30 kV) has been used according to Abdel-Kareem (2015) to examine the surface morphology of the selected coins. For EDAX analysis, 15 selected coins were investigated to provide us with the average of the identified elements on the investigated coins. Also, the coins were analysed with X-ray diffraction (XRD) to identify the component of the coins and the corrosion compounds that disfigured the surface. This analysis was carried out on Philips X-ray diffraction, type PW 1840, giving 40 kV, Cu Kα radiation at 25 mA; the scanning range of 2θ was from 5 to 60° and the scanning speed was 2°/min. The samples were prepared and investigated according to Abdel-Kareem (2015).