Use of a Vibro-graver Tool for Mechanical Cleaning of Copper Alloy Stamp Seals

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INTRODUCTION

Kaman-Kalehöyük is situated in Central Anatolia, southeast of Ankara and 52 km from the center of Kırşehir. Its covers an area of 1.799 km^2, with a diameter of 280 m and a height of 16 m. Kaman-Kalehöyük excavations started on May 31, 1986 and many artifacts and architectural remains from the Early Bronze Age to the Ottoman Period have been found. The finds consist of clay tablets, pottery, stamps, stamp seals, painted earthenware, bullae and animal figurines, made of bronze, iron, wood, clay, copper and bone. In this article we will focus on the cleaning of copper alloy stamp seals from the excavations at Kaman-Kalehöyük. At Kaman-Kalehöyük a survey of stored metal artifacts is carried out every excavation season. During this survey; several copper alloy stamp seals with active corrosion products have been identified.

These seals themselves are important elements in the ancient society and the study of their multifaceted significance is rewarding. They express the relationship between individuals, the economic hierarchy and legal identity and render the visible mythopoeic interpretation of the universe, that is the relationship between the divine and human worlds. All seals are protected, whatever the impressions are made of. The shapes (animal shapes, zoomorphic shapes), materials and texts on the seals are very important features. From an artistic point of view, seals serve as a miniature record of themes that might have been used in now-lost large-scale artworks (Westenholz 1995: 7-8). This explains the necessity and importance of the conservation of copper alloy seals.

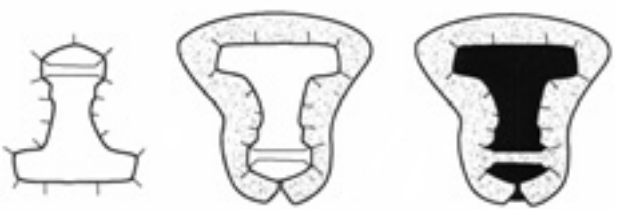

Fig.1 Lost Wax Casting in a Clay Core with Protruding Chaplets
1. Modeled wax stamp seal 2. Wax stamp seal is invested with clay core and then heated and fired to remove the wax and harden the core 3. Bronze is cast into the space originally occupied by wax. Headers and chaplets are later removed

In antiquity most copper alloy stamp seals were made by casting, in the lost wax technique (Hodges 1998).

This article aims to discuss and evaluate the advantages of using the "vibro-graver tool" for the cleaning of highly mineralized copper alloy stamp seals.

CLEANING METHODS AT KAMAN-KALEHÖYÜK

The most acceptable method of cleaning copper alloy seals is mechanical cleaning, by using simple hand tools (such as scalpel, pin pick, glass bristle brush and dentist drill with a soft brush). The main advantages of this method are the easy control and selectiveness which enables the conservator to remove only the unwanted layers and to preserve the rest. Therefore, when the patina is present, mechanical cleaning is the only method which will succeed in preserving it. On the other hand, chemical cleaning has many disadvantages; such as

difficulties in controlling the extent of the process, as well as the side effects of the after-treatment residues which may result in losing valuable archaeological and technological evidence. Nevertheless, there are certain cases where the use of chemicals could be advisable and since the identification of a stamp seal is very important, chemical cleaning is an alternative treatment when the details cannot be revealed by mechanical means. However, for most conservators this method is considered irrelevant. Chemical cleaning has many drawbacks: it is an uncontrollable stripping method, it needs special equipment, and the danger of metal re-deposition is always present (Jones 1998).

In the Kaman-Kalehöyük Treatment Procedure Protocol for copper alloy artifacts, it is emphasized that before undertaking any conservation treatment, it is essential to examine all the copper alloy artifacts under the microscope. If there is no bronze disease present on the artifact, soil and the superficial corrosion are mechanically cleaned while working under the microscope. Ethanol or water solution may be used on swabs or by pipettes and immersion to remove the soil. When bronze disease is present, it is recommended to use the same procedure, followed by the cleaning of active corrosion spots with a probe, scalpel or high-speed rotary drill tool to expose the bare metal if possible. If no metal core is remaining, it is suggested to remove the powdery corrosion products only.

METHOD OF VIBRO-GRAVER TOOL CLEANING

Before attempting the overall mechanical cleaning of an object, it is essential to do an exploratory cleaning to evaluate the extent of the treatment that is necessary to achieve a desirable result for display purposes. This work may also be necessary to assess the mechanical stability of the object, to determine whether it is totally mineralized or some metallic core exists. The surface will be investigated at this stage for any unusual corrosion features, surface finishes, or mineralized remains.

During the actual cleaning process, when removing soil or earthy minerals, to reveal the outermost layers of the bronze patina, there are usually no special problems encountered. However, the real problems begin with the attempts to expose the object's original surface, which may be preserved in a cuprite layer below the outer?, sometimes swollen, covering layers of basic copper carbonates and basic chlorides. These layers are often quite hard and the cuprite layer itself may be either very compact or sugary, which cannot be gauged without prior exploratory cleaning (Scott 2002).

To carry out the aforementioned cleaning processes, vibro-tool cleaning, which is investigative is appropriate. Investigative cleaning is "micro archaeology" and the removal of material only after careful recording, will the reveal metal structures below. These structures may be an element of a discrete object or may be classified as related material. Decisions concerning the extent of the

Fig.2 Vibro-graver tools

Fig.3 Vibration levels (from 1 to 5)

cleaning process will be made according to what is to be exposed and what must remain.

The vibro-graver tool works with an "in and out movement of its pointed head," which dislodges the overlying debris of the object. The vibro-graver tool has different vibration levels between 1 and 5 and the vibration level can be chosen by the operator according to the roughness of the corrosion products, as well as the stability of the object (Cronyn 1990).

The vibro-graver tool among the other electrical cleaning instruments is very useful as it cleans almost any hard corrosion layer without leaving a permanent mark on the original surface. When fragile or delicate specimens require a gentler touch, this can be provided by vibro-graver tool's pneumatic mini air hammers (http://www.flmnh.ufl.edu/natsci/vertpaleo/resources/prep.htm). The hand-held electric vibro-graver tool can also be used with a needle fitted instead of the engraving point. This tool has a positive on-off switch and a spark-free motor that vibrates at 7200 strokes per minute. The calibrated adjustment dial changes the length of stroke and depth of mark. Only 6 inch long and it is as easy to use as a pencil, which can be operated on 110V AC for a long time without heating up or tiring the hand (http://www.shorinternational.com).

METHODOLOGY USED AT KAMAN-KALEHÖYÜK

During our work at Kaman-Kalehöyük, the copper alloy stamp seals were observed under the microscope and then all the details on the objects were examined by using investigative laboratory equipment and methods (metal detector, chemical analysis, etc.). Then overall surface soiling was removed with scalpel and brush, followed by immersion of the object in ethanol to soften the dirt. At the completion of the cleaning of the surface soil, the vibro-graver tool was used for cleaning under the microscope. The object was supported on a bed of polyethylene during this process to minimize the effects of vibration. Cleaning was initiated from a selected part of the object and the following parts were treated likewise up to the level of the original surface reached. The vibro-graver tool vibration level was set at 1 and the process was performed under the microscope to provide a controlled cleaning. Stamps cleaned with this method are illustrated in Figures 6-8.

RESULTS AND DISCUSSION

The elemental composition of three stamp seals from Kaman-Kalehöyük obtained by X-ray fluorescence analysis showed that a high percentage of arsenic, about 20%, is present (Table 1). All three objects have no metal core and they were covered with thick layers of hard corrosion products. Copper alloy stamp seals #C99-594 and #C04-333 were analyzed only after mechanical cleaning (AT) whereas #C99-593 was analyzed both before (BT) and after (AT) cleaning treatment.

As seen in Table 1, the untreated object #C99-593 (BT) shows a significantly higher copper content and lower arsenic content in the analyzed upper layer of corrosion products, as compared to the surface exposed by investigative cleaning, #C99-593 (AT). This might be the result of different corrosion activity of copper and arsenic. Arsenic has a considerable hardening effect on copper alloys (Hodges 1998). It is thought that arsenic hardens the mineralized original surface of the object, preserving the details of its shape.

During the excavation seasons from 1989 to 2004

Table 1 Chemical composition of three stamp seals (mass %)

Samples	Cu	As	Pb	Fe	Sb
C99-593 (BT)	87.5	6.4			
C99-593 (AT)	77.5	21.3	-	0.52	0.54
C99-594 (AT)	59.8	31	-	8.4	-
C04-333 (AT)	72.7	13.4	6.6	0.2	6.9

Table 2 Quantitative information of Cu alloy stamp seals in Kaman-Kalehöyük (29 stamp seals)

Heavily corroded stamp seals	29
Stamp seals with bronze disease	10
Stamp seals without bronze disease	19
Stamp seals with metal core	23
Stamp seals with no metal core	6

Fig.4 Before cleaning treatment (#C94-86)

Fig.5 During cleaning treatment (#C94-86)

Fig.6 After cleaning treatment (#C94-86)

Fig.7 Before cleaning treatment (#C94-87)

Fig.8 After cleaning treatment (#C94-87)

at Kaman-Kalehöyük, archaeologists found twenty-nine copper alloy stamp seals and their condition features are summarized in Table 2. The data from the conservation reports show that most of the stamp seals were cleaned mechanically with scalpel, pin and brush and the details were not clarified after cleaning. One stamp seal was cleaned chemically and the result was not only unsuccessful, but also the original surface of the object was lost. Therefore it was found necessary to use a new cleaning technique for mineralized and heavily corroded stamp seals.

The vibro-graver machine was proposed and tested for the mechanical cleaning of these objects. Four seals were successfully cleaned using this machine. All four objects were completely mineralized and heavily corroded. However, in each case, the original surface was found and very clear details appeared on it.

CONCLUSION

In 2005 three copper alloy stamp seals were chosen for conservation re-treatments during the condition survey, for they had active corrosion products. During the mechanical cleaning and stabilization of these objects with a vibro-graver tool, we reached to the original surface and clear details appeared on the stamp seals. The elemental composition of these seals obtained by X-ray fluorescence analysis showed that arsenic is present in all three objects, which have no metal core. Examination results indicated that heavily corroded copper alloy objects with such archaeological importance need to be examined more carefully and a cleaning instrument such as the vibro-graver tool, which will clean the corrosion layers without damaging the original surface, should be employed. This method can be also recommended for other objects that have a bulky appearance (not for flat fragile ones). However, one should bear in mind that this method can be a slow process.

Finally, examination and analysis of the remaining copper alloy stamp seals from Kaman-Kalehöyük will help us to evaluate the results obtained during the investigation and conservation work undertaken during the 2005 campaign.

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