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A. Artusi, M. Joly-Parvex, G. Lucet, A. Ribes, and D. Pitzalis (Editors)

Virtual Replication of the Idalion Tablet

B. Robin[1], T. Hilpert[1], K. Miyazawa[1], P. Callet[2,5], F-X. de Contencin[3], A. Zymla[4]

[1] Ecole Centrale Paris, 2nd year Student, France
[2] Ecole Centrale Paris, MAS, France
[3] Ecole Centrale Paris, LGI, France
[4] Ecole Centrale Paris, LGPM, France
[5] Centre Français de la Couleur, France

Abstract

The Idalion Tablet is an antique bronze (480-470 BC) found around 1850 in the antique city of Idalion in Cyprus. It has an important historical value for Cyprus, as it is the longest testimony of Cyprus sillabary writing. The tablet has been the property of the Bibliothèque Nationale de France (BNF) *since 1862. Our final goal is to realise a perfect physical copy of the Idalion Tablet (scale 1, with no patina) as a donation to the Idalion Museum in Cyprus. In a few months the historical building "Richelieu" of the* Bibliothèque Nationale de France *is going to be renovated, leading the museum to close for an unknown time. We present here the realisation of a high quality virtual copy of the Idalion tablet, with the same shape and a spectrally simulated visual appearance of the precious artefact as it could be in the ancient times. We used 3D digitization to create a virtual and accurate replica of the tablet shape as we were not allowed to handle it directly. The* Centre de Recherche et de Restauration des Musées de France (C2RMF) *took a sample of the alloy out of the Idalion Tablet, and analysed its elementary composition using the PIXE method. The complex index of refraction of the alloy was calculated using previous scientific results. The virtual copy was then computed with the Virtuelium free software. The physically based images obtained by spectral simulation will be used on the BNF website to give the public an access to its collections. A didactic movie is also in progress for that purpose. We shall then realise the physical copy of the tablet by rapid prototyping, and casting, in collaboration with the* Centre Technique des Industries de la Fonderie (CTIF) *and the* Ecole Supérieure de Fonderie et de Forge (ESFF).

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—Digitizing and scanning

1. Introduction

We realised a virtual copy of an antique bronze from Cyprus, the Idalion tablet, with the same visual aspect as the original one, by spectral simulation with the software *Virtuelium* using a CIE colorimetric standard observer and CIE normalized illuminants. This work is part of a bigger project, which aims at realising a perfect physical copy in bronze of the Idalion tablet, using digitization, rapid prototyping and casting. We first present the historical context of the project, and its goal. Then we explain how we digitized the Idalion tablet and how we got the necessary data for the spectral simulation: elementary composition of the bronze and its complex index of refraction.

2. Short History of the Idalion Tablet

The Idalion tablet is named from the antique city where it was found in Cyprus. Here we explain why it has an important historical value for Cyprus.
Idalion was an antique city of Cyprus (near the current town of Dali). According to the legend Chalcanor, an Achaean hero of the War of Troy, funded it. The Kingdom of Idalion was at the top of its cultural and economic power during the 7th century BC and until the conquest of the town by the Phœnician Kings of Kition during the 5th century BC. Idalion is now one of the most important archaeological sites in Cyprus.
The Idalion tablet is made of bronze (its dimensions are: (X: 14.2; Y: 21.5; Z: 1.1 cm) while its weight is 2 247.22 g).

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Some illegal excavators at the archaeological site of Idalion discovered it around 1850 [Mas61]. It used to be hanged in the temple of Athena. A French collector, Honoré d'Albert, the Duke of Luynes, bought it. In 1862, the Duke gave the tablet to the *Bibliothèque Nationale de France*, with all his collection. Cyprus syllabary writing covers the tablet on its two sides. The Idalion tablet is the oldest, longest and richest testimony known of this writing. Its discovery permitted the acknowledgement of the existence of this writing. The text, written in 480-470 BC, is an agreement between the King of Idalion Stasikypros and the doctors Onasilos and his brothers. The doctors commit themselves to cure the wounded after the siege of the city by the Persians and the Phœnicians of Kition. In exchange of their help, they will be given lands near the city.

3. 3D Digitization

As the tablet has an important cultural and historical value, we were not allowed to handle it directly neither to realise a mould by physical contact with the tablet. We used 3D digitization to create a virtual and accurate replica of the tablet shape.
We used a scanner Breuckmann derma*TOP*. The aim of the digitization was to get 3D image data, to be able to make a physical replica of the tablet. The digitization was done in collaboration with the Eotech company. Ecole Centrale Paris supported the financial needs of this step. Figure 1 shows an image of the 3D copy of the Idalion Tablet, and details of the writing on the 3D copy. The main difficulty of this step was the amount of data necessary to guarantee a good precision for the reproduction of the tablet by casting.

4. Analyses of the composition of alloy by the PIXE method

The goal of this project is to create a perfect copy of the Idalion tablet, which will be like the original one in its shape, writing and alloy composition. We wanted to see the tablet in its aspect at the time it was made, without the patina. The *Centre de Recherche et de Restauration des Musées de France* (C2RMF) analysed the alloy of the tablet using the *PIXE method* [Gov01] on the *AGLAE* particle accelerator . For the tablet analysis, the C2RMF used a beam of protons of 3 MeV and of about 0.5 mm of diameter, with a scanning of the surface on 0.5 mm x 0.5 mm. The analysis was done until 50 μm deep into the alloy.A filter of 100 μm of Al was placed in front of the detector of high energies. To be sure that no layer of alteration disrupts the mesurements, a RBS spectrum (Rutherford Backscattering Spectrometry) was acquired at the same time. The analyses were done on metallic shavings taken by microborehole (with a rapid drill in steel) near the suspension, that were laid out on an adhesive sheet of carbon. The results are shown in the table 1 below. As expected for a bronze, the main elements in the alloy are copper (96.5%) and stain (2.4%). In this alloy the ratio of copper is very high. This is probably due to the fact that there was a lot of copper available in Cyprus, which was very famous for its copper fields. We cannot compare those results with the composition of other antique objects from Cyprus, as the data on this subject is rare.

Element	Mn	Fe	Co	Ni	Cu
Mass (%)	<0.05	0.3	0.05	<0.03	96.5
Element	Zn	As	Ag	Cd	Sn
Mass (%)	<0.08	0.04	<0.09	< 0.06	2.4
Element	Sb	Te	Au	Pb	Bi
Mass (%)	<0.9	<0.4	<0.1	0.8	<0.06

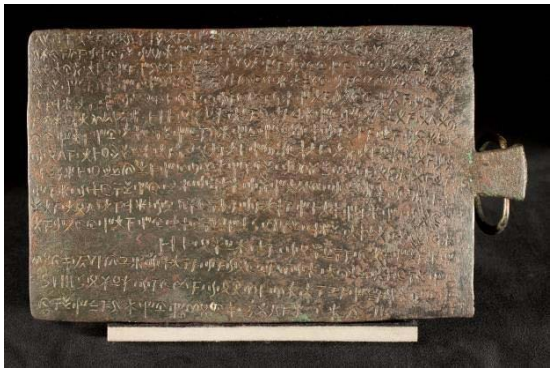
Table 1: *Elementary composition of the metal of the Idalion tablet (results in mass percentages).*

5. Virtual replica - Virtuelium

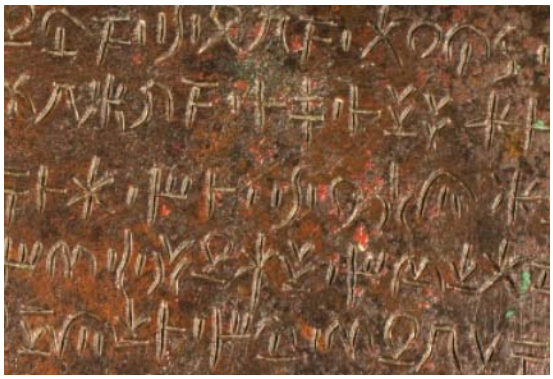
In a few months the historical building "Richelieu" of the *Bibliothèque Nationale de France* is going to be renovated and the museum where the Idalion tablet is exhibited will close for an unknown time. Thus, we decided to realise a virtual copy of the Idalion Tablet which could be shown on the BNF website and accessible to everybody even during the renovation period. To do that, we used the Virtuelium open-source software.
Virtuelium was developped by a research team of laboratory MAS (Mathematics applied to systems) of the Ecole Centrale Paris . Its authors (for the V.4.2 release online) are P. Callet, Ariane Genty, Sylvain Dumazet. It is available online at http://virtuelium.free.fr . Virtuelium renders physically based realistic images. It differs from other renderers because it uses the most fundamental material properties in its algorithms. In addition, it is able to consider many optical phenomena, usually ignored in the rendering software such as spectral dispersion due to a material with variable indices, or polarization of light. Virtuelium is a renderer and not a modeler. Thus, it renders the 3D scenes described in XML format that links shapes exported from other software (OBJ format) and materials to use. Some of the main characteristics of Virtuelium are:

1. Spectral rendering with a parametrable wavelength sampling for all elements (viewer, materials, illuminants, propagation media) ;
2. Polarization effects accounted for all steps of the computations ;
3. XML formalism for 3D scenes and data descriptions ;
4. Multithreading and/or grid computing ;
5. Multilayered materials (macroscopic layers of paints or multiple thin films assembly) ;
6. High Dynamic Range Imaging ;

A special photon-mapping algorithm according to Jensen [Jen99] specifications is implemented in Virtuelium software and used here for realistic rendering. To run, Virtuelium



(a) The Idalion tablet: original and copy



(b) 3D image of the Idalion tablet rendered with CAD Software CATIA (non spectral rendering)

(c) Detail of the writing on the Idalion tablet: on the original tablet

(d) Detail of the writing on the 3D copy of the Idalion tablet with the software Rapidform

Figure 1: *The Idalion tablet: High definition digitized original and virtual copy (with no spectral rendering)*

needs the computation of the following elements: the 3D file of the digitized tablet and complex indices of refraction of the tablet material. To get these complex indices, given the fact that we have the elementary composition of the tablet thanks to the analysis made by the C2RMF, we used previous ellipsometry measurements [Cal05b, CZ06, R. 67] to calculate by linear interpolation the real and imaginary parts of the index of refraction of the bronze of the Idalion tablet. Ellipsometry [Fuj07] is an optical technique for surface analysis based on the measure of the change in the polarization state of light after reflection on a flat surface. The measurement is performed on all visible spectrum. As the lead has no influence on the visual aspect of the alloy, it was not taken into account for calculating the complex indices. Figure 3 and 2 show the results for the real part N and the imaginary part 'Kappa'. With those results, and thanks to the 3D copy of the Idalion tablet, we were able to use Virtuelium to compute the final virtual copy of the tablet. The obtained results are shown in image in the figure 4.

6. Conclusion

The virtual simulation of the Idalion tablet is complete. The next step of the project is the realisation of the physical replica of the Idalion tablet, in collaboration with the *Centre Technique des Industrie de la Fonderie* and the *Ecole Supérieure de Fonderie et de Forge*. It will give us the opportunity to confirm our results, by doing ellipsometry [Fuj07] and roughness [Jen99, Cal05a] measurements on a piece of the alloy (from the blowholes for exemple) used to cast the replica of the tablet. Thanks to previous work [Cal05b] relating to chinese bronzes, we had the opportunity to determine the alloy composition of the real tablet. The validation process cannot be achieved without these physical data extrated from the physical replica to be obtain. We shall then compute new images of the tablet using Virtuelium, and next, shall compare them to the presented work at VAST 2010 Conference.

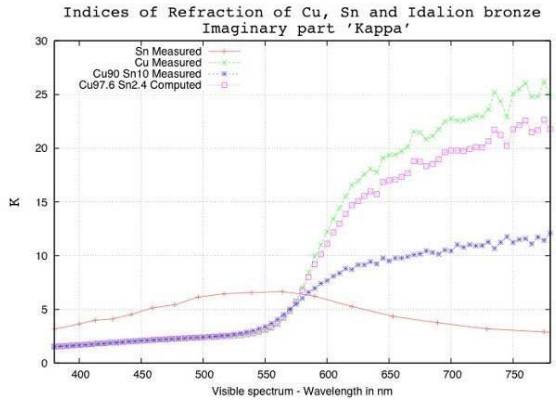


Figure 2: *Indices of Refraction of Cu, Sn and Idalion bronze, Imaginary part 'Kappa'*

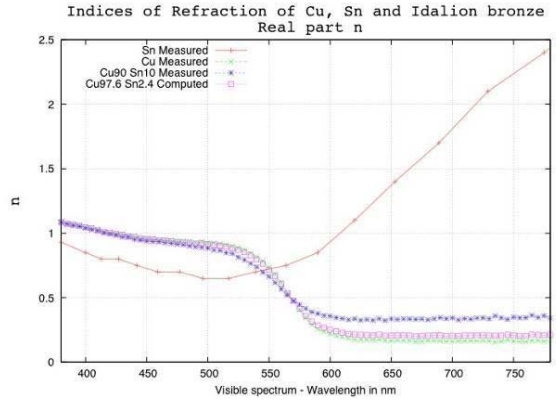


Figure 3: *Indices of Refraction of Cu, Sn and Idalion bronze, Real part N*

7. Acknowledgements

We acknowledge the Medals and Coins department of the *Bibliothèque Nationale de France* for allowing us to digitize the Idalion tablet, P. Denizet and M.-F. Monanges for realizing the documentary film on our work, and D. Bourgarit for analysing the elementary composition of the tablet alloy. This work would not have been possible without the financial support of our school of engineers *Ecole Centrale Paris*.

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Figure 4: *Virtual replication of the Idalion tablet using Virtuelium in spectral rendering with normalized lighting conditions (CIE D65 illuminants, CIE 1964 10*deg *colorimetric observer*

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