

Relating the damage assessment of outdoor bronze and copper monuments in Greece to the environment, techniques of construction, and past cleanings

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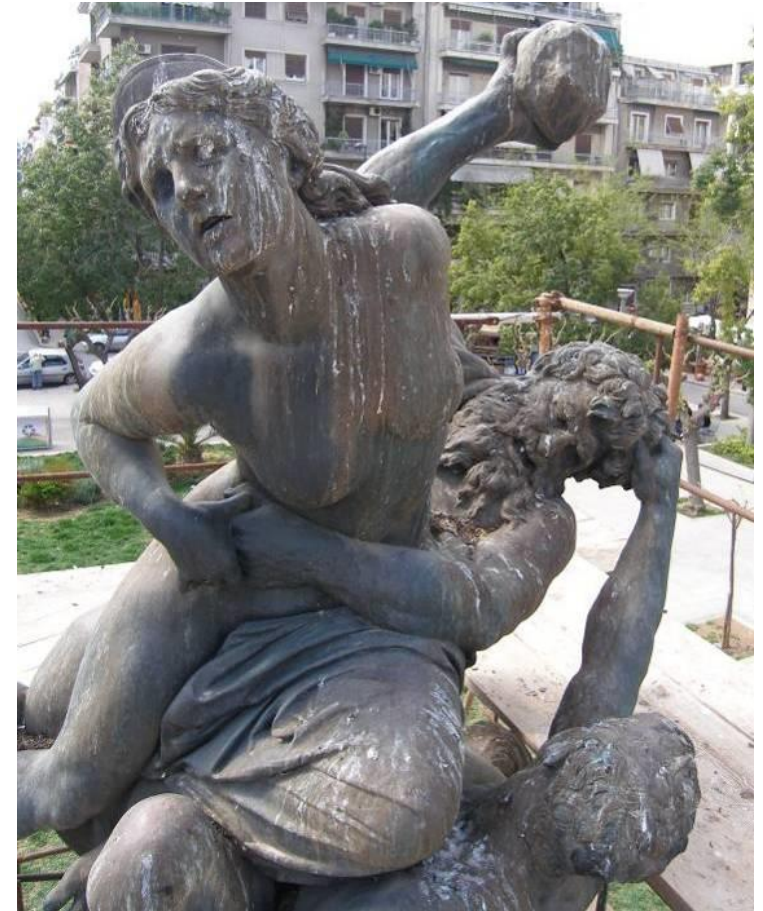
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OPEN AIR METAL OUTDOOR METALLIC
SCULPTURE FROM THE XIXTH TO THE BEGINNING
OF THE XXTH CENTURY

Kolokotronis in Nafplion and Athens



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SCULPTURE FROM THE NINETEENTH TO THE BEGINNING
OF THE TWENTIETH CENTURY

Objectives

- condition assessment for unique masterpiece monument located in Athens since 1927 “Theseus saves Hippodamea” constructed in 1908, artist Joh. Pfuhl, German manufacturer WMF in Geislingen
- Compare the types of corrosion products to past research carried out for the Kolokotronis monuments in Athens and Nafplio
- to better understand the techniques of fabrication, corrosion, and damages of this monument, in relation to its environment and past cleanings.



Theseus by Johannes Pfuhl in 1907

- Looks and sounds like cast bronze but copper
- 'Hollow type' expensive to make as opposed to 'Core type'
- Key is thickness of wall
- Good replication technique



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Famous monuments in Poland and Germany

Perseus Monument in the catalogue of WMF (1910)



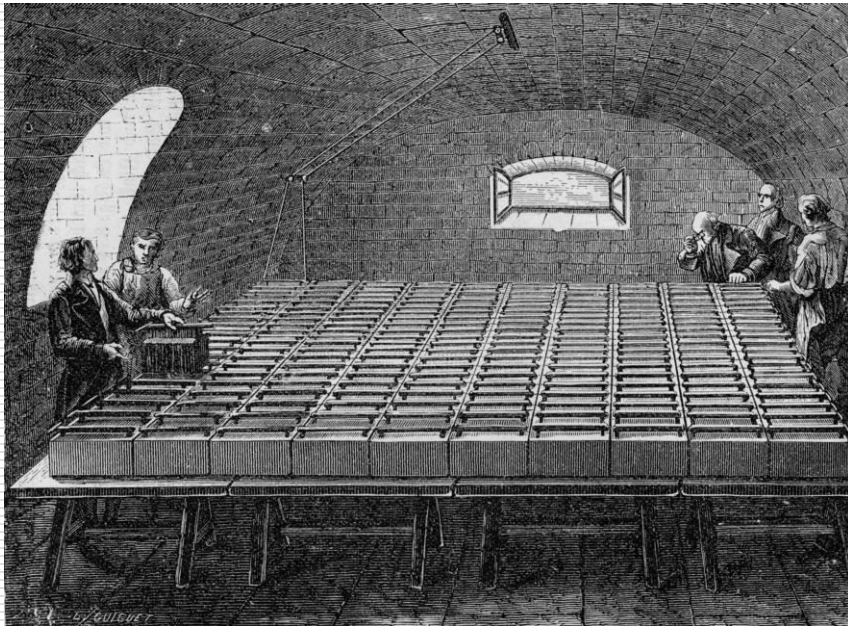
Perseus Monument on the roof of the "Theater des Westens", Berlin



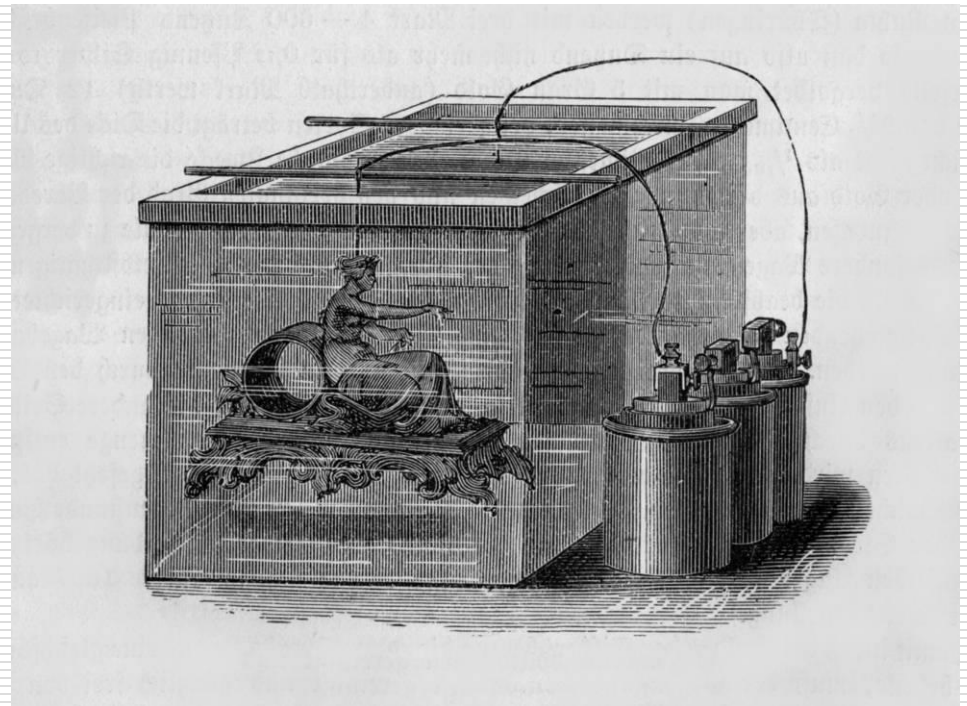
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Electrotype technology

German WMF company founded an electrotype department in 1890



Voltaic power source in the laboratory of the chemist Sir Humphry Davy (1778-1829) made up of 200 copper-zinc galvanic elements

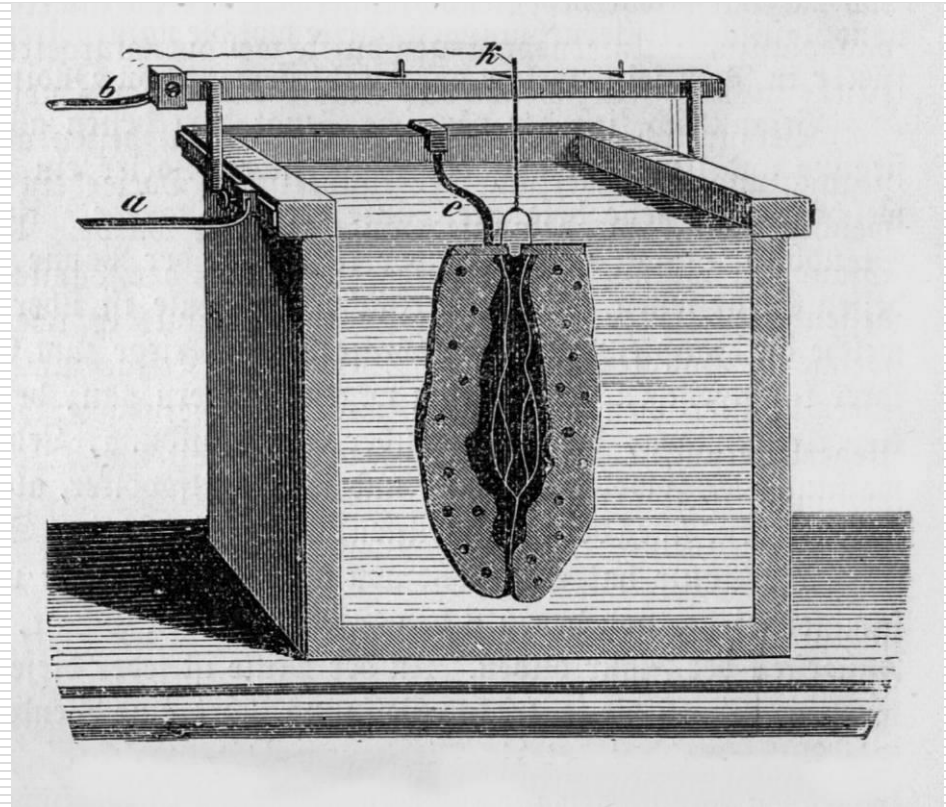


Schematic diagram of the "core type" process.

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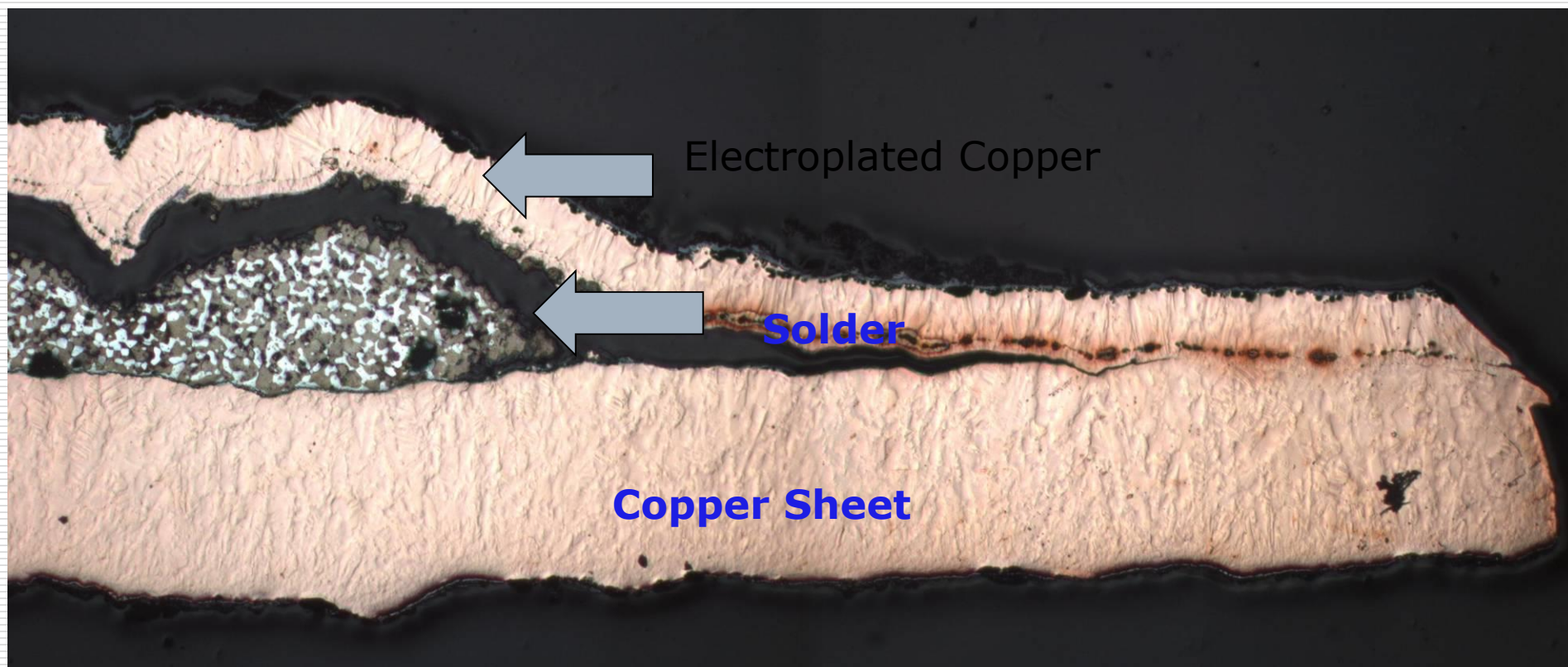
“Hollow Type” Process

- Graphite layer on mold (negative)
- Thin wire net in galvanic liquid (positive)
- Thicker walls than ‘Core type’ process
- No gypsum is required for core



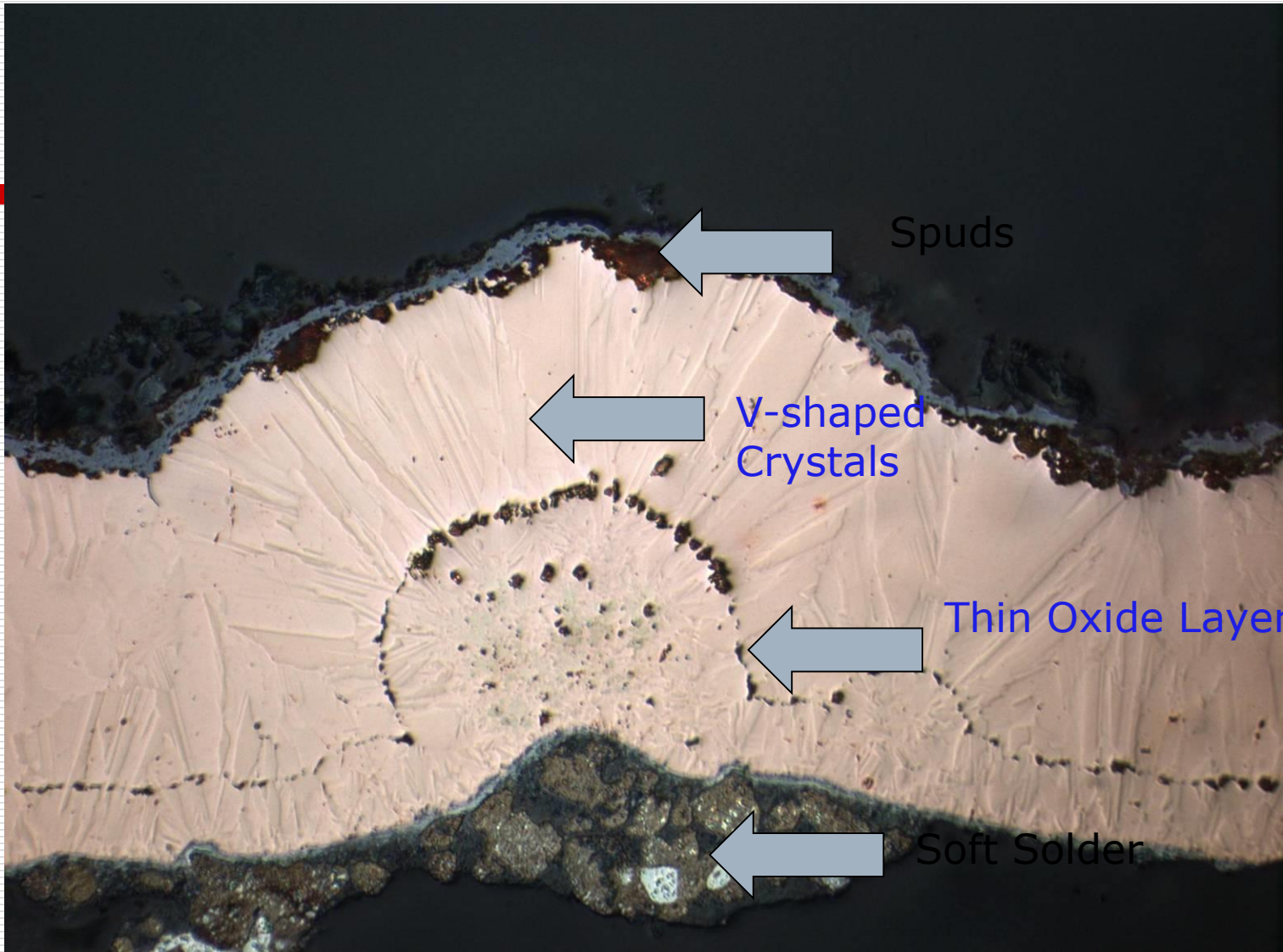
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Strap of the interior fitting at plinth
stilts inside the plinth were fixed with narrow bands of
electroplated copper



Wieland Fischer, Struers GmbH (Photo: M. Mach).

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Cracks - disequilibrating actions within the sculpture. the plinth is not able to absorb the complete weight of the overlying parts of the monument



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Examination of Iron Bars

Simple Magnet



Endoscopy and Digital Camera



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Visual Examination with an endoscopic and a digital camera



- The plinth inside is stabilised by an afloat base-ring made up of pig iron
- On this base-ring there are 5 tubes mounted vertically to stabilise the upper parts of the plinth

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The iron base-ring is heavily corroded partially consisting of layered rust and partially already vanished



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CENTURY

Iron Stilts

- The iron stilts, which were covered by a galvanic coating, are corroded, too.
- As a consequence, the stilts lost the ability to bear the weight of the sculpture.
- The stilts caved in and the galvanic coating burst off.



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Expected (magnet) and detected(endoscopy) iron bars inside the monument.



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Hind Leg of the Centaur

- This burst fissure is a clear indication for a transversal and lateral shift of the upper part of the monument.
- If this process will proceed, it can be expected that the complete sculpture will lose its integrity and will break down some day.



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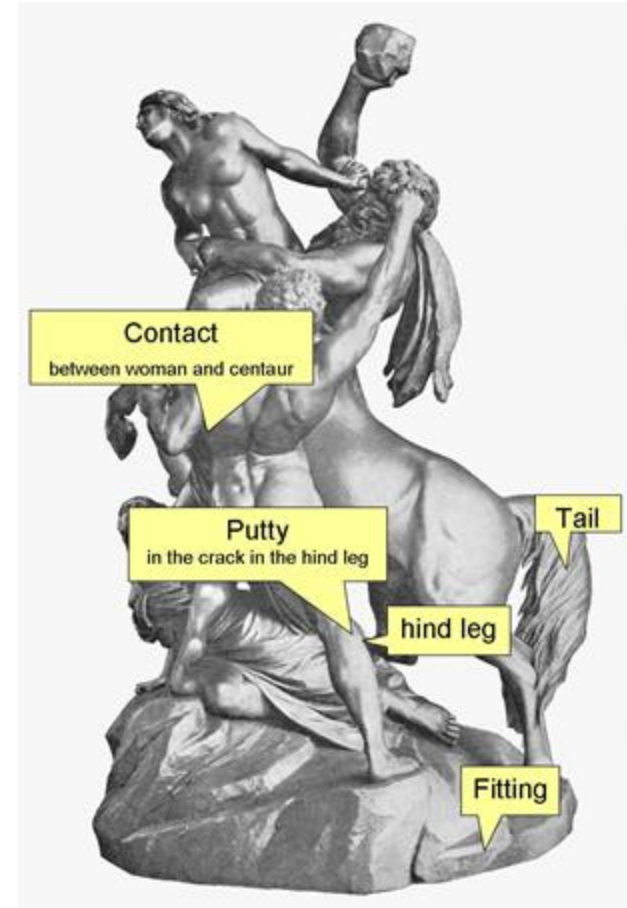
Sampling Locations



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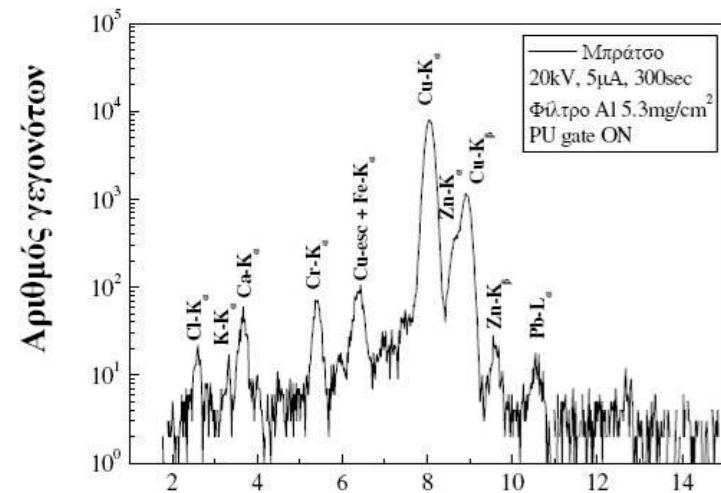
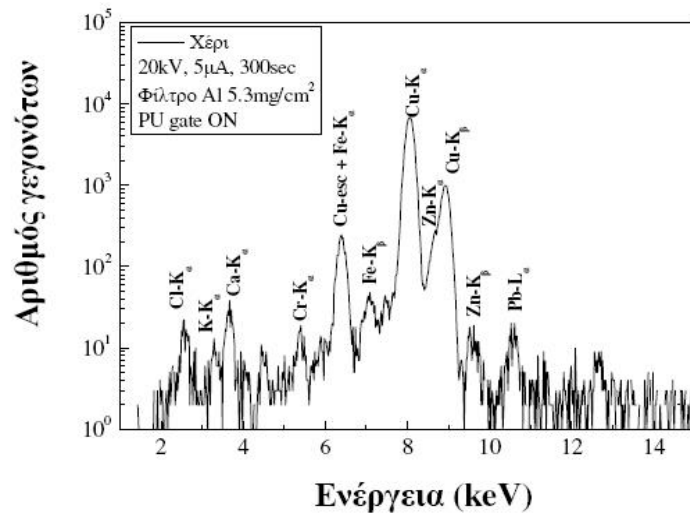
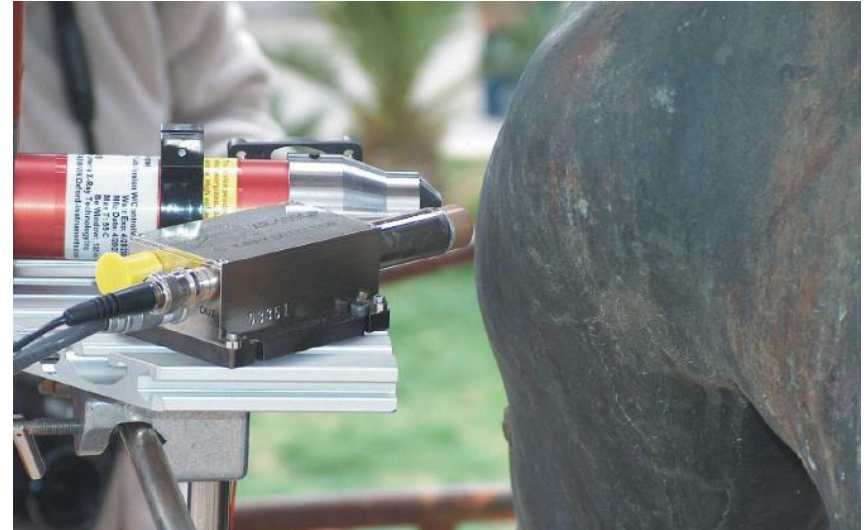
Documentation and Sampling Plan

- Monument's construction technique (materials, structure, morphology)
- Surface characterization (surface inclination, surface texture, orientation, colour, texture, coverage, adhesion, crust types, patina, presence of fillers, coatings or other materials) (surface area in terms of orientation)
- Cracks and other types of physical damages
- preliminary assessment of environmental/climatic and microclimatic data in relation to monument
- (rain/sun sheltered, exposed to wind/water/sun, in direct contact with wind/water, rain/water flow etc),



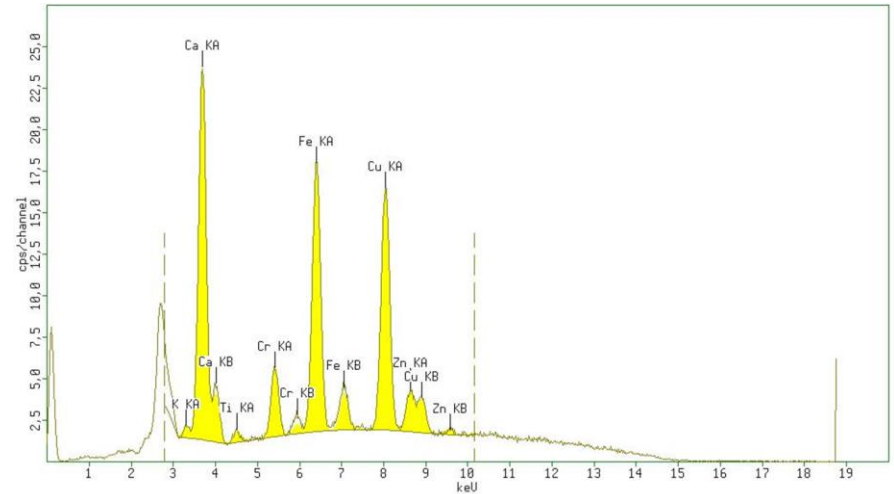
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Portable XRF right hand of lying lady



ΟΡΕΙΝ ΑΙΚΙΜΕΤΑΛ ΟΥΔΟΡΑ ΜΕΤΑΛΛΙΚΗ
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Join and crack: Centaur's right back leg and thigh



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Kolokotronis

Nafplio



Athens

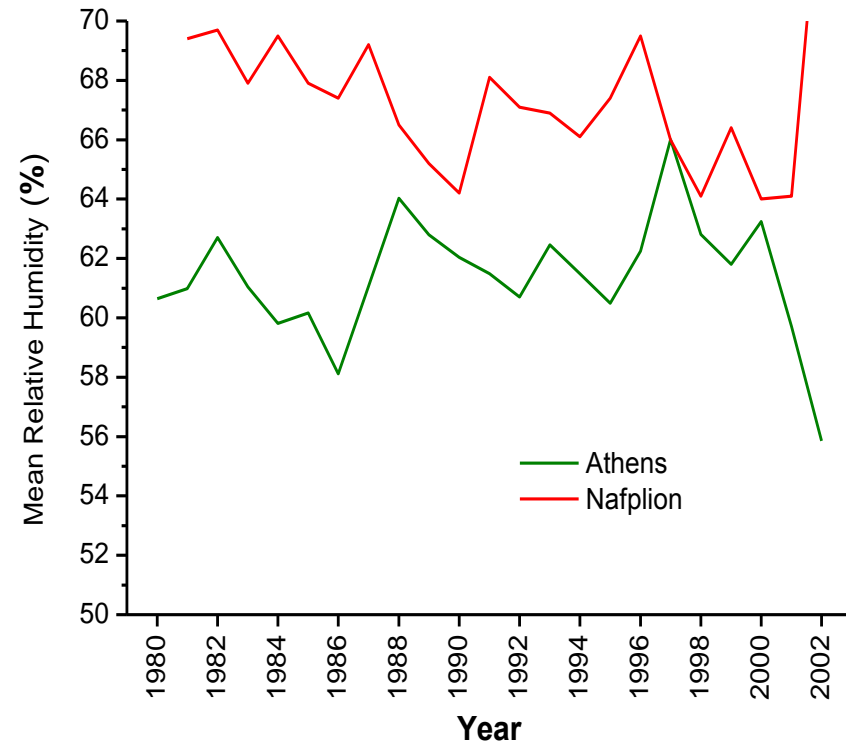
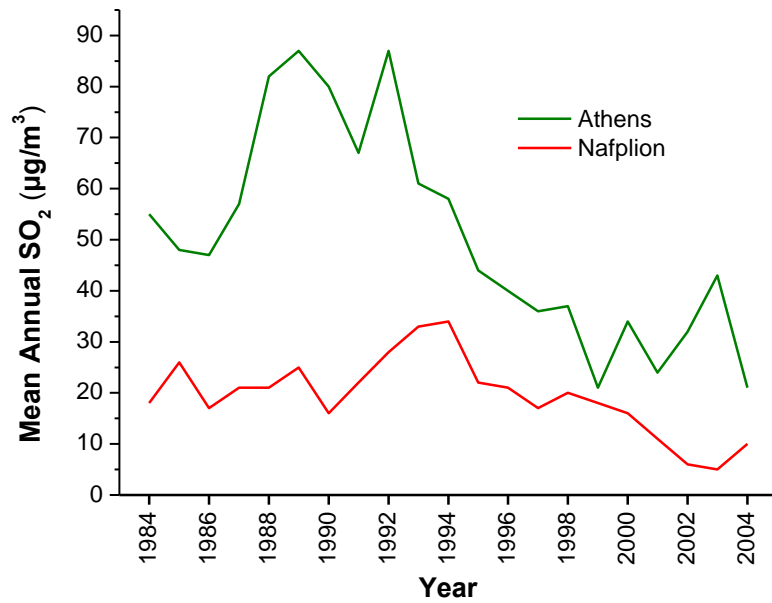


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Nafplion – Pitting Corrosion



SO₂ and RH



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Sampling Plan



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Portable XRF

Athens



Nafplion



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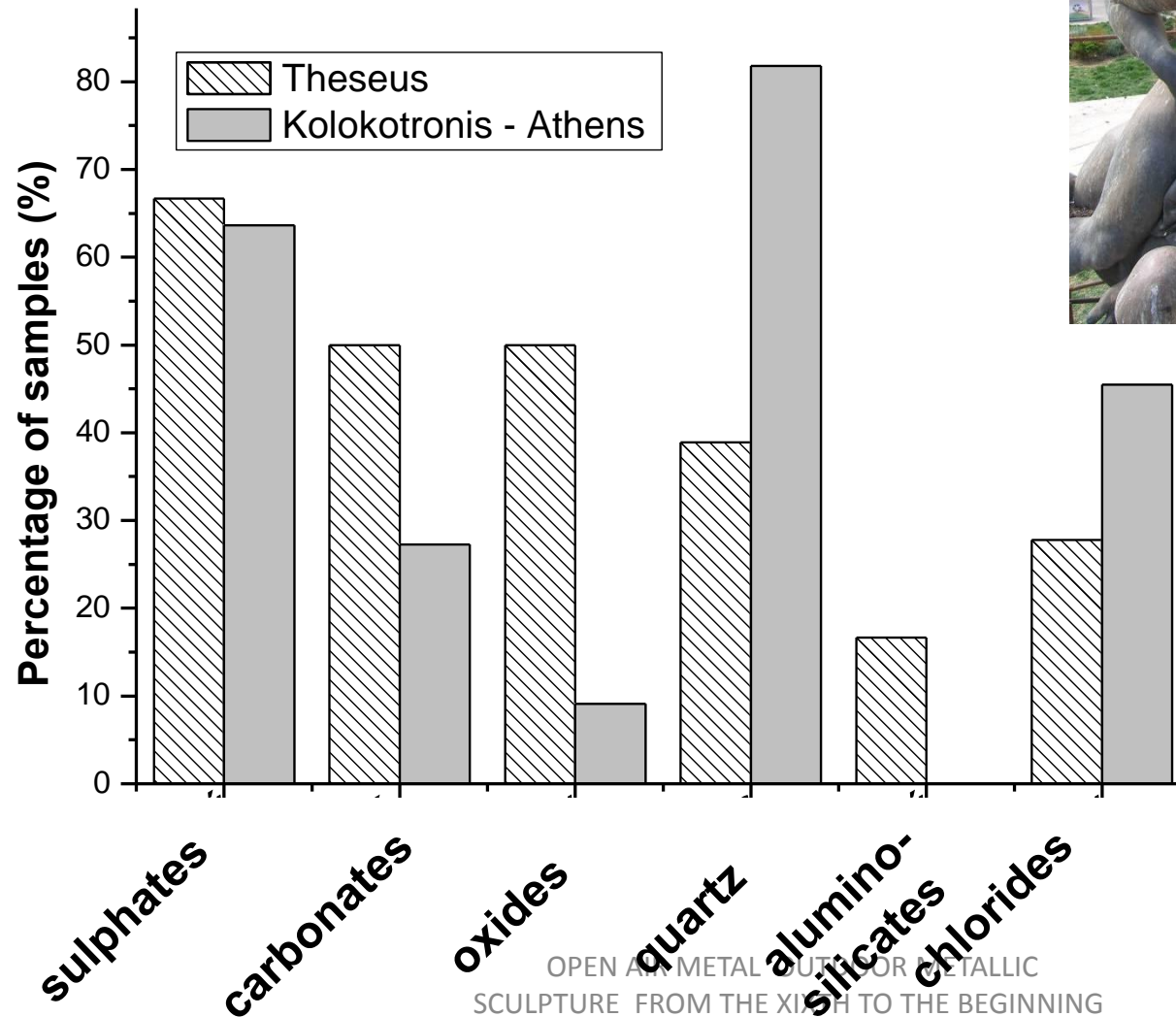
XRD in 2001 and 2006

- Siemens D500, X-Ray Diffraction system
- less than 20mg and zero Background (Si) sample holders were used to minimize the background
- DIFFRACPlus software (Brucker AXS) and JCPDS Powder Diffraction File
- In 2006, quantitative phase analysis was carried out using the Rietveld Method (TOPAS software, Brucker)
- relative percentages of the crystalline phases normalized to sum to 100%.

XRD in 2006

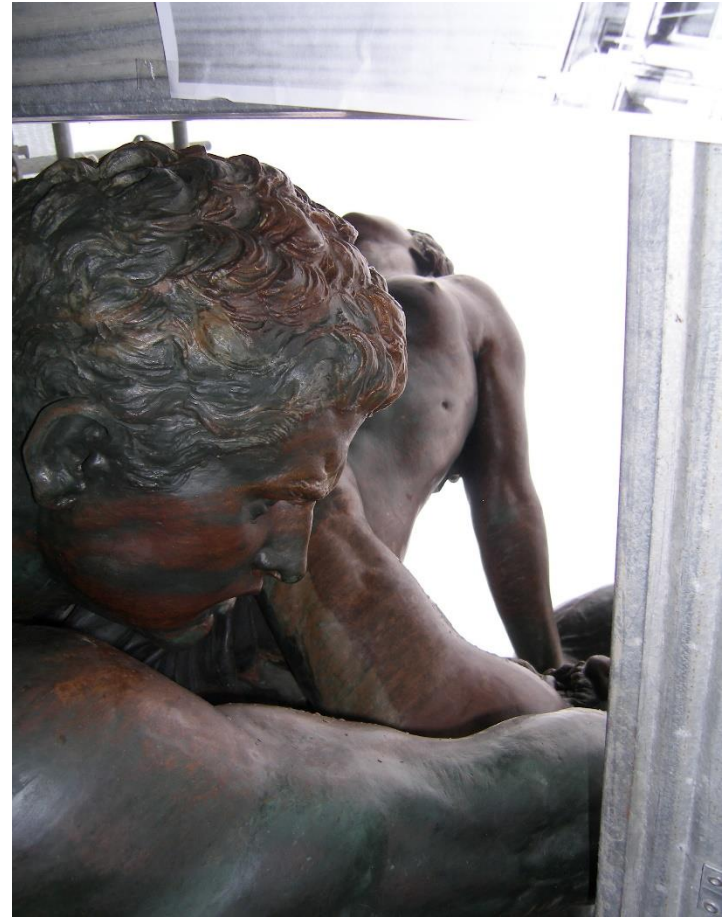
- Quantitative Analysis was carried out Nafplio
- quantity and crystallization of corrosion products is larger in Nafplio than in Athens due to conditions
- larger the quantity of crystalline phases in the sample, the better statistics we have when we measure the counts for each phase, so the quantitative analysis is easier.
- Athens, the sample more amorphous or at least less well crystallised phases, which do not result in well shaped peaks
- this creates problems to the fitting process and consequently to the quantification potential of the software

XRD Analysis



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Variations in colour –Cuprite and green patina



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