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Results of diagnostic campaign promoted by AIAr in the deposits of the Archaeological Museum of Paestum

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Abstract. Thirty artefacts from the Archaeological Park of Paestum were investigated by means of scientific techniques on the occasion of the 2016 exhibition 'Possessione. Trafugamenti e falsi di antichità a Paestum'. The multi-analytic diagnostic campaign was aimed at identifying forgeries. Results provided a deeper understanding of both ancient technology and contemporary forgery techniques.

1. The diagnostic campaign

During the last 25 years the "Associazione Italiana di Archeometria" (AIAr) has been committed to promoting and disseminating research, education and professional development in the field of Heritage Science. As the main Association of Archaeometry in Italy, it aims at fostering cooperation among researchers in the Humanities and in the Natural Sciences in order to promote interdisciplinary studies on Cultural Heritage. Indeed, AIAr coordinates numerous events and activities whose goal is to disseminate conservation science and archaeometry.

In the occasion of the exhibition "Possessione. Trafugamenti e falsi di antichità a Paestum" (Possession. Robberies and forgeries of Antiquities in Paestum) held at the Archaeological Park of Paestum in 2016, a wide set of chemical analyses and imaging techniques were used to characterize the artefacts on display [1]. The results of this diagnostic campaign were subsequently presented at the second edition of the workshop "Arte e Scienza. Difendi il bello, combatti il falso" (Art and science. Protect beauty and fight forgery) dedicated to young audiences.

The antiquities market is constantly flooded with illegally excavated artefacts and forgeries. When illicit collections are seized by law enforcements, they are delivered to museums. Therefore, several inauthentic objects happen to enter the collections of public institutions. Some of the forgeries are

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sloppy copies of one specific original work or they are eclectic (and impossible) combinations of different traits taken from various ancient artefacts. In this case they can be detected by the expert's eye [2, 3, 4]. Most often, however, forgeries are reproductions of a common artefact's type and their authenticity can only be tested through scientific analyses [5]. Forgeries' detection is a fast-evolving branch of both archaeology and archaeological science, as the refinement of forgers' methods has required scholars to find always new solutions, constantly improving on existing techniques [a recent and complete handbook on forgeries' detection is 6].

A large number of artefacts (pottery vases, bronze statuettes, coins and painted stone slabs) were selected to be displayed in the exhibition. The storage of the Archaeological Park of Paestum hosts several thousands of illegally excavated artefacts, mostly grave goods from the rich necropolises outside the ancient walls. The analytic campaign regarding the artefacts on display aimed at integrating archaeological methods and hard sciences. The selected artefacts were first analysed from a typological and stylistic point of view, allowing archaeologists to express their ideas and doubts about their authenticity. The most doubtful artefacts were then selected to be the object of a multi-analytic campaign aimed at dating, authenticating and characterising the artworks. The results were used to validate archaeological assumptions or, in some cases, to disprove them. The latter were the most interesting findings, as they induced archaeologists to investigate further, resulting in an advancement in knowledge.

2. Thermoluminescence dating

Thermoluminescence dating is a trapped charge dating technique that measures signals from negative charges trapped in the crystalline structure of samples due to exposure to ionizing radiation, estimating the time elapsed since the 'traps' were last voided, which in the case of pottery usually corresponds to the last firing of the pot [for a more detailed account of TL dating see 7, for artificial radiation and other techniques used by forgers to deceive TL analyses cf.8]

Eight vases of various shape, seized between the 80s and the 90s, were analyzed by means of thermoluminescence (TL). Three modern reproductions of red-figured vases were identified. The samples present very low natural TL signal, high sensitivity to irradiation, and linear TL dose response. In all three cases, the absorbed dose is lesser than 0.5 Gy, a value that is not compatible with ancient artefacts (Figg.1a&b – 2a&b – 3a&b – 4a&b).

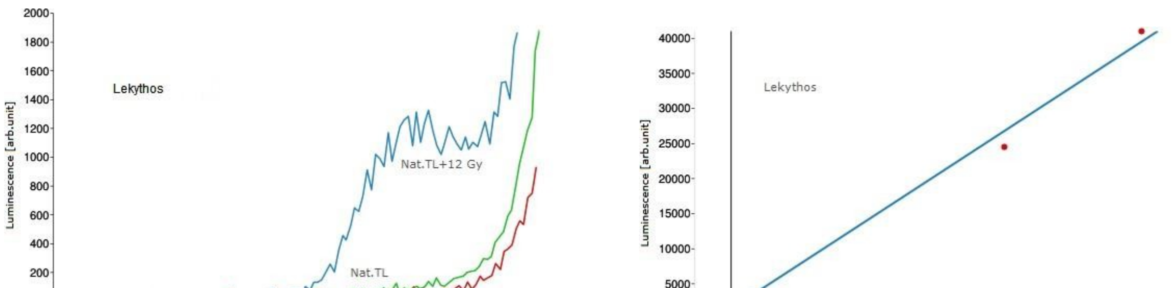

Fig 1 – a) TL curves of the squat *lekythos* PAE 000063; b) absorption rate of the squat lekythos PAE 000063. (CUDAM, Centro Universitario Datazioni e Archeometria Milano Bicocca)

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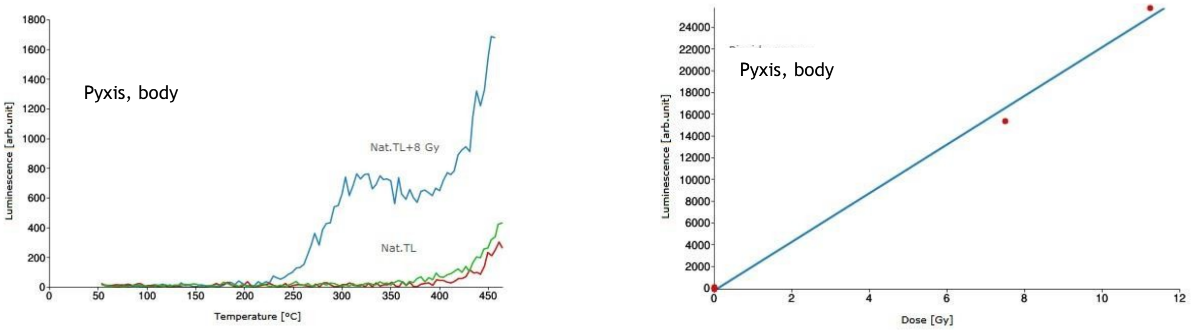

Fig. 2 – a) TL curves of the sample taken from the body of the globular pyxis PAE 000061; b) absorption rate of the sample taken from the body of the globular pyxis PAE 000061. (CUDAM, Centro Universitario Datazioni e Archeometria Milano Bicocca).

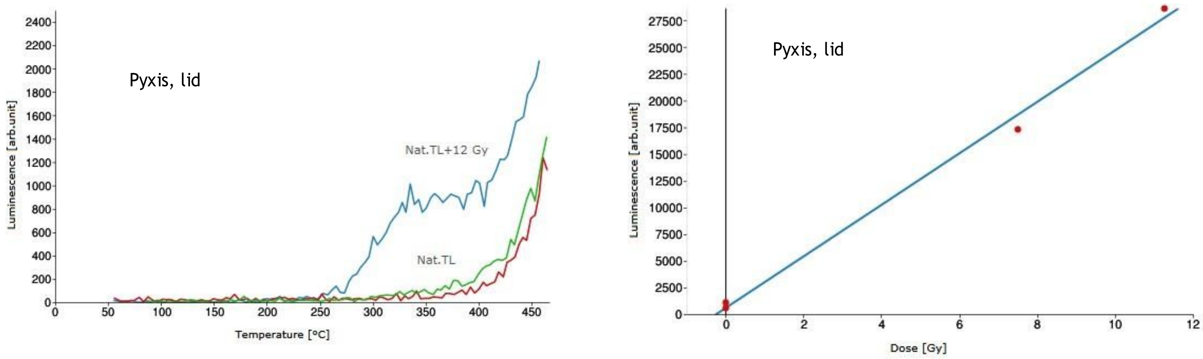

Fig. 3 – a) TL curves of the sample taken from the lid of the globular pyxis PAE 000061; b) absorption rate of the sample taken from the lid of the globular pyxis PAE 000061. (CUDAM, Centro Universitario Datazioni e Archeometria Milano Bicocca).

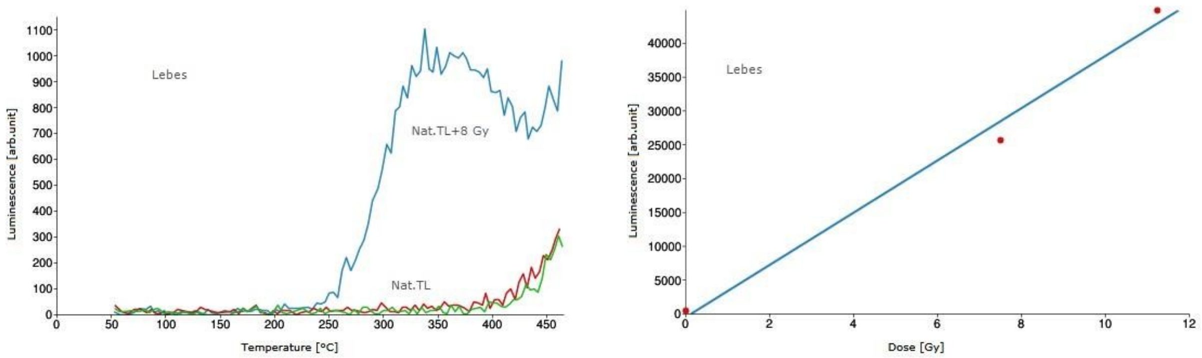

Fig. 4 – a) TL curves of the sample taken from the lebes PAE 000062; b) absorption rate of the sample taken from the lebes PAE 000062. (CUDAM, Centro Universitario Datazioni e Archeometria Milano Bicocca).

A surprising result came from the thermoluminescence dating of a red figured Lucanian panathenaic amphora, whose authenticity was largely questioned by scholars. The vase had been in storage for over fifty years and it had never been displayed to the public because of these concerns regarding its authenticity. The analysis shows moderate natural TL signal, moderate sensitivity to irradiation, and linear TL dose response. The absorbed dose is 9.9+0.9 Gy, a value that is compatible with ancient productions [1, p. 136]. This result induced archaeologists to investigate further. Indeed, the reason why some scholars had doubted its authenticity was the disproportion and coarseness of the figures and the oddity of the composition. On further inspection this vase was understood to be the work of a painter close to the Choephoroi Painter [9, p.26-27] and the Primato Painter [9, p.33-37], from the third quarter of the IV century B.C. This amphora can be considered a very accentuated instance of a general tendency of late Lucanian vase painters, who disregard natural proportions and balanced composition while enhancing symbolic details [10].

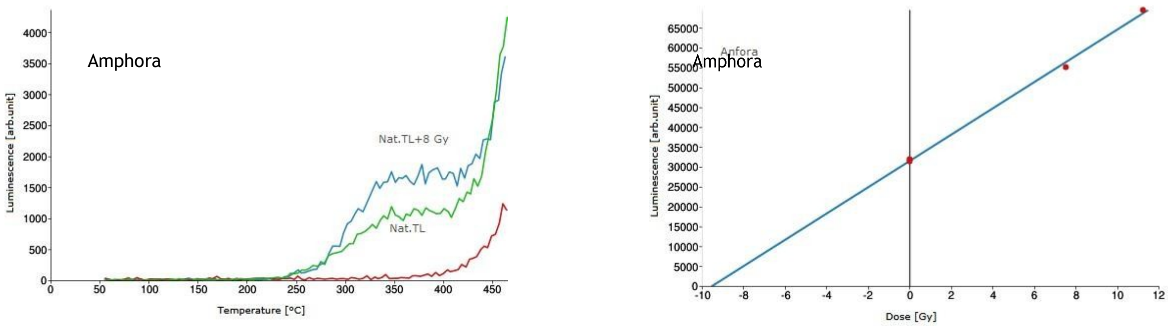

Fig 5 – a) TL curves of the Lucanian Panathenaic amphora, Zuchtriegel 2016 n°13.1; b) absorption rate of the Lucanian Panathenaic amphora, Zuchtriegel 2016 n°13.1 (CUDAM, Centro Universitario Datazioni e Archeometria Milano Bicocca)

A second vase, whose TL curve is compatible with ancient dating, posed a similar problem. A first sample (sample A) was taken from its base: it was treated with HCl (10% wt) and analysed through fine-grains method. Effective dose value is 9.5+1.1 Gy, compatible with a date between the IV and the II century B.C. However, even after further inspection, the shape of the vessel could not be related to any known typological group and it remains an isolated occurrence.

Since the sample for TL dating was taken from the bottom of the pot, a hypothesis has been advanced that the upper part of the vessel had been added in recent times to 'fix' a fragmentary ancient vase. Indeed, the body of the vessel corresponds to the normal shape of a lebes, whereas its neck resembles those found in amphoras [11].

To test this hypothesis, a second sample (sample B) was taken from the neck of the vase and analysed with matching protocol: effective dose value is 10.0±1.3 Gy, which confirms the authenticity of the vessel. A new hybrid ceramic shape was thus discovered in virtue of these investigations. This artefact constitutes one more piece of evidence confirming the tendency of late Paestan potters to deconstruct and combine traditional vessels' types.

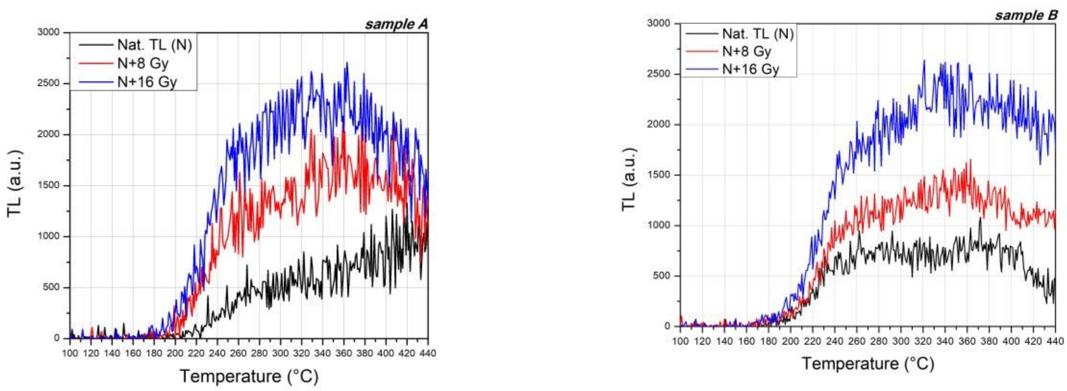

Fig. 6 – a) TL curve of the so called 'amphora-lebes' vase, sample A; a) TL curve of the so called 'amphora-lebes' vase, sample B, inv. PAE 000132. (TecnArt S.r.l.).

3. An 'embellished tomb'?

The so-called 'T2 Sequestro Finanza' is a Paestan painted tomb that was seized in 1980 by the Guardia di Finanza. The stone slab had been 'slimmed' with mechanical means to be transportable. The antiquities' dealer who was found in possession of the painting, was known for his habit of consolidating and creatively restoring ancient artworks. Therefore, a multi-analytic campaign was required to discriminate possible 'embellishments' to the original painting. UV fluorescence photography was used because, when exposed to ultraviolet light, different materials (pigments, binders, consolidants, etc.) respond with different colours, identifying intrusions and areas suitable for further chemical analyses [more on UV fluorescence in 12]. Fiber Optics Reflectance Spectrometry (FORS) and X-ray fluorescence (XRF) were used to identify the pigments [further information on chemical analyses on painted surfaces can be found in 13 and 14, and bibliography therein]. UV fluorescence images allowed identifying both organic and inorganic non-original materials (Figg. 7a&b – 8a&b). These intrusions were probably applied in more than one phase. They sometimes overlap and are made of different materials (some of which synthetic), as it was established by FORS and XRF analyses. A certain number of interventions should be attributed to the 2005-2006 restoration campaign promoted by the museum after the restitution of the slabs. However, it is impossible to decide whether earlier intrusions are to be attributed to the dealer's action or to an earlier phase of the same restoration campaign [1, p.108].

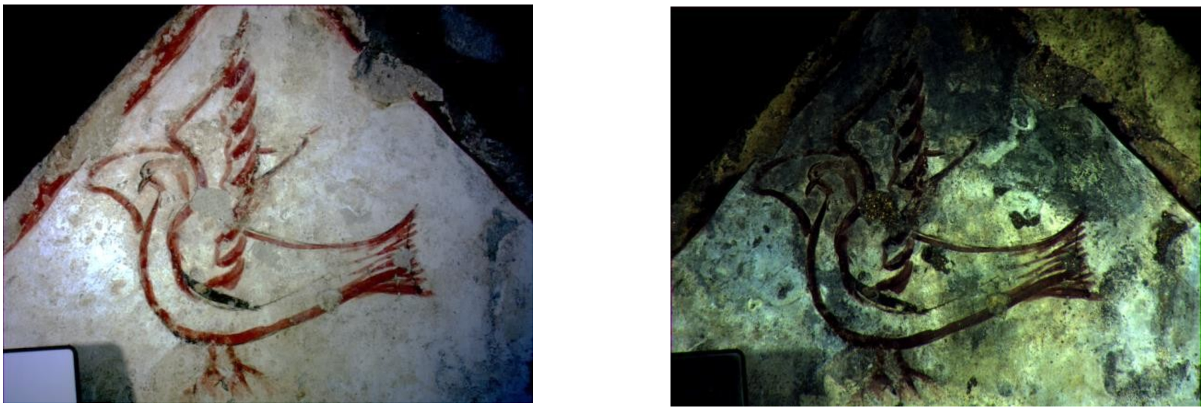

Fig. 7 – a) UV fluorescence image RGB of a detail from the West slab of the T2 Sequestro Finanaza, PAE 000057; b) visible light image RGB of a detail from the West slab of the T2 Sequestro Finanza, PAE 000057.

Fig. 8 – a) UV fluorescence image RGB of a detail from the West slab of the T2 Sequestro Finanaza, PAE 000057; b) visible light image RGB of a detail from the West slab of the T2 Sequestro Finanza, PAE 000057.

4. Chemical analyses of bronze statuettes and coins

Five bronze statuettes resembling Etruscan and Roman exemplars, six metallic surgical instruments and three coins were selected for analysis because of their stylistic anomalies. Non-destructive methods were used to identify the alloy and the occurrence of superficial patinas, in order to compare them with published data on the composition of known original artefacts. X-ray Fluorescence (XRF) was used to acquire a qualitative (and in some cases quantitative) spectrum of chemical elements in the alloys and patinas [on the use of XRF for forgeries' detection see 6 and bibliography therein].

Sample	Cu	Sn	Pb	Fe	Ag	Co	Zn	Ni	Re	Mn	Bi	Cr	Cd	TOT
	% (ε±2)	% (ε±0.02)	% (ε±0.3)	% (ε±0.3)	% (ε±0.01)	% (ε±0.01)	% (ε±1)	% (ε±0.3)	% (ε±0.01)	% (ε±0.01)	% (ε±0.01)	% (ε±0.01)	% (ε±0.01)	%
SI 1	73.60		0.47	0.41	0.02		25.39	0.07	0.03					99.99
SI 2	69.62	0.24	0.55	0.60	0.03	0.04	28.57	0.28	0.04			0.03		100.00
SI 3	72.07	0.24	1.17	1.38	0.04		24.85	0.15	0.04	0.02			0.04	100.00
SI 4	69.51	0.20	0.90	0.68	0.13		28.21	0.27	0.02	0.04	0.03			99.99
SI 5	68.05	0.02	1.31	0.52		0.05	29.79	0.17	0.05	0.04				100.00
SI 6	67.29	0.17	2.10	2.40			27.78	0.11	0.03	0.10			0.03	100.01

Table 1 – Compositional analyses on modern imitations of Roman surgical instruments (PAE 000069)

In particular, a curious set of Roman surgical instruments (Fig. 9) was investigated by means of micro-EDXRF Bruker Mistral M1 (spot 0.3*0.1 mm, HV 50 kV, current 800 μA, time 150s). Results are reported in Table 1. The surgical instruments were found to be made of a Cu-Zn alloy. However, Zn concentration was higher than expected for Roman melting technology, thus validating the stylistic judgment of inauthenticity [15, 16].

Fig. 9 – Modern imitations of Roman surgical instruments (PAE 000069)

XRF analyses were also performed on a statuette representing a kouros discophoros. The patina has been found to be a very thick layer of basic carbonates and copper chlorides/hydrochlorides, without any trace of zinc. However, measurements taken in areas with no or thinner patina layer revealed Zn in the bulk alloy. Archaeologists have interpreted this result as a possible indicator of an artificial patina used by forgers to give an 'older' look to their artefacts [17,18].

A fragmentary statuette of Venus pudica was analysed by means of a portable XRF spectrometer (AmpteK Mini-X; X-123SDDetector; parameters: 0.5 mm Al filter, spot 0.25 mm2, HV 35 kV, current 80 μA, time 100 sec). The spectrum (Fig. 10b) revealed the typical composition of brass alloy and allowed identifying traces of titanium in the outer surface. Titanium was discovered by William Gregor in England in 1789, but was first used in pure form in 1825 by the Swedish chemist Jacob Berzelius. Therefore, its presence can be attributed to a chemical treatment used by the forger to make the artefact look ‘older’ [17].

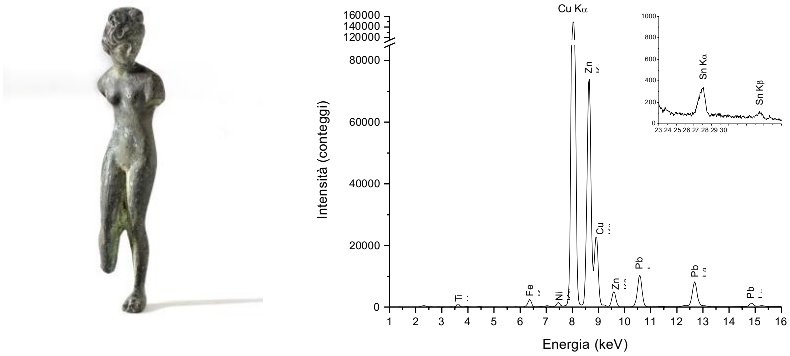

Fig. 10 – a) Venus pudica statuette (PAE 000067); b) Typical spectrum acquired from alloy analysis of a Venus pudica statuette (PAE 000067)

A coin resembling the mint produced in 193 C.E. by Didia Clara (a famous Paestan citizen) was seized in 1989 together with hundreds of other artefacts: this coin along with several other objects from this collection were found to be forgeries. Compositional analyses were performed by means of a portable XRF spectrometer (AmpteK Mini-X; X-123SDDetector, parameters: 0.5 mm Al filter, spot 0.25 mm2, HV 35 kV, current 80 μA, time 100 sec). The spectrum (Fig. 11b) revealed the presence of zinc, which is not compatible with historical data on the chemical composition of denarii in the II century C.E. [19, 20].

Fig. 11 – a) Modern imitation of a Denarius of Didia Clara (PAE 000072); b) Typical spectrum acquired from alloy analysis of Denarius of Didia Clara (PAE 000072).

The same collection that hosted the aforementioned metallic artefacts also included two coins resembling Nero’s Port of Ostia sestertii, coined between 66 and 68 C.E. Because of its high market value, this coinage is often reproduced by modern forgers. Therefore XRF and micro-EDXRF analyses were performed both on the patina and on the alloy in order to compare their composition with historical data. The two coins have different chemical composition. PAE 000073.1 is made of copper (70.90% ±1), tin (6.23% ± 0.5), lead (22.5% ±1), iron (0.09% ± 0.02), silver (0.06% ± 0.02), cobalt (0.17% ±0.05). PAE 000073.2 is made of copper (91.52% ±1), zinc (7.5% ±0.5), tin (0.08 ±0.02), lead (0.14% ±0.5), iron (0.39% ±0.02) and traces of nickel, rhenium, silver and bismuth.

Studies on the composition of Nero's coinage showed that sestertii were made of orichalcum, an alloy of copper and zinc, with the latter in a 15-20% percentage [21]. This information allows identifying PAE 000073.1 sestertius as a modern forgery. The second coin could be a late exemplar of the Port of Ostia coinage, re-melted over and over from old coins: this process would explain zinc depletion, as Zn is a very volatile element. However, they are more likely accurate modern forgeries, due to the small timespan over which this coinage was produced.

5. Conclusion

The diagnostic campaign promoted by AIAr and the Archaeological Park of Paestum on the occasion of the 2016 exhibition 'Possessione. Trafugamenti e falsi di antichità a Paestum' was a successful example of integration of stylistic and scientific methods, as it allowed for a deeper understanding of both ancient technology and contemporary forgery techniques. Archaeometric results were included both in the exhibition catalogue and in the explanatory apparatus, in order to foster awareness on the contribution of science to Cultural Heritage studies.

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