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Archaeometric analyses of the stuccoes and polychromy on temple C at Selinunte (Sicily)

*Analyse archéométrique des stucs et de la polychromie du temple C de Sélinunte
en Sicile*

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Fig. 1. Selinus, temple C, the northern *peristasis* in June 2017, after the last restoration. © L. Lazzarini.

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Abstract. *The most recent restoration of the re-erected part of temple C of ancient Selinus (modern Selinunte, Sicily) made it possible to carry out direct observations and a sampling campaign on the very few extant ancient stuccoes and polychromy traces on the columns and capitals of the northern peristasis. The samples were submitted to laboratory analyses including XRD on powder, OM, as well as SEM-EDS, on polished and thin sections, providing a stratigraphic reconstruction of the various stuccoes applied over the biocalcarene of the temple. The composition of the stuccoes, together with that of the remaining polychromy, has been determined archaeometrically, thus allowing new hypotheses about the decorative materials and techniques used during the main lifetime (6th-5th centuries B.C.) of the temple.*

Keywords. *Selinus, temple C, stuccoes, polychromy, archaeometric analyses, stratigraphic units.*

Résumé. *La toute récente restauration de la partie reconstruite du temple C de l'antique Selinus (actuelle Sélinonte) a permis d'effectuer des observations directes et des prélèvements sur les rares traces de stucs et de polychromie conservées sur les colonnes et les chapiteaux du péristyle extérieur septentrional. Les échantillons ont fait l'objet d'analyses en laboratoire, comprenant la DRX (diffraction des rayons X) sur poudre, la MO (microscopie optique) et la MEB-SDE (microscopie électronique à balayage-spectroscopie à dispersion d'énergie) sur des lames minces polies, pour aboutir à une reconstitution stratigraphique des différents stucs appliqués sur la pierre en biocalcarénite du temple. La composition des stucs et celle de la polychromie résiduelle, déterminées par l'analyse archéométrique, soulèvent de nouvelles hypothèses quant aux matériaux et techniques employés pour la décoration durant la principale phase d'activité du temple (VI^e-V^e siècles av. J.-C.).*

Mots-clés. *Selinus, temple C, stucs, polychromie, analyse archéométrique, unités stratigraphiques.*

Introduction

Temple C (fig. 1), generally dated around the middle of the 6th century B.C. and probably dedicated to Apollo¹, is world famous for its beautiful archaic *metopai* discovered by William Harris and Samuel Angell in 1826², now in the Salinas Museum of Palermo. It is the only temple partly re-erected in modern times on the acropolis of ancient *Selinus* (present-day Selinunte)³, the westernmost Greek colony in Sicily. Temple C was considered the most suitable for reconstruction and as a landmark on the Selinuntine acropolis. The anastylosis of its northern *peristasis* was decided at the beginning of the 20th century and carried out by the engineer Francesco Valenti in the years spanning from 1924 to 1927⁴; it made a massive use of reinforced concrete with steel bars that later rusted and at times badly damaged the stone of the capitals and lintels⁵.

This resulted in the need for a long restoration effort in recent years (2011-2015). It took place in two phases. The first one was completed in 2012 and was a minor intervention with an emergency and experimental scope, but it included a complete survey, mainly conducted on the re-erected *peristasis*. Taking advantage of the scaffolding that allowed a close view of the surfaces, it was possible to collect information about the materials and building technique of the archaic Selinuntine temples⁶, as well as discover and study the traces of the original (and later, however ancient) stuccoes applied on the yellow biocalcarene used for building the temple⁷. We refer to the “thin coating of fine plaster” that Harris and Angell saw “still remaining perfect on many parts of the architecture⁸” during the Selinuntine stage of their tour. Such stuccoes covered the surface of the biocalcarene of the temples, as well as most of the other public monuments of the

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Greek town. The use of a white stucco on the surface of soft limestone/calcarenes was very common in all Sicilian temples for more than one reason: it improved the aspect of the stones and made them look like marble⁹; it provided a flat surface suitable for polychromy¹⁰ and, finally, protected these highly porous stones¹¹ from the very aggressive marine environment typical of all the major Greek coastal towns in Sicily¹².

All these reasons are taken into account by Jakob Ignaz Hittorff in his publication *L'Architecture polychrome chez les Grecs*, in which he rejects the ideal of whiteness characterizing the Neoclassical aesthetics of the 18th century¹³: "Il appuie sur l'importante et juste remarque qu'indépendamment du bel aspect de la surface unie des stucs, en lieu et place de la vue désagréable d'une matière poreuse, cette application conservait essentiellement les pierres ; et il fait ressortir avec non moins de vérité combien le poli donné aux marbres et aux granits les plus durs, et la couche de cire cautérisée, la *καὶ σις*, dont on couvrait ces précieux matériaux, aidaient à leur belle conservation et à leur durée¹⁴."

Hittorff's reconstruction of the painted decoration of the small prostyle temple B at Selinus (of Early Hellenistic age, situated south of temple C), which he called "Temple of Empedocles", ignited the 19th century dispute about the polychromy of Greek architecture. According to Marconi, this intense controversy "infiamma per anni il mondo accademico francese, finendo con l'estendersi ad altri paesi europei¹⁵". Hittorff based his reconstruction on a detailed observation of the polychrome traces still partially preserved on the temple¹⁶. The 20th century saw the adoption of a more scientific approach to the study of ancient polychromy on statuary and architectural elements with important contributions¹⁷. These have continued, greatly multiplying in the present century¹⁸, also with the organization of permanent international round tables, the proceedings of which have often been published.

A first general archaeometric investigation of the materials and technique of the stuccoes, on several Selinuntine monuments, was conducted in 2009 by one of the authors of the present paper¹⁹. It allowed gathering useful information on these precious, scarce remains of ancient surface finishing treatment on public buildings, whose survival was already in great danger of loss due to the lack of ongoing restoration and maintenance. From 2006 onwards, the excavations and studies made on temple B by the New York University, under the direction of Clemente Marconi, have contributed to the overall knowledge of the ancient Selinuntine temple polychromy, and led to reconsider that such knowledge "differs significantly from those found in earlier literature, including that by Hittorff himself²⁰".

Experimental

Our research on the surfaces of temple C at Selinus, whose results are presented here, was directly influenced (as well as limited) by the overall very poor state of preservation of the

monument. The rare remains of white stuccoes on the capitals and columns of the northern *peristasis* (fig. 3-5), and the extant traces of polychromy (fig. 2, 4, 6) were micro-sampled by the technicians of the restoration firm *L'ISOLA laboratori di restauro* after an accurate autoptic study of the stratigraphy of such traces. Samples were then examined at the LAMA (Laboratorio di Analisi dei Materiali Antichi) of the University IUAV of Venice (Italy) in order to determine the nature of the constituent materials and the chronological sequence of the stratigraphic units of the coatings²¹. This allowed collecting information on the execution technique and reconstructing possible and coherent images of the temple over time.

All types of surviving mortars and stuccoes (original, and pertaining to ancient restorations), as well as of pigments, were sampled and examined in the laboratory with minero-petrographic and chemical methods that included the microscopic study under transmitted-reflected polarized light of thin and polished sections (OM, Leitz DM RXP), X-ray powder-diffraction (XRD, PANalytical Empyrean operating with CuKα at 40 KV, 20 mA), scanning electron microscopy (SEM, Philips XL30) coupled with qualitative and quantitative chemical analyses by energy-dispersive spectrometry (EDS, EDAX Ametek operating at variable Kev) directly on samples and on their polished and thin cross-sections.

Results and discussion

The obtained results allow distinguishing and identifying the following stratigraphic sequence of the surface treatments on the columns and capitals (starting from their flattened stone):

SU 1. A yellowish lime mortar (in Italian called *rinzafo* or *rattoppo*) containing abundant aggregate formed by local dune-river sand (fig. 2): this putty imitates the color of the Selinuntine biocalcarene and was applied to fill the natural irregularities (small cavities/very large pores) that were quite frequent in the non-homogenous quarried stone.

SU 2. A thin red-ochre layer found in the grooves of the annuli of the capitals (fig. 3): it was brushed directly on the calcarenite below the white stucco since the red layer partially impregnated the stone substratum underneath (thin section in fig. 3), and should thus have been applied in a liquid suspension (probably with the addition of a medium such as animal glue).

SU 3. A rather thin and compact yellowish *arriccio* made of lime mixed with a small amount of dune or river sand (fig. 4). Its composition is similar to that of the *rinzafo* though generally with a finer aggregate (polished cross-section in fig. 4). It was a preparatory layer, normally a few millimeters to about half a centimeter thick, originally probably present all over the columns and capitals and on all other surfaces, except for the annuli and all those minute details of which it would inevitably alter the morphology.

SU 4. A white stucco (*intonaco*) (fig. 4) composed of lime and of a small amount of aggregate formed by white limestone

clasts (polished cross-section in fig. 4): it was applied *fresco su fresco* on top of the *arriccio*, that is, by wetting this layer with a cloth and/or brush while the layer was still drying (macrophotograph in fig. 4). Unfortunately no traces of polychromy was found over the original white *intonaco*.

SU 5. A subsequent white coating that looks like a sort of *marmorino* (fig. 5) made by mixing lime with a small amount of aggregate formed by ground calc-sinter (*calcite di vena* in Italian)²², finely crushed in a mortar to obtain an artificial aggregate that would reflect well the sunlight. Its presence is characterized by clasts showing the typical rhombohedral cleavage (photomicrographs of thin sections in fig. 5). These are clearly traces of later work of “modernization”: this ground calc-sinter aggregate is in fact fully comparable with that found in intonacoes of temple B, and thus it may be dated to the same Early Hellenistic period²³.

SU 6. Traces of a blue layer on top of the *marmorino* (polished cross-section in fig. 6); it was found only on the renovation stucco (Early Hellenistic?). In the corresponding polished section, the finely ground Egyptian blue appears intimately mixed with lime, indicating a *pittura alla calce* (limewash) technique²⁴. Some other traces of polychromy, namely of a yellow layer made of yellow ochre (fig. 6) were observed on top of a thin white stucco that covers the grooves of the annuli; the polished cross-section in fig. 6 shows areas impregnated by this ochre indicating the use of a sort of *fresco* technique (the yellow pigment was very likely applied distempered in water before the setting of the *intonaco*'s lime).

Traces of a final maintenance lime-wash (*intonachino-scialbatura*) made of pure calcite, without aggregate, were observed on the white *marmorino* (SU 5) and no trace of polychromy has survived on the columns.

Conclusions

The observations in situ and the results of the archaeometric studies allow us to conclude that the original white stucco (SU 4) was either laid directly over the yellow biocalcarenite

Fig. 2. Capital IX, a coarse lime mortar *rinzafo* locally used to fill the natural irregularities of the non-homogeneous stone. a. Thin section of the yellowish lime mortar, showing the colophorm calcite with abundant dune-sand aggregate. N+, long side = 2.35 mm. Grafic elaboration: A. Tomaselli. © K. D'Ignoti/L. Lazzarini.

Fig. 3. Annuli of the capital VIII. Red paint brushed directly on the calcarenite, below the white stucco (SU 2). a. Polished cross-section showing the red layer partly impregnating the stone substratum. Reflected light, long side = 2.3 mm. Grafic elaboration: A. Tomaselli. © K. D'Ignoti/L. Lazzarini.

used for building the temple, or over a yellowish preparatory layer (*arriccio*). In the annuli of the capitals, this stucco was applied above a thin layer of red ochre. It is most likely the very color described by the Duke of Serradifalco: “*circostanza singolarissima, che il capitello di uno de' triglifi scorgesi pria*

Fig. 4. Drum of column VIII with the original white *intonaco* (SU 4) applied on top of the *arriccio* (SU 3). a. Polished cross-section (long side = 2.3 mm) showing the stratigraphy with the *intonaco*, composed of lime and of a small amount of aggregate formed by small white limestone clasts, over a fragment of the yellow preparation (*arriccio*) made of lime mixed with a small amount of dune or river sand. Grafic elaboration: A. Tomaselli.
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Fig. 5 a-b. Annuli of the capital XI: traces of later work of "modernization" with a white coat that looks like a sort of *marmorino* containing an aggregate formed by calc-sinter (SU 5). a. Photomicrograph of the thin section of the new *intonaco*, showing a *calcinello* (a lime inclusion) and an aggregate obtained by crushed calc-sinter. N+, long side = 2.3 mm. b. Thin-section showing clasts with the typical rhombohedral cleavage of calc-sinter. N+, long side = 0.95 mm. Grafic elaboration: A. Tomaselli. © K. D'Ignoti/L. Lazzarini.

Fig. 6 a-b. Annuli of the capital XI. Traces of a later work of “modernization” with a white coat that looks like a sort of *marmorino* as for fig. 5. a. Polished cross-section showing a yellow-ochre layer on a thin white intonaco. Reflected light, long side = 2.3 mm. b. Polished cross-section showing a layer of Egyptian blue on top of the thick white *intonaco*. Reflected light, long side = 2.3 mm. Grafic elaboration: A. Tomaselli. © K. D'Ignoti/L. Lazzarini.

di rosso sulla pietra dipinto, poscia intonacato di stucco, ed in fin ridipinto del colore medesimo²⁵.” It could have been the first and most ancient chromatic decoration of this and other Siceliot temples²⁶. This hypothesis is supported by the observation of the frequent presence of extensive red areas on the entablature and altar elements from the Athena temple of Syracuse²⁷ (fig. 7), kept at the local Paolo Orsi Archeological Museum, and on the fragments of cornice from the archaic temple of Heracles in Agrigento (fig. 7), kept at the Antonino Salinas Museum in Palermo.

According to this hypothesis, proposed here for the first time, the capitals would thus have been characterized by the same chromatic finish as the famous metopes and conceived for the same context. On the other hand, Marconi does not hesitate to attribute the plan of the sculptures of the frieze of temple C to the architect²⁸. The latter used methods of polychrome finishing similar to those preceding the “petrification phase” of which temple C is one of the first examples²⁹. Clearly, this decorative technique could not imitate the marble temples, which even in the motherland are attested only in a later historical period. The use of polychrome clay tiles would also be

replaced in Selinus by Parian marble tiles later on, for example in temple A.

However, neither of the two plasters identified by us (SU 4 and SU 5) contains any trace of “*blanc de Sélinonte*”, a local white chalk or clay that would have been used, according to Jean Hulot and Gustave Fougères, “dans la composition des enduits³⁰”. Thus the reconstruction that the two Frenchmen

Fig. 7. The Harris and Angell's watercolour of the Gorgon metope (Angell, Evans, 1826) (left); the altar frieze of the Syracusan Athenaion (local calcarenite, inv. 34603, 226 x 95 x 36 cm) in the P. Orsi Museum, Syracuse (upper right), and a fragment of the cornice of the Heracles' temple of Agrigento (local calcarenite, inv. 66268, 49 x 19 x 9 cm) in the A. Salinas Museum, Palermo. © G. Alfano.

would go on to make of the chromatic apparatus, according to which “la polychromie des parties hautes, corniches, cimaises, tuiles faitières en terre cuite faisait un diadème chatoyant et pittoresque à la façade d’une blancheur marmoréenne”, while “la couleur rouge était appliquée sur les parties ombrées pour les réchauffer³¹”, can be considered reliable only if referred to the second phase (whether Late Archaic or Classical) when the surfaces were probably already eroded and may have required a new coating for protective purposes. The same can perhaps be said of the Early Hellenistic phase, when the shapes of the capitals were remodelled in stucco (SU 5), thus concealing the engravings of the annuli that were reshaped with a new profile³². The metopes, however, were devoid of the white coating, preserving their archaic appearance, as Harris and Angell would later find in the early 19th century when they documented traces of polychromy in their watercolours (fig. 7).

The information gathered here, though insufficient largely due to the lack (or extremely poor state of conservation) of the original surfaces of temple C, is however very useful to reconstruct the original aspect of one of the most important Archaic temples of the western Mediterranean Greek colonies.

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Notes

1. For the peculiar architecture of this temple and its Siceliot context, see Gullini, 1985. For the most recent bibliography on the same subject and on the restoration perspectives of the Selinuntine temples, see Mertens, 2016.

2. On these two brilliant British architects/travelers whose activity was compared to that of Lord Elgin, see Angell, Evans, 1826; Pisani, 1823 (ristampa, 1998); Marconi, 2008.

3. For the re-constructions of temples at Selinus, see Tusa, 2016.

4. A detailed description in Genovese, 2016.

5. Though not fully satisfactory, the restoration performed by Valenti resisted well to the powerful Belice Valley earthquake in 1968.

6. Bennardo, Mannuccia, 2016, and bibliography therein.

7. For a minero-petrographic and physical characterization of the biocalcarene, see Lazzarini, 2016.

8. Angell, Evans, 1826, p. 35.

9. This is confirmed by various sources, including Charles Robert Cockerell who, in referring to the Olympeion of Akragas, noted: “The whole of this sculpture and the architecture was coloured with a thin coat of hard plaster presenting a surface like the finest marble”, Cockerell, 1830, p. 5.

10. Politi, 1826, p. 16, wrote “tutto era impellicciato di calce, leggermente colorata a varie tinte” (“everything was coated with lime, slightly coloured in various shades”).

11. Some porosity measurements by mercury intrusion on the biocalcarene of

Selinunte gave an open porosity of about 28% (Lazzarini, 2016, p. 150). On the need for a stucco, see also Lazzarini, 2009, p. 138.

12. The Duke of Serradifalco believed that the stucco could have been applied to “preservare dalle ingiurie dell’aria, delle piogge e degli anni i loro tempi (...) onde gli artisti della Grecia si valsero di questo modo di conservazione...” (“to preserve their temples from the ravages of the air, rain and years (...) so the artists of Greece adopted this method of conservation...”): Lo Faso Pietrasanta di Serradifalco, 1834, vol. II, p. 26.

13. On the use of colour in ancient architecture and sculpture in the 19th century, see Hittorff, 1851; Wünsche, 2004; Marconi, 2008.

14. Hittorff, 1851, p. 595-596 (“He insists on the important and cogent observation that regardless of the beautiful appearance of the uniform surface of the stuccoes, instead of the unpleasant sight of a porous material, this applied layer essentially preserves the stones; and exalts with no less genuineness how much the smoothness given to the hardest marbles and granites, as well as the layer of cauterized wax, the *kaūsiq* coating which covered these fine materials, contributed to their beautiful preservation and durability”).

15. Marconi, 2008, p. 79 (“has been raging for years in French academia, ultimately spreading to other European countries”).

16. Lazzarini, 2009, Lazzarini, Marconi, 2016.

17. For architecture, see Campisi, 1987.

18. See for example the relevant contributions in the catalogue of the

important exhibition “I colori del Bianco” held at the Musei Vaticani, and the references reported therein.

19. Lazzarini, 2009.

20. Lazzarini, Marconi, 2016, p. 193.

21. According to a procedure that follows the archaeological method of reconstructing stratigraphic units, even far away from each other. This method, established by Harris, is based on the presence of the same characteristics shared by these units: an explanation and comment on this method can be found in Arce *et al.*, 1996.

22. This calc-sinter was obtained by grinding calcite alabasters/speleothems (such as stalactites) that are common in the caves-quarries of the Menfi area, a few kilometers away from Selinunte.

23. Lazzarini, Marconi, 2016, p. 196.

24. Also identified in the blue areas of the Selinuntine Temple B, Lazzarini, Marconi, 2016, p. 195.

25. Lo Faso Pietrasanta di Serradifalco, 1834, p. 29 (“a very unique circumstance that the capital of one of the triglyphs features red paint on the painted stone, then plastered with stucco, and finally painted again with the same colour”).

26. Another possibility is that it may have been connected to the incision of the annuli as a check of their depth and precision, or a “check layer” pertaining to a manufacturing phase (control of the surface-flattening of the stone).

27. “Tutta l’opera di rilievo è poi ravvivata da una forte colorazione a guazzo di un rosso sanguigno, che malgrado i 24 secoli trascorsi, in gran parte sotterra, mirabilmente resiste e si conserva (...). È

una decorazione semplice, austera e quanto mai vigorosa, di vivace effetto decorativo, anche per l'impiego del colore rosso-fuoco" ("All the reliefs are then enlivened by an intense blood-red gouache colouring, which, in spite of the 24 centuries that have passed, most of which underground, admirably resists and is preserved (...). It is a simple, austere and very vigorous decoration, with a lively decorative effect, thanks also to the use of the fire-red colour"). Orsi, 1918, p. 693-695.

28. Marconi, 2006, p. 622.

29. "The great revolution that Greek architecture, understood in the broadest geographical sense, experienced in the course of the seventh and first half of the sixth centuries, consisted (...) in the introduction and progressive spread of the use of stone throughout the edifice, to the point of making it the raw material which, from now on, would characterize all the manifestations of Greek architecture almost as a distinctive mark" (Gullini, 1994).

This "petrification process" was reflected in the mother country, but it featured many original Sikeliot characteristics and the Temple C is a key link in its evolution with the transition from monolithic columns to those made of drums that took place for the first time during its long construction. The present study offers an interpretation of the evolution of the coloured coating, starting from the traces unexpectedly found and from the reflections made during the course of this long effort.

30. Hulot, Fougères, 1910, p. 30 ("in the composition of the plasters"). There is no certainty whether "craie de Sélinonte" ("earth/clay of Selinus"), as called by the two Frenchmen, was actually invented in Selinus. Moreover, this type of "earth" was very likely a marly limestone that could not be used as a plaster, but rather as a pigment (in fact, this is the case mentioned by Selim Augusti in his book on the colours of Pompeii, Augusti, 1967). In addition, no deposits of white clay have been found to date in Selinunte and the surrounding area. Strabo and Pliny mention a river called Selinus in various places of the ancient world: in Achaea, in Ilia, and also near the city of Cilicia as well as in Ephesus, where there was also a lake with the same name into which the river *Caystrus* flowed. Therefore, the statement made by Hulot and Fougères is not, in our opinion, reliable.

31. Hulot, Fougères, 1910, p. 226-227 ("the polychromy of the upper parts, cornices, friezes, and terracotta ridge tiles constituted an iridescent and picturesque diadem on the facade of a marmoreal whiteness", while "the red colour was applied on the shaded parts to warm them"). An anastatic edition of this work was recently published by the *Centro Regionale per l'Inventario, la Catalogazione e la Documentazione* of the Sicily Region.

32. Robert Johann Koldewey and Otto Puchstein reported the "modernization" of the profiles of the annuli: "Aus derselben Zeit dieser Modernisierung stammen: die schuppenförmige Veränderung der

ursprünglich gleichschenkligen Kerben am Ringband, (...) Der Stuck der Säulen kennzeichnet sich somit als bedeutend späterer Zeit angehörig" ("Of the same period of this 'modernization' comes the deterioration of the incisions in the band of annuli originally of an isosceles shape (...) the stucco of the columns is thus marking itself to pertain to a much later period"). Koldewey, Puchstein, 1899, p. 99.

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