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Small but beautiful: Scientific investigation of the materials and painting techniques of a small group of Hellenistic painted tombs from the necropolis of Aigina

Amerimni Galanos, Yanna Dogani, Nadia Kalamvoka (Lithou Sintirisis Conservation Consulting Company, Athens, Greece), Adamantia P. Panagopoulou (Department of History and Archaeology, University of Barcelona, Spain / Institute of Nanoscience and Nanotechnology, 'Demokritos' NCSR, Athens, Greece), Katerina Charatzopoulou (Institute for Classical Archaeology, Free University Berlin, Germany)

Painted tombs of Aigina: a rediscovery

The tombs under study are among the few surviving witnesses of a once impressive number of Hellenistic rock-cut chamber tombs, some of them lavishly decorated, located in the necropolis of Aigina, in the northwest part of the island. Out of eleven painted tombs described by scholars of the 19th and early 20th century, only a few could be documented by the German archaeologist Gabriel Welter (1890-1954) in the 1930s; drawings and watercolours were made by the Austrian architect Isidor Demant (1880-1953).

The tombs, dated from the late 4th/early 3rd to the middle of the 2nd century BCE, are of a mixed construction: the burial chamber and the stepped passageway (*dromos*) are carved into the rock; additional elements, such as barrel vaults covering the *dromos,* are constructed using local limestone (*poros)*. Masonry-style decorations are usually found in the *dromoi*. In earlier examples, monochrome zones in bright colours with ornamental motifs, separated by garlands, decorate the burial chamber. In this poster, we highlight significant findings of the ongoing scientific investigation of the mortars and plasters from four tombs (T1-4, fig. 2) and the painted decoration of two tombs (Tomb 1, 2nd half of 3rd c. BCE, fig. 1; Tomb 2, end of 4th - early 3rd c. BCE, fig. 3).

The stone

The stone, either as the bedrock into which the burial structure is cut or used as building material, is a yellowish Pliocene oolitic limestone with medium to high porosity and calcite as the main mineral. The 50-500μm-sized grains are composed of a nucleus around which micritic or sparitic calcite is formed by repeated sedimentation.

Fig. 1. *Tomb 1, burial chamber, north wall. The garland banded with sleeves and taenias loosely draped (a), and a diadem (b). Stratigraphy of samples (d,f: Optical Microscopy; e,g: Scanning Electron Microscopy) from the dark yellow shadow of the garland (c=>d,e) and from a yellow triangle of diadem 4, east wall (f,g).*

Technology of mortars and plasters

Analysis of mortars and plasters from a total of four tombs (T1-4) aimed to determine their constituent materials and stratigraphic structure by means of microscopy, granulometry, simple mortar analysis measurements of specific apparent weight, water absorption by saturation, tensile strength, and mineralogical analysis (XRD, X-Ray diffraction analysis). Petrographic analysis (PLM, Polarized light microscopy; SEM-EDX, Scanning Electron Microscopy-Energy Dispersive X-Ray) on selected samples was performed by Dr. Johannes Weber (University of Applied Arts, Vienna). **The arriccio** (1-3 cm thick) was applied directly and exclusively on the rock-cut surfaces (fig. 2). It is a lime-based hydraulic mortar. It contains aggregates of fossiliferous limestone, some seashells, some chert grains, with very little fine-grained aggregate, which points to the collection of beach sand for mortar preparation. Besides lime, the binder also contains volcanic aggregates – pozzolan and/or scoria – as Aigina is almost entirely composed of eruptive material. These aggregates are responsible for the hydraulic reaction, which is evident in microscopy by the hydration rims around these grains. The binder contains more silica than calcium, reinforcing these findings, and amorphous material is often identified in XRD analysis. The arriccio aggregates from tomb 2 are of a warmer shade, suggesting that sand was collected from a different location than for the other tombs. **The intonaco,** the thin (<0,8mm) compact white layer used as a preparatory layer for paint, is found on all tombs directly applied on stone elements (e.g. intrados of barrel vaults). It contains lime and secondary calcite. According to Dr. J. Weber, sparite, a translucent coarse-grained calcite, was deliberately collected from clear veins running through carbonate or even volcanic rocks, and used either for its aesthetic effects as the crystals sparkle and/or due to the lack of marble.

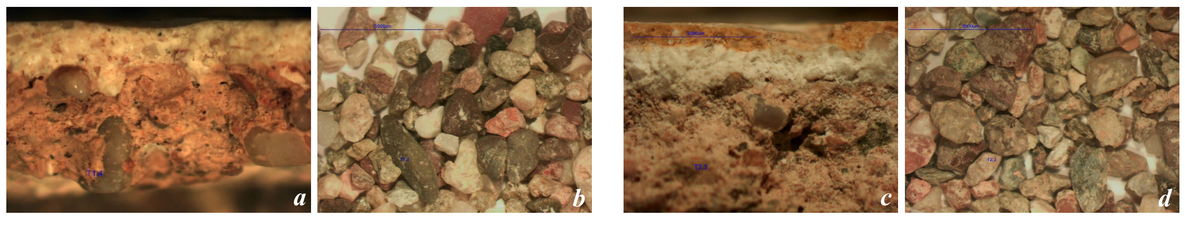

Fig. 2. *Stratigraphy (micro 10X) of samples and characteristic aggregates from the inner coarse-grained layer (arriccio) from the dromos of tomb 1 (a,b) and from the burial chamber of tomb 2 (c,d).*

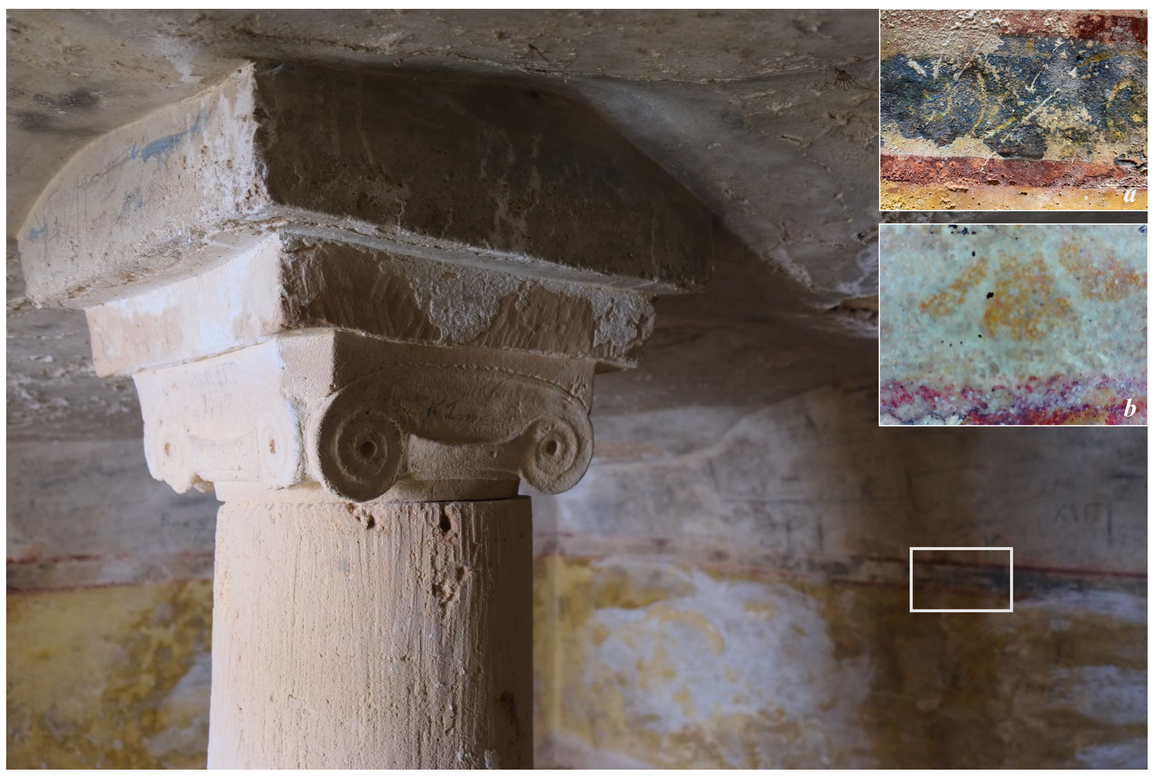

Fig. 3. *Tomb 2, burial chamber. A continuous running scroll between white and yellow zones: yellow on blue background (a, layer 1); and, underneath, yellow-orange on white background (b, layer 2).*

Painting techniques and materials

A comprehensive set of paint samples, selected from representative areas of the painted decoration of T1-2, was analysed using Optical Microscopy (OM), X-Ray Fluorescence Spectroscopy (pXRF), Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS) and Raman Spectroscopy to study their stratigraphy and identify painting techniques and pigments. On the coloured wall zones of both tombs, and the floor of tomb 2, paint was applied on a fresh surface in *fresco* (fig. 1c); painted motifs were executed in fresco secco (fig. 1b,f,g).

Tomb	Pigment	Main elements	Chemical formula	Methods
Tomb 1 & 2	Egyptian blue	Cu	$CaCuSi_4O_{10}$	pXRF, SEM-EDS, Raman
Tomb 1 & 2	Red ochre	Fe	Fe_2O_3	pXRF, SEM-EDS, Raman
Tomb 1	Cinnabar (red)	Hg	HgS	pXRF, SEM-EDS, Raman
Tomb 1 & 2	Red lead	Pb	Pb3O4	pXRF, SEM-EDS, Raman
Tomb 1 & 2	Yellow ochre	Fe	$FeO(OH)\cdot nH_2O$	pXRF, SEM-EDS, Raman
Tomb 1 & 2	Chalk (white)	Ca	$CaCO_3$	pXRF, SEM-EDS
Tomb 1 & 2	Charcoal (black)	C	C	pXRF, SEM-EDS

The painters' palette comprised natural inorganic pigments **(red and yellow ochre, cinnabar)** and artificially produced materials **(Egyptian blue, red lead)**, indicating a variety of sources. Egyptian blue applied on the upper part of the myrtle garland, on the north wall of the burial chamber of tomb 1, was used to indicate the light falling on it from west, casting a shadow on the wall, under the garland (fig. 1a,c); on the opposite wall, in mixture with yellow ochre, it was used to produce a green tone for a more naturalistic depiction of the garland. Egyptian blue, applied over a black layer, is found on the diadems, alternating with white, red and yellow triangles (fig. 1b). A powerful aesthetic statement is reflected in the remarkable variety of red hues and tones based on the use of cinnabar, red ochre and red lead, pure or in mixture, that were employed on the sleeves of the garland (fig.1a). Red lead mixed with red ochre on a white background was used in the continuous running scroll on the walls of tomb 2 to achieve a strong visual impact (fig. 3b).

Conclusions

The study of the manufacturing technology of mortars and plasters, as well as the painting techniques and materials used in this small group of Hellenistic tombs from Aigina, revealed a high level of technical skill and expertise. This is proven by the intentional use of hydraulic mortars, applied exclusively to the rock-cut surfaces to confer strength and waterproofing properties in a moist environment, and by technical refinements such as the preparatory layers containing sparitic crystals. Despite their poor state of preservation, the painted decorations display qualities characteristic of a craft tradition as well as an awareness of broader trends in Hellenistic wall paintings.

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A. Galanos, lithousintirisis@gmail.com**; A. Panagopoulou,** adamantiapanagopoulou@gmail.com**;**
K. Charatzopoulou, kcharatzo@zedat.fu-berlin.de