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**2nd Historic Mortars Conference and
RILEM TC 203-RHM Final Workshop
HMC2010**

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Mortars and Plasters under the Mosaics and the Wall Paintings of the Roman Villa at Piazza Armerina, Sicily

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Abstract The Roman Villa at Piazza Armerina in Sicily, built in many successive steps over the 2nd and 3rd centuries A.D., is renowned all over the world for both the wealth and the refinement of its mosaic floors. In February 2007 the Regional Government of Sicily started a restoration project of the whole archaeological site. The systematic survey and study of all decorative elements highlighted the value of wall paintings, which until then were almost unknown except for casual approaches to specific problems of conservation, carried on without any relation to the far and away famous mosaics. This paper shows the results of a physical chemical investigation of the mortars used for both floors and walls, which were extensively sampled both indoor and outdoor, including the crushed brick mortars of the basins at the monumental front entrance of the Villa. The mineralogical petrographic study of mortars and plasters was performed by XR diffractometry and by optical microscopy using polarized light through thin sections. Pigments were analyzed by micro-Raman spectroscopy, simultaneous thermal analysis was also performed in a few cases, in order to further investigate the recipe of the mixture. The results describe the composition of mortar under the mosaics and afford an unpublished view of both materials and techniques used in the wall paintings of the Villa at Piazza Armerina, giving the opportunity for interesting comparison with others archaeological sites under study.

1 Introduction

The Villa Romana del Casale in the neighbourhood of Piazza Armerina, Sicily, was built in many successive steps over the 2nd and 3rd centuries AD, and it is one of the most luxurious of the Roman Empire especially noteworthy for the finest mosaics which decorate almost every room [1]. When the villa was discovered during the '50s, minor importance was given to the traces of colours on the walls

hidden by a thick and strong layer of sinter due to alluvial debris. The restoration project of the whole archaeological site that started in 2007 highlighted the value of wall paintings, which until then were almost unknown [2]. In fact, every wall, both indoor and outdoor is decorated with subjects related to the use of the rooms: the paintings on most of the external surfaces look like the coloured marbles of the opus sectile in the Basilica, in the rooms floored with figurative mosaics the wall paintings are figurative as well, harmonized as for both the colours and the subjects.

The painting layer is often severely decayed by different phenomena mainly crystallization of soluble salts, i.e. efflorescences, that induced decoesion of the surface layers of plasters, including the painted film; moreover mostly walls are covered by a thick sinter. Therefore, the knowledge of composition and texture of the layers of mortar and plaster became a key step in order to achieve proper restoration intervention [3].

2 Materials and methods

The mortars and the plaster were extensively sampled both indoor and outdoor, including the crushed brick mortars of the basins at the monumental front entrance of the Villa, (Table 1).

The mineralogical-petrographic and the physical chemical investigations of mortars and plasters were performed by XR diffractometry and by optical microscopy using polarized light through thin sections. Micro-Raman spectroscopy was employed for the detection of some specific areas of thin sections where some recrystallization processes are visible.

Optical microscopy, both in reflected and in transmitted light on thin-sections, to analyze composition and texture; the thin sections were observed by means of an Olympus petrographic microscope equipped with a digital camera and Image Pro Plus software.

X ray diffraction was performed to identify the crystalline phases, by CuK α radiation on powdered samples in the 2 θ range from 4 to 60 degrees, after separation of the layers of mortar.

MicroRaman spectroscopy was performed by means of a Renishaw Invia Raman Spectrometer, using two different excitation wavelength, 633nm and 532 nm. Spectra were collected by means of a CCD sensor air cooled by Peltier effect, in a raman shift range from 200 to 3000 cm⁻¹.

Table 1 Characteristics of collected samples

| Sample | Material | Location | Note |
|---------|-----------------|-------------------|--------------------------------|
| 09PA 04 | Painted plaster | Room of "Dominus" | |
| 09PA11 | Painted plaster | Monumental door, | Painted band in the bedrock. A |

| | | | |
|---------|-----------------------------|--|---|
| | | external, left | fragment already detached with a strong biological deterioration, it contains pointing, finish, paint and deposit layers. |
| 09PA 12 | Painted plaster | Monumental door, external, right | The residual band in the bedrock is very broken up. The fragment seems to contain just one layer of paint. |
| 09PA 13 | Crushed brick mortar | External basin, left external lining | |
| 09PA 14 | Crushed brick mortar | Musive internal basin, right internal lining | Thick layer of mortar beneath. |
| 09PA 15 | Painted plaster | External wall, right | |
| 09PA 20 | Painted plaster | External wall, right | |
| 09PA 21 | Plaster | Parete esterna frigidarium | Painted plaster covered with scale/crosta |
| 09PA 22 | Sinter on painted plaster | palestra | powder |
| 09PA 23 | Painted plaster | Four-sided portico wall | Triple layer of plaster, the sample concerns the second layer (the most ancient painting) |
| 09PA 24 | Fragments of painted mortar | Four-sided portico wall | Triple layer of plaster, the sample concerns the third layer (the most recent painting) |
| 30PA 01 | Mortar fragments | External wall of the octagonal hall | |

3 Results and discussion

The observation of the thin sections allowed to give the description of characteristics of the composition and the texture of the mortars. Their mineralogical composition has been verified by XRD (results are in table 2).

The joint mortars of the internal mosaic lining of the tanks, see figure 1, are crushed brick mortars, they also contain granules of vitrophires, quartz grains (600-1500 micron) and more rarely carbonate ones, even of bioclastic origin and sporadic feldspar ones. The inert ones have very variable dimensions, from some mm to the dimension of a silt. The ratio Inert/Binder (I/B) varies between 0.4 and 0.7. Macroporosity is less than 5%. In the binder around the inert one there are thick spherulitic concretion (100 micron) and fringes of radiate calcite. In these concretions, the analysis by means of Microraman spectroscopy has revealed the presence of strontianite. The setting of this mortar has been realized in various levels.

Table 2 Results of XRD analysis of the samples

| Sample | Calcite | Magnesite | Quartz | Feldspar | Kieserite |
|----------|---------|-----------|--------|----------|-----------|
| 09PA11 | ++++ | | +++ | +++ | |
| 09PA 12 | +++++ | | +++ | traces | |
| 09PA 13A | ++++ | | ++ | traces | + |
| 09PA 13B | ++++ | | + | traces | + |
| 09PA 14 | +++ | + | + | traces | |
| 09PA 15A | ++++ | | ++++ | traces | + |
| 09PA 21 | +++++ | | ++ | + | + |
| 09PA 23 | ++++ | | ++++ | + | |
| 09PA 24 | ++++ | | ++++ | traces | |

Key: the number of + indicates the relative abundances of crystalline phases within the sample.

The results of X ray diffractometry indicate that the most present mineralogical phases are calcite and quartz, often associated with feldspar. The presence of Kieserite, a magnesium sulphate $MgSO_4 \cdot H_2O$, is related to the presence of sulphatic water in the environment of the villa that caused severe problems both to mosaics and wall paintings, mostly due to formation of efflorescences.



Fig. 1 joint mortar of the internal mosaic lining of the tank at the monumental door

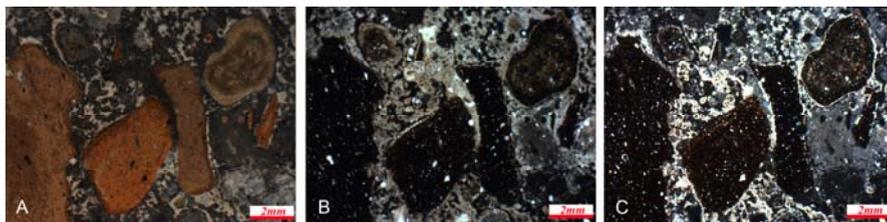


Fig. 2 micrographs of the thin section of the sample 09PA14: A reflected light, B ppl (plane polarized light) and C xpl (cross polarized light)

The mortars of the external lining of the tanks are crushed brick mortars as well, and they do not differ from the ones of the internal lining either for the inert/binder ratio (I/B 0.4-0.7), or for the composition or the granulometry of the inert ones. Only the porosity is a little larger 5%-10%. The superficial layer differs; it is not covered by tesserae, but it is covered by a layer of lime with a I/B ratio 1.5, in this are present inerts which composition reflect the one of the local rocks, consisting of quartz and carbonates, also bioclastic ones, and rare granules of feldspar and muscovite, and some fragments of vitrophires and igneous rocks. The lesser attention of the setting of this mortar that did not have a waterproof function is highlighted by the presence of not dissolved, cracked and inert lacking lumps of binder.

The mortars from the zone of the thermal baths belong to two typologies: the external wall of the frigidarium, sample 09PA21, is lined by a lime with a I/B ratio of about 0,6 and aggregate made by granules of broken up local rock (quartz, rare feldspars, carbonates and bioclastes), and, unlike the others, it is characterized by the presence of a thick rating of withdrawal fractures; on the contrary a remarkable cohesion characterizes the sample of external wall of the octagonal hall, sample 30PA01, that is the entrance environment to the thermal complex, where the humidity rate in the air is always really high, the figures are painted on a single layer of crushed brick mortar, which was very well smoothed on the surface.



Fig. 3 Polished cross section in reflect light of the crushed brick mortar with a red painted layer coming from the external wall of the octagonal hall

The paintings on the surfaces of the Villa perimetric wall and on the individual included buildings were realized on two overlapping mortar layer linings, the external one, which has a variable thickness from 1500 to 600 micron, is formed just by binder, appearing collophorm, with rare presence of some granule of inert of dimension between 400 and 15 micron, consisting of carbonatic rocks and quartz. Porosity is at maximum 5%.

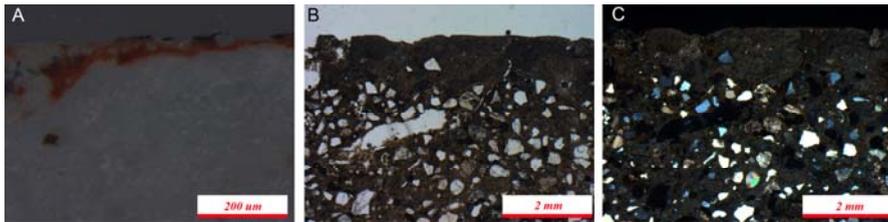


Fig. 4 micrographs of the thin section of sample 09PA12: A reflected light, B ppl and C xpl

The adhesion to brickwork layer contains as aggregate quartz grains that are fairly assorted concerning the granulometry, the dimension are variable between 400 and 30 micron, with a mode that varies from 150 micron in same sample to about 30 in others, e.g. 09 PA11. The binder shows collophorm texture. The ratio inert/binder varies from 0.80, sample 09PA12, to 0.30, with a majority of values around 0.5. Porosity is quite variable from 5% to 30%, in the most of the cases is 10% and it spreads in macropores, of about 400–200 micron in diameter with irregular shapes, and in mostly spherical bubbles of small dimension, ranging from 50 to 150 micron.

The covered household room mortars, sample 09PA04, do not essentially differ from the ones on the open air masonry lining; microscopic analysis of thin section of sample 09PA04 shows that the painting is approximately 25 micron thin and it is applied on a layer of almost inert free carbonatic binder, with rare quartz aggregates. There are some macropores shaped as fenestae and some micropores irregularly shaped. The inner layer, in contact with the masonry, is a mortar with quartz aggregates that are well selected as for particle size, bimodal distribution, 125 and 25 micron respectively, spherical pores with variable diameter are present.

The in situ observations on the frescos of the four-sided portico have revealed the overlapping of two pictorial series, as shown in figure 5, applied on substrate mortars, whose characteristics do not essentially differ from the ones already described.



Fig. 5 the two pictorial layers on the four-sided portico wall

The thickness of the pictorial film goes from 100, sample 09PA24, to 20 micron, sample 09PA23, each pictorial film is applied on a layer of plaster that is almost completely composed by binder superposed on the reinforcing mortar. Yet, it is evident that the reinforcing mortar of the most recent pictorial series is a lot richer in binder, i.e. $I/B=0,2$, than other samples. Also in this case the aggregates are mostly composed by quartz grains and less by carbonate rocks, sparitic and microsparitic, by rare feldspars, even rarer muscovite lamellae and casual bioclasts, this highlights that the material comes from local arenaceous outcrop. The binder has a collophorm texture also in this case.

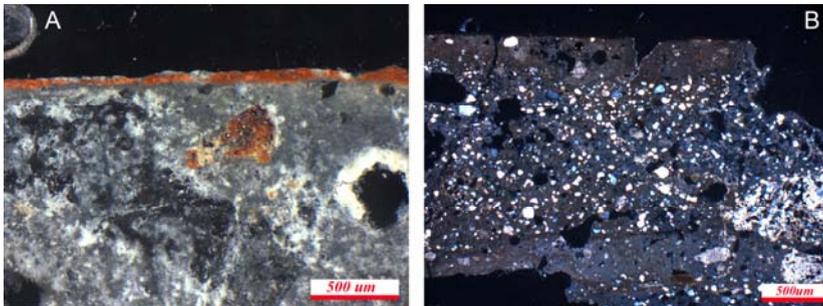


Fig. 6 Micrographs of the sample 09PA23 taken from the oldest pictorial layer. A reflected light and B xpl.

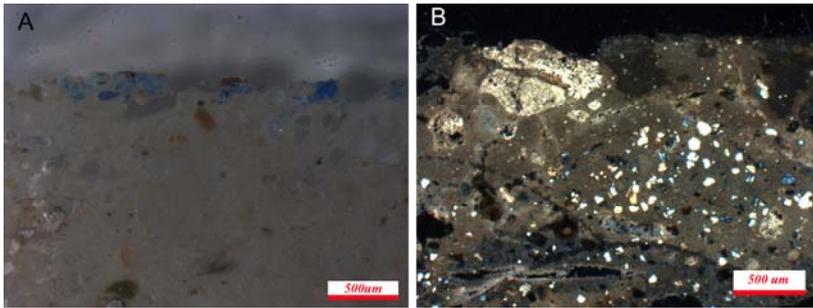


Fig. 7 Micrographs of the sample 09PA24 taken from the most recent pictorial layer, A reflected light and B ppl

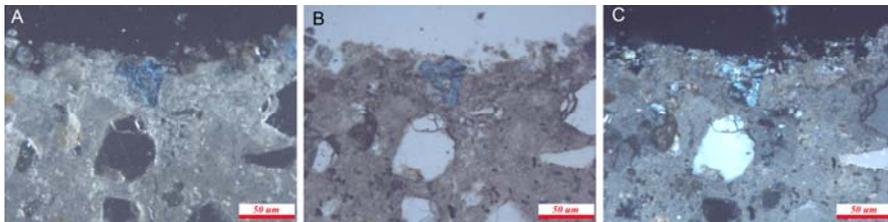


Fig. 8 Sample 09PA24 micrographs of the grains of the Egyptian blue: A in reflected light, B ppl and C xpl. In the latter it is evident the birefractivity of the crystals.

4 Concluding remarks

The composition and the stratigraphy of the wall mortars varies all over the site according the real use of the Villa rooms.

The substratum of wall painting of internal and external walls consists of two levels: external level is perhaps a pure binder, the inner one is a mortar rich in quartz aggregates

The painted layer, brown in colour as observed on thin section in ppl, is 100 to 20 micron thick and has generally a colloidal texture, excluding Egyptian blue that is birefractive in xpl. Except for some fortuitous cases, in presence of microfracture of the layer of “pure binder”, is not observed any diffusion of the pigments towards the inner layers, in fact there is, in general, a marked line of boundary. Two overlapped layers of paintings separated by a thin veil of lime were found in the peristyle and in the external wall of the Villa, which testify repainting of the wall.

The sample of external wall painting of the complex of thermae presents a crushed bricks mortar, this latter is also the substratum of mosaic internal covering and painted external surfaces of basins located on open air near the monumental gate of the villa. The contemporary presence of the mortar aggregates, used for the

water contact, the cocchiopesto and the vitrophires is quite spread in Roman age mortars, as a matter of fact it had been already well-grounded in Thermae waterworks [4] to guarantee an hydraulic effect such has been verified in historic mortars from completely different sites [5, 6].

For the correct formulation of the restoration protocol [7, 8] both of the mosaics and the wall paintings was truly important the diagnostic phase of the materials with which the Villa was built, of the techniques used by the ancient workers, and in particular of the study of the composition, the texture and the condition of the mosaic allurements mortars, of the wall finishing and pictorial supporting surfaces of the frescos mortars.

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An objective of the 2nd Historic Mortars Conference is to bring together scientists, technicians and professionals involved in research and studies of historic mortars to present and discuss advances in this topic. The main theme of the conference is the conservation of historic buildings and works of art, i.e. studying mortars with respect to repair. This is a unifying field where a truly interdisciplinary collaboration is needed and where contributions of archaeologist, architects, civil and structural engineers, geologists, material scientists, chemists, conservation scientists and art restorers interested in mortars should have their place. The special focus of the conference will be on the application of research and technical knowledge to conservation practice and vice versa in its reflection on such recommendations.

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