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Ancient Wall Plasters Found in Archaeological Excavations in Marseilles (France): Evolution of Techniques and Materials

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Abstract A multidisciplinary research project has been initiated to study wall plaster fragments found in recent archaeological excavations in Marseilles. The chemical, petrographical and physico-chemical characterization of these mortars allows the determination of their evolution and their processing techniques from the ancient Greek city of the 6th century BC until its Romanization in the 3rd century AD. Several important steps are apparent within the plaster fragments; these show a gradual development from the earth plasters associated with earthen architecture, to the gradual introduction of lime, crushed tiles or bricks as a pozzolanic material and the use of various aggregates, to the use of pure lime plasters with siliceous sand and pozzolanic material.

1 Introduction

The Archaeological Department of the City of Marseilles and the Inter-regional Centre for Conservation and Restoration of Cultural Heritage, in collaboration with the National Institute of Preventive Archaeological Research, have initiated a research program to study the wall plasters from Marseilles (painted wall plaster and mortar) which date from after its Greek foundation until its Romanization.

Since 2005, the materials discovered in up to ten archaeological sites throughout the city have been systematically studied. Mineralogical and physico-chemical analysis has been performed on selected samples in order to describe their materials, technical design, implementation and evolution. Three major phases of mortar design are apparent; these relate to the following temporal
periods present during the development of the city between the 6th century BC to the 3rd century AD:
- throughout the period of Greek Marseilles, first Archaic then Hellenistic
- the Late-Hellenistic and Augustan period
- during Roman times

A synthesis of results will be presented for each of these three phases and a conclusion providing information regarding specific techniques found in several sites, will also be provided.

2 Methodology

Pluricentimetric fragments of wall plasters found in secondary position demolition layers or filling layers have been dated by the ceramic objects contained within these layers or in the level of origin. The chronological processing was of course more difficult on these fragments than it would have been for coatings still in place, but at the same time, there was a reluctance to use some of these scattered remains for the investigations.

Each fragment was described under a stereo microscope. Chemical elemental analyses were carried out by micro-fluorescence (µXRF, ARTAX/BRUKER, source Rhodium, 50Kv-800µA with a collimator diameter of 600µm under helium flow (magnesium being the lightest detected element)) directly on the mortars and paintings to determine their bulk composition. Some sample fractions were ground for X-ray diffraction analysis (BRUKER D8 Focus, Co, 40mA-35Kv, Lynxeye detector). Samples were cut by sawing in order to make cross and thin sections that were observed under a petrographic microscope. Micro-Raman analyses were both performed on these preparations or on grains, mainly for the identification of pigments. Samples were also observed under a scanning electronic microscope (SEM/LV, FEI Philips XL30, LaB$_6$) fitted with a microanalysis probe (Energy Dispersive Spectrometry EDAX 4). The size distribution of aggregates was made by sieving after the dissolution of the carbonates using dilute Hydro-Chloric acid, HCl (15%).

3 Earth-based plasters in Greek Marseilles

3.1 Archaic Greek Marseilles

The only ancient text referring to the construction techniques of ancient Marseilles is that of Vitruvius [1] detailing the specific use of mud, for both the design of roof daub and adobe for the walls. Analyses were performed on the earth
plaster of two sites of the Archaic Period: Place de la Madeleine and College Vieux-Port (Fig. 1), where the building is probably connected to worship.

In the site Place de la Madeleine [2], some fragments of earth plaster have been found in the filling of an archaic structure dated to 575-550 BC. They consisted of fragments of daub showing superficial traces of a red colouring. The mortar, which contained some vegetal fibres, was a mixture of an orange clayey and sandy earth and a brown calcareous earth. This coating was spread in two layers each 6mm thick. The mineralogical analysis showed the predominance of calcite associated with quartz, and a muscovite/illite mineral. Chemically, traces of titanium, zinc and sulphur were systematically detected.

At the site of College Vieux-Port [3], dated from the early 5th century BC, the wall plaster material was a mixture of slightly dolomitic, gypseous clayey earths of different colours with a rather similar elemental composition. The presence of kaolinite and the extreme brittleness of the earthy matrix confirmed that it was not fired. The analysis of the brown earth revealed mainly calcite associated with quartz, dolomite, clay minerals (smectites, kaolinite, muscovite/illite), traces of gypsum and feldspar. The grey portions of earth also included organic components and looked like a marine mud deposit. The enrichment in calcium and the mixture of different earths play a stabilizing role for the material and serve to reduce cracks which are due to shrinkage [4].

This mix of brown and dark grey earth was found within the adobe and joints of the masonry. These plasters contained fine sand or silt (added or naturally present in the soil), and rounded quartz sand with many mollusc shell fragments, which serve to indicate a marine origin.

![Fig. 1 The archaic painted plaster on the site of College Vieux-Port (Photography S Mathie, INRAP)](#)
quartz, dolomite, traces of gypsum, mica and kaolinite minerals. These mixed earth based materials were still used throughout the Hellenistic period.

3.2 Hellenistic Greek Marseilles

Earth plasters were also found in the domestic habitations of the Hellenistic period. Plasters from two close sites, Tunnel de la Major and Esplanade de la Major, were studied.

The layer of demolition of the house 1, Tunnel de la Major [5], following the last occupation of the 3rd century BC, included some rather compact fragments of painted earth plaster. The blue, red or white paint layer was applied upon a thin white layer of lime showing a slight relief.

The fragments of earth plaster painted in blue (Egyptian blue) from the site of Esplanade de la Major [6], have been found in the filling materials of the Augustan levels; however these were found to have come from an earlier occupation. The plasters made of clay, lime and sand, were 5mm thick and very brittle. They were covered with a white lime-based layer. Above them, decorative reliefs made with the same earth as the bottom layer, were painted in black and blue.

4 Plasters made of earth, lime and crushed tile and brick in the Late-Hellenistic – Augustan period

At the last quarter of the 2nd century BC, which corresponds to the creation of the Roman Province of Narbonensis after the Roman conquest of the region, two new elements appeared in the composition of earth plasters: lime and crushed tile or brick. The addition of these compounds makes them harder and more resistant than simple earth plasters. These coatings have been observed at several archaeological excavations from Marseilles: Bourse, Pistoles, Tunnel de la Major, Esplanade de la Major, and Place de la Madeleine.

In Esplanade de la Major, very hard earth–based coatings painted in red were discovered in the fillings of the end of the Hellenistic / Augustan period. The matrix had a pinkish colour and was a mixture of lime and earth. The coating contained approximately three volumes of lime and about one volume of insoluble residue. This residue consisted of a very thin clayey earth with particles less than 0.15mm. The aggregates were composed of thin quartz sand with a few crushed tiles or brick (particle size less than 4mm). The analysis confirmed that the earth was unfired and indicated calcite as a main compound, associated with quartz, mica, dolomite and feldspar. The pigments were applied al fresco on a very thin layer of lime.

Excavations within the habitations of Place de la Madeleine provided a few fragments of painted plaster which were made of earth and lime. The observation
of polished cross sections showed a mixture of lime, unfired clay, some rounded crushed tile or brick and angular quartz sand of 0.2mm in average diameter, with a few rounded coarser grains (1mm in diameter).

The habitations of the late Hellenistic period (end of the 2nd century AD), at the site of College Vieux-Port, had also provided fragments of a pink wall plaster covered by red or black painting. This coating was relatively hard, resistant and compact. The pinkish matrix seemed to be a marly earth extracted locally from the Stampian marl formation, and mixed with lime; it was seen to contain quartz, calcite, muscovite/illite, a low proportion of kaolinite clay minerals, feldspar and traces of gypsum. The analysis, which did not show any dolomite, indicated a source of marl different from that used during the Archaic period. The aggregate was composed of an angular quartz sand of a very fine particle size (50% was less than 0.18mm in diameter) with a few coarser grains. The amount of lime was relatively large: two volumes of lime for one volume of sand. The material also included a few crushed tiles or brick with a grain size between 2mm and 0.25mm, mica, charcoal, nummulite microfossils (also present in Stampian marls), and a few grains of red ochre pigment.

5 Roman plasters based on lime, sand and crushed tile or brick

The Roman plasters have been studied from two major sites, Ilot 9 [7] and Rue François Moisson [8], where coatings were found as fallen fragments on the ground. They were made of two layers, each 10mm thick, of lime mortar with quartz sand and sometimes a few crushed tiles or brick inclusions. The grain size was coarser than in the Hellenistic period. The sand was very clean and rounded, which implied a fluvial or marine origin. Vitruvius [1] advised the use of crushed tile: "If one wished to add to the river and sea sand a third part of crushed and sieved tile, this would produce a mixture of an even better use."

Fragments of painted plaster, collapsed on the floor of a domus on the site of Ilot 9 (first half of the 1st century AD) showed a mortar made of lime and sand. The mortar was spread in two layers of different compositions. The lower layer, 10mm thick, was a white lime mortar with a 1 to 1.5 volume of lime for 1 volume of rounded quartz sand, with a few fragments of crushed tile or brick with a grain size of 0.25 to 4mm. The average diameter of the aggregate was 0.85mm, with less than 3% under 0.15mm. The upper layer was a pinkish mortar, 10mm thick; its matrix was composed of lime (2 to 3 volumes for 1 volume of sand) and powdered tile or brick with the addition of rounded quartz sand.

On the site of Rue François Moisson, the painted plaster collapsed on the floor of another domus, of the late 1st century AD - 2nd century AD, was made of two layers each 10mm thick. The mortar matrix was white, lime-based (from 1.5 to 2 volumes for 1 volume of sand), with fine to coarse rounded sand, a few crushed
tiles or brick and many echinoderm spicules suggesting a marine sand. About 40% of the aggregate were grains larger than 2 mm.

6 Specific techniques

6.1 The struggle against humidity

Humidity affects both the comfort and the durability of a building; construction techniques against humidity appeared as early as the Hellenistic period through the use of insulating materials such as ash or crushed pozzolanic material. Such material was found within several of the sites in Marseille.

At Ilot 9, under the decorative painting of the median part of the wall of a domus, (first half of the 1st century AD), was an upper pinkish layer of plaster which was seen to contain about 8% of broken tile dust. Such addition of pozzolanic material (crushed tile or brick), might have been done with the intention of providing the coating with hydraulic properties in order to prevent its degradation. The installation of terraced housing within a damp environment in this sector of the town probably required such protection.

The plinths were subjected to more specific treatment. In the domus of Rue François Maission, dated from the second half of the 1st century AD, ash was added to the lower layer at the bottom of the walls in order to prevent moisture; such a technique has been referred to within Vitruvius [1] and had already been used in the Hellenistic house G of Tunnel de la Major, 135 BC.

Fig. 2 Place de la Madeleine. Floor and walls in opus signinum (Photography LF Gantès)

Plinths covered with a Roman concrete (opus signinum) were a common feature within many of the excavated sites. This kind of mortar was recommended by Vitruvius [1] for the bottom of the walls up to a height of three foot, for rooms located on the ground floor, in order to reduce damage caused by moisture. The
opus signinum was also used as a flooring material within the late Hellenistic (2nd Century BC) houses of Tunnel de la Major and Place de la Madeleine (Fig. 2).

Analyses were performed on the wall plaster of one such house in Place de la Madeleine. It was a very fine, dense and extremely hard (resistant) pozzolanic mortar. Lime (2 volumes of lime for 1 of aggregate) and pozzolanic material (60-75% of residue had a particle size less than 0.06mm) was mixed with a small portion of sand and a few coarser fragments of crushed tile or brick (less than 4mm in diameter). This coarse mortar was made from 2 volumes of lime, with an aggregate consisting of 1/3 volume of sand and 2/3 volume of pozzolanic material. It was applied in two layers; the bottom layer, containing mica minerals (muscovite, illite) and a smaller amount of sand, was weaker than the upper layer. The latter contained twice the amount of sand and traces of kaolinite clay minerals, but no mica or illite. Kaolin fired clay is known to react better with lime than illite, the use of which may have lead to disintegration [9, 10].

The hardness of the upper layer may be due to a superficial strengthening treatment like beating. Since the firing temperature did not completely destroy the clay, one could assume that the tiles or bricks were fired at a low temperature (below 700°C). Such clays, when fired at low temperatures, prove to be more reactive as pozzolanic materials [10].

6.2 Improvement of adhesion

Traces corresponding to surface patterning on the wall or on a lower layer have been preserved on the back of the Hellenistic earth or lime plasters from the site of Esplanade de la Major. Such a surface treatment could have been used to improve the adhesion of the plaster prior to application. An alternative system, with fragments of amphora embedded in the earth masonry and in the plaster, has been identified at the sites of Tunnel of Major, (Hellenistic period), Rue Trinquet [11] (second half of the 1st century AD), and in the domus of, Rue François Moisson (late 1st century AD - 2nd century AD).

6.3 The treatment of the finishing layer

In some cases, the finishing layer received a specific treatment according to the colour of the paint layer: for example, the blue paint layer (Egyptian blue) of the earth plaster at Esplanade de la Major was applied over a grey earth layer in order to darken the blue pigment. White marble grains were also seen to be introduced within some of the mortars to make their surface glitter. Vitruvius [1] made reference to how such marble was prepared for use: “We crush the chips with iron hammer, we sift them into three kinds of powder”.

At Rue François Moisson, the blue paint layer of the wall plaster of the domus (late 1st century AD - 2nd century AD) was applied to a grey earth-based layer that contained fine marble grains. The marble served to highlight the blue and brought
a shimmering glow to the paint. The same technique was applied at Esplanade de la Major and Ilot 9 where yellow paint was applied over a finishing layer containing crushed marble. Occasionally, the yellow paint layer was applied on a pink upper layer to provide a colour enhancement. Micro-analysis on fragments of the pink coat from Rue de la République Nord [12], showed that the pinkish colour was the result of the presence of iron, most probably pure hematite or red ochre.

7 Conclusions

This study allowed for the distinction between the three major developmental phases of plastering in Marseilles, to be made. Throughout the Greek period, the city continued the tradition of earth-based architecture and plastering. The use of lime was limited to elements of decorative stucco work only and the material used was of a local origin.

At the end of the Greek period, which corresponds to the creation of the Narbonensis, crushed tile or brick and lime were added to improve the durability of earth-based plaster. Finally, with the Roman phase of the city, coatings based on lime, sand and a few crushed tiles or brick became usual; as is seen throughout Roman Gaul. Specific techniques to enhance the comfort or durability of the construction, were also seen to appear throughout this period.

These studies served to both trace and understand the techniques of building, and served to provide an aid in dating such material. The analytical data collected on wall plasters can also to be taken into account in terms of compatibility, when modern materials are going to be used for the consolidation and the restoration of ancient buildings.

It must be pointed out that the study of earth plaster is still rare because of the very bad state of conservation of such brittle and fragile coatings. Careful excavation methods and sampling techniques are crucial to their preservation and study. Complementary studies are suitable for this kind of material, especially for clay quarries.

8 References