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ARCHEOLOGICO
DI POMPEI

Agneta Freccero

Wall Painting in Pompeii Plaster Stucco Paint

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P O M P E I I

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Progetto grafico:
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On the cover:

Casa del Frutteto, room 7, south wall, detail. Plasters and stucco. Photo: A. Feccero

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PREFACE

Massimo Osanna

Il volume di Agneta Freccero analizza gli apparati decorativi sia in stucco che ad affresco da una prospettiva diversa rispetto a quella degli altri volumi editi precedentemente nella Collana di Studi e Ricerche di Pompei, e che esula da un approccio legato solo allo studio delle officine e dello stile per entrare nella materia prima costitutiva degli stessi. L'autrice parte infatti dall'analisi dell'unità minima che compone lo stucco e la pellicola pittorica per risalire, attraverso un percorso di sintesi dal particolare al generale, ad una seriazione crono-tipologica da confrontare con la tradizionale, e ormai in parte superata, divisione della pittura pompeiana in quattro stili, sempre di pari passo con lo studio delle tecniche artigianali di cui l'impiego e la lavorazione della materia prima costituiscono una delle poche tracce tangibili. Per raggiungere questi risultati l'autrice ricorre a diversi tipi di analisi sia minero-petrografiche, con sezioni sottili dei campioni di stucco e delle preparazioni delle pitture, che chimiche con diffrattometria a raggi X, spettroscopia FTIR e in alcuni casi con microscopio elettronico a scansione (SEM).

Come dovrebbe essere prassi in ogni buono studio di carattere archeometrico, il dato analitico qui non è mai disgiunto da un accurato studio archeologico dei contesti, sia al momento del campionamento che nella sintesi dei dati. Una scelta attenta e ragionata del contesto archeologico, così come la sua conoscenza approfondita, rappresenta infatti la base imprescindibile per un efficace campionamento, in grado di portare ad importanti risultati sul piano storico-archeologico. In questo volume la metodologia applicata è chiaramente espressa e replicata in ogni contesto, così da offrire al lettore tutti i mezzi per verificare il percorso conoscitivo messo in atto: la presentazione del contesto archeologico, l'indicazione dei punti di campionamento, l'analisi delle ca-

ratteristiche chimico-fisiche dei campioni e la creazione di gruppi di riferimento. Il lungo orizzonte diacronico trattato, dall'età sannitica al Quarto Stile, contribuisce inoltre all'interesse di questo volume, in quanto permette una riflessione sulle variazioni a livello tecnologico degli apparati decorativi; e tali variazioni non sono solo di tipo verticale e quindi cronologico ma anche orizzontali, legate alla molteplicità di officine operanti nel territorio. Il volume è quindi un interessante esempio di come uno studio archeometrico possa contribuire ad indagare da un'altra prospettiva temi ampiamente dibattuti nella tradizione di studi pompeiani quali l'organizzazione delle officine e la scansione cronologica degli stili pittorici oltre a temi più marcatamente di storia sociale, quali il ruolo del committente nella scelta delle maestranze e delle materie prime.

Il volume affronta anche il tema della conservazione con una riflessione sulle tecniche e i materiali impiegati negli scorsi decenni per la tutela degli affreschi e degli stucchi delle *domus* pompeiane, con una *overview* che si ferma agli interventi precedenti all'azione del Grande Progetto Pompei. E su questo tema ora il Parco Archeologico di Pompei, grazie a quel grande laboratorio interdisciplinare non solo di restauro ma anche di ricerca che è stato, e continua ad essere, il Grande Progetto Pompei, è riuscito ad elaborare delle linee guida e degli interventi esemplari che si pongono come paradigma per i futuri interventi nel sito. A partire dal "*Piano operativo delle opere per il consolidamento e restauro*", Pompei è diventata un centro di conoscenze in cui si intrecciano professionalità diverse e complementari, che hanno permesso di progettare una strategia comune e un approccio globale al monumento, in cui tutti gli elementi che lo compongono vengono ricondotti a unità per tutelare e dare la giusta dignità alle strutture archeologiche. E

questo approccio olistico ha riguardato tutti gli ambiti di intervento, dalla messa in sicurezza al restauro strutturale o degli apparati decorativi fino alle coperture, così da restituire alla città una sua immagine organica. Nel caso specifico del restauro degli apparati decorativi qui ampiamente discussi, si è giunti alla costruzione di un processo virtuoso che non si limita a un occasionale e non pianificato pronto intervento – come era consuetudine in passato – ma piuttosto mira ad una azione criticamente elaborata e proiettata verso la conservazione. Il restauro è quindi stato concepito da un lato come una imprescindibile risoluzione di uno stato di degrado spesso avanzatissimo per una prolungata mancanza di manutenzione, dall'altro come un'attività fondamentale per permettere una fruizione sempre più ampia e diversificata del sito. E molte delle *domus* discusse e presentate in questo volume sono state oggetto di interventi di restauro concepiti in tale quadro metodologico, come la Fullonica di Stephanus, la Casa di Paquio Proculo, la Casa del Frutteto, la Casa della Venere in Conchiglia, la Casa di M. Lucrezio e la Casa del Marinaio. In questi interventi sono state messe in campo negli ultimi anni una grande varietà di soluzioni, con scelte progettuali che valutavano caso per caso il contesto, rispettandone la specificità e al tempo stesso sottolineandone l'eccezionalità, secondo i criteri del minimo intervento, della compatibilità, della riconoscibilità (ma con discrezione) e della reversibilità. Si è quindi ricorso sia a tecniche tradizionali che ad altre più innovative come la pulitura al laser, valutando per ogni singolo caso l'opportunità di procedere alla ricomposizione figurativa sulla base di valutazioni legate sia alla durabilità dell'intervento che alla percezione visiva.

La scelta di pubblicare un volume dal carattere così interdisciplinare riflette anche uno dei principali indirizzi di ricerca posti in essere dal Parco Archeologico di Pompei. Il Parco, infatti, ha non solo avviato come vero e proprio ente di ricerca nuovi cantieri di scavo in tutta la città con la collaborazione delle più importanti Università italiane e straniere, ma negli ultimi due anni grazie al Laboratorio di Ricerche Applicate ha anche intrapreso un nuovo programma di coordinamento delle ricerche multidisciplinari condotte sul sito, i cui risultati saranno a disposizione di tutta la comunità scientifica. Il Laboratorio, nato negli anni '90 del secolo scorso grazie all'attività della dott.ssa A. Ciarallo, ha rappresentato fin dalle sue origini un primo passo importante per avviare a Pompei un nuovo filone di studi che uscisse dal tradizionale approccio storico-archeologico per aprirsi a evidenze diverse, e per certi versi uniche, quali semi, frutti, conchiglie, tessuti, resti archeozoologici e antropologici, che permettono di ricostruire l'ecosistema e il paesaggio antico, così come i consumi degli abitanti. Oggi il Laboratorio non è solo il luogo di conservazione di questi reperti ma è innanzitutto uno spazio di ricerca internazionale, con all'attivo circa 20 convenzioni sia in ambito conservativo e che riguardano i materiali lapidei e le malte, che nel campo conoscitivo, per riuscire a dar voce a tutte le fragili testimonianze conservatesi sotto le ceneri.

Tornando al volume, non possiamo che apprezzare questo studio per lo sguardo nuovo a temi, quali quello degli stucchi e degli affreschi pompeiani, spesso studiati per la loro qualità estetica e per il portato semanticamente rilevante e molto meno per quanto riguarda la materia prima impiegata per dare forma a questi significati.

INTRODUCTION

The scope of my study was, firstly, to investigate whether there is a chronological development of Pompeian plasters and a correlation between typology and chronology from the Archaic Period and up until the last days of Pompeii. Secondly, I wanted to examine whether there is a correlation between plaster types and the Four Pompeian Styles, and whether plaster analyses can be used as a complementary tool for dating decoration layers also when the painting has disappeared. Thirdly, I wanted to study the quality of the craftsmanship with the aim of understanding whether the quality of the plasters can be linked to individual workshops, to a specific time period or both. This begs the question of whether there is a correlation between the quality of the craftsmanship and the standard and size of the house, based on the assumption that it reflects the social and economic status of the owner.

Plastering materials can usually not be detected with the naked eye since they are found in between the standing structure and the painted surface. In the present study, they are regarded as one single unit where the plaster is the principal material. I believe that studying the intermediate stratum in isolation would be pointless – it has to be considered in the relevant context, that is to say as one stratum of a decorated wall structure. It means that the building technique and the painting have to be observed too, as both have undergone technical and/or stylistic alterations during the time period in question.

This study is composed of three sections. The first contains general information and a discourse on the methods that have been applied on the material, including problems that concern methods and the identification of samples. The second section is a collection of case studies; that is to say the houses in which the methods have been tested. The third contains discussions on my observations of the different phases – organized by property and case study area – as well as a thematic discussion on the way the research data support the overall conclusions.

My earlier studies seemed to indicate that different kinds of plaster were used for wall decorations attributed to different periods or styles.¹ All plaster studies associated with the Häuser in Pompeji project, even recent ones, have regarded one house at a time, which makes comparison between plasters in different houses quite difficult.² This is the case in other studies too: plaster examinations have been treated as part of an archaeological, stylistic or conservation-related approach regarding plastering in rooms within one building.³ When one building alone is studied, the plasters can be labelled according to any system used in that particular house, but when plasters obtained in two or more houses are compared, there needs to be some common classifications that enables overall conclusions. As I planned to study many houses in my investigation, it was necessary to develop criteria for the definition of plaster types, and

¹ A method of studying plasters under the microscope and describing their components was developed by restorer Reinhard Meyer-Graft within the German project “Häuser in Pompeji”. When Meyer-Graft instructed me in his method I had already made plaster studies at the Villa of Livia at Prima Porta outside Rome, applying scientific analysis of samples. I had also studied fragments found at structures below the Church of San Lorenzo in Lucina in Rome. My method used at Pompeii is a combination of the methods mentioned above.

² MEYER-GRAFT - EHRHARDT 1997, pp. 317-328; STAUB GIEROW 1994; ALLISON - SEAR 2002; EHRHARDT 2004.

³ GRAVE *et al.* 2002; PRISCO 2005; ESPOSITO 2009; LEPINSKI 2015.

to place these plaster types into preliminary groups that were not strictly linked to individual houses, but could be used for plasters in any building investigated. The primary examination method used *in situ* was a qualitative examination of plaster components. Plaster types were determined according to the plaster components and the aggregate's density in the matrix. Such differences can be detected by the naked eye and are clearly visible under the microscope. Plaster groups were determined in two stages beginning with ocular examination of small samples under a stereo microscope followed by laboratory analyses.

It was extremely important to start working on the project in a limited area where all known decoration periods were represented. This possibility was offered in conjunction with the British archaeological research project in *Insula I 9*, which includes houses with well-known decorations in the Four Pompeian Styles. As it became possible to look for plaster types in these houses, the next step was to determine a logical starting point for sampling; a random search would have been a waste of time. I intended to look for the earliest possible period in a stratigraphy, because that would immediately reveal two decoration periods, and presumably two plaster types. It was therefore essential to collect information on wall constructions and decoration periods.

After overall observations of the rooms and decoration layers had been made, and the most relevant sampling spots selected, systematic sampling began. From that point onwards, focus was on the composition of the plaster until a preliminary set of all plaster types within the house had been collected. The same procedure was then repeated in the next house, after which I was able to begin to make comparisons between the samples that had been obtained in conjunction with decorations in the first two houses. This was repeated with samples from the third house and so on.

During the *in situ* investigation and sampling process, the house, its rooms and their walls became familiar to me, and as a result new sampling areas came to the fore, either due to new discoveries or because there were doubts that called for an explanation. After completion of the ocular examination of samples in the first three houses, these were dispatched to a laboratory for analysis.

The study was conducted in three stages. The method was first tested and further developed at *Insula I 9* and then at the Forum. Samples were collected at both sites in order to identify consecutive decoration phases. Eight plaster groups were established and labelled A–H. In the next phase samples were collected from decorations dating to the earliest periods that have been discovered in Pompeii so far and virtually no samples were collected from decorations pertaining to later periods. During the second stage of the investigation, the method was tested on selected layers still *in situ* or on fragments of painted plaster. A new group designated 0 was created for the earliest plaster type and Group A was divided into sub-groups Aa and Ab. This resulted in ten plaster groups and an additional Group X, which includes additional materials such as modern conservation materials, cement, and cocciopesto. Finally the method was tested against the large collection of plaster samples from *Insula V 1*, obtained during the Swedish excavations conducted in 2001–2011. The dual objective was to examine all reference samples from those houses, compare them to the plasters in my established groups and, if possible, to incorporate both sample collections into a joint database.

Clearly, there is a methodological difference between the three stages of my investigation. During the first stage each context was carefully studied in order to determine the decoration periods. During the second stage only the earliest decoration phases were investigated. Alternatively, the method was used to resolve specific issues. The objective during the third phase was to incorporate a previously studied and defined plaster collection into the by then established plaster groups. One important distinction is that I had direct knowledge of materials as well as contexts relevant to the first two stages of the investigation, but not of those relevant to the comparative study, which had been compiled and sampled by another expert.

Before I embark on an account of my working methods, I will briefly explain some of the terminology used throughout my investigation.

Mortar is a mixture of slaked lime, sand and water where lime is the binder and sand is the filler or aggregate. *Plaster* contains a more fine-grained filler than mortar. In Pompeii, the aggregate mainly consists of volcanic matter.

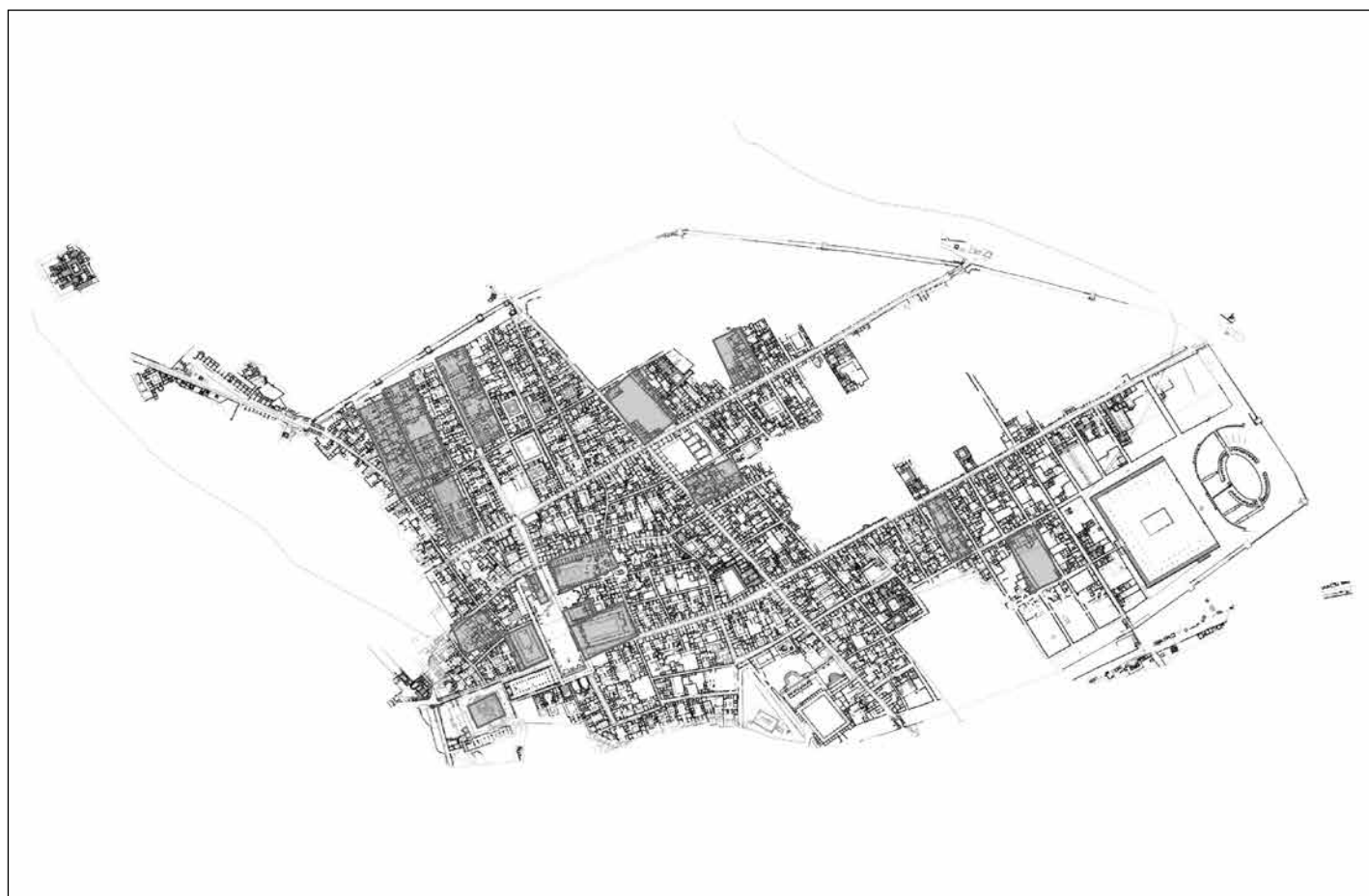


Fig. 1. Plan of Pompeii. The grey areas refer to the *insulae* where houses were sampled.

Lime plaster indicates that the binder is slaked lime. *Hydraulic lime* sets under water. Because of its hydrophobic properties, it was used at the socle level in damp or humid areas as well as in baths, basins and cisterns. *Pozzolana* is a volcanic material that was ground and used as a filler in hydraulic lime. Burned clay or terracotta can also be used as an aggregate in hydraulic lime. *Stucco* is a term used to either denote a material – a mixture of lime and crushed marble – or a specific kind of decorative relief work, or stucco, on Roman friezes or ceilings, i.e. *stucco-work*. In this context, *stucco* is used to denote the usually smooth, white top layer used for painting on. *Plastering* began with a layer of mortar and continued with layers of plaster, which were covered in a 2-7-millimetre-thick layer

of stucco. In some cases, the stucco had a pink or red hue due to the addition of pozzolana or terracotta. Simply a single layer of lime is very rare. *Plaster layer* indicates an application of plaster that covers at least two stones. If the plaster appears on one stone only, it is not considered a layer but a plaster *remnant*, which is not indicative of a plastering phase; the stone may be a reused detail from another context. (Figs. 2-3).

The criteria used in this cross-disciplinary research consists of a sequencing of plaster types obtained from decoration layers that have been identified and dated by means of stylistic interpretation and archaeological verification in combination with *in situ* observations and documentation of decoration periods, determination of



Fig. 2. Casa di Amarantus. Relative chronology of plaster layers in room 5, *tablinum*. The yellow socle is part of the original First Style decoration. The floor level was raised in the 1st century AD and the room redecorated in the Fourth Style.

qualitative distinctions under the microscope as well as analytical laboratory methods used on the plaster samples. Once all of the above criteria were met, the plaster types were divided into a series of groups designated A, B, C etc.



Fig. 3. Temple of Jupiter. A fragment of First Style plaster and white stucco on the west podium wall is trapped behind the abutting arch. Two layers of plaster and two of stucco are discernible. Also note the smooth stucco surface.

The working methods that have been applied are described in detail below. They are followed by a number of brief informative texts that are pertinent to this investigation: Roman housing and tradition; the Four Pompeian Styles; painters' workshops and materials; and conservation issues. These are only intended as a short background to the subject of this study. Construction periods and materials define the broad time perspective. The building types and their status and the quality of the materials relate to the quality of the work carried out at the workshop as well as the social status and prestige of the person who commissioned the work. The styles bring us closer to the more precise period in which plastering and painting took place. At the end of Section I, there will be a discussion regarding various problems associated with this method.

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SECTION I

TOPICS RELEVANT TO THIS STUDY

METHODOLOGY

The methods applied in this study can be divided into four distinct areas: a) study of context and documentation, b) sampling and qualitative analyses of samples, c) petrographic and technical laboratory investigations, followed by d) archaeological and art historical issues. These aspects will be presented under separate headings.

CONTEXT AND DOCUMENTATION

Work in each building started with a general inspection of the context, that is to say the size of the house, its location within the *insula*, the number of spaces with remnants of decorations, whether these were figural paintings or monochrome areas and, not least, whether a chronology of decoration phases could be determined. Significant sampling areas were selected and added to a table that contained all key data including samples, details of the room, the wall, the sampling spot and its level on the wall. All sampling spots were photographed and indicated on the photographs as well as on a plan of the house.

Information about plaster and stucco components was entered under the initial designations together with additional observations and notes on evidence of rebuilding and redecoration shown in the form of stratigraphic layers, walled-up doors and windows or layers with indentations. Stratigraphic plaster layers may indicate two separate decoration periods, but not necessarily. If the

first layer is un-decorated it may be part of the plastering technique. However, if the plaster has a painted decoration and is covered by a layer belonging to a later period we are clearly faced with two distinct periods.

Indentations made by a pick-hammer are also evidence of redecoration. A pick-hammer was often used to make new plaster adhere to a surface. The characteristics of the paint layers were also noted, for example whether they were in the form of white stucco or *cocciopesto*, or simply an application of lime. The colours were noted if there was painting. The above factors reveal the level of craftsmanship and offer information on the materials used for decoration. This information may indicate a certain workshop or the economic or social status of the person who commissioned the work as well as of the use of the room and the period in which the decoration was made.

The wall structure needs to be considered too. If there are remnants of a decoration on a brick wall, the plaster cannot be dated to a period earlier than the introduction of that type of wall construction. A plastered area on a Sarno ashlar construction, on the other hand, can be part of a 2nd century decoration or any period after that, in which case, according to Ehrhardt, the plaster's composition can be compared to other coating remnants in the same building and used for dating. Ehrhardt has found that decorated areas in a house where the same type of plaster has been used can be dated if one of the decorations has been stylistically recognized.⁴ The usefulness of plaster studies has been tested in a number of projects beginning with the German Häuser in Pompeji project, which has been described in a work on the Casa

⁴ EHRHARDT 1995, p. 143.

delle Nozze d'Argento (V 2,1).⁵ Plaster analyses in Casa della Caccia Antica (VII 4,48) have shown that even though each room is different from the others, all the paintings in the house were made during the same decorative phase.⁶ More recently, plaster examinations were used to establish decoration phases in Casa dei Vettii.⁷ According to Strocka, the thickness, quality and composition of plaster layers change over time.⁸ The significance of studying plaster and its technical and material characteristics is pointed out by Lepinski who stresses that materiality, which encompasses both its material and social facets, is fundamental to the process of visual representation and reception as it mediates the physical and the perceived.⁹

SAMPLING AND QUALITATIVE ANALYSES OF SAMPLES

Sampling is planned in co-operation with an archaeologist with expert knowledge of the house, and it begins where there is a clear stratigraphy, often linked to a First Style decoration. I refrained from obtaining samples from areas with paint layers because my main objective was to study plasters, not paint. Some samples have a complete set of layers, in which case the pigments, the composition of the stucco and its thickness were studied too.

Each small sample was identified by the initial letter of the house and the order in which it was sampled, e.g. GM1 (Casa del Granduca Michele, sample no.1). The first sample is always a reference sample. In principle, sample no. 2 is a reference sample too: it is removed from a layer that covers no. 1 and represents a new plaster type and a later period. Each plaster type is connected only to the building in which the sample was obtained. The types are later compared to reference samples from other

buildings, and samples that are considered similar constitute one group. That is to say, all plaster samples in the same group are, typologically, of the same type. The composition of plaster samples is examined under the microscope during sampling *in situ* and afterwards. The variables studied are,

- i) the characteristics of the lime,
- ii) filler components (aggregate), and
- iii) the proportion of lime in relation to filler.

i) *The characteristics of the lime*

The chief characteristics to look for in the lime are colour and consistency. It may be white, yellowish or beige depending on the colour of the stone that was burnt and slaked. Lime is produced by heating calcium carbonate (CaCO_3), i.e. limestone or marble, to about $1,000^\circ\text{C}$, when it turns into calcium oxide (CaO) or quick lime.¹⁰ Heat is produced by adding water, and the end result of the chemical reaction is calcium hydroxide ($\text{Ca}(\text{OH})_2$), or slaked lime. To ascertain that the process is complete, the lime should be kept in closed pots or caves for several years. Slaked lime can be smooth and even, or contain residue from the burning and slaking process in the form of lumps, which, in some cases, may indicate an inferior product.

ii) *Filler components*

At Pompeii, the filler consists almost exclusively of volcanic particles such as pyroxenes and pumice.¹¹ The shape and colour of the grains vary; it is likely that different caves provided filler material at different periods. The composition of volcanic matter depends on the prevailing conditions during the eruption.¹² Most of the particles are pumice, although some aggregates have a high pyroxene content. There are two types of pyroxenes: ortopyroxenes and clinopyroxenes. The former

⁵ MEYER-GRAFT - EHRHARDT 1997, pp. 317-328.

⁶ ALLISON 1992, p. 236.

⁷ PRISCO 2005, p. 355ff.

⁸ STROCKA 2007, p. 304.

⁹ LEPINSKI 2015.

¹⁰ On issues related to lime, see BLÄUER-BÖHM, JÄGERS 1997; MARCHESI *et al.* 2001, pp. 24, 27.

¹¹ MEYER-GRAFT - EHRHARDT 1997, p. 317; GRAVE 2002, p. 62; SABBIONI *et al.* 2001, p. 39f.

¹² SIGURDSEN 2007, p. 43ff.

consist of long black, rhombic crystals and the latter are monocline, transparent and translucent. The grains are described according to how they appear under the microscope: *compact grains* are fragments of volcanic rock, limestone or marble; *porous grains* is *cruma* or baked brick; and *crystals* are pyroxenes or vitreous materials. The colour of the particle is also noted.

It is reasonable to assume that the aggregate used for the Pompeian plasters derived from deposits in the Somma-Vesuvius complex where it was found in abundance and close at hand. There are caves in this region with stratigraphic layers that were formed during long series of volcanic eruptions, and these have been studied, documented, and described.¹³ Vesuvius has had minor eruptions as well as violent explosive eruptions in the past thousand years.¹⁴ Each eruption produces specific volcanic materials that are spread in the nearby area or at a distance, depending on the force of the eruption.

iii) *The proportion of lime in relation to filler*

Some plasters are made with a well-proportioned aggregate mixed with clean lime. Others may have inclusions of reused materials mixed with fresh lime. In general, the top layer contains a visibly higher percentage of lime than the rough coat. Another aspect is grain size: some plasters have homogenous, large-grained fillers, and the lack of small particles may cause cracks or cavities in the plaster when it sets. Other plasters have very small grains. A well-balanced, solid plaster contains grains of various sizes, and the smaller grains fill up the spaces in between the larger grains. The aggregate's density, as well as the cavities, or "airbags", as well as fissures due to shrinkage are important characteristics, since such features are indicative of rapid and careless work, especially if the lime is of an inferior quality.

The lime and its density within the matrix, that is to say the proportions between lime and filler, are not absolutely constant along a wall, but they are normal vari-

ations in the successive mixtures of plaster during a day's work. Such differences in the lime/aggregate proportions do not necessarily indicate different plaster types and periods. At least two plaster layers were applied in each decoration period, and the proportions between lime and aggregate sometimes varied. There is often a little more lime in the top layer compared to underlying layers, but only the proportions vary, the lime and the aggregate are otherwise identical in both layers.

Volcanic material such as pumice and pyroxenes are stable and they have distinct characteristics, therefore they are the focus of this study. The other main component, lime, on the other hand, is prone to change and decay. As a result, the quality of the lime has been recognized, but it is considered of a lesser importance. Moreover, the proportions of lime and filler are unstable factors for two reasons. One is that two components are combined, and it is not possible for the same proportions to be present in every single square centimetre of a man-made mixture. Secondly, plaster layers that have been exposed to the elements are often different from sheltered layers since some of the filler may have been washed away after the lime has lost its properties.

LABORATORY EXAMINATIONS

When the plaster types had been determined by ocular examination according to the above-mentioned criteria, a selection of representative, samples were sent to CNR/ICVBC for petrographic and chemical investigation. Seventy-four samples from *Insula I 9* and the Forum were subject to analyses in 2003-2005 and another 31 samples were analysed in 2010-2012. Following photographic documentation of each sample, samples were collected for FTIR and XRD analysis.¹⁵ Cross and thin sections from each sample were obtained successively. Thin sections were observed in optical mi-

¹³ CIONI - VECCI 1988, pp. 119-126; GRAVE 2002, p. 62; SIGURDSEN 2007.

¹⁴ SIGURDSEN 2007, p. 43.

¹⁵ Fourier Transform Infrared Spectrometry was performed with a Perkin Elmer System 2000 in transmission mode after dispersion of the sample in KBr obtaining a 13 mm pellet. The acquisition was carried out at a resolution of 1 cm⁻¹, averaging 8 scan in the range 4000-370 cm⁻¹.