The Wall Paintings of Çatalhöyük (Turkey): Materials, Technologies and Artists

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I, Duygu Çamurcuoğlu confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Duygu Çamurcuoğlu

ABSTRACT

Neolithic site of Çatalhöyük (Turkey) presents the most detailed and the interesting story up to date on Neolithic art and technologies both for the prehistoric archaeology and the material science studies. Çatalhöyük wall paintings are significant in terms of understanding the ideas of beliefs, rituality, symbolism and the social organization within the Neolithic community as well as the development of Neolithic wall art, since there are no other Neolithic sites at which the wall paintings were found of a similar scale in sizes and varieties in representations. However the technological processes which these paintings were created by did not seem to be interconnected with the discussions on the social aspects. The constantly developing field of material science has proved that the social studies on these paintings would not be complete without the study of their technologies which ultimately created these images. For the first time, this research aims to investigate primarily the technological make up of these paintings in detail and tie up the previous studies on the Çatalhöyük pigments and plasters within a broader technological and social context. The nature of wall painting production as a whole i.e. the materials used and their interaction with each other, tools and techniques and how "specialized" this practice was within the Neolithic community were investigated with the variety of analytical techniques available in order to understand the painting methods and the use of materials/sources within their archaeological and technological context. The research showed that most households at Çatalhöyük have involved in the making of wall paintings, their selection of materials/techniques were developed via their close environment and the production work was based on long-lived practices and traditions which were created through simply discovering and experimenting.

By undertaking this research, it was also possible to understand the nature of the individual wall painting materials and thus to develop better conservation strategies for their preservation whilst setting up parameters for their safe retrieval from soil, sampling, stabilizing and safe storage which will help to increase the level of information provided by these very old paintings.

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(All microphotographs were taken by Duygu Çamurcuoğlu, unless stated otherwise).

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This thesis is dedicated to my dearest friend, Özge Karabıyık (1977-2012)
for giving me the strength to hang in there.

Chapter 1

Introduction to the Research and the Methodology

1.1 The Significance of the Research

This PhD project focuses on the technological study of the wall paintings from the Neolithic site of Çatalhöyük (7400-6000 cal. BC) in Turkey (Fig.1), which illustrate a detailed and interesting story of Neolithic art and technologies both for prehistoric archaeology and material science studies.

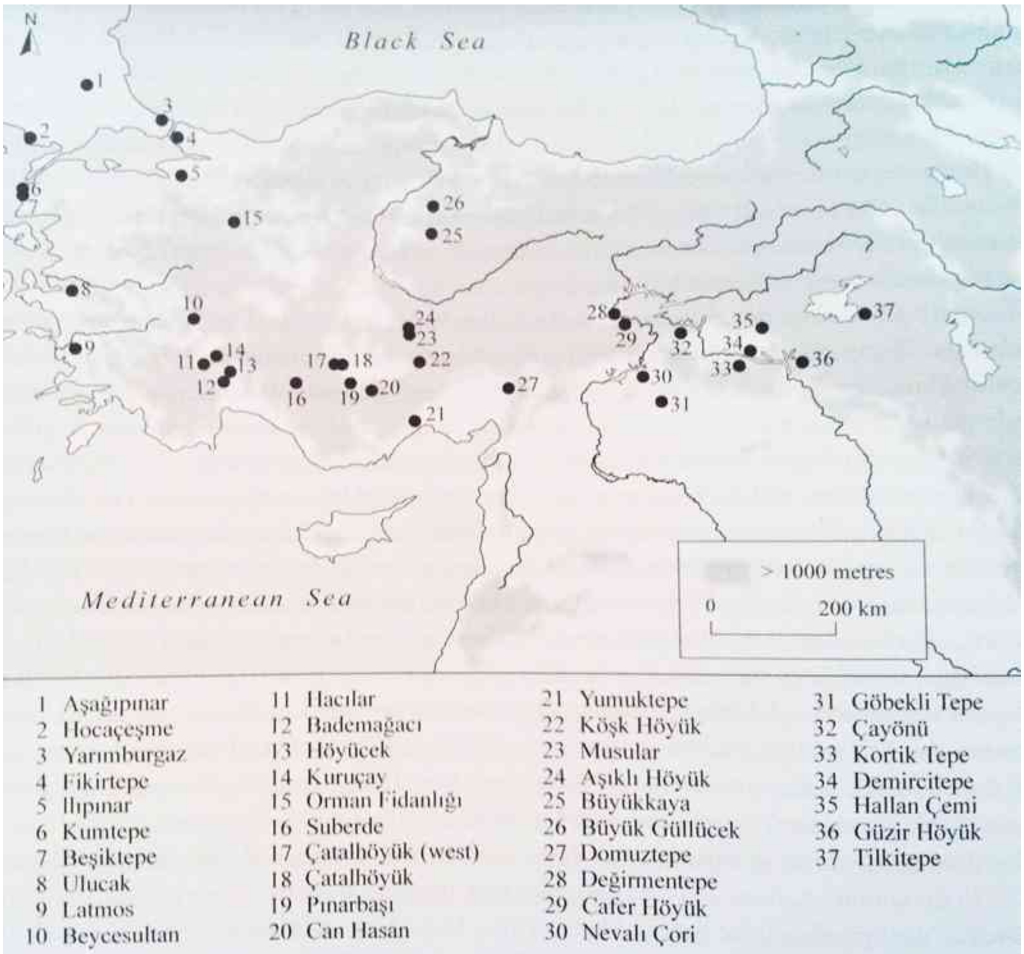


Fig.1. The location of Çatalhöyük (West and East mounds, 17,18) and the surrounding prehistoric sites in Central Anatolia.

As Mellaart (1967), Hodder (2006, 2007), Meece (2006) and Last (1998) have argued the Çatalhöyük wall paintings are very significant in terms of understanding ideas of beliefs and symbolism within Neolithic society. The connection between these ideas and the development of Neolithic art is also an important area to discover within

Anatolia and the Near East, as no other Neolithic sites have been found so far with wall paintings of a similar scale in terms of size and variety of representations (Figs. 2, 3, 4).

Fig.2. Hunting Scene from Çatalhöyük, B.V.1, South Area (Ian Todd, Çatalhöyük Research Project).

Fig.3. A geometric painting from Çatalhöyük, B.VII.21, South Area (Ian Todd, Çatalhöyük Research Project).

Fig.4 Hand paintings from Çatalhöyük, B.77, 4040 Area.

The technological processes used in the production of the Çatalhöyük paintings, as well as a few others found in other Neolithic sites (see below), have not previously been included to any great extent in scholarly discussions and the scholars themselves seem to have been mainly interested in detailed investigations of imagery instead of technologies. Only the representations seen on the paintings were considered in exploring the social values and activities of society (Cauvin 2000, 235-248, Conkey *et al.*1997, Verhoeven 2002, 5-13, Rollefson 2000, 163-188) while the techniques/materials used to create those representations were not considered to be able to answer social questions, but have simply explained how things were made. However, the constantly developing field of material science suggests that iconographical studies are not complete without the study of the technological processes by which those images were created. Therefore one of the aims of this study is to show that technological analysis is important for interpreting the practices and choices that formed these images and that such analysis can enhance our understanding of the social aspects of prehistoric wall paintings in ways that iconographical studies cannot achieve alone.

Several technological studies have been published on Paleolithic paintings, particularly on cave paintings from Western Europe, i.e. Altamira (Spain), Lascaux and Chauvet (France) (Figs. 5, 6, 7), as they were the earliest examples using colours and various techniques to represent daily lives/activities and therefore have received the most attention (Leroi-Gourhan 1982b, Ruspoli 1987, Bahn 1998, Valladas *et al.* 2001, Clottes 2002, 2003).

Fig.5 A cave painting from Lascaux cave (France)(www.mattlarsen.com/lascaux-cave-paintings).

Fig.6 A cave painting from Altamira cave (Spain)(www.macroevolution.net/altamira-cave.html).

Fig.7 A cave painting from Chauvet cave (France)(www.oddee.com/item_93915.aspx).

By comparison, there have only been a small number of studies (or still to be published) on the Neolithic paintings, particularly on those in Anatolia and the Near East, which is the main region of study in this thesis. Yet these studies often focus on the archaeology of the sites where the paintings are located but only briefly mention them. Most significant of those which may be compared to Çatalhöyük are:

- Djade al-Mughara (Syria) (Cartwright 2008, 4, also see Chapter 2, Section 2.2)

- Basta (Jordan) (Gebel *et al.* 2004, 135, 161)

- Bouqras, (Syria) (Akkermans *et al.* 1983, 335, 346, Akkermans *et al.* 1981, 485, Akkermans *et al.* 1982, 45-58)

- Abu Hureyra (Syria) (Moore *et al.* 1975, 50-77, Moore *et al.* 2000)

- Umm Dabaghiyah (Iraq) (Kirkbride 1972, 1973, 1975)

- Tell Halula (Syria) (Guerrero *et al*. 2009)

- Ain-Ghazal (Jordan) (Rollefson 1984, 3, Rollefson 1992, 443-470, Rollefson, Simmons 1987, 104,105, Banning, Byrd 1984, 16-17)

- Teleilat Ghassul (Jordan) (Lovell 2001, Cameron 1981).

Some scholars have worked on the Çatalhöyük pigments and plasters (Matthews 2005a,b, Doherty 2006, 2007, 2008, Tung 2008, Wiles 2008, Turton 1998, Westlake 2006, Na'as 2009, Zararsız *et al.* 2008), but none of these studies were tied into each other. Nor did they look at wall painting production as a whole, in a broader and systematic way, by exploring both technological and social aspects. By which I mean questioning the individual materials and their interaction with each other, tools and techniques used (particularly a number of ground stone artefacts found on site which might be associated with plastering/painting practices) and how specialized this practice was within the Neolithic community (Dobres, Hoffman 1994, Dobres 2000, 2001).

When people create material culture, social activities and relations are involved in a material production. The steps of material production (including day-to-day manufacture, usage, repair and discard) and the final products as "objects" become material and/or symbolic things through which people perceive the world that they live in. Studying various elements, i.e. technological or social, of the material culture can help in understanding the social steps of prehistoric technology, i.e. scale, context, materiality and production/reproduction, as well as the nature of social organization, relationships and practices within the communities (Dobres, Hoffman 1994, Dobres 2000, Dobres 2001, Lemmonier 1986, Ingold 1990). As it is summarized by Dobres and Hoffman (1994, 213):

> "A micro and macroscaler perspective highlights the dynamic nature of prehistoric technological action within communities and recognizes that prehistoric production was a meaningful and socially negotiated set of material-based practices as well as a technical means by which to make things".

An alternative is looking into material choices, sequences of modification, technical developments and archaeological contexts via the *chaine opératoire* technique to explore individual skills and/or the larger society involved in art making. Developed by Leroi-Gourhan (1964) this concept has been used since the 1960's and enables one to reconstruct steps of progression involved in prehistoric artefact production such as obtaining raw materials, modification, manufacture, use etc. (Karlin, Julien 1994, 152-164, Lemonnier 1993, Skibo, Schiffer 2008). Lithic remains were the starting point for the *chaine opératoire* technique to be developed, as lithics are durable, abundant and allows for the recreation of entire technical sequences. In one of the most recent studies in this field Farbstein (2011, 404) also discusses how it has been used to study other materials such as ceramics, organic tools, textile, shells and beads. She was also able to study ceramic, stone and some organic material remains, i.e. bone, antler and mammoth ivory from four Upper Paleolithic (Pavlovian) sites situated in the eastern Czech Republic (Moravia) via this method in order to understand and compare the technological choices available for working on different materials and how these technologies link and generate social networks within the same region (Farbstein 2011, 401-432).

However, this PhD project will not attempt to use any one of these methods, but try to draw from them when applicable. As mentioned above, the most crucial information missing from understanding the Çatalhöyük wall paintings is how these paintings were actually made, i.e. the nature of painting materials, possible application methods/tools, the interaction between individual materials and how these information are linked together. Therefore for the first time, this thesis will focus on making a detailed investigation of the technological make up of these paintings using analytical techniques available for this study, this is in order to understand wall painting production and the use of materials/sources within the archaeological and technological context. Based on this technological study this research also aims to briefly explore the possibility of specialization in wall paintings production at Çatalhöyük. Unfortunately, due to the limitations in sampling (see Section 1.5.4), it has not been possible to look at linking iconography and the composition of paintings with the technological/social practices and choices.

Since the dependability and consistency of the data feeding into the technological and analytical study is directly related to the age and the level of preservation of the material under study setting up better conservation strategies and parameters for the preservation of these paintings now and in the future, i.e. their safe retrieval from the soil, sampling protocols, stabilizing and safe storage, are also considered during this study in order to help increasing the level of information provided by these very old samples.

1.2 The Summary of Previous Research on Çatalhöyük Painted Plasters and Pigments

The first and the most well known wall paintings from Çatalhöyük were discovered and excavated by James Mellaart between 1961 and 1965. They became very important as they were very large in size, made up from many layers of plaster and the large diversity of designs represented on them (Matero 2005, 76). The first excavation season in 1961 found paintings on the East Mound. Two shrines in Levels III and IV (for Mellaart 'Level' system, see Section 1.5.3) as well as two buildings in Level VI were exposed by Mellaart. This brought to light some of the best examples known from Çatalhöyük, including the famous "Hunting Scene" from Shrine A.III.1 (Mellaart 1962, 976) (Fig.2) and some of the others in A.III.13, E.IV.I, VII.8, VI.B.10, VI.B.10, VI.A.63 (Mellaart 1967, 170) (see Chapter 2, Section 2.4 for details and images of some of the paintings). Following these discoveries, Mellaart presented Çatalhöyük as "the largest Neolithic settlement and the most extensive mudbrick architecture found with the unexpected discovery of highly elaborate wall paintings and the relief sculpture" (Mellaart 1965,77). Today it is known that Çatalhöyük is one of the larger Neolithic sites in Anatolia and the Near East, others being Abu Hureyra (Syria) (Moore 1975, 50-77, Moore *et al*. 2000), Bouqras (Syria) (Akkermans *et al.* 1983), Kfar Ha Horesh (northern Israel) (Goring-Morris 1991, 77-101) and Ain Ghazal (Jordan) (Rollefson *et al*. 1992, 443-478, Rollefson *et al*. 1996).

The first technical analysis of the paintings was undertaken by S.J. Rees-Jones of the Courtauld Institute of Art during the second excavation season in 1963 (Matero 2000, 78). Further conservation work and basic material analysis was pursued by Pamela (Pratt) French between 1968 and 1974 (French 2008 *pers. comm.*). She continued to undertake detailed conservation work on the paintings, which were brought to the Ankara Anatolian Civilizations Museum, following the complex operation to remove them from the site. During her work, she used some chemical spot testing to identify the type of plaster and particularly the red/brown pigment used. As French explains, the plaster samples had high calcium carbonate content (according to results of the ammonium oxalate test) and the red/brown pigment was considered blood based on the benzidine test. However, these results were unclear. In 1971, some plaster samples were analysed at the British Museum research laboratory using X-ray Diffraction (XRD) indicating that the Çatalhöyük plasters were dolomite (calcium magnesium carbonate) rich (Werner 1971).

There were no other technical analysis of the wall paintings until the current excavation project run by Prof. Ian Hodder which started in 1993. Since then Matthews (2005a, 2005b), Kopelson, Turton (1998) and Moss (1998) have contributed to better understanding of the wall painting materials with further analytical work. Matthews has particularly focused on the plaster studies and the micromorphology of the plasters found at Çatalhöyük (followed by Tung 2008). By working with the geologists on site (Boyer *et al*. 2006, Roberts *et al*. 1999) she studied the chemistry of plasters within the surrounding geology by using various analytical methods and the effects of the environment on the material formation. She has also looked at the use of plasters and their life cycle in building contexts in order to contribute to understanding of the social, symbolic and practical importance of the material for the Neolithic community (Matthews 2005a,b, 1996).

Following on from Matthews, Turton and Moss have focused more on the preservation of the paintings and the mudbrick walls as they aimed to advance previously used methods for the emergency stabilization and removal of the wall paintings, as well as addressing environmental control on the site. In order to investigate better techniques, it is necessary to understand the issues of preservation as well as the chemistry of the actual materials within their archaeological matrix. Therefore these researchers briefly analysed the pigments and painted plasters, providing a basic body of information on their identification (Turton 1998, Unpublished MSc thesis, Moss 1998, Unpublished MA thesis).

Most recently Westlake and Na'as have studied selected samples from the 1960's wall paintings at the Courtauld Institute of Art in London as a part of their Master's studies (Westlake 2006, Unpublished MA thesis, Na'as 2008, Unpublished MA thesis). Once again, they examined and analysed the samples in order to characterize and identify some of the materials used, i.e. pigments and plasters. Zararsız et al. have also recently carried out non-destructive portable X-Ray Flourescence (XRF) analysis on the 1960's paintings (particularly on pigments) that are housed in the Ankara Anatolian Civilizations Museum (Zararsız *et al*. 2008). The work undertaken by Zararsız and others was part of a project that aimed to attract funding for the conservation and restoration of these important paintings. However, lack of interest from the relevant stakeholders meant that this project could not be pursued.

1.3 Research Questions

The main questions of this PhD research are:

- How were the wall paintings of Çatalhöyük made?
- How did each element of the wall painting matrix interact?
- Did the techniques change through time?
- What can the material data tell us about the social production of these wall paintings?

Under these headings, the aim is to investigate the areas below and try to answer the questions that are listed in Sections 1.3.1, 1.3.2, 1.3.3 and 1.3.4:

1) Pigments

2) Plasters

3) The interaction between plasters and pigments, i.e. the plastering/painting methods and tools

4) Possible specialization of painting production within the Neolithic community via studying the spatial distribution of the possible ground stone tools related to painting practices.

1.3.1 Pigments:

1) What kind of pigments were used?

2) What were the raw materials for pigments and their possible sources?

3) What were the different methods of pigment preparation/modification for paintings?

4) What were the reasons to use particular pigments as opposed to the others available, i.e. practical, symbolic or social?

1.3.2 Plasters:

1) What types of plaster were used?

2) What were the raw materials and their sources used to produce plaster?

3) What were the different methods of plaster production?

4) What was the nature of plaster application in relation to the production of wall paintings production?

1.3.3 Painting methods:

1) What type/types of painting methods might have been used?

2) What kind of tools might have been used to produce paintings, i.e. brushes, bone, textile, skin, wooden tools, ground stone tools including polishers, ochre processers or pigments?

3) Is there any evidence of organic binders?

4) How did the pigments interact with the plasters?

1.3.4 Social Aspects of Wall Painting Production and Investigating Specialization:

1) Were paintings generally produced by a larger scale practice (involving the whole community), or was it possible that wall painting production was a specialism and only undertaken by individual craftsmen?

2) How often is it possible to find pigment residues on ground stone tools (Fig.8)? Are they present only in certain houses or can they be found in most houses?

3) Is there any indication for concentration of possible painting tools in particular houses as opposed to most houses?

Fig.8 CH05/South/U.11372/K1, an abrading slab (sandstone) with possible pigment residues (Courtesy of Dr Karen Wright).

4) Is it possible to detect any variation in painting techniques across the site? If yes, might this be related to specialization in wall painting production?

1.4 Research Objectives

In order to achieve the primary aim of this research, the technological aspects of pigments and plasters used during the prehistoric era were examined in comparison with those of the Neolithic period, with special reference to Çatalhöyük. Study of the materials and techniques, defining tools and their distribution, study of the paintings and on-site observations/experiments with the material is used to create a systematic data set. It is hoped that this will be clear and informative enough to be used, consulted and questioned by researchers both in the fields of both archaeology and conservation.

The results gathered from the technological study are used to investigate the idea of specialization in the production of paintings during the Neolithic period in Çatalhöyük, as well as looking for the evidence of specialist painters/houses that may have existed within the society and formed the material world. It is also hoped that the outcome of this research will be relevant to the other sites with wall art and plastered objects particularly in Anatolia and the Near East and will create a platform for further research and comparisons in Neolithic wall art production.

As summarized in Section 1.2, some technological studies have been carried out on painted plasters at Çatalhöyük, but this is the first time that this material is being subjected to a study where three different methods were chosen to look at the research questions from a broader perspective by using:

1) Non or micro-destructive instrumental analysis

2) Experimental work following the analytical results

3) Investigating whether the evidence can tell us if there was either a communal or a specialist practice of wall paintings production within the Neolithic society.

In order to answer the questions above, the main methodology is applied in three aspects: Technological, Social and Experimental.

1.5 The Methodology for the Research Questions: Technological Aspect

Material analyses were used for the identification of selected painted plaster and pigment samples, possible organic binders and the tools and techniques with which the paintings were executed. Different analytical methods/instruments for characterizing materials were chosen to be complementary. The results are then examined within the technological and social setting of Çatalhöyük.

1.5.1 Data and Sampling

The archaeological data which constitutes the main interest area for this research consists of the wall painting related material at Çatalhöyük such as the painted plasters, pigments and the possibly related ground stone tools. The principal idea behind the sample selection was to investigate "primarily" the wall painting technologies including materials, techniques, tools and the possible choices made by people. Initially, I planned to sample the earliest and the most elaborative wall paintings excavated by Mellaart housed in the Ankara Anatolian Civilizations Museum (both in the form of fragments and large paintings) and the paint-related objects, i.e. the painted/plastered skull in Konya Archaeological Museum. However, I was not able to get permits from these museums to take samples. Although I hoped to find relationships between the technological and iconographical choices on the paintings via the analytical study, the problems with sampling made this impossible to achieve. As a consequence this research focused only on the recently excavated wall painting data from the Hodder excavations. Even though these samples provided sufficient information on the technology of the Çatalhöyük wall paintings, the variations on their iconography was very limited and did not allow me to find correlations on the choice of materials used for creating the various designs and scenes which were represented on the Çatalhöyük wall paintings. I visually examined a few of the complete Mellaart paintings at the Ankara Anatolian Civilizations Museum, but these did not suggest any possibility of new or different information in comparison to the most recent paintings from the Hodder excavations. Some of the painting fragments from the Mellaart excavations are stored at the Courtauld Institute of Art in London. These have been previously studied as the subjects of two different Masters' theses by Westlake and Na'as (Westlake 2006, Na'as 2008, see also Section 1.2). Zararsız et al. also investigated some of the Mellaart paintings at the Ankara Anatolian Civilizations Museum (Zararsız *et al*. 2008). These studies have employed techniques such as Polarised Light Microscopy, UV reflectance, IR false colour imaging and X-Ray Flourescence, though their results presented the same chemical compositions/fabrics as the most recent Hodder samples which are decided to be the main focus of this research. These work demonstrated that the Çatalhöyük paintings and pigments (from both Mellaart and Hodder excavations) present a similar dataset across the site. For this reason the samples that are available at the Courtauld Institute of Art have not been re-studied for this research to prevent any repetition of results and to save more time for the further questions aimed to be explored within this thesis.

At this point, it is also important to clarify that the "other" wall art at Çatalhöyük, i.e. painted/non-painted plastered reliefs and incised decorations (Mellaart 1967, Cutting 2007, 467-472), were not included in the scope of this research. The main focus is on the wall paintings and their technologies. It is, however, clear that understanding the detailed technology of the wall paintings would help us to recognize the technical similarities and differences on other wall decorations at Çatalhöyük and thus create an avenue for future research to investigate their individual technologies and where they were placed both technologically and symbolically within the "material world" of Çatalhöyük.

Similarly, unpainted wall plasters including floor and constructional plasters were not included in this research either, since there is already extensive work being undertaken on unpainted plasters (Matthews 1996, 2005a, 2005b, Tung 2008, Doherty 2006, 2009) and it was decided that the results of those plaster studies could be correlated with the wall paintings research.

Ideally, the methodology of sample collection for this research would have required samples being taken only from the secure (primary) contexts such as the in situ painted walls and burial contexts, from each level, each building and in different areas of the site in order to present a consistent and a reliable picture (In this thesis the word 'primary' will be used to describe contexts where the wall painting related samples can be directly linked to, i.e. painted walls, burial contexts and object clusters. For the contexts where the samples cannot be directly linked to, such as fills and middens, the terms 'insecure/secondary' are used).

However, the examination of previously collected samples on site (see below) and the sampling pattern developed during this research (mainly depended on the retrieval of samples as they came up on the site) made it clear that wall paintings and pigments were often 'not' found in situ and 'not' in most buildings and levels across the site, resulting in a large number of samples being derived from insecure (secondary) contexts, i.e. middens and fills, that imposed certain limitations on the sampling (see below). As this might be due to some preservation issues (see Chapter 3, Section 3.2), it may also be an indication of some houses undertaking painting practices more than the others. It is also possible that wall painting fragments were scattered between different contexts in relation to discard/re-use within the re-building processes of Çatalhöyük houses (see Chapter 2, Section 2.4) and this may have caused some building contexts producing only a few samples whereas others produced more (see Table 1.2a).

As a result of the limitations mentioned above, the judgmental sampling as explained by Orton (2000, 21) seemed to be the most suitable method for this research, but could only be pursued as the samples and their contexts enabled it. The main idea is that the samples are selected according to certain criteria determined by the specialist's experience and the initial study of the material, i.e. in this research, the painted plaster and pigment samples were selected according to the:

1) The reliability of their archaeological/contextual information.

2) The excavation areas and chronological levels from which they were excavated across and through the site.

3) The contexts, i.e. buildings, spaces, features or locations in which they were found.

4) Their condition and reliability for analyses.

5) How the samples answer the research questions.

Following this methodology the samples were aimed to be collected from the different levels, different buildings and different areas of the site in order to make both cross-site and level-by-level comparisons in between, and if possible to observe any similarities or changes throughout. A few pigments that are in the form of lumps or lose powders are also found in Çatalhöyük burials with close relation to the bodies rather than being found in burial fills, of which the exact contexts could not be identified. These pigments were also considered to come from the secure (primary) contexts, since they indicated that they may have been used as burial gifts and had ritual/symbolic importance. However as the research developed, it became impossible to focus on the pigments and burial practices at Çatalhöyük as well as my main focus "wall painting materials and techniques" since the latter was already a very wide topic to tackle. Also, the low number of burial related pigments did not enable me to retrieve conclusive results. For these reasons, the study of Çatalhöyük pigments in the context of burial practices was excluded from the scopes of this research.

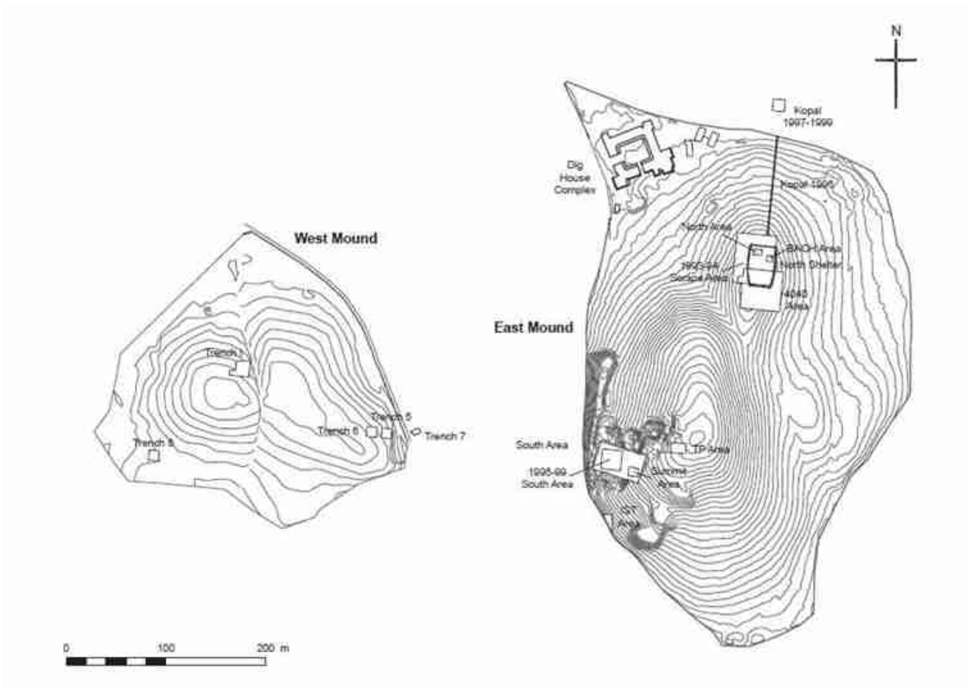


Fig.9 Çatalhöyük site plan showing the past and present excavation areas
(Çatalhöyük Research Project).

1.5.2 Sampling Contexts: The Excavation Areas

The samples selected, i.e. the pigments/painted plasters and ground stone tools (in consolidated masses and powders, different sized fragments and in complete forms), all come from the different areas of the Neolithic East Mound (South, 4040, BACH, see below) at Çatalhöyük between 1996-2010 (Fig.9). Below the excavation areas at Çatalhöyük are briefly explained. More detailed information about the site and its archaeology is presented in Chapter 2, Section 2.4.

1.5.2.1 South Area (Appendix 8)

The South Area is the oldest excavation area of the East Mound at Çatalhöyük. It is located on the south part of the East Mound. It was first surveyed and excavated by James Mellaart in the 1960s. From the fifteen superimposed building levels (see Section 1.5.3. for the Mellart "Level" system), the earliest level below Level XII is called Pre-level XII. There were no buildings excavated in this level during the present excavations, but there were a few midden spaces, i.e. Space 181, 198, 199 (Cessford 2007, 59-102), below Buildings 18 and 23 in Level X and XI. Space 181 (Pre-level XII) has been the main context in the South Area for wall paintings research, since a number of units in this space contained both painted plaster and pigment samples.

1.5.2.2 4040 Area (Appendix 9)

The 4040 Area is situated on the northern part of the East Mound and the recent excavations undertaken by the Hodder's team aim to investigate an area of 40m x 40m in order to focus on the "neighbourhood areas" at Çatalhöyük. From 2003 to the present, several adjacent Neolithic houses were exposed together with possible alleyways and their relationships with each other, as well as Building 5 - one of the first buildings on the northern part of the East Mound which was excavated in great detail (Cessford 2007, Cessford 1998) - are being studied (Farid 2004). This area has yielded the most recent wall painting and the pigment data.

1.5.2.3 BACH area (Appendix 9)

The BACH area excavations were undertaken by the Berkeley Archaeology Team and took place between 1997 and 2003. The aim was to link this excavation area with Building 5 to be able to understand the life histories of houses in a "neighbourhood" context as well as the continuity and social formation of the East Mound (Tringham 1997). The BACH area present an interesting set of data, mainly consisting of pigments and painted plasters in secure and interesting burial and building contexts.

1.5.3 Çatalhöyük Phasing System

When Mellaart first started excavating the site in 1960's he set up a general site phasing/stratification system and described it "Level" meaning that fourteen superimposed buildings which he excavated would be linked to a level which was numbered with Roman numbers, i.e. 0 being the most recent (at the top) and XIII being the earliest (at the bottom, in the deep sounding of the South Area) (Mellaart 1962, 44). Thus the numbers presented the location of a building in a series of buildings which were built over each other, for instance a Level V building would be the fifth building down in a fourteen building phases. During the current project run by Ian Hodder, Mellaart's "Level" system was re-evaluated and it became clearer that it was not always comparable with the phasing of the other areas of the site (Farid 2008, 15-18). Recent excavations have shown that linking the stratigraphy of the different areas on the East mound has become very difficult. Farid (2008, 15-18) explains that some areas of the mound may also have been occupied at different times. Following these issues a new phasing system is introduced as a result of the work completed in the 2008 season.

As Farid explains:

> "the new phasing is based on a single stack or column of buildings, which can be constructively demonstrated as sequential in time. It will also be based on best fit stratigraphical relationships, which have been excavated by the current team. The 1960s data will only be drawn upon where no other option exists. In some cases abutting relationships will have to be used" (Farid 2008, 18-27).

At present, the new phasing system is only linked with the South and 4040 Areas (Appendix 6 and 7) and the work will continue for all the remaining areas in the near future meaning all the levels of the different site areas will be able to be linked with each other and compared with the original Mellaart levels in the South area (Farid 2008). Since the present study started before the new system was introduced it follows the Mellaart phasing method with the current additions of the Hodder phases. Table 1.1 shows the current understanding of the Mellaart and Hodder phasing levels, which is mainly based on the pottery and lithics studies.

Levels		
Mellart	**South-4040**	
0,I,II	TP6	6400-6000
	South T-4040J	
	South S-4040J	
	South R-4040I	
	South Q-4040H	
(V)	South P-4040H	
VIA	South O-4040G	6500-6400
VIB	South N-4040G	
VII	South M-4040F	6700-6500
VIII	South L-4040F	
IX	South K	7400-6800
X	South J	
XI	South I	
XII	South H	
PRE XII (XIII)	G1, G2, G3, G4	

Table 1.1 Mellaart and Hodder levels across the different excavation areas (East Mound) (Duygu Tarkan, 2012)

In the table, newly developed Hodder levels (named by the excavation areas and the letters in alphabetical order, going from top level down, i.e. South T-H and 4040 J-F) are associated with the Mellaart levels (between 0 and Pre- Level XII).

1.5.4 Sampling Methodology and the Limitations

141 samples (pigments/painted plasters, see Appendix 1) were chosen initially by examining the previously collected samples by the excavators (1996-2007) as well as the samples collected by myself during the course of my research (2007-2010). Both macroscopic and microscopic examinations were useful in order to understand the nature and the conditions of the samples. During this initial process it became obvious that it would not be possible to subsample every painted plaster and pigment found on the site due to the vast numbers of material. The initial examination of the material therefore helped for:

1) Observing the technical aspects of the material via a surface study.

2) Deciding what would yield useful information to sample.

3) Deciding the type of analysis which the samples might require, i.e. microscopic and instrumental analysis.

Often the macroscopic study helped to see certain details on the samples, i.e. the multiple layers on the painted plasters (particularly on fresh breaks) as well as the surface features. This first step was also useful to cut down the sample numbers, since a vast amount of material was collected during excavations but most of these were not relevant to this research or not in a good condition to be studied. Microscopic study gave clearer answers about the material, since it provides more detail under high magnification. The surfaces and sections were observed under the microscope in order to get a general idea about the nature of the material by looking at any brush/tool marks, number of paint layers, plaster layers beneath the paint, plaster types, structures, inclusions and any evidence of foundation layers.

Through this study, it was clear that the condition of the samples varied and this played an important role for their selection. The past and present conservation measures applied on the samples, i.e. consolidation practices, inappropriate packaging and storage, as well as the way that painted plasters and pigments were recorded, affected the nature of samples and sampling as well as the information which could be extracted from them via instrumental analysis. For example, most samples were packed and handled inappropriately, causing them to crumble and powder away and the wrongly labeled samples resulted in incorrect understanding of the material and therefore the unnecessary selection of some samples. Any contamination and severe deterioration due to long-term burial conditions and the initial conservation treatments, i.e. consolidation of some samples, also had an influence upon the results.

Following these observations, an initial selection needed to be made to choose the most reliable samples in terms of their conditions and the find contexts. Within the buildings and spaces, painting related material is mainly found in the contexts below:

1) On walls

2) On floors,

3) In construction fills, infills/room fills, backfills,

4) Near hearths and ovens,

5) In burials (particularly infant and female burials),

6) In cluster contexts

7) In middens.

Only a small amount of samples (36 painted plaster/pigment samples) have come from the occupation contexts such as in situ walls, burials/burial fills and object clusters within the buildings and they are described as the most secure (primary) contexts (Appendix 2) where the information provided on the steps of wall painting production would be considered the most reliable. The larger amount of samples (105 painted plaster/pigment) came from the insecure (secondary) contexts (Appendix 3) such as room/infills and middens. They had to be studied because some of these samples represented the earliest levels on site (Pre-level XII, Levels IX-X) and there were no secure contexts in these levels throughout the site. However, these secondary samples may not have provided the most accurate data, since the material found in these contexts may not originally have come from them but may, for various reasons, have been brought from other contexts in different areas and levels, either during the Neolithic or later.

There were also other limitations in sampling which were come across throughout the study and resulted in the sample numbers given above being reduced. These limitations are explained below:

1) As mentioned above, the wall paintings and the related finds are not found in every building or every level and when they are found, they are often not in situ and in a very fragile condition to be studied in order to give reliable results. Therefore, in many cases, it is not really possible to link the material to a secure context to retrieve consistent results.

2) Even though 141 samples were initially collected, not all these samples would respond to analysis. The repetition of analyzing the same type of samples, which have the same nature and colour pattern, i.e. Space 181, Pre-Level XII, was also minimized by selecting a smaller number of samples within, which would produce the same results.

3) Not enough buildings have been excavated during the current project, which would provide comparable information between certain levels and areas, i.e. the earliest levels of the 4040 Area have not yet been excavated, and therefore it is not possible make direct comparisons with the earliest levels of the South Area.

4) In the South Area, the excavation of a few buildings/spaces have not been completed such as the Building 17 and 18 where the deep sounding was opened by Mellaart in 1960's. Therefore, the full contextual information as well as the stratigraphy cannot be obtained from these buildings/spaces.

5) Some samples had to be eliminated if they did not have the potential to present answers for the research questions asked, if they were very fragile and would crumble away during the transportation/sampling, had an extensive conservation treatment or were too small to be subsampled. As mentioned above, some of the samples selected for this study also presented problems during the analytical work, i.e. fluorescing under Raman spectroscopy (see Chapter 3, Section 3.3.5), and therefore did not produce any results. Attempts were made to analyse these samples using other techniques and if it was still not possible, they had to be eliminated from the dataset.

As a result of the limitations explained above, a total of 121 samples were used, including more "in situ" samples collected during the course of the research, as the new buildings have been excavated in 2009 and 2010. Within 121 samples 83 samples (Appendix 4-dispersion samples under polarized light microscopy) were decided to be the most suitable for the pigment analysis, while 38 samples (Appendix 5- thin-section analysis under optical light microscopy and scanning electron microscopy) were selected for the painted plaster analysis in order to identify:

1) The pigments used,

2) The nature of pigments,

3) The nature of plasters,

4) The nature of paint/plaster relationship,

5) The plaster types, structures, inclusions

6) The nature of plaster/paint modification,

7) Application and the possible tools.

Table 1.2a presents the excavation areas, buildings, spaces and levels from which the painted plasters/pigments were sampled. It also presents the sample numbers taken from each context indicated in red.

		South (7400-6000 cal.BC)			4040 (6700-6000 cal.BC)			BACH (6600-6300 cal.BC)
Pre-level XII		Sp.181 (12)		Scrape G?	B.23/Sp.17 (2)	Level VII-VI	BACH G?	B.3/Sp.86 (9)
Level X	South J	B.18 (1), B.23 (1)	Level VII-VI	4040 G	B.49/Sp.100 (12) B.59/Sp.311 (1) B.77 (14)			
Level IX	South K	B.2 (2) B.17/Sp.170 (8)	Level VI-V	4040 H	B.60/Sp.278 (3) B.67 (1)			
Level VII	South L	B.43/Sp.235 (2)	Level VI-V	North G?	B.1/Sp.188 (1)			
Level VII	South M?	B.8 (2) Sp.168 (1)	Level IV-III	4040 H,I	B.55/Sp.256,268 (5)			
Level VIA	South O	B.79/Sp.134 (3)	Level IV-III	4040 J	B.47 (1)			
	South P	B.75/Sp.332 (1)		4040 Unstratified	Sp.1006 (1)			
	South Q	B.65 (2)						
Level V-III	South R	B.56/Sp.121 (1)						
Level IV-II	South R	B.44 (1)						

Table 1.2a The excavation areas, buildings, spaces and levels of which the painted plaster/pigments were sampled from, with the number of samples available (in red).

Selected ground stone tools and pigment lumps (approx. 127 samples) were also examined following a more general ground stone study undertaken by the specialists at Çatalhöyük. Of particular interest were those stones which appear to present pigment residues, possible marks or worked surfaces/edges such as palettes, abraders or polishers. These were studied in terms of the nature of the stones, their surface features and the contexts where they were found, in order to investigate whether they might have been related to the wall painting practices and if it would be possible to identify the "specialist" use of these tools by looking at their spatial distribution across the site.

Orton, however, explains that there are some risks involved in the method of judgment sampling like "underestimating the variability of population or the overconfidence in the results" (Orton 2001, 21). During the selection of samples and throughout the interpretation of the microscopic and the instrumental analysis, it was clearly known that the amount of samples studied and the results gathered from the samples did not always represent a secure and detailed information on the wall painting practices throughout the life of the settlement (due to the limitations explained above) but do provide some facts and ideas from a bird's eye view over Çatalhöyük. As mentioned above, a more systematic sampling method would be appropriate for this research if the material studied and its contexts were consistent across the site. The judgmental sampling seemed to be the most suitable method to use in this case with some modification according to the nature of the site as well as the material under study. As an example, in some cases only a few samples were found to answer a specific question, i.e. blue and green pigments or the ground stone tools and pigment nodules with possible surface striations, to see if they would be matched with the tool marks on the painted plaster surfaces. Since only two abraded pigment nodules clearly showed evidence of surface striations, it was not possible to provide a conclusive data to suggest a connection between the ground stone tools or the pigment nodules used for the actual painting process, but these samples still needed to be studied to get an idea about what the possibilities might have been.

1.6 The Methodology for the Research Questions: Identifying materials, tools and techniques

The analytical techniques used during this study were chosen after discussions with my supervisors and my literature research on the technical studies of ancient wall painting materials. It was agreed that the selected instruments would provide satisfactory results both quantitative and/or qualitative, depending on the analytical questions being asked and on the nature and conditions of the samples collected. Most practically these instruments were also readily available to me in the Wolfson Archaeological Laboratories at UCL's Institute of Archaeology and Chemistry Department, as well as the British Museum's Conservation and Scientific Research Department. The use of Raman spectroscopy was enabled in collaboration with the UCL's Chemistry department and it was hoped that it would present reliable results for the initial analysis of the pigments alongside optical microscopy (See Chapter 3, Section 3.3.5).

1.6.1 Pigments

For the characterization of pigments and the pigment technology, three different methods were selected in order to identify their nature. Reflected (RLM) and Polarised (PLM) Light Microscopy, Scanning Electron Microscopy (SEM-EDAX) and Raman Spectroscopy were used in order to:

1) Identify the available pigments and the pigment mixtures at Çatalhöyük by using raw and dispersion samples.

2) Identify the pigment processing/modification. It was also hoped that the possibility of pigment modification via heating could be studied in the context of Çatalhöyük. Techniques such as X-Ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR) could have been employed to investigate red ochre (hematite) samples to clarify crystal structure. However, this was not possible within the scope of this research.

FTIR could also have been used as a complementary technique to Raman, however following the inadequate Raman spectroscopy results on the pigment samples, it was decided not to pursue other spectroscopic methods at this stage.

In terms of categorizing the different tones of red colour on plasters, simple Munsell soil colour chart was used, since colour measurement instruments such as colour readers, choroma meters, spectrophotometers were not available to use during this research.

1.6.2 Plasters

RLM, PLM and SEM (EDAX) were used to assess the micro-morphology and the mineralogical composition of plasters used for paintings in order to understand:

1) The characteristics of the plaster fabrics

2) Inclusions within the plaster matrices

3) The interaction of paint and plasters layers as well as the use of different type and quality of plasters.

These would help to identify raw materials and their possible sources to define what "plaster" really means in the context of Çatalhöyük and assess plaster technology. Even though it is difficult to source the raw materials for pigments and plasters with certainty, it would be possible to observe the range of raw materials which were or were not readily available to the inhabitants of Çatalhöyük by also investigating the geology of minerals within the surrounding environment. This would provide a basis on the availability of local materials, which may have been used and open an area for a detailed provenance research in the future.

Semi-quantitative X-ray Flourescence (XRF) would be another instrument to use alongside the techniques above, but the SEM (EDAX) was easily accessible and has been found useful to contribute to the analysis of pigment and plaster compositions.

1.6.3 Application Methods/Tools

Five different techniques/methods were used to determine how the wall paintings were made:

1) The investigation of painted plaster cross-sections under RLM in order to understand the thickness of the plaster and paint layers, how the paint and plaster might have been applied (wet or dry), how the application techniques might vary across the site, i.e. level to level, area to area, building to building, and if there is a visible consistency or difference in application methods.

2) The investigation of the painted plaster and ground stone tool surfaces by using SEM (EDAX) with the purpose of acquiring surface information regarding features of use, plaster and paint application, the nature and processing of the pigments/plasters and the traces of tools and workmanship. The images were captured at a range of magnifications depending on the nature of the sample, since the detection of tool marks and the evidence of pigment processing required lower magnification on some samples.

3) Ground stone artifacts were studied within the context of wall paintings to investigate them as possible painting/plastering tools. These artifacts were generally multifunctional at Çatalhöyük but there are indications that some of them were relevant to pigment and plaster processing, wall plaster burnishing and possibly application of plaster/pigments. Further discussion of this will be presented in Chapter 4, Section 4.5. The distribution of the ground stone tools within the different areas, buildings and levels, was also studied in an attempt to identify the levels of specialization in the wall painting production which is an area to explore whether such tools were common in most houses or restricted only to particular ones (Baysal, Wright 2005, Wright *et al*. 2013).

4) An experimental methodology was designed (Chapter 5) following the analytical study of the archaeological samples, since the samples did not provide sufficient information to set up experimental work prior to their analysis. For this reason the analytical results taken from the individual materials and techniques were later applied to the experimental study (where possible and also when no answers could be retrieved from the samples via analysis). Experimental study enabled me to:

- extract more information from the samples,

- investigate the practicality of possible application methods, tools and how individual materials would react with each other (rather than the individual materials themselves), and

- compare and complement results with the analytical work.

It also helped communicating with the villagers of Küçükköy and understanding the paintings from a more practical point of view. For the experimental work natural marl, modern red iron oxide pigment, crushed carbonized wood and selected binding media (with reference to the original materials which were identified by the analytical study, see Chapter 5) were tested to get a feel of the most basic methods of painting. The experimental samples of painted plasters were decided to be studied by SEM (EDAX) for high magnification surface imaging in order to look at the application techniques and to observe materials such as fibres or finer tool marks which could have given ideas on the painting techniques/tools may have been used. These results were then compared to archaeological samples to see if any similarities were evident.

5) For the characterization of any possible organic binders, Gas chromatography-Mass spectrometry (GC-MS) was used to detect any evidence of surviving binders.

Following above, Table 1.2b presents the samples and the type of analysis applied to them.

Sample no	Material	Area	Unit	Type of Analysis	Analytical instrument applied
s3	Painted plaster, pigment	Bach	8203	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s3	Painted plaster, pigment	Bach	8226	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX), GC-MS
s5	Painted plaster, pigment	Bach	2270	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
x1,2	Painted plaster	North	1309	Cross section/thin section	PLM, RLM, SEM (EDAX), GC-MS
x2	Painted plaster, pigment	South	5383	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX), Raman, GC-MS
s1	Painted plaster, pigment	South	17348	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s1	Painted plaster, pigment	South	10501	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s22	Painted plaster, pigment	South	13352	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s3	Painted plaster, pigment	South	18145	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s1	Painted plaster	South	18568	Cross section/thin section	PLM, RLM, SEM (EDAX)
x2,3	Painted plaster, pigment	South	4221	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s1	Painted plaster, pigment	South	4629	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s2	Painted plaster, pigment	South	4709	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s3	Painted plaster, pigment	South	4709	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX), GC-MS
s3	Painted plaster, pigment	South	4844	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s11	Painted plaster, pigment	South	4844	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX), GC-MS

s2	Painted plaster, pigment	South	5273	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s28	Painted plaster, pigment	South	5290	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s7	Painted plaster, pigment	South	5315	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s6	Painted plaster, pigment	South	5325	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s4	Painted plaster, pigment	South	17390	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s13	Painted plaster, pigment	South	5328	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s6	Painted plaster	South	5294	Cross section/thin section	PLM, RLM, SEM (EDAX)
s6	Painted plaster, pigment	4040	7913	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX), GC-MS
s7	Painted plaster, pigment	4040	10349	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s19	Painted plaster, pigment	4040	10396	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s3	Painted plaster, pigment	4040	11966	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s1	Painted plaster, pigment	4040	12313	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s3	Painted plaster, pigment	4040	13481	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s1	Painted plaster, pigment	4040	16694	Cross section/thin section,dispersion ,raw sample	PLM, RLM, SEM (EDAX), Raman
s3	Painted plaster, pigment	4040	17494	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s2	Painted plaster, pigment	4040	13669	Cross section/thin section,dispersion ,raw sample	PLM, RLM, SEM (EDAX), Raman
s1	Painted plaster, pigment	South	18523	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s3	Painted plaster, pigment	4040	13453	Cross section/thin section,dispersion ,raw sample	PLM, RLM, SEM (EDAX), Raman
s1	Painted plaster, pigment	4040	16695	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)
s10	Painted plaster	South	5291	Cross section/thin section	PLM, RLM, SEM (EDAX)
s10	Painted plaster	South	5286	Cross section/thin section	PLM, RLM, SEM (EDAX)
s2	Painted plaster, pigment	South	5223	Cross section/thin section,dispersion	PLM, RLM, SEM (EDAX)

x19	Pigment	4040	7575	Dispersion, raw sample	PLM, Raman
x1	Pigment	4040	7597	Dispersion	PLM
s1	Pigment	4040	17535	Dispersion	PLM
s6	Pigment	South	5294	Dispersion	PLM
s1	Pigment	4040	17563	Dispersion	PLM
x2	Pigment	4040	16308	Dispersion	PLM
x1	Pigment	4040	16133	Dispersion	PLM
s1	Pigment	4040	19050	Dispersion	PLM
s2-s8	Pigment	4040	19037 (layer 1-7)	Dispersion	PLM
n/a	Pigment	4040	17562	Dispersion	PLM
s1	Pigment	4040	19078	Dispersion	PLM
s1	Pigment	4040	19214	Dispersion	PLM
s1	Pigment	4040	17589	Dispersion	PLM
s1	Pigment	4040	19051	Dispersion	PLM
s1	Pigment	South	18538	Dispersion	PLM
n/a	Pigment	4040	19010	Dispersion	PLM
s3	Pigment	South	4849	Dispersion	PLM
s3	Pigment	South	10524	Dispersion	PLM
s3	Pigment	4040	14453	Dispersion	PLM
s2	Pigment	BACH	8151	Dispersion	PLM
s1	Pigment	South	4246	Dispersion	PLM
s3	Pigment	4040	7597	Dispersion	PLM
s3	Pigment	4040	13676	Dispersion	PLM
s4	Pigment	South	11670	Dispersion	PLM
s3	Pigment	South	17301	Dispersion	PLM
s8	Pigment	South	4921	Dispersion	PLM
s10	Pigment	South	1889	Dispersion	PLM
s1	Pigment	South	5218	Dispersion	PLM
s1	Pigment	4040	16748	Dispersion	PLM

s1	Pigment	4040	10231	Dispersion	PLM
x1	Pigment	4040	13342	Dispersion	PLM
s3	Pigment	4040	16605	Dispersion	PLM
s3	Pigment	4040	13110	Dispersion	PLM
s9	Pigment	South	5048	Dispersion	PLM
s3	Pigment	4040	13416	Dispersion	PLM
s1	Pigment	4040	1007	Dispersion	PLM
s3	Pigment	4040	15932	Raw sample	Raman

Table 1.2b The list of painted plaster/pigment samples that were analyzed.

1.7 The Methodology for the Research Questions: Social Aspect

Two methods were used to study the nature of wall painting production within houses:

1) A contextual and material study within those buildings, middens and burials which have evidence related to wall paintings production was pursued to determine if certain areas of the site produced more wall paintings and related ground stone tools than others. Also, it was aimed to observe if the wall painting production was mainly undertaken by the specialist people (or houses) or was a general practice within the community, which most households would have been involved in.

2) Analysing the surface topography of the painted plaster samples together with selected ground stone tools also contributed to the investigation of whether recognizably individual techniques and/or tools for wall painting production could be identified.

1.8 The Structure of the Thesis

This thesis aims to investigate the research questions explained above by using both technological and social perspectives. It is composed of six chapters.

Chapter 1

This chapter outlined the significance of the research and identified the specific research questions and objectives. It briefly introduced the site itself while looking at the previous work undertaken on the wall painting materials, in order to give an indication of the significant gap that exists in the study of this material both in the context of Çatalhöyük and in the archaeology of prehistory. Finally, it explained the research methodology undertaken in order to explore the possible answers to the research questions.

Chapter 2

In the second chapter, the first appearances of pigments and cave paintings are discussed in relation to the development of material technologies during the Paleolithic era. The Neolithic of central Anatolia and the Near East is discussed as a region where Neolithic houses and the first wall paintings started to appear as technological innovations took place and certain ideas were applied onto different media. This chapter also places Çatalhöyük in its archaeological context, whilst looking at the site in detail from where the wall painting material comes. Important examples of Neolithic wall paintings in the region are also summarized to indicate the rarity of detailed technological studies of this specific material.

Chapter 3

The third chapter investigates the material under study in a practical context by discussing three topics: conservation and preservation considerations, sampling methodology (and actual sample-taking) and the analytical techniques used. The first aspect looks at the condition of painted plasters and pigments at Çatalhöyük, including past and present conservation issues. The second aspect explores various analytical techniques applied on the prehistoric paintings so far to understand the most useful methods for studying the Çatalhöyük wall paintings. Finally the third aspect describes each instrument used in the course of this research, whether for analytical or investigative purposes.

Chapter 4

The fourth chapter continues the theme of Chapter 3, presenting the results obtained from the analytical work. The materials under study, i.e. painted plasters, pigments and ground stone tools, are examined within the analytical framework. The analysis of the materials, as well as the possible application methods in relation to experimental work (Chapter 5) are compared and discussed.

Chapter 5

This chapter details the methodology and results of the experimental work, which aimed to support the analytical study where it could not answer certain questions on the making of wall paintings. The analytical results obtained and conversations with the villagers of Küçükköy are combined to develop a practical understanding of possible plastering and painting practices of the Neolithic people.

Chapter 6

Finally chapter 6 brings all the analytical and experimental work results together by applying archaeological interpretations and discussing the production of these paintings within the technological and social context of Çatalhöyük. It investigates if painting walls and/or creating wall art was a “specialized” or a “communal” activity that was undertaken either by individuals or by most households within the Neolithic community. This chapter also identifies any future work to be pursued in this area and sets parameters for specialists on how to excavate, handle and store very old painted plasters, pigments and ground stone tools in order to achieve the safest retrieval of archaeological information.

Chapter 2

Material Under Study: Theoretical Background

2.1 A Brief Introduction to the prehistoric paintings in the Central Anatolia and the Near East

Starting from the Paleolithic era (c. 45,000 cal. BC-10,300 cal. BC) the production of simple objects for daily use (or for symbolic and/or practical reasons) progressed towards putting people' thoughts, experiences and skills into more complicated and challenging ideas, which led complex technologies to be developed and used from the Neolithic period onwards (Rollefson 1990, 33, Karlin, Julien 1994, 152-164, Bahn 1998, 96). Wall paintings, plaster, stone, clay figurines/statues and various types of pottery were the first products of these more elaborate techniques and practices. In comparison to Europe (Bar-Yosef 2002, Clottes 2002, Bahn 1998) however, ornamental or symbolic art objects such as incised or engraved stone and bone, domestic tools, animal and human figurines were rarer in the Near East and central Anatolia during the upper and Epi-paleolithic (Mesolithic). This is also some evidence for paintings (Bar-Yosef 1997, 161, 163-188) even though painting, drawing, engraving rocks and cave walls seem to be a very important activity during the upper Paleolithic of the same region. The oldest evidence showing the complete development of cave art was found in Western Europe (mostly France and Spain) dating to around c. 40,000-10,000 cal. BC, i.e. the paintings at Lascaux (France), sculptures at Cap-Blanc and Roc-aux-Sorciers (France), black drawings at Niaux and Le Portel (France), polychrome paintings at Altamira, Cueva de las Manos and El Castillo caves (Spain), clay modellings at Tuc d'Audoubert and engravings at Les Trois-Freres (France). The latest research in Maros Cave on the Sulawesi island (Indonesia) also discovered some of the oldest paintings (c.39,900 cal. BC) in the world and extended the geography of cave art further than Europe (www.news.nationalgeographic.com/news/2014/10/141008-cave-art-sulawesi-hand-science, 10.10.2014). Paintings mentioned above are particularly important as extensive research show that they are the first examples of obtaining materials, creating technologies and attributing meanings to painting practices (Ruspoli 1987, Clottes 2002, Clottes 2008, Clottes 1993, Lawson 1991, Leroi-Gourhan 1982b, Bahn 1998, Mora *et al*. 1984, Valladas *et al.* 2001, Clottes 2003). Central Anatolia and the Near East do not present comparable data possibly because the evidence of the Paleolithic was much less developed in this region and therefore it might just not have been discovered yet. Although I believe that the development of art, skill levels, material technologies and choices also occurred around the same time and possibly preceded the production of wall paintings during the later periods when designs and techniques have flourished.

One of the most important aspects for creating paintings was colour. The discovery of pigments encouraged the development of pigment modification and use during the Paleolithic, as well as tools for production and the ways to store pigments (See Section 2.1.1). Even though the Near Eastern and central Anatolian cultures presented some evidence of pigment use in this era, it is in much smaller quantities than in Europe (Schmandt-Besserat 1979, 144, Wreschner 1976, 718, Wreschner 1985, 389, Marshack 1981, 188-191, Ruspoli 1987). Bar-Yosef (1997,166) notes that red ochre was recorded in most sites in the Near East, dated from as early as 30,000 cal. BC. The earliest examples of red ochre were found (both as lumps and in relation to stone tools) in Qafzeh and Hayonim caves from the Mousterian sites in Israel. Marine shells often associated with ochre were found in many sites and burials in the Near East and several ochre burials were found in the Natufian settlements of Nachal Oren, Yonim Cave, and Eynan in Israel (Wreschner 1980, 632). The cave of El-Wad (Israel) has pebbles and basalt pestles which were found with red and yellow ochre residues, indicating that ochres were ground and prepared with stone various stone tools before they could be used (Weinstein-Evron 1994, 461-467, Dubreuil 2004, 1613-1629). The evidence of "a coloured pebble, a small bladelet with some traces of red colour on one edge, and two coarse nodules of a hard black and red material" (Minzoni-Dèroche *et al.* 1995, 153) found in Uçağızlı cave (c. 32,000 cal. BC), which is in Hatay Province of Turkey, on the eastern Mediterranean coast proved that pigment preparation and modification was also known in Paleolithic Anatolia (Minzoni-Dèroche *et al.* 1995, 153-158).

It is, however, interesting to note that even though the sourcing, use and the modification of ochre pigments (as shown by the evidence of several ochre processing tools, i.e. handstones, grinding slabs, basalt pestles, Dubreuil 2004, 1613-1629) was known and already developing during the Near Eastern and Anatolian Paleolithic, there are only a few sites which produced cave paintings. Cave art seems to be mainly seen in the form of carvings and engravings in central and southwestern Anatolia with the examples coming mainly from two regions (Sagona, Zimansky 2009, 27-33).

The Taurus mountains between Hakkari and Antalya, and the Van region along Pasinler and Kars (Sagona, Zimansky 2009, 27). Around Hakkari Tirşin Plateau has two groups of incised/carved animal and human images located very close to each other (Kahn-ı Melkan and Taht-ı Melkan). Sagona and Zimansky mention that rock art is widely present near Kars, i.e. Camışlı, Yazılıkaya, Çallı, Azat and Yarnak, mostly consisting of engraved animal images. However, only a few rock paintings are mentioned, i.e. the caves of southwestern Anatolia such as Karain and Öküzini in the Taurus mountains, the Cave of Maidens in the Beşer mountains, the caves of the Latmos (Beşparmak) Mountains in the western Anatolia. Yeşilalıç and Azat in the Van region present painted animal and human images but their imagery is not clear (Sagona, Zimansky 2009, 27-33, Bar-Yosef 1997, 168). Some later engravings from Mount Carmel (Israel) were also mentioned (Hovers 1990, 321, Ronan, Barton 1989).

While Paleolithic evidence of pigment use and some cave paintings have been found in Central Anatolia and the Near East, I have not come across any technological studies (the work could still be in progress or the level of preservation did not enable detailed studies). In any case, the paintings often do not seem to have been studied from a technological point of view and therefore it is not easy to find a trail leading up to the development and use of materials, techniques and the tools in the Neolithic period of the same region. As such, much of the theory below is based on the research undertaken on the Paleolithic wall paintings from Europe.

*2.1.1 Prehistoric Colour and the Use of Pigments

The roots of colour symbolism go back to Paleolithic era. The use of colour in the form of minerals and modified pigments seems to have been attached to various symbolic meanings as people seemed to use colours to express their social and ritual activities as well as to convey symbolism through material culture (Boivin, Owoc 2004, 6, Scarre 2002, 227, Watts 1999, 113-146). The importance that was given to colours might have been linked to the meanings given to some minerals from which the pigments were obtained. People sometimes travelled far from their settlements to reach mineral sources, which may have been located below the surface of the ground. This activity would have required long journeys and effort in the sourcing and collection processes (Boivin, Owoc 2004, 10). The symbolic meaning of these journeys might have been related to the minerals themselves, i.e. red ochre, cinnabar (Boivin, Owoc 2004, 11), but also the experiences gained during the journeys might have been very important as they might have been quite ritual involving various members of the community (McBryde 2000, Charles *et al.* 2004, 43-70).

Scholars suggest that once minerals were obtained from their sources they would be subjected to a variety of social and technological processes to create pigments and as a result the pigments might have acquired specific meanings (Boivin, Owoc 2004, 13, Lewis-Williams 2001, 30). Red one of the earliest and most widely used colours, seems to have been associated with blood. According to Scarre blood and the colour red have been connected since the middle Paleolithic and this may present the earliest evidence for colour symbolism (Scarre 2002, 228). Wreschner suggests that when red ochre started to be applied on human burials the colour red seemed to be attached to another meaning "life". For example, red ochre was sprinkled on the body or on the ground where the body was laid, as seen at Qafzeh Cave (40,000 cal. BC) in the Near East, indicating that the red colour might have been associated with "life-giving blood" (Wreschner 1980, 631). During the upper Paleolithic, the colour red is considered also to have been linked with fertility (Wreschner 1980, 631). Wreschner mentions that applying colour onto the body might also have been the evidence of status or "a sign of danger, which may be derived from red=blood" (Wreschner 1980, 631). However Marshack suggests that even though there are these possible meanings attached to red ochre, there were other possible uses and meanings such as the use of colour for painting bodies to indicate status, sex or age, or to decorate objects, tools of daily life or ritual places for symbolic reasons (Marshack 1981, 190). These different meanings of red were also symbolized on the cave/wall paintings since the upper Paleolithic, i.e. hunting scenes where wild animals were represented in red and the colour red may have been a sign of danger "blood" and also an important food source "life". Tacon also suggests the red ochre pigment having been applied onto rock surfaces to produce an ancestral power (Tacon 1991, 204, 205).

Pigments are often found in caves or in other covered places where they can be preserved in the form of lumps. To produce paintings and drawings with pigments, required a complex procedure. For drawings, solid colouring material such as charcoal or the naturally occurring "crayons" (a waxy, compact pigment lump with chalk which is used for drawing) would be used like a natural pencil for reds and yellows (Leroi-Gourhan 1982b, 12). The pigments used for the paintings were easily available and mainly derived from naturally occurring iron oxide minerals and possibly from plants (Clottes 2002, 66, Lawson 1991, 52). During prehistoric times plant based colours were mainly obtained from wood and roots of plants as well as seeds and bark. However, these organic colours were not durable and their lack of permanence may have encouraged people to find more durable natural minerals (Gettens 1942, 138, Mora *et al.*1984, 57, Boivin, Owoc 2004). Mineral resources might have been discovered during the dedicated sourcing trips, minerals collected in various ways and brought back to the site to be stored and prepared as needed (Barnett *et al.* 2006, 1, Ruspoli 1987, 192). These mineral colours were typically earthy substances known generically as ochres. An ochre may be defined as a friable, finely particulate geological deposit, rich in metal oxides (Read 1947). Even though ochres are rich in metals such as cobalt and nickel, iron-rich ochres are the most common, and specialists studying pigments often use the term 'ochre' to describe iron-rich ochres. Red ochres are rich in hematite (Fe_2O_3, Fig.10) whereas yellow ochres are typically rich in either the phases goethite (FeOOH) and jarosite ($KFe^{3+}_3(OH)_6(SO_4)_2$). Ochres are impure geological deposits and often show a range in mineralogy. Other metal oxides and sulphides may be variably present as well as detrital minerals such as quartz or calcite. For further discussion of the iron ochres see Eastaugh *et al.* (2004).

Fig.10 An example of a hematite pigment. www.gwydir.demon.co.uk/jo/minerals/hematite.htm.

The earliest evidence of the use of red ochre was found at Olduvai Bed II of site BK (Tanzania, Africa) in the form of lumps and dated probably earlier than 500,000 cal. BC (Wreschner 1985, 389). The excavations at Terra Amata Cave, in France also showed that the ochre was deliberately collected around 300,000 cal. BC. A large number of ochre pieces were found in early Acheulean layers, varying in color (yellow, red, purple and brown) and with artificially abraded surfaces (Wreschner 1976, 717). More evidence was discovered in Blombos cave in South Africa where ochre lumps, mortar and pestles and the processing remains found around the hearths indicate "a processing toolkit and a workshop where a liquefied ochre-rich mixture was produced and stored in two *Haliotis midae* (abalone) shells 100,000 years ago" (Henshilwood *et al*. 2011, 219). This was a very strong evidence indicating the "early technological and behavioral developments associated with Homo Sapiens" and it was clear that they had a basic "knowledge of chemistry and the ability for long-term planning, production and curation of pigments” (Henshilwood *et al*. 2011, 222).

Apart from various ochre colours, black pigments were produced from manganese oxide-rich earths, charcoal or soot, or by charring plant material or bones. Some of these organic derived pigments are not well preserved (Barnett *et al.* 2006, 2, Helwig 2007, Ruspoli 1987, Eastaugh *et al.* 2004). No evidence of the use of blue and green colours has been found so far on Paleolithic paintings.

Natural minerals were also processed to give pure colours or additional shades, i.e. ‘burning’ yellow ochre to produce shades of red, brown and black. In order to produce purer pigments, the raw minerals would be first washed to remove any impurities (Delamare, Guineau 2006, 16). After they dried they would possibly be sieved and ground into finer powders and if necessary were modified further in several processes, i.e. more grinding and sieving to achieve brighter colours, mixing different pigments or changing colours via heating. Minzoni Dèroche mentions that some striations were evident on crayons from Lascaux and Arcy-sur-Cure caves in France, indicating that pigment powder might have been obtained via scraping (Minzoni-Dèroche *et al.* 1995, 153, Couraud 1991, 17-52). Studies have shown that the heating method was also used from the Chatelperronian (36,000-32,000 cal. BC) period onwards as a way to modify pigment colours. As the temperature increases the yellow iron hydroxide changes from yellow to yellow brown, then to red iron oxide at about 250-300°C. It then changes to red-purple and finally to black at about 575-650°C (Chakraborty 1999, Abdouni *et al*. 1988). This transition results in a change of phase and therefore the iron oxide re-crystallizes as it reaches successive oxidation states. In non-laboratory settings, ‘disordered’ crystal structures form and they are typical of many ‘synthetic’ red ochres. The evidence of small ochre lumps which were found in the hearths of Lascaux and Arcy-sur-Cure caves in France showed the different levels of oxidation and suggested that heating might have been used regularly for changing pigment colours (Pomiès *et al.*1999, Ruspoli 1987, 192, Chalmin *et al.* 2003, Minzoni-Dèroche *et al.* 1995, 153). Moreover raw pigment lumps from La Ferrassie cave in France were found together with some firing residue and stone artefacts which may have been used for the pigment heating (Minzoni-Deroche *et al.* 1995, 153).

Following the preparation of raw pigments into powder “crayons” or “pencils” the powder form would be made more or less runny by mixing with an extender such as clay, talc, calcite, bone etc. When it comes to binding the pigments onto the rock surface water or other organic materials such as water, egg white/yolk, plant oils, urine, saliva, blood, animal fat, casein etc. might have been used (Wreschner 1976, 717).

Even though the identification of the organic binding media proves to be very difficult after thousands of years the scientific analysis undertaken on the samples from some of the Magdalenian caves in the French Pyrenees showed that the paint was created by mixing pigments with mineral extenders and binders enabling the paint to adhere better to the rock surface and preventing cracking/flaking as it dried (Clottes 2002, 66, Lawson 1991, 52,53, Minzoni-Dèroche *et al.* 1995, 153). This evidence proves that the preparation processes can improve the level of pigment adhesion, control pigment consistency and as a result better paint coverage and preservation can be achieved (Chalmin *et al.* 2003).

There are various methods which are considered in terms of the application of paint, but due to the preservation issues of these paintings it may often be very difficult to identify. One of the main techniques *secco* is described as mixing the pigments with water or an organic binder to apply onto a dry rock surface. It is the binder which adhere the pigments onto the surface. If an organic binder was used to apply the pigments as mentioned above (as in *tempera* technique) the finely ground pigment and the binder mixture would be kept for days to enable a better pigment dispersion (Mora *et al.* 1984, 72, Barnett *et al.* 2006, 452, Helwig 2007, 40). This method intensifies the shade of colour seen in the painting. Some studies mention that the water from caves seemed to be the best binding agent since it was rich in dissolved calcium salts, which fix pigments in the crystalline mass and form a very hard coloured calcite. The study of Franco-Cantabrian Magdalenian paintings, particularly at Lascaux, showed the movement of calcium carbonate through the rock and its crystallization on the surface (Ruspoli 1987, 194, Leroi-Gourhan 1982b, 11).

Before ending this section, it is important to repeat that the Paleolithic cave paintings of central Anatolia and Near East have not been studied in great detail maybe due to their rarity or the preservation issues. For this reason there appears to be an important gap not only in archaeological information but also in the material/technological studies of these upper Paleolithic paintings from central Anatolia and the Near East.

Decorating walls with imagery seems to have gained more importance during the Epi-Paleolithic and Pre-Pottery Neolithic A, B (PPNA, PPNB) in Anatolia and the Near East. The transition between painting in caves and on house/building walls began in the

Epi-Paleolithic and Neolithic. This is further evidence of how people may have carried and adapted their resources, techniques, styles, ideas and beliefs into built houses/buildings which they established as their new living environments. Also for the first time the stone architecture was carved with significant designs such as zoomorphic and anthropomorphic figures as in Göbekli Tepe and Nevalı Çori in southeast Anatolia (Schmidt 2000, Hauptman 1999, 65-86) and in Jerf El Ahmar in Syria (Stordeur 2000, Stordeur *et al.* 1996). Plastering and painting house walls seems to have started in the PPNA with the construction of mudbrick and stone houses, however the paintings were often in a monochrome style and very simple (see Section 2.2). The increase of settlement sizes and population during the PPNB may have supported the development of symbolic, technological and artistic activities where particularly the wall art had more variety in terms of imagery. During this period wall paintings seem to show some distinctive similarities with the Paleolithic cave art of which there are a great amount of studies on the development of painting materials and techniques, i.e. the colour palette, possible use of binders/extenders, painting methods/tools as well as the designs painted (Ruspoli 1987, Clottes 1990a, Brunet *et al.*1982, Buisson *et al*. 1989, Begouèn, Clottes 1991, Pepe *et al.* 1991, Clottes 2002, Clottes 2008, Clottes 1993, Leroi-Gourhan 1982b, Bahn 1998, Valladas *et al.* 2001, Clottes 2003, Ballet *et al.* 1979, Clottes *et al*.1990b, Pike *et al*. 2012, 1409-1412). However, the scale and the occurrence of the Neolithic paintings was still restricted. Even though lime burning and the use of a variety of plaster types was well developed (see Section 2.2), the amount of decorative and simpler wall paintings produced during the central Anatolian and the Near Eastern Neolithic is not comparable with the amount of cave art produced in Europe. It could be possible that the lack of cave and wall art in the upper and Epi-Paleolithic of the Near East and Anatolia was related to the rarity of other art forms in these regions throughout the early Neolithic, which could be the result of a slower development in art production as opposed to Europe. This could have also affected the development of Neolithic painting practices.

According to Belfer-Cohen (1988, 25-29, Hovers 1990, 321) the decline of Paleolithic art production in the Near East and Anatolia could not really be explained with biological factors, since Homo sapiens sapiens lived in both continents and would be able to produce the same skills and thought processes. Bar-Yosef suggests that the answer could be much simpler. It is possible that the objects of art and cave paintings were composed of materials which may not have survived the conditions of the different environments/environmental changes or it may be that "not enough sites" were excavated from these periods (Bar-Yosef 1997, 180, Hovers 1990, 321). He also points out how the society of the Epi-Paleolithic of the Near East had smaller sites with small populations which may have resulted in fewer connections within and between communities (Bar-Yosef 1997, 180, Hovers 1990, 321) whilst symbolic expressions may also not have been needed for social cohesion.

2.2 The Neolithic of Central Anatolia and the Near East: Developments in Architecture, Art and Related Technologies

During the Epi-Paleolithic (c.13100 – 9500 cal. BC), the climate started changing significantly from warmer/wetter to colder/dryer again (this was the Younger Dryas, ca. 11,000- 10,000 cal. BC) and created a “climatic instability” (Sagona, Zimansky 2009, 39) which caused people to move around more and required more effort to find suitable

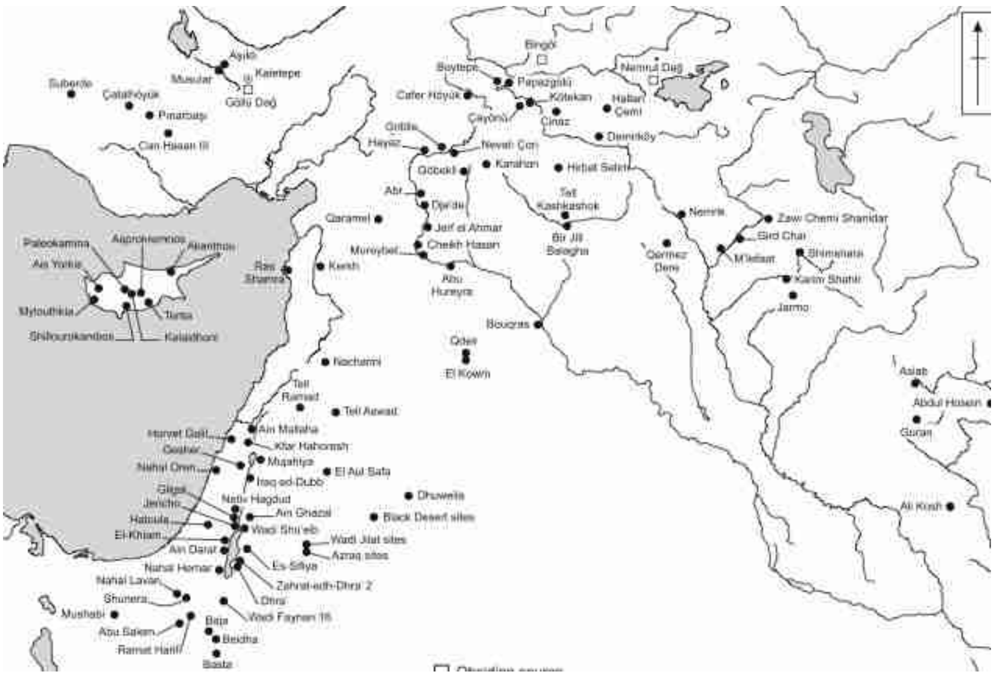


Fig.11a Some of the Neolithic sites in Central Anatolia and the Near East (Asouti 2006, 89).

resources and places for living (Figs.11a,b). This was followed by people settling into new environments, and the resulting population growth together with necessary technological developments required the creation of new social structures in communities. These factors significantly determined the start of the Neolithic period in central Anatolia and the Near East (described as Western Asia and dated between 10,500 cal. BC and 6000 cal. BC by Asouti 2006, 88) where the transition from hunting-gathering to the first agricultural societies took place and is considered to be an economical/technological revolution that also resulted changes in the forming of new social communities as well as in developing technologies and art (Kujit, Goring-Morris 2002, 361-440, Cauvin 2000, Banning 1998, Twiss 2007, Bar-Yosef 1997, 4).

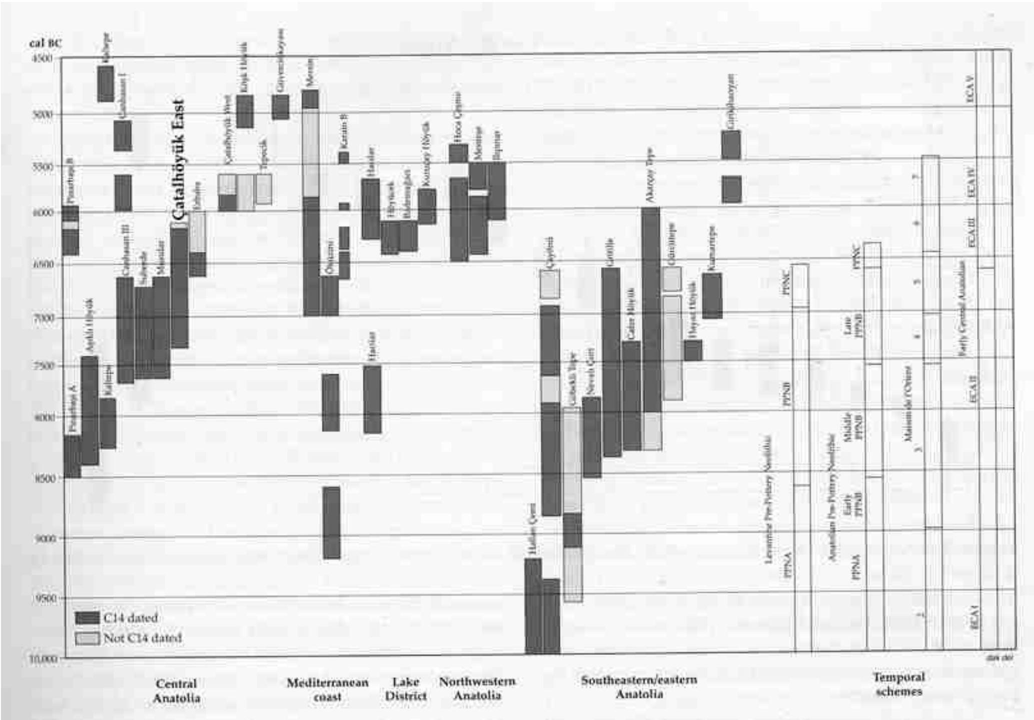


Fig.11b The chronology of Çatalhöyük and the surrounding sites in Central Anatolia (Hodder 2005, 7).

2.2.1 Painting as a part of the Neolithic House

One of the most important changes during the Anatolian and Near Eastern Neolithic was that the people started constructing built structures either in the form of simple, domestic houses or special buildings with the aim of living in or for use as communal spaces. Building practices, materials and styles developed throughout the Neolithic, and this also introduced variations in settlement sizes and architectural patterns. Symbolic interpretations of Neolithic life via wall art also found its place inside the Neolithic house and it is important to see that people carried their skills, experiences and the ways that they would connect with their surroundings into their new life styles.

Following the Epi-Paleolithic**,** there is the PPNA which is placed c. 9600-8500 cal. BC in central Anatolia and the Near East (Kujit 2000, 75-102, Hodder 2007, Banning 1998, Byrd 2005, 231-290). These early sedentary communities were small in size and most common in southeast and central Anatolia, i.e. Hallan Çemi, Demirkoy, Kortik Tepe, Pınarbaşı and the earliest levels of Çayönü (Sagona, Zimansky 2009, 24). These earliest buildings were made of stone, mud, clay, wattle/daub or *pise,* all naturally available materials. They initially had rounder forms, i.e. Pınarbaşı (Baird 2005, 55-74), Hallan

Çemi and the early levels of Çayönü, but later gradually changed to rectilinear, i.e. later buildings of Çayönü with grill planning. There seems to be no evidence of paintings during this period.

As settlements grew during the early and middle PPNB (c. 8700 cal. BC) such as Basta and Beidha (Jordan), Aşıklı Höyük, Musular (central Anatolia), Cafer Höyük, Nevalı Çori or Göbekli Tepe (southeast Anatolia) (Özdoğan 1999, 35-41, Kuijt and Goring-Morris 2002, 388, Sagona, Zimansky 2009, 49), building forms began to change again. The first "channel buildings" appeared which were modified from the long and rectangular grill buildings. Channel buildings had stone foundations and the walls were made of chaff-tempered mud which were the predecessors of mudbrick. "Pyrotechnology" which means using fire to produce art and objects of daily life (Kingery *et al.* 1988) was first discovered during the middle PPNB. As a result lime plaster was developed, initially for plastering the floors and interior walls of houses, followed by the production of fired clay pottery during the late PPNB (Kingery *et al.* 1988, Nieuwenhuyse *et al.* 2010). Studies have shown that Neolithic plasters used at most sites in central/southeastern Anatolia and the Near East in the PPNB was mainly lime plaster. Only some evidence of gypsum plaster was found as well as a small evidence of marl use for wall plastering and making small objects at a few Neolithic sites in northern Israel (Goren *et al.* 1991, 131-140) and also at Çatalhöyük (Turkey) (see Sections 2.3 and 2.4). Lime plaster was obtained from burning (calcining) limestone ("true lime plaster") (Kingery *et al.*1988, Frierman 1971, 213, Gourdin, Kingery 1975, Garfinkel 1987, Goren *et al.* 1991, Thuesen, Gwozdz 1982, Karkanas 2007, Goren, Goring-Morris 2008). The calcined lime products and the earliest kilns date to the PPNB and consisted of a pit used as a fire chamber with stones piled on top of it (Kingery *et al.* 1988, Garfinkel 1987, 69). When the stone ($CaCO_3$) was burnt (calcined) from 650°C to 900°C for days it would first turn into pure lime (calcium oxide, CaO) and was then mixed with water (calcium hydroxide, CaOH) to change into putty like material, which becomes lime plaster. It is known that true (burnt) lime plaster has a hard, waterproof surface that is very durable. The surface of the stone foundations or mudbrick walls/floors in PPNB houses were often covered with thinner layers of lime plaster. Apart from adding various inclusions, i.e. vegetal additives, aggregates, binders to achieve strength and flexibility, burnishing plaster surfaces with small, hard polishing stones would smooth out the surface and make it more resistant for painting. For example at Çatalhöyük, hand sized stone polishers were discovered and possibly used for plaster smoothing and polishing (some still have distinct polished surfaces) (Wright, Baysal 2005, Wright *et al.* 2013). It was also discovered in the PPNB that polishing plastered walls/floors with a deep red ochre pigment makes the surfaces more durable (Kingery *et al.*1988, Matthews 2005b, 371). Apart from red being a symbolic colour since the Paleolithic, maybe it was the added durability that meant early and middle PPNB walls and floors were often painted red and this became a common practice such as at Boncuklu (central Anatolia) (Baird 2006, 2007, 2008, 2009), Aşıklı Höyük (central Anatolia) (Esin, Harmankaya 1999, 115-132), Çayönü (southeast Anatolia) (Özdoğan 2011, 185-269), Hacılar, Can Hasan III (central Anatolia) (French *et al.* 1972), Ain Ghazal (Jordan) (Banning, Byrd 1988) and Tell Halula (Syria) (Guerrero *et al*. 2009). Red paintings as well as more elaborate designs, i.e. floral designs, simple dots, geometrical motives and daily scenes were later seen in some of the PPNB "mega" sites (see below).

Following plaster production lime plaster also enabled other forms of art to emerge. It was used to decorate human/animal skulls (Bonogofsky 2003, 2005, 2006) and masks, as well as creating pottery, anthropomorphic figures, figurines and sculptures. Examples are seen in Jericho (Palestine), Ain Ghazal (Jordan) (Rollefson 1990, Tubb, Grissom 1995), Göbekli Tepe (southeast Anatolia), Kfar HaHoresh (northern Israel) (Horwitz, Goring Morris 2004, 165-178), Çatalhöyük (Hodder 2007), Aşıklı Höyük, Köşk Höyük (central Anatolia) (Özbek 2009, 379-386), Çayönü (southeast Anatolia), Tell Ramad (Syria), Hama (Syria) and Hajji Firuz Tepe (Iran). Art and symbolism became closely related to burial practices during the middle to late PPNB and burial inside houses became common a practice, i.e. Aşıklı Höyük and Çatalhöyük (Cauvin 2000, 217, Goren *et al.* 2001, 661-690, Banning 2003). Twiss mentions that "children and adults of both sexes were often treated and their skulls given life like new plaster faces with painted or shell eyes, and sometimes hair" (Twiss 2007, 30). Figures and statues that were found in Ain Ghazal (Jordan) and Jericho (Palestine) are also interesting examples of the use of plaster. Particularly the Ain Ghazal figures were modeled from plaster around a reed core which was tied together with twine. Reed and twine impressions can still be seen inside the figures (Tubb, Grissom 1995, Grissom 1996). Eyes were sometimes made of shell or limestone (white), which were placed into plaster on skulls and statues, and often lined with bitumen (black) and with bitumen irises.

Another type of objects which illustrate the importance of plaster use throughout the early and middle PPNB were the "white ware" vessels. These vessels were made of lime plaster and were first produced during the early PPNB, together with the first examples of unfired clay vessels (Wengrow 2001, Garfinkel 1999). In many ways, these plaster – or sometimes limestone– vessels preceded fired clay pottery production which occurred during the later Neolithic. White ware vessels were not fired in kilns but were made of burnt lime plaster which resulted in more durable and possibly waterproof containers than ones made of non-resilient materials, i.e. basketry, unfired clay. Also, some examples of white ware vessels with ribbed surfaces show some of the construction techniques, i.e. coil building, moulding and turning which was also used for clay pottery (Banning 1998, 205, Kingery et al. 1988).

In the middle and late PPNB "mega" sites with larger populations (Asouti 2005, Banning 1998, Twiss 2007) that showed significant development in technology, art and socio-economic practices emerged particularly in the Near East, i.e. Bouqras (Syria) (Akkermans *et al.* 1983), Ain Ghazal (Jordan) (Rollefson 1984, 3-14), Kfar HaHoresh (northern Israel) (Goring-Morris 1991, 77-101) and Abu Hureyra (Syria) (Moore *et al.* 1975, 50-77, Moore *et al.* 2000). Çatalhöyük (see Section 2.4) was also one of these "mega sites", although chronologically later, located in central Anatolia and "had the character of a late pre-pottery and early pottery agglomerated settlement" (Hodder 2007, 106). The central open spaces of the early PPNB disappeared during this time, i.e. the flagstone and skull buildings at Çayönü and the cult buildings at Nevalı Çori (Hauptmann 1998, Özdoğan, Özdoğan 1998). Activities were mainly undertaken inside and on the roofs of closely built, rectangular (cell) houses with alleways and courtyards. They were often made of mudbrick. Best examples of these houses are seen at Can Hasan III (French *et al.* 1972), Boncuklu (Baird 2006, 2007, 2008, 2009), Aşıklı Höyük (Banning 1998, Byrd and Banning 1988, 65-72, Byrd 2005, 231-290, Esin and Harmankaya 1999, 115-132), Musular (Özbaşaran 1999, 147-156), Hacılar (Sagona, Zimansky 2009, 56), Çatalhöyük (Mellaart 1967, Hodder 2006, Hodder 2007), Suberde and Erbaba (Duru 1999, 165-192) in central Anatolia and at Cafer Höyük in southeast Anatolia. The sizes and the internal arrangements of the houses varied and rooms were divided for specific activities (Goring Morris *et al.* 2009, 185-252). Unlike the Epi-Paleolithic and PPNA certain characteristics of these houses, i.e. the use of building materials, building above previous houses, or the use of plaster on walls and floors, were similar at the sites mentioned above with the exception of stone buildings and foundations at Suberde, Erbaba and Musular. Important sites such as Ain Ghazal, Abu Hureyra, Bouqras and later Çatalhöyük show evidence of red painted floors/walls and sometimes the use of red and black colours to create decorations. Later in the PPNB more features, i.e. storage rooms, platforms, hearths and ovens were added into the houses when food and tool production increased (Wright 2000, 89-121).

Until now painting on walls and floors seems to have been a simple activity undertaken in domestic houses with some practical and symbolic meanings. As houses and their decorations continued changing forms throughout the middle and late PPNB, so the technology and art on other media, and materials, techniques and decorations influenced each other in many ways. Pottery was one of those media which passed through various stages of production and used similar methods of manufacture to some of the other media, such as wall paintings. For example the very early signs of pottery technology produced plant tempered, undecorated, irregularly and crudely formed vessels as well as other items, i.e. human, animal figurines, geometric token, made of lime plaster, clay, stone, basketry and bitumen which were defined by some studies as "soft ware technologies" (Nieuwenhuyse *et al.* 2010, Vandiver 1987, Rice 1999). Some examples of these are found in Mezraa Teleilat (southeast Anatolia), Tell Halula (Syria), Akarçay (southeast Anatolia), Seker al-Aheimar (Syria), Salat Cami Yanı (southeastAnatolia), Neolithic levels of Çatalhöyük (central Anatolia) (Yalman *et al.* 2013) and Tell Sabi Abyad (Syria). Later on mineral tempered pottery (Nieuwenhuyse *et al.* 2010, 77) with painted decorations appeared. Pots were shaped and finished with more care by burnishing in order to create even and glossy surfaces before the simple forms of painting, i.e. red slipping, diagonal lines and waves, could be applied. This method of creating smooth surfaces by burnishing was also evident on wall paintings (see Section 2.4).

Painting and decoration on pottery developed in Anatolia and the Near East during the middle and late PPNB with continuation through the PPNC and the Pottery Neolithic (PN). Wengrow suggests that this development might have been inspired by other decoration forms, i.e. basketry, textile work and wall paintings (Wengrow 2001, 173). For instance some of the decorations used on basketry and textiles such as plaiting and twining were also applied on clay and plaster pottery either in the form of moulding and modelling. (Banning 1998, 210, Bar-Yosef 1985, Stordeur et al. 1996). We also see painted motifs such as stripes, cross hatching, dots, zigzags, triangles, diamonds, chequered patterns, geometric shapes, human, animal and anthromorphic figures both on wall paintings and pottery (Wengrow 2001, 179). Some examples of these were found in Tell Sabi Abyad, Hacılar, Kuruçay, Chalcolithic Çatalhöyük and on Samarran and Halaf pottery as well as on the wall paintings as early as 9000 cal. BC from Djade al-Mughara (Coqueugniot 2011, 151-156, Coqueugniot 2009, 1-7), Umm Dabaghiyah, Çatalhöyük, Basta and Ain Ghazal (Kirkbride 1972, 1973, 1975, Mellaart 1963). This may show the use of similar materials, designs and ideas on different media and indicates that the earliest technologies and decorative patterns during the Neolithic might have been the result of close interactions between various object forms which may have provided the necessary knowledge and meaning/s for the Neolithic people and influenced them to apply what they see onto other objects through generations.

The first indication of communal buildings were identified during the PPNA and PPNB at sites such as Çayönü, Göbekli Tepe, Nevalı Çori, Tell Abr 3, Jericho, Jerf El Ahmar, Aşıklı Höyük and Çatalhöyük (Rosenberg, Redding 2002, 39-62, Hodder 2007, 107, Schmidt 2000, 45-54, Schmidt 2011, 41-83, Banning 2003, 4-21, Banning 2011, 619-660). This was the first time when buildings were defined as "shrines" or "temples" to indicate their special/ritual purposes for the communities rather than serving as domestic houses. During the PPNB, painting designs became more elaborate with a variety of decorations (animal/human figures showing scenes from daily life, hand motives, geometric decorations/signs and vegetal designs) indicating that wall art might also have been influenced by the social developments within houses as well as in the larger community.

The evidence of these elaborate paintings, intricate stone carvings, painted reliefs and installations were also seen as some of the distinctive features in order to define some of the houses/buildings as "special". For instance Mellaart's idea of Çatalhöyük "shrines" as possible communal buildings was mainly based on the buildings with sophisticated wall paintings/reliefs and bucrania installations (Mellaart 1967, 77-79). Sites like Göbekli Tepe and Nevalı Çori in southeast Anatolia (Schmidt 2000, Hauptman 1999, 65-86) presented monumentality and different architectural forms than the small size domestic buildings. In its set up, Nevalı Çori had houses and monolithic pillars (richly decorated with carved animal/human figures on stone) built very closely to each other whilst Göbekli Tepe had only small and large T shaped limestone pillars, elaborately carved with various animal figures in low relief (Schmidt 2010). These very significantly built pillars at Göbekli Tepe dated around the early PPNB and are similar to the examples such as at Qermez Dere (Iraq) and Jerf El Ahmar (Syria) (Stordeur 2000, Stordeur *et al.* 1996) in the Near East. It is very possible that in both sites, the monumental "temple like" architecture with animal symbolism may support the idea that these sites could have served as special social/ritual places for communities. They might have aimed to bring people together to achieve some kind of a group cohesion, thus helping them to adjust in their new life styles via beliefs, ritual systems and symbolism (Verhoeven 2002, 5-14, Cauvin 2001, Verhoeven 2002, 233-258, Schmidt 2010, Curry 2008). The “non-settlement” nature of these sites may also be the reason why the monumental limestone pillars were built and decorated instead of mudbrick or stone houses with plastered and decorated surfaces. These monumental pillars were carved to create symbolic figures and scenes. Was it because carving was a more skilled and a suitable technique for limestone as opposed to painting? Did the unavailability of resources, materials and the lack of knowledge for the painting technologies and practices not enable it?

However, the recent work on this particular discussion argue that these “special” buildings or “temples” may not necessarily have been used for communal purposes. For example the latest studies at Çatalhöyük showed that the idea of “shrines” could no longer be valid since all houses have some evidence of simple activities such as food preparation/consumption, tool making and the production of daily or symbolic objects. They were only different in terms of their levels of decoration, i.e. some buildings had simple red paintings, others had decorative ones or bucrania installations, but most houses were decorated (see Section 2.4) (Asouti 2005, Hodder 2006, Hodder and Cessford 2004). Banning also argues in his latest paper (2011, 619-660) that temple like monuments at Göbekli Tepe may also have been residential houses, only very large and more spacious than the early Neolithic houses. He mentions that if we only think about these structures as “temples” it is possible to miss some important information on the early Neolithic households. And he adds that maybe “they would not house nuclear families but substantially larger co-residential groups” (Banning 2011, 639), which would be the earliest evidences seen in the Neolithic period. And the elaborate carvings on these houses may have been symbolic and represent “emblems” for a clan, house or social units which might have helped to identify the way that they were socially organized (Banning 2011, 640).

Either in communal or ordinary houses/buildings, wall art in its different forms seem to be attributed with more meanings towards the middle to late PPNB. It became an important part of the house which connected people to their surroundings and was connected to the values of daily life, the idea of symbolism and to the developing human skills and operational technologies.

To sum up, a number of plastered/painted walls and floors are known from the early/middle PPNB and later Neolithic sites (Pre-Pottery Neolithic C and Pottery Neolithic, 7th millennium cal. BC onwards), i.e. Boncuklu (central Anatolia) (Baird 2006, 2007, 2008, 2009), Aşıklı Höyük (central Anatolia) (Esin, Harmankaya 1999, 115-132), Çayönü (southeast Anatolia) (Özdoğan 2011, 185-269), Hacılar and Can Hasan III (central Anatolia) (Mellart 1970, 1998, French *et al.* 1972), Djade al-Mughara (Syria) (Cartwright 2008, 4, Coqueugniot 2011, 152-156, Coqueugniot 2009, 1-7), Abu Hureyra (Syria) (Moore *et al.* 1975, 50-77, Moore *et al.* 2000), Umm Dabaghiyah (Iraq) (Kirkbride 1972, 1973, 1975), Basta (Jordan) (Gebel *et al.* 2004, 161, 135), Bouqras (Syria) (Akkermans *et al.* 1983, 335, 346, Akkermans *et al.* 1981, 485, Akkermans *et al.* 1982, 45-58), Tell Halula (Syria) (Guerrero *et al.* 2009), Ain-Ghazal (Jordan) (Rollefson 1984, 3, Rollefson 1992, 443-470, Rollefson, Simmons 1987, 104,105, Banning, Byrd 1984, 16-17), Çatalhöyük (see Section 2.4, Mellaart 1967, Hodder 2006, www.catalhoyuk.com, Çatalhöyük Archive Reports) and Teleilat Ghassul (Jordan) (Lovell 2001, Cameron 1981). Some of these paintings –during the early Neolithic– were simple red washes. Nevertheless, unique examples, i.e. Djade al-Mughara with its geometric decoration, are also evident. After the 8th millennium cal. BC, paintings contained more elaborate motives including naturalistic and geometric designs, as well as scenes from daily life, as seen at Umm Dabaghiyah, Basta or Çatalhöyük. However, it was very hard to find information on the technology and imagery of these paintings, which may indicate that most of them had preservation issues and therefore only a small number were subjected to very limited studies.

Some of these paintings on which there is limited information available, are summarized below:

Djade al-Mughara

The Neolithic site of Djade al-Mughara is located to the northeast of Aleppo in Syria. In 2007 excavations revealed a geometric wall painting, showing red, black and white rectangular decoration on the mudbrick wall of a circular building (Fig.12).

Fig.12 Wall painting at Djade al-Mughara (Syria) (http://www.reuters.com/article/topNews/idUSOWE14539320071011).

Carbon 14 dating showed that this two square meter painting dated to around 9000 cal. B.C. At present there is no published information on the technology of these paintings with only the general coverage available online. This painting was part of an adobe wall of a large house with a wooden roof. As the archaeologist Eric Coqueugniot explained to reporters, the red colour was burnt hematite, white was obtained from crushed limestone and charcoal provided the black. Currently, this painting seems to be earlier than the Çatalhöyük wall paintings and it may show similarities in its architectural features, geometric subject matter, and possibly the painting technology, which are still under research.
(Coqueugniot 2011, 151-156, Coqueugniot 2009, 1-7, Cartwright 2008, 4) (www.archaeologybriefs.blogspot.co.uk/2007/10/syrian-wall-painting-dated-to-11000.html).
(www.mobile.reuters.com/article/topNews/idUSOWE14539320071011?i=1).

Basta

Basta is dated to the early Neolithic period (around 8000 cal. BC) and is located between Wadi Musa and Ma'an in Jordan. The houses of Basta were mainly made of limestone and the remnants of the plaster found in the room fills indicated that the walls might have been plastered. Excavations revealed some remains of red painted floor plasters found in the houses in Area A, as well as fragments of painted wall plasters found in situ and room fills in Area B (Area B, Room 19, Square 50, Room B VIII, 2) and in room fills in the northern part of Area A (Gebel *et al.* 2006, 161). Studies show that the painted surfaces often consisted of a coarse mud

Fig.13a Red painted wall plaster in Basta (Gebel *et al.* 2006, 269).

Fig.13b Vegetal design on wall plaster from Basta (Gebel *et al.* 2006, 284.

layer followed by smoothing and an application of a thick reddish brown paint (Fig.13a). It is not known if this was a preparation layer for the next step or if the walls were finished off in this way. In addition it is not clear whether the whole room would be painted in this way or if the paint was only applied onto certain areas. Further observations made on the in situ fragments (Area B, Room 19, Square 50) show an application of a thin layer of lime plaster over the mud, which was then smoothed and painted with geometric designs, i.e. lozenges, pentagons, triangles. The reddish brown colour seemed to emphasise the geometric patterns applied on the white surface. The fragments found in the fills of Room B VIII, 2 showed the same construction, however they had a vegetal design with red coloured bushes and black fruits on a white background (Gebel *et al.* 2006, 135, 161, Fig.13b).

Bouqras

Tell Bouqras is a Neolithic settlement, located in the west part of the Euphrates valley in eastern Syria (Akkermans *et al.* 1981, 485). It is dated to around 6400 cal. BC. Studies showed that the mudbrick walls and floors of the houses were plastered in layers of clay, gypsum plaster and red ochre paintings applied in some areas (Akkermans *et al.* 1982, 45-58). Apart from several undecorated buildings, the excavations discovered a few houses with decorated and painted walls, i.e. House 17 with a wall painting of 18 ostriches and cranes in red ochre on gypsum plaster (Fig.14) and House 16 (on a pier, opposite the hearth) with a relief of a human face, painted in red ochre and with obsidian eyes (Akkermans *et al.* 1983, 335, 346).

Fig.14 Ostriches and crane painting in Bouqras, House 17. (Akkermans *et al.* 1982, 49).

Ain-Ghazal

An important Neolithic site, Ain Ghazal, is located near the Wadi Zarqa in Jordan and dated to around 7250-5800 cal. BC (Rollefson 1986, 45). The stone houses with mud and lime plastered walls and floors did not have any evidence of painted designs on the walls but mainly solid red paintings. Rollefson explains that red ochre was used to paint the plaster floors during the different phases of the settlement and it seems that the people developed a unique method during the middle PPNB to apply the pigment onto floors. In the late PPNB and PPNC phases a few floors were found which were painted with a thick layer of red ochre and the technique was not clear. However in the middle PPNB, painted floors indicated that they were possibly painted with fingers showing “parallel and subparallel lines” (Rollefson, Simmons 1987, 104,105) and some of these lines were described as bird feathers (Rollefson 1992, 443-470). Several abrading stones and one mortar fragment with red ochre residues were also found on the site, indicating that red ochre was ground to be used (Rollefson 1984, 3, Banning, Byrd 1984, 16-17).

Teleilat Ghassul

Wall paintings at Teleilat Ghassul are unique examples of Ghassulian (4000 cal. BC) paintings in Jordan. Multiple schemes or superimposed layers were detected in the paintings. The thick layers and surface unevenness were distinctive on these paintings as well as the designs with geometric motives in red, black and white colours (Schwartzbaum et al.1980, Cameron 1981).

Apart from the paintings mentioned above, the Çatalhöyük paintings are very significant since a large number of them were discovered in the 1960’s and are still being discovered. They also seem to be the most skilled and complex for the Neolithic era in terms of their sizes and the imageries represented. Baird points out that the simple red paintings of the earlier Neolithic could be “an evidence of continuity” between all those important sites and an indication of “the beginnings of symbolism” which appeared in different architectural settings much earlier than Çatalhöyük (Baird 2006, 15). Çatalhöyük was possibly an exception where simple paintings were executed, while experimenting with social, artistic and symbolic thoughts that would be put into practice by creating more complex representations from the daily life and the material world around people.

The fact that most of the paintings at Çatalhöyük are also well preserved enables us to undertake detailed technological studies and gather clues on the wall painting materials, technologies and practices which may be common to the other sites within the Neolithic Anatolia and the Near East. The next two sections will look at Çatalhöyük and its close environment in detail and place these important paintings into their geographical and archaeological setting in order to examine the resources and methods used to create them.

2.3 Placing the Material into Context: The geographical setting surrounding Çatalhöyük

The Konya basin (around 10,000 km^2) lies in the west part of the Greater Konya basin ("latitude 37–388N, longitude 32–358E, altitude 1000m", Inoue *et al.* 1998, 229), on the south of the Central Anatolian plateau (Boyer *et al.* 2006, 676) (Fig.15). It is surrounded by mountains (i.e. Taurus and Anatolides) to the north, east and south and there are wide valleys and high plateaus in its west and north (Zohary 1973, 13, Inoue *et al.* 1998, 229).

Fig.15 The location of Konya Basin in Turkey (Tung 2008, 147).

Rivers stream into the Konya Basin both from western and southern parts of the basin, as well as some depressions that are present in the form of lakes such as the largest Tuz (salt) Lake (Kuzucuoğlu 2002, Inoue *et al*. 1998, 229).

The Konya Basin lies to the north of the Taurus Mountains and south of the Anatolides. The former are constructed of thrust nappes of pre-Miocene marine sediments. In contrast the Anatolides are assembled from Palaeozoic carbontates and low-grade metasediments. A number of Neogene andesitic to basaltic volcanoes are located on the Konya Plain. The region is also dissected by a number of faults, some of which are associated with geothermal activity and sulphur-rich springs and travertine terraces (Inoue *et al.* 1998, 231) (Fig.16).

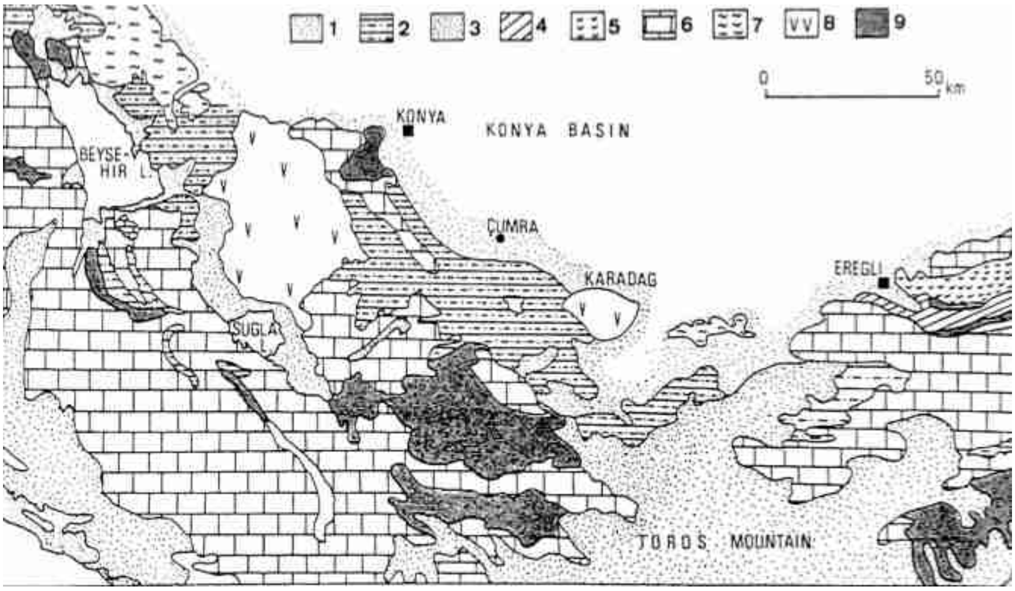


Fig.16 “Geological map in the Konya Basin. 1: alluvium, 2: limestone (Neogene), 3: limestone, marly sandstone (Miocene), 4: flysch, 5: gypsum, marly limestone (Oligocene), 6: limestone (Mesozoic), 7: schist (Paleozoic), 8: andesitic basalt, 9: ultrabasic mass” (Inoue et al. 1998, 231).

De Meester (1970a,b) divided the Great Konya Basin plain into seven zones: uplands (surrounding mountain belts and volcanic highlands), colluvial slopes (unconsolidated screes), piedmont plains, bajadas (alluvial fans), fluvial terraces, alluvial plains, and lacustrine plains.

Çatalhöyük is one of the settlements situated in the Konya Basin which is a relatively flat and inland basin, with a local geology dominated by white, carbonate mudstones, described as marls. In terms of drainage in the plain, water flows to the Tuz Lake as well as to the Taurus mountains in the south even though it is a closed basin. Paleoenvironmental studies on the surroundings of Çatalhöyük show that the basin was occupied by the paleolake Konya which formed during the last glacial maximum (c. 25,000 cal. BC) (Boyer *et al.* 2006, 675, Roberts *et al.* 1979, Fontugne *et al.* 1999, Kuzucuoğlu *et al.* 1999). Post glaciation during the Younger Dryas (c. 11,000 to 10,000 cal. BC) the lake waters dried out. The lakebed surface became flat with slight undulations and the rivers Çarşamba and May, which flowed onto this surface from the Taurus Mountains (Boyer *et al.* 2006, 676). The ancient branches of the river May flew and joined the Çarşamba river, which then flowed towards the south of Çatalhöyük, dividing the East and West mounds. Boyer also explains that after the last glacial maximum, the Çarsamba and May rivers were responsible for creating alluvial planes on the Konya Basin. The largest example is the Çarsamba alluvial fan (Fig.17), which formed c. 7,500 cal. BC and covers an area of 474 km^2 in the central part of the Konya basin (Boyer *et al.* 2006, 676). Çatalhöyük took shape on the Çarsamba alluvial fan around the same time (Roberts *et al.* 1999). Several settlements were set up on the sediments of Çarşamba alluvial fan from the early Neolithic onwards, mainly in the form of mounds or tells (De Ridder 1965, 231, 235).

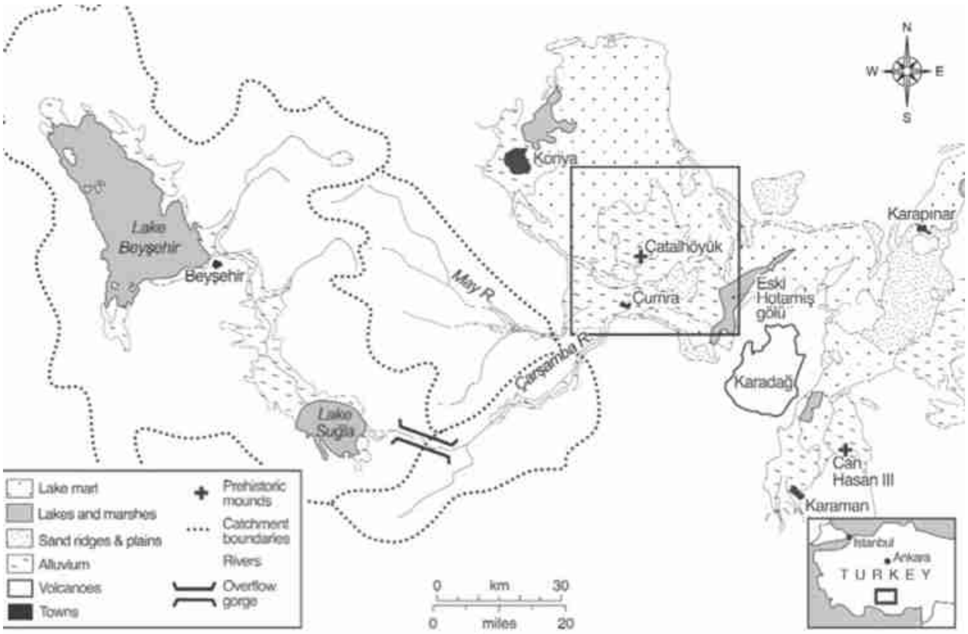


Fig.17 Location of the west side of the Konya Basin and the Çarsamba Alluvial Fan (Boyer et al. 2006, 677).

In terms of the natural geological resources available to the settlements, the Konya basin is dominated by the carbonate marls and the alluvial plains associated with the river systems. A series of sediments known as “soft-lime” (which has a freshwater origin) (Matthews *et al.* 1996, De Meester 1970a,b, De Ridder 1965, Doherty 2011, 91, Doherty 2013, *pers.comm.*) integrated with these marls. Fossils are sparse, but species of the freshwater mussel *Unio* do occur. Both soft lime and marl sediments are pale, white carbonate, soft limes having a high magnesium content (dolomitic). Both of these naturally occurring sediments would be clearly attractive as materials for plastering floors and walls at Çatalhöyük (Matthews 2005a,b). They out crop at several places on the basin rim, especially near Çumra and they also are found to the north of Konya.

At Çatalhöyük, two individual coring projects have been undertaken at different times in order to gather information on the geology of the surrounding environment. The initial KOPAL (Konya Basin Paleoenvironment Research) project aimed to collect information about the micro-environment around Çatalhöyük during the Neolithic (Roberts 1982, Boyer *et al.* 2006). The KOPAL work took a number of cores from the East Mound, the irrigation channels around the site and from the KOPAL trench which was located in the northern part of the East mound (Boyer 1999, Boyer *et al.* 2006, Roberts *et al.* 1996, 1999, 2007). These cores were analysed and the results showed that the palaeolake Konya has an uneven, calcium carbonate rich marl surface which changes by over a metre in depth (Boyer *et al.* 2006, Kuzucuoğlu *et al.* 1999, Roberts *et al.* 1999, 624). The study also found that there was a dark organic clay layer above the marl, nearer to the site and this is considered to be contemporary with marshy areas from other parts of the Konya Plain, i.e. Hotamış, and might point out a marsh/lake phase before Çatalhöyük was established (Roberts *et al.* 1996). This might also support the theory that there was a wetter environment and climate during the early Holocene.

Two main alluvial deposits were investigated within the Çarşamba alluvial fan dated to both the early and late Holocene (Boyer *et al.* 2006, De Ridder 1965). They are referred to as the Lower Alluvium (early) and the Upper Alluvium (late). A thin (< 20cm) layer of dark grey organic clay separates the marl from the Lower Alluvium which is dated around c. 10,000-9500 cal. BC. The earliest Neolithic settlement was formed around 7400-7100 cal. BC (Boyer *et al.* 2006, 683, Cessford, Near 2005), indicating that the settlement was possibly established during a period when the rivers were carrying a high sediment bedload which was deposited on the basin (Boyer *et al.* 2006, 683). The lower alluvium consists of approximately 1.5m of dark grey-brown smectite-rich alluvial backswamp clay. This unit must have started depositing just before the Neolithic settlement was formed and continued until the Chalcolithic. The separation between the Lower and Upper alluvium is clear. The Upper Alluvium has a silt content with a reddish-brown silt-clay of up to 1.3m thickness and contains less organic matter (Boyer *et al.* 2006, 683). "The end of sedimentation between the Neolithic and early Chalcolithic is confirmed in the KOPAL 99 trench sequence where a buried soil horizon and stabilized ground surface above the Lower Alluvium has been Carbon 14 dated to 8000 cal. BC" (Boyer *et al.* 2006, 683, Roberts *et al.* 1999, 626-7). While the investigations showed that the alluvial sedimentation of the Çarşamba fan might have started during the early and continued during the later Holocene not much information is available about the May river's alluvial fan which is known to cut the Çarsamba river fan (Boyer *et al.* 2006, 687). Doherty suggests that a sandy sediment which is below the marl seems to be the May river alluviation (De Ridder 1965, 249) and that some of Çarsamba and May river sediments might have mixed together.

De Ridder mentions that "among the different types of sediments encountered in the basin, fine- grained, lake-deposited sediments, indicated as marl, have the greatest distribution" (De Ridder 1965, 252). Due to the uneven surface of the paleolake Konya, it is considered that Çatalhöyük was situated on a higher part on the marl (Rosen, Roberts 2005) next to a branch of the Çarsamba River. The Çarşamba river had a number of channels where overbank sediments of lower and upper alluvium units can be seen. Çatalhöyük was divided into two mounds (East and West) by one of these paleochannels (Roberts *et al.* 1996, Roberts, Rosen 2009). Doherty mentions that the fine grained sediments observed in the lower alluvium as well as the number of paleochannels around the site suggests that Çatalhöyük may have been located seasonally, "if not permanently", in a flooded environment with marshy and wet conditions (Doherty 2007, 379), since the area around the site might have experienced severe flooding during the spring months (Boyer *et al.* 2006). When Rosen and Roberts (2005, 49) talked about Çatalhöyük having a wetland environment, they mentioned that this was not ideal for dry land cultivation, for which evidence is presented by both paleobotanical and phytolith remains recovered from the site (Fairbairn *et al*. 2002, Asouti 2005). Doherty also explains that the evidence of wet conditions was also clear in the clays and clay based materials at Çatalhöyük. The studies on the clay based materials show that most sediments used in construction in the earlier levels of the settlement are dark grey silty, backswamp clay with rich organic matter, which is related to a marshy environment. Between Levels VII-VIII there seems to be a sharp change in the use of reddish-brown "mineral-based" clay with less organic matter, possibly presenting strongly oxidizing conditions which would be seen in the dryer landscapes (Doherty 2007, 369, Tung 2008, 156). Roberts et al. mention that the soil change in the KOPAL area (6100-5900 cal. BC) indicated that dryer conditions might have taken place c. 8200 years ago as a result of the cooling period, but they may also have resulted from changes in river courses (Roberts *et al.* 2007).

Following the KOPAL project, Doherty and colleagues later decided that in order to solve the wet land/dry land question the surrounding landscape had to be investigated in terms of its sedimentary history to be able to determine its wet and dry zones. Therefore a new coring project was undertaken between 2007 and 2009 looking at the distribution of different sediments around the mound and their exact locations, to study the environment, while providing "information on local soils/sediments in terms of their suitability for construction/fabrication materials, cultivation and other aspects of land use" (Doherty *et al.* 2007, 382-390, Doherty *et al.* 2008, 263-272).

Test cores were taken during the 2007 and 2008 seasons by Chris Doherty and Dr Michael Charles in the close surroundings of the site, and the alluvial formation of the main Çarsamba paleochannel was studied. The differences observed in the levels and the locations of the lower and upper alluvium indicate that their formation might have been generally linked to the topography of the area and they might have been formed around the same time, possibly due to the geomorphological changes in the Çarsamba river system, as opposed to climatic changes (Doherty *et al.* 2008). The studies present some inconsistency within the Holocene environments such as in the wet and dry areas different sediment formations occurring near the ground surface as well as in different locations during the Neolithic occupation, and some variations within the timing of the upper and lower alluvium units. According to the study "The depth of marl along the paleolake Konya, seems to be relatively uniform with only minor variation east-west along the transect marl" (Doherty, Charles, Bogaard 2007, 382-390). The marls of different colours and purities seem to be interbedded with sands, silts and gravels. This indicates deposition at the margin of the paleolake. The interbedded facies possibly have developed due to fluctuations in the lake level, with the resulting movement of the shoreline position. The sandier facies may have been near the surface at the time of occupation. Doherty mentions that this is also supported by their evidence in some of the post-Level VII mudbricks. The interbedded permeable silt and sand facies would explain the balance of wet and dry areas around the site. As Doherty explains, the sandier facies might have drained more quickly following flood events (Doherty *et al.* 2007, 390).

One of the materials in focus for this study, the Çatalhöyük plasters, were based on these siltier and sandier facies deposited at different distances from the margin of the paleolake Konya. At this point it is important to define what it is meant by "plaster" in the context of the Çatalhöyük wall plasters and paintings. The clay based material which is rich in calcium carbonate content and covered the mudbrick walls of the houses at Çatalhöyük was analysed to be "marl" in general, which is naturally available from the marl beds of the Konya Basin, extending underneath the site. To cover ("to plaster") the walls, marl might have been collected in a wet or a dry state and mixed with water to achieve either a slurry or a putty like product. The studies by Matthews, Doherty and Tung on plasters (also this study) indicate that there are slight differences in colours (white to pale brown) and natures (purer to impure) between the marl plasters used at Çatalhöyük. These types of differences in the plaster fabrics used for painting may indicate changes in the locations from which the marl was obtained at different times (see Section 2.4, also Chapter 6, Section 6.1) (Matthews 2005b, 364-373, Doherty 2007, 371, 372, Tung 2008, 252-257). Matthews also mentions the use of “soft lime” deposits as white washes (which are the naturally weathered, fresh-water Neogene limestones with 95% calcium and magnesium content) on multi layered wall and floor plasters. These deposits are still found within 5km of Çatalhöyük (Matthews 1996, 304, Matthews 2005b, 364).

The studies of clays and clay related materials at Çatalhöyük also indicate that various mineral and rock inclusions in most clay and plaster fabrics within the basin were mainly derived from “Palaeozoic, Mesozoic and Tertiary” rocks and minerals in the basin, which were carried by the Çarsamba and May rivers. They would collect these inclusions from the Taurus mountains (De Ridder 1965, 252) (see SEM (EDAX) analysis results on the painted plaster samples for these mineral and rock inclusions, Appendices 27-202). The Çarsamba was the active river, but the May was responsible for carrying most of the pre-Holocene alluvium underlying the Çatalhöyük-Çumra area Sediments from this river system have volcanic rocks (andesites), limestone, schists (De Ridder 1965, 252). Even though the similarities were evident, the differences in fabric inclusions present a base for identifying the clay sources for the clay-based materials at Çatalhöyük.

2.4 Placing the Material into Context: The Neolithic Site of Çatalhöyük

The Neolithic site of Çatalhöyük is placed on the Konya plain in central Anatolia. The site consists of two mounds, the East Mound (Neolithic, around 7400 to 6000 cal. BC) and the West Mound (Chalcolithic, 6000-5600 cal BC). Overall the settlement dates from between the late PPNB/PPNC and the Pottery Neolithic (PN) of which many characteristics are evident on site (Hodder 2012).

Çatalhöyük was first excavated by James Mellaart between 1961-1965. He exposed a large Neolithic settlement which was, according to Hodder, occupied for approximately 1400 years due to its location and the existence of natural resources around (Hodder 2006, 7). The current excavation project that is run by Prof. Ian Hodder began in 1993 (Farid 2007,45) and showed that Çatalhöyük was established “well after the first farmers and the first settled villages” (Hodder 2006, 19). He and his team have been studying this important site which was mainly maintained by agricultural economy where understanding the crucial links between social organization and daily life, artistic/technological approaches and the material culture has been proved to be challenging (Hodder 2006, 7, Hodder 2007, 107, Hodder 2012) (Fig.18).

Mellaart started excavating Çatalhöyük in 1961. He excavated around 160 buildings on the south part of the East Mound during four excavation seasons (Mellaart 1967, 80). He found that the buildings were constructed closely to each other to form an "agglomerated" settlement with external (midden) areas around them (Mellaart 1967, 49). He also discovered a large quantity of plastered animal reliefs, wall paintings with a variety of designs and large horn cores[1] installed on the walls of the buildings which he called "shrines" (Mellaart 1967, 77-79). Following Mellaart's work, the current project has aimed to find the complete depth of the Neolithic settlement and since 1993 Mellaart's old trenches in the South area are being recorded and re-excavated whilst also excavating and studying the northern part of East mound (Hodder, Matthews 1998, 43-51, www.catalhoyuk.com).

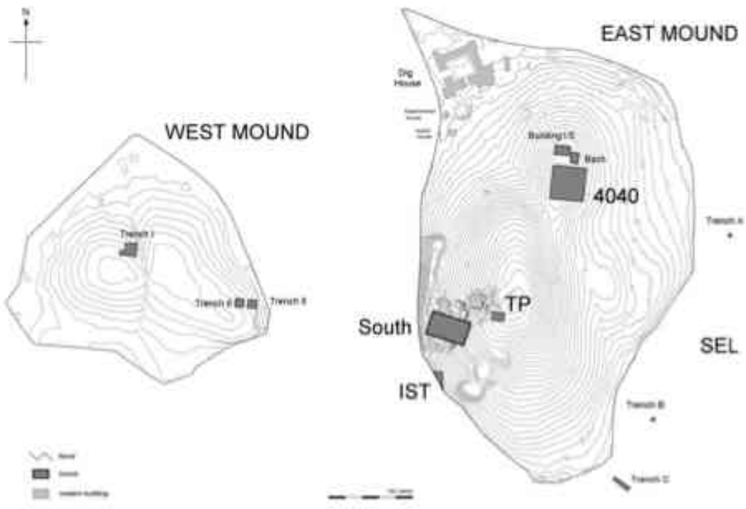


Fig.18 The plan of the recently excavated areas at Çatalhöyük (Çatalhöyük Research Project, Archive Report 2006, p.2)

Stevanović mentions that clay was one of the most important materials utilized in the Neolithic of Anatolia and the Near East (Stevanović 1997). People made houses and decorated them with clay, created objects and things that supported their daily lives in many different ways, i.e. technologically, socially and ritually. Çatalhöyük is a good example where the great dependency and extensive use of clay took place.

[1] Horn cores, antlers, auroch and sheep skulls were often found in buildings both in the Near East and Anatolia i.e. at Jerf El Ahmar (Syria), Hallan Çemi (southeast Anatolia) and also later at Çatalhöyük, possibly carrying rituel and symbolic meanings (Cauvin 2000).

Çatalhöyük houses were built on top of each other (onto the demolished walls of earlier buildings) and were made up of various types of mudbrick. To make mudbricks the raw materials were collected from the local alluvium and the variety of sediments surrounding the site (see Chapter 2, Section 2.3, Matthews 2005a, 129, Matthews 2005b, 364, Doherty 2007, 369, Boyer, Roberts, Merrick 2007). Pits were dug outside the site to obtain various types of clays including “marl” which the walls and floors of the houses were covered, “plastered”, in multi layers. (Matthews 2005a, 129, Doherty 2006, 298-310, Doherty 2007) (Fig.19).

Houses were entered through the roofs, since the closeness of buildings did not allow any space for streets or alleys. It is assumed that the roofs at Çatalhöyük were important in people’ lives. Apart from providing entrance for the houses, they may have provided secondary living areas for food preparation and other activities during the dry seasons. They were also used as walking areas, since there was no space for streets (Stevanovic 2005, 25, 26). As Mellaart (1962, 46-8) and Hodder (2007, 41-2, Hodder 2006, 7,8) described the houses generally contained a larger living space with smaller rooms for storage and food preparation, as well as ovens, hearths, benches and platforms with burials underneath. The entrance of the buildings was located above the ovens/hearths which were placed on the southern walls.

Fig.19 The possible set up of the Çatalhöyük houses (Çatalhöyük Research Project).

At Çatalhöyük building and decorating houses, plastering walls, floors and other surfaces, creating wall reliefs/installations, painting walls and making objects/things for maintaining the daily life was “strongly tied to clay, to the clay house and the hearth” Hodder 2011, 168). According to Hodder this was a part of the entanglement process between humans and things (Hodder 2011, 168, Hodder 2012). Being in close relationship with *chaine opératoire* and behavioral chain approaches (Lemonnier 1993, Skibo, Schiffer 2008) entanglement process played an important role in organizing operational sequences (undertaken by humans) to follow each step of production in order to achieve an end result (things). It also enabled the development of a technological and social relationship between humans and things. As Hodder explained “humans and things, humans and humans, things and things depended on each other and produced each other” (Hodder 2012, 88).

Following the construction of the roof, the interior of the Çatalhöyük houses were decorated by using “sediment-rich packing material for platforms, storage areas, ridges on floors and any initial constructional mouldings on the wall, i.e. ladders, wall posts” by which the divisions in the house were marked (Matthews 2005a, 134). The oven and hearths were made of clay and most areas in the house were covered “plastered” using clay (also in the form of soft lime and marl) which had to be frequently maintained and modified. These clays were mainly smectitic of volcanic origin and were very susceptible to quick expansion and shrinkage with water. The relationship between the materials and the people taught them how to look after their houses as well as to develop techniques and materials for better constructions, i.e. doubling walls, regularly covering wall surfaces with marl, using large wooden posts to support the walls, or making bricks with more sand content.

Hodder mentions that the domestic entanglement with clay at Çatalhöyük helped the constant development of the Neolithic house (Hodder 1990, 2006, 2011, 2012). Looking after the house caused people to modify their environments and lifestyles. The need for adapting to change also resulted in material production, care and maintenance. People became socially, technologically and symbolically dependant on the house, as the house also depended on people. Some houses were built only once or a few times, whilst others were rebuilt exactly in the same way and the same location many times (see below). In Hodder’s words “house, human, and society were all materially entangled together” (Hodder 2011, 169).

2.4.1 “Plastering” the House at Çatalhöyük

The analysis by Tung showed that there were differences between the nature of sources and how the marls were prepared in relation to where they were applied within the houses (Tung 2008, 253, 255). For example different parts/rooms in the houses might have been defined as “dirty” and “clean” areas (Matthews 2005b, 365). The southern end of the buildings (dirty) with smaller rooms were generally plastered with thicker and coarser mud plaster and used for cooking as well as for production practices, whilst the larger elaborate rooms that are in northern parts (clean) containing platforms with burials, kerbs, benches and paintings/installations were plastered with fine, white and pale brown marl plaster which can be considered to be made more neatly by using a better quality of marl (Doherty 2006, 306) in order to possibly indicate the importance of certain areas in the house.

As mentioned in Section 2.3, the nature of the plaster materials used at Çatalhöyük has already been studied by previous scholars (Mathews 2005a,b, Wiles 2008, Doherty 2006, 2007, 2008, Tung 2008). Roberts’s, Matthews’s and Doherty’s geomorphological and off-site work at Çatalhöyük has concluded that “marl was derived from the calcium carbonate rich marl beds of the Konya basin and Çarşamba Alluvial fan that also extend under Çatalhöyük” (Roberts *et al.* 1999, 624, Roberts *et al.* 1996, Doherty, Charles, Bogaard 2007, 382-390, Matthews 1996, 304, see Section 2.3). The cores taken by Roberts as well as Doherty et al. show that today the Neolithic surface is around 6m below the Konya plain (Tung 2008, 150). According to Doherty, marl still occurs as a natural product around the site. It is called “Ak Toprak (white soil)” in the villages of Çatalhöyük, being used for re-plastering houses. However this view is still under discussion, since it is not clear whether the villagers use this name for marl or soft lime deposits. Soft lime is very pure in colour (white) and texture (Doherty 2011, 91, Doherty 2013, *pers.comm.,* see Chapter 4, Section 4.2.1) and was used as white washes on the multi layered plasters by mixing them water (Matthews 2005a,b, 1996).

Unlike these this study found that marl plasters have derived from different sedimentary sections of Çarşamba alluvial fan, therefore being slightly different from each other in their nature and colours (Matthews 2005b, 364-373, Doherty 2007, 371, 372. Tung 2008, 252-257, Doherty 2006, 309, see Chapter 4 and Chapter 6, Section 6.1.). White marl generally have more than 50% calcium content, whereas pale brown marl have less than 50% (see Chapter 4, Section 4.1.1-4.1.5).

Roberts stated that marl plaster started to be used at Çatalhöyük above Level XI (c. 7100 cal. BC) (Tung 2008, 150). Some examples of earlier plasters (white, single layered, 5000µm or less) with possibly burnished red and yellow surfaces found in the South Area (Pre-level XII, Space 181, Levels X, IX, VIII) were recorded as being "very hard" textured and were considered to be true lime plasters (Matthews 2005a, 129, Cessford, Near 2005, 179), suggesting that lime burning technology may have already been known at Çatalhöyük before the production of pottery, similar to some PPNB sites throughout central Anatolia and the Near East such as Çayönü (southeast Anatolia), Aşıklı Höyük, Hacılar (central Anatolia), Tell Ramad (Syria), Ain Ghazal (Jordan), Jericho (Palestine), Hama (Syria) (Gourdin and Kingery 1975, 133-150, Kingery *et al.*1988, 219-244, Garfinkel 1987, 69-76). One of the main questions asked during this research was therefore "was true (burnt) lime plaster used for the production of wall paintings, before the transition to marl plaster took place". This question is investigated within the Chapters 4 and 6 where the results of the analytical work are presented and discussed.

According to Matthew's and Tung's analytical work, the impure (pale brown) marl plasters generally deriving from silty clay deposits had approximately 5% plant material added to them which is evident from the elongated voids in the marl plaster thin sections (Matthews 2005b, 355-398, Tung 2008, 253). However, Doherty recorded (2007, 371) 50% of plant inclusions within a plaster construction/floor in one of the buildings in the 4040 areas (B.59), which is supported by this current research. Previous studies showed that the wall plasters and most features such as platforms and benches were generally made of silty clays while the floor plasters contained sandy natured marl (Tung 2008, 253, Matthews 2005b). This research also identified that some of the wall plasters contained a mixture of both silty and sandy marl.

As mentioned previously most of the wall plasters at Çatalhöyük were applied over a foundation layer, approximately 5000µm thick. There was a colour variation within the raw material (see Section 2.3), but when observed under the naked eye the plasters mainly consisted of two tones: pale brown 10YR 7/3 very pale brown, and white 5YR 8/1 (Munsell Soil Colour chart, 2000). The additions of plant material within the pale brown marl plaster matrices was evidently for additional strength and flexibility, and also to create a rough surface for the following layers to be applied to (Matthews 2005b, 366). Current study showed that white, soft lime washes (<1000µm) with no plant inclusions were followed by pale brown marl layers with plant inclusions (1000µm or more). The surface of the fine layers was possibly burnished to make them more durable and to prepare them for painting in some cases. The current study indicated that the practice of plastering in multi layered form showed variation throughout time and through the different parts of the site so whilst some buildings presented 450 layers, i.e. Building 5 (Level VII-VIII), (Matthews 2005a, 136), some only consisted of 10 or less, i.e. Building 79 (South O) (Eddisford 2009, 19-24). As Matthews indicates this practice might have been based on seasonal or annual cycles (Matthews 2005a, 136) supporting a continuing tradition of plastering today, where the process is repeated annually in villages and particularly undertaken during the dry summer months.

2.4.2 Houses and the Paintings

Mellaart explained the architectural differences between the houses by describing them either as “shrines” or as “simple” houses. According to Mellaart “shrines” had large and elaborate wall paintings, plaster reliefs with animal figures, mouldings and horn cores placed into benches as installations, figurines and burials with pigments which were interpreted as the materials of ritual and symbolic significance (Mellaart 1967, 77-105). He also mentioned that the “shrines” came in a variety of sizes and shapes, while also having differences in their arrangements. They had variety between themselves, but also sharing the same features with the simple houses, which were identified as having at least one red painted panel on one of their walls (often northern and eastern walls), indicating that most buildings at Çatalhöyük had some sort of decoration which perhaps carried a symbolic significance.

Most of Mellaart’s shrines were located in the southwest part of the East mound. The northern part of the mound also exposed a number of Neolithic buildings during excavations and they were similar to those that were found during the Mellaart excavations. As opposed to Mellaart’s interpretations of “shrines” (Mellaart 1967, 60, 77-79, Matthews *et al.* 1996, Hodder, Cessford 2004, 17-40), the current project considers those buildings with burials and symbolic/ritual decoration to be “domestic” houses and investigates the differences with the simpler ones (Hodder 2010, 163-186). Hodder also suggests that some houses have clearly been built more elaborately than others and may be identified as “dominant”, since they seem to be different than the “less elaborate-simple” houses by the number and sizes of their internal features that they present, i.e. basins, pillars, mouldings, paintings, platforms and benches (Hodder 2006, 151, Ritchy 1996, Düring 2001). While these houses may exist at all levels together with the less elaborate ones, their "dominancy" may also depend on the large number of burials such as in Buildings 1, 49, 60 and 59 (also containing layers of paintings) on the northern part of the mound (Hodder 2010, 179, 180, Hodder 2006, 152). Hodder mentions that large number of burials as well as the other ritual objects/installations throughout the different levels are particularly observed in larger and more elaborate houses with long life history and that they were rebuilt many times. While he explains that these houses may have been "dominant" as a burial site for other buildings around, he also introduces the idea of "history houses" which have many burials, more elaboration and repetition than the normal/simple houses in the same location (Hodder 2010, 180, Hodder, Cessford 2004). Even though there may be an overall pattern indicating this evidence, there are also elaborate houses with fewer burials or less elaborate, simple houses with no burials. The meaning of these differences between houses is still being investigated. According to Hodder, the history houses "preserve a collective memory" (Hodder 2006, 161). They were only slightly changed and each time they were rebuilt across a few levels in the sequence. History houses seem to be the evidence of historical memories. They give a good indication of life continuity inside individual houses and through construction, use, ritual/daily activities, abandonment and reuse (Hodder 2010, 181).

Painting practice in Çatalhöyük houses was very popular from the earliest levels and seems to have coincided with the production of fired clay figurines and marl plaster (c. 7400 cal. BC) but not with fired clay pottery. There appear to be no close relationship between wall paintings and the pottery in terms of designs and materials used since the fired pottery occurred in Level XII (7000-6900 cal. BC) was initially organic tempered and crudely made without any decoration. Later on mineral tempered pottery with red slipping was evident on some examples but still without decoration (Yalman *et al.* 2013) whilst many different scenes and designs are used on the wall paintings. Hodder explains a possible reason for this as being that most of the pottery at Çatalhöyük was used as cooking pots to process domesticated animal products such as goats and sheeps. These animals were never used in the symbolism on site and this might be the reason why the pottery was undecorated, possibly "being entangled in a world of domestic production and processing, separated from the entanglements surrounding the production of histories, wild animals, death and burial" (Hodder 2011, 170). Symbolism and decoration focused mainly on the wall paintings (alongside the wall installations), particularly on wild animals, scenes from daily lives and on other elaborate motives, which may have been influenced by textiles, basketry and weaving patterns that are no longer evident on site. Burial practices were also closely related to wall paintings as part of the rituals and symbolism (Hodder 2006) and houses contained burial platforms that were emphasized with red paintings or various painted decoration.

Decorated pottery at Çatalhöyük was seen from the Chalcolithic period (after 6000 cal. BC) and it steadily increased from Level V onwards (Franz 2007, 2012). Hodder suggests a possible change through time particularly via symbols and images that were previously "only" used inside the houses such as paintings, and later on being moved between the houses in the form of smaller objects, i.e. pottery, seals, figurines which would enable carrying/sharing histories and memories between the houses (Hodder 2006, 168). This view may also be linked to the collapse of the pre-pottery Neolithic when cultural practices seem to be reduced with the establishment of smaller sites and the communities which had more interactions with each other outside their own "households" (Sagona, Zimansky 2009, 77).

The wall paintings of Neolithic Çatalhöyük are some of the first examples of prehistoric style painting associated with architecture (Figs.20, 21). Whilst they present the richness of symbolism within the whole of Anatolia and the Near East (Last 1998, 356) they are arguably the most elaborate, not only in terms of expressing a high level of art and symbolism in the Neolithic period, but also in terms of their sizes, technological complexities as well as the variety of designs that they present.

Fig.20 The famous "Hunting scene" B.V.1, South Area (www.corbisimages.com/stock-photo/rights-managed/42-25028825/neolithic-wall-mural-from-catal-hoyuk).

Fig.21 Recent geometric paintings from B80, South Area (Jason Quinlan, Çatalhöyük Research Project).

They are evident throughout the life of Çatalhöyük (in different levels and different areas) and they also reflect elements from the hunter-gatherer Paleolithic period. Similar imagery such as animals/humans, hand motives, various signs and symbols were painted on the walls of the mudbrick houses which were an important part of sedentary lifestyle for the Neolithic communities. These paintings may have served ritual purposes as well as depicting daily life such as hunting scenes (Clottes 2003, Leroi-Gourhan 1982b, Ruspoli 1987). The earliest fragments of wall paintings were found in the midden below a house of Level X (7300-6800 cal. BC) and the latest, covered the walls of Level II (6400-6000 cal. BC) in the South Area (Mellaart 1967, 131). According to Mellaart, these paintings were divided into the following groups (Mellaart 1967, 132, 149, Forest 1993, 1-14, Cutting 2007, 467-472) following the designs and representations described on them.

1) Geometric designs in both monochrome and polychrome, sometimes repeating themselves or mirror images (Fig.22).

2) Symbolic images such as "circles, quatrefoils, crenellations, stars, stylized flowers, swastikas and triangles" (Fig.23) (Mellaart 1967, 132).

3) "Panels painted with handprints and silhouettes, usually with frames with geometric or naturalistic designs (Fig.24)" (Mellaart 1967, 132).

4) "Naturalistic images describing human figures (male, female), animals including deer, bear, bulls, birds, leopards, vultures, either by themselves or grouped into elaborate scenes, such as hunts, ritual scenes" (Fig.25) (Mellaart 1967, 149).

5) "Images showing landscapes i.e. a settlement structure and a volcano in the background" (Fig.26) (Mellaart 1967, 149).

6) Multiple layers of simple red paintings on the lower parts of the walls, on floors, platforms and benches (Fig.27).

Fig.22. A geometric painting, B.2, South Area (Çatalhöyük Research Project).

Fig.23. A painting with circles from South Area (Ian Todd, Çatalhöyük Research Project).

Fig.24. Hand and geometric motives, B.VI.B8, South Area (Courtesy of Anatolian Civilizations Museum).

Fig.25 A painting with a human figure , B.III.1, South Area (Ian Todd, Çatalhöyük Research Project).

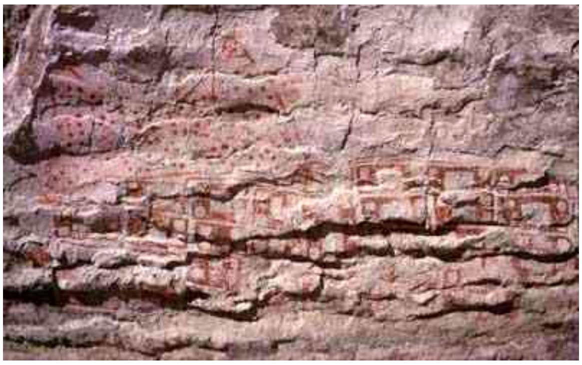


Fig.26 A painting possibly showing the settlement structure with the volcano on the background, B.VII.14, South Area (Courtesy of Anatolian Civilizations Museum).

Fig.27 A monochromic simple red painting, B59, 4040 Area (Jason Quinlan, Çatalhöyük Research Project).

The themes mentioned above were repeated on the Çatalhöyük paintings within the life-time of the individual buildings. For instance the geometric motifs were painted at least twice in the early phases of Building 1, twice in B.VI.8 (Mellaart 1967, Matthews 2005a 141, 142) and at least four times in A.III.8 (Mellaart 1967, 31-34). The geometric paintings were also found in B.VII.21 and B.VIII.14 during the Mellaart excavations as well as in Building 2 of the Hodder excavations, which were tied into Level IX. Also Building 49 (Level VII-VI, Hodder 4040.G) had at least four layers of geometric paintings in Sp.335, F.1491 (W.wall) and F.1661 (N.wall) superimposed with at least two red painted panels.

It appears that the elaborate depictions of daily and ritual life were often painted in the buildings of Level IV and III. For instance animal and human hunting scenes in A.III.1 were painted on at least three occasions, then covered with 30-35 layers of plaster (Mellaart 1967, 173-174, Matthews 2005a, 141). A.III.13 and E.IV.I also contained lively hunting scenes as mentioned by Mellaart (1967, 170). He also mentions the scenes of vultures attacking human bodies found mainly in Levels VII and VIII (i.e. VIII.8., VII.8, VII.21). Symbols such as human hands, quatrefoils were also found, mainly in Levels VI and III, i.e. VII.8, VI.B.10, VI.B.10, VI.A.63 (Mellaart 1967, 161-165). The most common painting practice on the later Levels seems to be red monochrome paintings, particularly applied on the lower part of the walls. Building 3, 59, 77, 82 in the Northern part of the East mound presents some of the best examples from Levels VII-V? (4040.G?). The study undertaken by Matthews showed that the walls from Level IX above seem to have been painted less regularly throughout the site, even though the plastering practices had a distinctive frequency (Matthews 2005b, 367). The paintings were applied either on a white or a pale brown wash layer of marl plaster with no plant inclusions, and were superimposed with many layers of unpainted marl plaster. However due to their single layered nature the earlier paintings (Pre-level XII up to Levels X, IX, VIII) might not have involved the seasonal/annual cycles of repainting/replastering as suggested by Matthews.

As Matthews mentions, it may be that the themes on the paintings as well as the repainting/re-plastering processes in the houses might have been connected with important occasions in the lifetime of people, i.e. birth, death and ritual events. Therefore re-plastering and re-painting over previous paintings may have had significant meanings as this would mark new events/occasions whilst preserving the evidence of the previous ones (Matthews 2005b, 367). Matthews also shows that (Matthews 2005b, 365) the paintings were normally found on the northern and eastern walls of houses whilst southern walls (where oven and ladder were often located) as well as the small rooms and storage areas were never painted (Matthews 2005b, 368). Beside symbolic reasons a practical explanation could be that the heavily used areas (close to hearths and ovens and therefore exposed to the repeated cycles of hot and cold, wet and dry) may not have provided the plaster qualities that are needed, i.e. the ease of paint application and durability (Doherty 2006, 310).

Seasonality might also have been an important consideration for the Neolithic people for choosing the right time to re-plaster and paint the walls. For instance in winter the heavy use of hearths and ovens inside houses might have generated a lot of soot and grease which might have covered the surrounding plastered walls more than in the summer and become a disadvantage in terms of the plaster/paint application. Spring/summer/autumn times may have been more suitable for re-plastering and painting practices with less dampness and dirt, more light and space inside the houses with people spending more time on the roofs and fewer people getting in the way of the skilled work required. Undertaking these practices in the summer or autumn may also have marked the beginning of a new cycle too as it might have signified a clean start before the winter arrives, together with all the repairs made in the houses to make them safer and stronger to withstand the winter months, with parallels to the approach today in nearby villages. In terms of plastering the houses, Matthews mentions about some general practices which are undertaken in the nearby villages today. Whilst men actually build/construct the houses, women would plaster the walls and floors as well as doing plaster repairs as part of the main house activities (Matthews 2005a, 136).

The painting process would consist of many stages some of which might have involved collecting/preparing materials and tools prior to the actual painting work that would have taken some time to achieve. Similar to the Paleolithic palette, the main colours used at Çatalhöyük are inorganic, based on certain minerals found in nature. They are iron oxide colours, i.e. red/yellow ochre and were modified to achieve different tones within. Other colours such as green and blue copper based pigments (malachite and azurite- found in burial contexts), manganese-mauve and lead-based minerals were also vaguely mentioned by Mellaart (Mellaart 1967, 131). Cinnabar (mercury sulphide) - another type of red pigment (vivid/bright red)- is also recorded during the Mellaart and Hodder excavations (Mellaart 1967, 131). The only organic based pigment was carbon black and it seems to have been obtained by burning animal bones, fat and woody plant material. Since, there are no in depth studies undertaken previously on the Çatalhöyük pigments, their sources and preparation/modification methods for paintings, as well as the possible painting tools/techniques, the current research aims to investigate these areas individually whilst looking at the wall painting production as a whole and whether it was a “specialized” practice within the Neolithic community.

2.5 Conclusion

In this chapter the development of architecture, art and the related technologies were investigated within the context of pre-Neolithic/Neolithic Anatolia and the Near East. Following from Paleolithic caves, the first wall paintings were placed into Neolithic houses and their development from very simple examples to more elaborate ones was examined in relation to the architecture and material technologies. Çatalhöyük, where the most well-preserved Neolithic wall painting material comes from, was investigated in detail and the other examples of Neolithic and later paintings in central Anatolia and the Near East were summarized to indicate the rarity of detailed technological studies of this specific material.

Chapter 3

Material under Study: The Methodology of Sampling and Analysis

3.1 The Nature and Condition of the Painted Plasters at Çatalhöyük

Chapters 1 and 2 presented the significance, main questions and the methodology of this research while placing the material into its archaeological context. This chapter focuses on the painted plasters and pigments as materials for painting. It looks at the physical and environmental conditions that affect the nature of these materials as the state of preservation highly influences the sampling process and the analytical results. During the sample collection process at Çatalhöyük some painted plasters were found in situ or in secure (primary) contexts across the site, while some were found in secondary contexts where the archaeological information was not secure. Many of these painted plasters were severely friable and deteriorated. Their condition was observed both in situ and in the on-site lab-macroscopically and microscopically. The samples were selected according to the variety of features which they contained and their state of preservation. The criteria for the sample selection were:

1) Good preservation, i.e. non-deteriorated painted surfaces and cross-sections of both multi and single layered plasters, non-consolidated or treated samples.

2) Samples presenting a variety of features that could provide information on the research questions, i.e. multiple/single plaster layers, painted surfaces with/without tool marks, and a range of colours. Examples of these are shown in Figs.28, 29, 30, 31.

In an archaeological context, the state of material preservation depends on a range of factors during and after the burial to excavation period as well as post excavation processing, conservation and storage (Feilden, Jokilehto 1993, 17-21, Pye 2001, Caple 2000, 15-17). When the Mellaart excavations were stopped at Çatalhöyük in 1960's and the site was abandoned for around 30 years, non-systematic burial methods caused the site to suffer severe deterioration. The site still continues to suffer in general but in a more controlled way than before, due to very cold winters with heavy rain/snow and dry hot summers with fluctuations of relative humidity and temperature throughout day and night. Mudbrick walls dry, erode and collapse leading to large sections of plaster/painted plaster becoming delaminated and detached while the tops of walls wear away through uncontrolled walking over the site. An irrigation program in the area which was set up in the 1990's (Matero 2000, 71-89) and the construction of two large shelters on the southern and northern parts of the East mound as part of the site conservation program have significantly affected/changed the nature of the soil. Soluble salt levels have increased and the preservation of organic materials in the lower levels of the site has been highly affected. The shelters currently cover the exposed archaeology throughout the year and seem to affect the archaeology in both positive and negative ways, as the effects of the micro environment (or otherwise) that they create are crucial to the preservation of the mudbrick/plastered and painted walls (Çamurcuoğlu Cleere 2007). All deterioration factors are linked to each other and affect the material both externally and internally.

As explained in Chapter 2, the type of plaster material generally used at Çatalhöyük is "marl", containing a silty and sandy clay particle size. It is known that the main cause of damage to clay based plasters occurs because of the nature of the material. Clay particles and to a certain extent of silt are the binding elements in these plasters. When affected by water, the volume of clay minerals first increases, then decreases and the particles become "dispersed in a water suspension" (Balderrama, Chiari 1984, 110), damaging the plaster matrices as well as the other materials related to the plasters such as paint.

3.2 Factors affecting the condition of the Çatalhöyük Painted Plasters and Pigments

There are a wide range of factors that affected the condition of the painted plasters and pigments. These are summarized in the following sections.

3.2.1 Condition of the Painted Plasters:

1) The burial environment, external impacts and the continuous climatic fluctuations at Çatalhöyük cause severe physical damage to painted plasters, i.e. distortion which made it difficult to follow the individual plaster/paint layers, as well as harder to study/analyze the surface features such as the designs represented, possible tool marks and the true marl/pigment layers for individual paintings (Fig.28).

Fig.28 A wall painting from 4040 Area, U.13223, Sp.227 showing surface distortion (Jason Quinlan, Çatalhöyük Research Project).

2) Porous marl, which form a base for the Çatalhöyük wall paintings loses moisture when first exposed to heat after many years of burial and severe damage/delamination can occur in a few minutes due to quick drying (Cronyn 1990, Mora *et al.* 1984, Matero 2000, 71-88). In particular the clay particles and impurities within marl tend to dry upon moisture loss, causing cracks and crust formations on the painted plasters (Doherty 2007, 371) (Fig.29). This affected the study of surface features and materials since the delamination caused individual marl layers to be damaged and the loss of paint and iconography.

Fig.29 A wall painting from 4040 Area, U.12314, Sp.256 showing cracking (Jason Quinlan, Çatalhöyük Research Project)

3) Soluble salts on the surface or within the depths of marl plasters cause damage when reacting with fluctuating relative humidity (RH) and temperatures (Cronyn 1990, 104, Mora *et al.* 1984, 180-183). The salts within the marl matrix dissolve when the RH increases and re-crystallise as the moisture levels fall. If this movement were continuous, severe delamination and spalling would occur (Mora 1995, 91-100, Price 1996). The recent environmental data from Çatalhöyük shows constant but regular fluctuations of the RH levels on site (under the shelters) which unfortunately result in the weakening of the exposed structures and the failure of previous conservation treatments (Atalay *et al*. 2010, 9-10, Çamurcuoğlu 2008-2011).

4) Dampness in the soil from the ground water softens the marl matrix and dissolves the internal components due to percolating water (Cronyn 1990, 119). Also the affects of ancient fires during occupation on the plastered/mudbrick walls cause the destruction of the internal components and weakening of the matrix, creating very powdery surfaces. Together with the fluctuations of RH and temperature, these buildings/walls are the most susceptible to severe deterioration and therefore often in very friable condition (Fig.30). Points 3 and 4 above caused painted plasters to become very friable and thus crumbling and loosing structure during the sample collection.

Fig.30 A wall painting from 4040 Area, Building 77, burnt west wall showing effects of fire (Jason Quinlan, Çatalhöyük Research Project).

5) Groundwater hardens the porous marl matrix, changing the texture and the natural appearance of marl plasters. Doherty explains that the water table was lower in the early levels of Çatalhöyük and as the mound became larger it has risen slightly. Therefore the floors of the early levels were in much closer contact to the water table than later levels. The lime-saturated groundwater would circulate through these lower levels floors/walls causing them to be impregnated with lime scale, this resulted in a hardening and cementing of the wall and floor fragments (Doherty 2013, *pers.comm.*) Some examples of this are seen on the painted plasters from Pre-level XII, Levels X, IX, VIII which look very solid and firm (Doherty 2006, 309), meaning they are often confused with burnt lime plasters (Fig.31).

Fig.31 A single layered marl plaster with a solid texture from Pre-level XII, Space 181 (Duygu Çamurcuoğlu).

6) The growth of flora and microflora, i.e. plant roots, severely affected the physical stability of the mudbrick walls together with the marl plaster layers, as they grow through the material, causing cracks, delamination and detachment (Caneva *et al.* 1991, 87, 127-134) (Fig.28), therefore resulting in the loss of paint and marl layers.

7) Various animals such as ants or burrowing animals dig holes into the archaeology and weaken the structural stability of the mudbrick walls and plastered surfaces, damaging the uniformity of paint and marl layers. The presence of the shelters at Çatalhöyük protects the archaeology without the need of reburying, however it has encouraged excessive animal activity on the site.

8) Physical damage caused by human action. Direct human intervention is often responsible for severe damage to the plastered/mudbrick walls. Most damage occurs during excavation through careless exposure of the archaeology, and through uncontrolled visitor behaviour.

3.2.2 Condition of the Pigments:

1) Both inorganic and organic pigments change colour and nature, due to high light levels, fluctuating pH and contact with moisture and oxygen (Cronyn 1990, 118, Mora *et al.* 1984, Bearat *et al*. 1997, McCormack 2000, 796-798). Practically this meant it was hard to determine if the variety of red tones used in the paintings were the original colours, or if they had changed due to the burial environment and exposure to air.

2) Loss of coherence of the pigment layer causes the loss of paint possibly due to the loss of any organic binders, which may have been used or because of the physical factors discussed above (Cronyn 1990, 119, Mora *et al.*1984, Masschelein-Kleiner 1995). It is known that Prehistoric artists had many organic natural binders available to them, but they are very difficult to detect analytically after thousands of years since they may not survive under constantly changing soil conditions.

3.2.3 Condition of the Painted plasters and Pigments following excavation

Apart from being subjected to the deteriorating effects of burial conditions, painted plasters and pigments can also be put in danger and their archaeological information lost in a very short time if they are not excavated, handled and treated with particular care. During this research the condition of the excavated material showed that painted wall plasters and mudbrick walls have severely deteriorated after their exposure because of the effects of the sudden changes in their microenvironment (relative humidity, temperatures and light) which were not mitigated. The deterioration was caused by non-careful excavation and not undertaking suitable conservation measurements, i.e. immediate protection following excavation and inappropriate storage. Crumbling, powdering and delamination of surfaces continued when the finds were placed in plastic bags in a disordered manner without the appropriate methods of protection, i.e. making breathing holes in the plastic bags if the material is damp and stored in large crates on top of each other, resulting abrasion and thus the loss of paint and plaster layers.

Further more, non-careful excavation and post excavation treatments such as using inappropriate tools to excavate very fine paint/plaster layers and washing/hard brushing find surfaces without guidance, i.e. ground stones and painting fragments, physically damaged the material and caused very important archaeological information to be lost, i.e. paint layers, pigments, surface topographies, original tool marks etc.

Moreover, some samples were treated by conservation without discussion with specialists and without taking/recording sub-samples before the process. This has affected the sample selection, since conservation treatments may hinder the results of scientific analysis as well as change the nature of the material, i.e. colours and chemical structures.

Finally the recording and storage of some of the pigments with the wrong finds and context information caused confusion and time loss during the sample selection process.

3.3 The Analytical Techniques Selected for investigating the Çatalhöyük Wall Paintings

This section presents the different analytical techniques that were used for the chemical analysis of the painted wall plasters, pigments and ground stone tools from Çatalhöyük. The analytical techniques were chosen by taking the following factors into account:

1) The information they provide

2) Availability and cost

3) Standardised use and results which can be comparable with other techniques

4) Minimal or non-destructiveness

The actual sample taking was a straightforward process. After selecting the painted plaster fragments, I cut them into <5-10cm square blocks and safely placed them into small and medium polyethylene bags and/or polyethylene food boxes (packed with acid free tissue) with their context labels. Even though the sample sizes mentioned above could be considered large when compared to other cases of studying painted materials/objects, the very old, friable samples which were available for this research were taken in larger sizes in order to enable further "sub" sampling process with the intention of using them for different type of analysis. For instance, very minute pigment samples were taken from larger painted plaster samples in order to be analyzed under Gas Chromatography – Mass Spectrometry (GC-MS) or they were used to make dispersion samples for optical microscopy. Larger samples were used in raw form under Scanning Electron Microscopy (SEM-EDAX) or Raman spectroscopy to study larger surface areas or were processed as cross and thin-sections. The pigment samples (either in consolidated masses or in powders) were placed into glass tubes or in polyethylene bags. When the in situ paintings needed to be sampled, a sharp scalpel blade was used to cut <5cm square, small to medium size samples (or sometimes whatever the condition of the paintings enabled) and the samples were placed into polyethylene bags with their labels. Ground stone tools, the pigment lumps and nodules could not be sampled, but it was possible to study them both on the site and at the Institute of Archaeology, UCL in London.

Analytical and sampling processes showed that even the samples which were considered acceptable and therefore collected were not always suitable for sampling and in depth studying. For instance it proved to be very difficult to analyse the possible tool marks on some of the painted plaster surfaces by using SEM (EDAX) due to the severe deterioration and distortion of the surface features during and after burial/excavation. Other samples crumbled/eroded away during the sample preparation process due to their friability and deterioration level. In particular the polishing process caused some samples to be eroded and to lose most of their actual sizes while preparing polished block samples. The distortion of the paint layers where the layers had undulated and slipped during burial, losing their even nature, also created difficulty to follow/analyse the individual paint layers in order to understand the sequence and nature of the paint/marl plaster application. The nature of the plaster material also acted negatively during the pigment identification by Raman spectroscopy as the white plaster surface charged/fluoresced during the analysis, hindering the possibility of achieving reliable results (see Section 3.5). Pigment sampling also presented problems as it was difficult to separate the pigments from the plaster layers on some samples. This could be related to the pigment layers being very fine and powdery, integrating into the plaster structure after thousands of years.

For this research, a combination of optical microscopy, SEM (EDAX), Raman spectroscopy and GC-MS was chosen as the most suitable approaches as no single method would give the best result for the analysis of the painted plaster material, providing both chemical and morphological information. As mentioned in Chapter 1 Section 1.6, these instruments were chosen after discussions with my supervisors and my literature research on the technical studies of ancient wall painting materials. It was agreed that they would be the right techniques to provide conclusive results both quantitative and/or qualitative, depending on the analytical questions being asked. They were also readily available for me to use in the Wolfson Archaeological Laboratories at UCL's Institute of Archaeology and Chemistry Department, as well as the British Museum's Conservation and Scientific Research Department. The use of Raman spectroscopy was enabled in collaboration with the UCL's chemistry department and it was hoped that it would present reliable results for the initial analysis of the pigments. However, the analytical results gathered from Raman spectroscopy were not consistent, possibly due to the age and level of preservation of the samples. This was considered a part of my learning process during my research and more reliable complementary techniques, such as optical microscopy were used instead.

3.3.1 Microscopy (Optical Stereomicroscope, Reflected Light Microscope/ RLM, Polarising Light Microscopy/PLM)

The painted plaster and pigment samples were examined both at a macroscopic and microscopic scale, the first helped in designing the sampling strategy and the analytical methodology. The use of a basic optical stereomicroscope, combined with optical polarising (PLM) and reflected light microscopy (RLM) were crucial in the study for identification of minerals and other components in the plaster matrices, the pigments and pigment mixtures and the application techniques. Sub-sampling (as cross sections and thin sections) proceeded further instrumental analysis such as the scanning electron microscopy (SEM-EDAX) and Raman spectroscopy. Before the PLM and RLM were used for the painted plaster/pigment analysis, the raw painted plaster and pigment samples were studied both by naked eye and under simple stereomicroscopy (GX microscopy, at x100, x200, x400) in order to understand the nature of the painted surfaces.

Through a detailed surface study of the samples, the following features could be examined:

1) Damaged, eroded and distorted paint layers in order to understand the effects of the burial/excavation as well as deciding what samples can produce secure answers for the study of the paint/plaster interaction.

2) The nature, sequence and thicknesses of different paint and marl plaster layers to observe any similarities or differences throughout the levels at the site and across the site.

3) Identification of specific inclusions both in paint and marl plaster layers in order to understand the nature of these materials in their archaeological and geological contexts.

4) Identification of the surface features, i.e. striations and/or tool marks to investigate the possible use of certain tools, i.e. brushes, pigment nodules, for the painting work, as well as to observe individual styles.

5) The nature and modification of pigments in order to understand the ways in which the pigments were obtained, prepared, mixed and used for different reasons.

3.3.2 Reflected Light Microscopy (RLM)

RLM enables one to study mainly opaque materials that do not transmit light, i.e. most organic and inorganic materials such as glass, ceramics, metal, plastic, paper, paint etc. The main reason for choosing RLM as one of the techniques for this study was to investigate the cross sections of painted plaster material. Since these materials are also opaque and do not transmit light, light is simply reflected off the surface and directed back up the microscope to the eyepiece.

In order to analyse the painted plaster material I had to prepare cross sections which involved sub-sampling from the main samples. This was carried out as follows:

1) The sample was cut by means of a fresh scalpel blade or mini-saw through its entire section.

2) A cross section making kit called “Easy Sections” was used (http://www.easysections.com/index.htm). The samples were placed in low quality Perspex wells which then were filled with two component embedding resin (Methyl Methacrylate based) that was allowed to set over a period of minimum 12 hours before it could be cut for sectioning and polishing. Label information was written on the Perspex wells.

3) Once the resin was set, the top layer of resin in the wells was cut flat by using grinding discs and then polished with coarser and finer sandpapers.

This preparation was time consuming (much of the work being manual) and also damaging for the samples, causing erosion of the samples due to their softness and friability. However the polished blocks do provide good samples to be studied and they can be re-used for other analytical techniques, i.e. for Scanning Electron Microscopy (SEM), after they have been coated with a conductive material such as carbon, gold or platinum. For the RLM analysis, I used a Leica DMLM polarising reflected light microscope (x100, x400) together with a Nikon Coolpix digital camera for the microphotographs of the cross sections in order to study:

1) The entire stratigraphy of the section and the relationship between the individual layers of both pigments and plaster.

2) The thickness of the pigment layers, their nature and the way of preparation/application.

3) The different plaster fabrics, their nature and inclusions.

4) The condition and the formation of the plaster layers.

3.3.3 Polarising Light Microscopy (PLM)

Polarized light microscopy can be used to gather both qualitative and quantitative data and is generally used for the study of minerals as well as inorganic and organic mixtures, i.e. ceramics, stones, plasters, pigments, organic fibres, polymers and the study of biological molecules like starch, wood or plants. PLM requires a microscope to be fitted with a polarizer (fixed) and an analyzer, which can be moved in or out of the light source. This method is used routinely in the fields of mineralogy and petrology and therefore is very well suited to the analysis of cultural material derived from geological sources. Descriptions of the optical physics and observed properties can be found in Eastaugh *et al.* (2004) and Gribble, Hall (1992).

PLM has been employed in two different ways in this study:

1) To study the pigment grains for pigment identification.

2) To study the thin sections cut from sections of the painted plaster samples.

PLM provides an optical method to identify pigments which can provide characterization and therefore identification of pigment phases present. This technique may be complemented by techniques such as Raman microspectroscopy to further refine analyses. However, it is important to note that PLM is very fundamental for identifying mineral phases in finely particulate, multi-component and potentially 'burned' materials such as iron ochres where often very poor spectra are obtained. Comparison of a large sample set using PLM can produce groupings based on parameters such as phases present, purity and particle size and therefore reduce the sample-set for further chemical or spectroscopic analyses (if necessary). This reduces analytical time and costs, which might be involved when using a more advanced instrument. It only requires minute samples and a trained practitioner can produce reliable results on an easily available instrument. It is a very practical way of examining the mineral origin of materials if there is a comparable databank. Importantly, if the pigments contain mixtures of colours other analytical techniques may not show this. However, PLM can easily separate out two different phases which may have been mixed to form a specific colour. It also has an advantage over chemical analysis as it is visual and therefore not only shows colour, but also shows compositional changes evident in the samples.

Before PLM was used for pigment analysis the raw painted plaster samples were studied under a GX stereomicroscopy in order to understand the nature of the painted surfaces. The initial observations were made under x100, x200, x400 magnifications. The sub-sampling involved a very small amount of pigment mounted onto a glass slide (as grain dispersions), which was enough for identifying the pigments. The process is explained below:

1) A few grains of pigment are taken from each sample and placed on a glass slide.

2) When put on the hotplate, a cover slip is placed onto the glass slide with MeltMount™ (refractive index of 1.662, melts at 60-70°C). The Meltmount goes underneath the cover slip and mixes with the pigment by capillary action. During this stage the pigment grains are dispersed by pressing gently on the cover slip with a rubber end of a pencil.

3) The mounted sample is then removed from the hotplate to allow the Meltmount to set making it ready for investigation by PLM.

I analysed the pigment dispersion samples under Leitz Orthoplan Polarizing light microscope with x10 oculars and with x400, x630 and x1000 (oil) objective lenses. Immersion oil with a refractive index of 1.52 was used with the x1000 oil objective. Microphotographs were taken by using a digital Nikon SLR camera attached to the microscope.

Using a combination of plane and cross-polarized light this method helped to observe and study the following:

1) The identification of the red, yellow, blue, green and black pigments.

2) The classification of different shades of red.

3) The pigment processing.

4) The application method.

PLM was also employed for the thin-section analysis of the painted plasters. The decision to study the painted plasters samples via thin sections came from the need to examine the inclusions in the plaster/pigment matrices that were visible through cross sections and were analysed by Raman Spectroscopy and SEM (EDAX). Since Raman and SEM (EDAX) analysis do not always separate out the different materials thin sections provided this extra information. Thin section preparation takes a lot of practice and time in order to achieve a workable section. In order to eliminate the risk of damaging and losing samples as well as losing time the raw samples were sent to Royal Holloway College to be prepared by a professional petrologist. A Leica DMLM polarising reflected light microscope (x100, x400) was used together with a Nikon Coolpix digital camera for the microphotographs of the thin sections in order to study the nature of the plasters and pigments as well as their interaction.

3.3.4 Scanning Electron Microscopy (SEM)

During this research, Scanning Electron Microscopy (SEM) has proved to be an important technique for the semi-quantitative elemental analysis of the samples while complementing the results taken from optical microscopy. With SEM it is possible to study a variety of materials under very high magnifications and a large depth of field. Surface topography and morphology of the samples can also be closely examined during this analysis. The Energy Dispersive X-ray analyzer (EDAX), which is attached to the equipment also analyses the chemical compositions of the individual elements semi-quantitatively. Moreover it is possible to map the sample surfaces qualitatively to see the distribution of elements within the sample. The high magnification images are produced in black and white and can be documented as photographs.

Before analysis carbon or gold coating must be applied to the samples in order to reduce their level of conductivity. Once the carbon coat is applied onto the thin and cross sections it is damaging to remove it. Therefore it is advised that the polished samples are first studied under optical microscopy before subjecting them to SEM analysis.

For this research, the following work was carried out by SEM (EDAX):

1) Elemental analysis of the thin sections in order to identify the inclusions/minerals in the plaster/pigment fabric.

2) High magnification images of the thin/cross sections to investigate how the paint was applied onto plaster (wet or dry?).

3) High magnification images to identify application tools through studying the surface topography of the painted surfaces as well as selected ground stone tools.

The SEM work was undertaken by myself at the Wolfson Archaeology Laboratories of the Institute of Archaeology, UCL, by using Philips XL-30 ESEM (EDAX) and Hitachi S3400N SEM (EDAX) to study the painted plaster fabrics on thin-sections, and the painted plaster surfaces (on raw samples) in high (>X50) magnifications. During the analytical process microscopic images of the pigments and painted plaster fabrics were also taken.

3.3.5 Raman Spectroscopy

Raman spectroscopy is a constantly improving and widely used technique for the compositional analysis of pigments as well as the variety of inorganic and organic materials as it is considered reliable, sensitive and non-destructive which would enable in situ analysis of materials whilst reducing the need for sampling (Edwards *et al*. 2000, Burgio, Clark 2001, Clark, Curri 1998, Vandenabeele *et al*. 2006).

> "It is a vibrational spectroscopy technique which involves applying a monochromatic light source such as laser on samples and detecting the scattered light. The majority of the scattered light is of the same frequency as the excitation source known as Rayleigh or elastic scattering. This scattered light source collects a unique chemical fingerprint for molecules. Each molecule has a different set of vibrational energy levels, and the photons emitted have unique wavelength shifts. Vibrational spectroscopy involves collecting and examining these wavelength shifts and using them to identify what is in a sample. Different peaks in the spectrum correspond to different Raman excitations" (www.st-andrews.ac.uk/seeinglife/science/research/Raman/Raman.html, www.inphotonics.com/raman.htm. 24.10.2014).

Even though this technique is very popular it has a few important disadvantages which prevents safe analysis. First of all, starting off or increasing the laser beam in an uncontrolled way can damage the samples severely. It has also proved to be less effective on very aged and deteriorated pigment samples, since it is difficult to gather reliable and strong spectra clearly presenting the compositional analysis of the pigments. Another disadvantage is the "sample fluorescencing" due to the florescent molecules and impurities within the samples reacting with the signal detection and therefore causing ineffective scatter detection (Smith 2007, 65).

Although optical microscopy is considered destructive and less technical than Raman spectroscopy, during this research it became clear that PLM provided more conclusive and reliable results and it was less time consuming and less expensive than Raman spectroscopy.

For this research Dr Sonal Brown, previously from the Chemistry Department at University College London analysed the selected pigment/painted plaster samples with my assistance, using Raman Spectroscopy. She recorded the Raman spectra of all raw samples at room temperature with a Renishaw Raman Microscope System 1000 equipped with an 1800 line/mm grating and a He-Ne laser operating at 632.8 nm (Brown 2009, *pers.comm.*) in order to:

1) Identify the nature of pigments (inorganic, organic, mixed).

2) To compare the quality of the results with those obtained by PLM and suggest, if necessary, a different methodology towards future sampling and analysis.

Raman spectra of selected samples were recorded with a Renishaw InVia Raman microscope system equipped with a 1200 lines mm^{-1} grating and a diode laser operating at 785 nm. The laser beam on sample was focused using a x20 or a x50 objective. All the measurements on red pigments were carried out at low laser power (≤ 0.4 mW) to avoid phase transitions due to laser heating. Furthermore all the measurements were first started at low laser power (0.25 mW) and slowly increased. 514 nm and 325 nm lasers with appropriate gratings were also used to avoid fluorescence (Brown 2009, *pers.comm*). However, the outcome was not different than the 632.8nm laser presented.

3.3.6 Gas Chromatography–Mass Spectrometry (GC-MS)

Gas chromatography–Mass spectrometry (GC-MS) is an instrumental technique comprising a gas chromatograph (GC) coupled to a mass spectrometer (MS), by which complex mixtures of chemicals may be separated, identified and quantified. This makes it ideal for the analysis of the complex mixtures of compounds, mainly organic residues, proteins and lipids typically present in archaeological samples (Stacey 2014, *pers.comm*., Evershed *et al*. 1990, 1339-1342, Robinson *et al*. 1987, 637-644).

In order for a compound to be analysed by GC-MS it must be sufficiently volatile and thermally stable. Samples are usually analyzed as organic solutions consequently materials of interest need to be solvent extracted and the extract subjected to various 'wet chemical' techniques before GC-MS analysis is possible.

Chemical analysis of possible organic binders for this study was attempted by using Gas chromatography–Mass spectrometry equipment at the British Museum by Dr Rebecca Stacey from the Department of Conservation and Scientific Research. An Agilent AS7683 auto sampler was used for the introduction of 1 µl painted plaster samples in order to identify any possibility of organic binding media which may have contained traces of lipids, protein and sugar.

The sample solution is injected into the GC inlet where it is vaporized and swept onto a chromatographic column by the carrier gas (usually helium). The sample flows through the column and the compounds comprising the mixture of interest are separated by virtue of their relative interaction with the coating of the column (stationary phase) and the carrier gas (mobile phase). The latter part of the column passes through a heated transfer line and ends at the entrance to the ion source where compounds eluting from the column are converted to ions. Two potential methods exist for ion production, the most frequently used method is electron ionisation (EI) and the less used alternative is chemical ionisation (CI). The GC-MS equipment at the British Museum used the El method. For EI a beam of electrons ionise the sample molecules resulting in the loss of one electron. A molecule with one electron missing is called the molecular ion and is represented by M+ (a radical cation). When the resulting peak from this ion is seen in a mass spectrum, it gives the molecular weight of the compound. Due to the large amount of energy imparted to the molecular ion it usually fragments producing further smaller ions with characteristic relative abundances that provide a 'fingerprint' for that molecular structure. This information may be then used to identify compounds of interest and help elucidate the structure of unknown components of mixtures. Once ionised a small positive is used to repel the ions out of the ionisation chamber (www.bris.ac.uk/nerclsmsf/techniques/gcms.html, 29.04.2014).

The next component is a mass analyser (filter), which separates the positively charged ions according to various mass related properties depending upon the analyser used. Several types of analyser exist; quadrupoles, ion traps, magnetic sector, time-of-flight, radio frequency, and cyclotron resonance. The GC-MS equipment at the British Museum had a quadrupole. After the ions are separated they enter a detector the output from which is amplified to boost the signal. The detector sends information to a computer that records all of the data produced, converts the electrical impulses into visual displays and the output is displayed as a ‘total ion chromatogram’ which shows the components of the sample and their relative abundance from which the unique mass spectrum for each component can be extracted (Stacey 2014 “*pers.comm*”).

Finally the data interpretation is achieved as the compound identities are determined according to their GC retention time and mass spectral identity based on comparative published/library database spectra and/or analysis of standards (Stacey 2014 “*pers.comm*”).

3.3.7 Colour identification

In addition to the analytical techniques described above readily available Munsell soil colour charts were used to identify the different shades of red colour on painted plasters. The Munsell colour system characterizes colours under three colour dimensions: hue, value (lightness) and chroma (color purity). It was developed by Albert H. Munsell in the beginning of the 20th century and adopted as the main colour identification system for soil research in the 1930s. Munsell system separated the colours into hue, value, and chroma for the first time and systematically presented the colours in three-dimensional space.

The use of the Munsell soil colour chart was suggested by my supervisors due to its availability and simple use. It is also commonly used in the field of archaeology for identifying soil colours. Although it provided a basic definition for the different tones of red pigment used on the paintings this information is subjective of my visual interpretation of the colours. However, I do think that it is not possible to achieve true colour measurements and find the actual tones on these very old and deteriorated red colours even by using the more high-tech instruments, i.e. colour spectrophotometers.

3.4 Conclusion

This chapter examined the wall painting materials, firstly from the preservation point of view, since the condition of the material is vastly affected by its archaeological environment. The state of preservation also plays an important role on the sample selection and preparation as well as on choosing the right analytical techniques. Both the former and the latter complement each other greatly. It is not possible to retrieve conclusive results from analysis without the correct sample preparation. The selection of the right analytical instrument for studying the material is also crucial to achieve an efficient study in terms of the results taken and the time/cost/labor related matters. Investigating the various analytical techniques applied on the wall paintings (prehistoric or later) so far, helped to understand the most suitable methods for studying the Çatalhöyük wall paintings. The following chapter will present the results of the analysis on the painted plaster and pigment samples by using the analytical methods described in this chapter.

Chapter 4

The Results of the Instrumental Analysis of the Çatalhöyük Wall Painting Materials

Following the detailed explanation of the designed methodology and analytical techniques used for this research in Chapters 1 and 3, Chapter 4 presents the results gathered from the material analysis. As mentioned in Chapter 1 (Section 1.6.3.4.) archaeological samples collected during this research did not provide sufficient information to set up an initial experimental phase to support the development of an analytical methodology. Therefore the analytical study was firstly set up to extract more information from the samples, i.e. the nature of individual materials, or the possible application techniques and tools. The information retrieved was then applied into the experimental set up (Chapter 5) wherever possible (the samples did not always provide reliable results or in some cases no information could be extracted from the samples). By employing both analytical and experimental studies it became possible to investigate the practicality of any information retrieved via the former, i.e. the possible application methods and tools, and where no analytical answers could be available, i.e. how individual materials would react with each other, the latter would be a useful tool to explore these areas.

Section 4.1 summarizes the analytical methodology of this study, Sections 4.2 and 4.3 talk about the macroscopic and microscopic study results respectively. The result of these analyses are then sectioned by the specific area of study/material, i.e. painted plasters, pigments, possible painting tools and techniques, organic binders and the possible ground stone painting tool kits.

4.1 The Brief Summary of the Analytical Methodology

As explained in Chapter 3 the painted plaster and pigment samples (see Appendices 11-26 for some examples of the painted plasters and pigments) were examined at both a microscopic and macroscopic scale. The latter helped significantly in both designing the sampling strategy and the analytical work programme. The use of a simple optical stereomicroscope, combined with the polarized (PLM) and reflected light microscopes

(RLM), with x100, x400 and x630 magnification was crucial in the study. These techniques greatly aided in the identification of minerals and other components in the plaster matrices, the pigments and pigment mixtures as well as the application methods and their outcomes were supported by the use of further instrumental techniques such as scanning electron microscopy (SEM-EDAX) and Raman spectroscopy. Before PLM was used for the painted plaster/pigment analysis the raw painted plaster and pigment samples were first studied both by the naked eye and under stereomicroscopy (x100, x200, x400) in order to understand the nature of the painted surfaces. A Leitz Orthoplan Polarised microscope at x400 and x1000 (oil) was used to analyse the pigments, mounted as grain dispersions in MeltMount™ (RI = 1.68) on glass microscope slides. This analysis was followed by using a Renishaw Raman Microscope System 1000 equipped with an 1800 line/mm grating and a He- Ne laser operating at 632.8 nm, to further confirm identification of the pigments used. For the painted plaster analysis Philips XL-30 ESEM (EDAX) and Hitachi S3400N SEM (EDAX) were used to study the painted plaster fabrics as well as the painted surfaces in higher magnifications (>x50 was aimed however on some samples <x50 had to be used). During the analytical process microscopic images of the pigments and painted plaster fabrics were taken either under x100 or x400 magnification. All photographs and microphotographs used in this chapter are taken by myself (unless stated otherwise).

4.1.1 Macroscopic Study Results

4.1.1.1 Paint colour and the nature of the paint layers

One of the most distinctive features of the painted plaster samples was the different shades of red used (Figs.32, 33, 34). Even though the nature of the red colour might have changed due to the long-term burial and post-excavation conditions, the variety of shades was still identifiable and ranged from orange red to brown red. While red was the most common colour on painted plasters, yellow and black were also found.

Fig.32 Red painted plaster (light), CH01/Bach/U.8203/S5.

Fig.33 Red painted plaster (dark), CH99/South/U.5315/S7.

Fig.34 Red painted plaster (orange/red), CH99/South/U.5325/S6.

4.1.1.2 Number of paint layers

Macroscopic observations showed that there was more than one paint layer on some painted plaster samples. However, it was difficult to count or investigate these layers due to the effects of long-term burial, surface erosion and deterioration. Therefore a microscopic study was pursued on cross and thin-section samples in order to understand the nature of these paint layers under high magnification and in relation to the matrix of the plaster material.

4.1.1.3 Application of paint layer on plaster material

It was possible to observe by naked eye that some paint layers had been applied onto white, fine layered plaster material, whilst others had been applied onto pale brown, coarser layers. In order to understand if there is any evidence of a pattern throughout the site and to investigate the nature of these applications, a microscopic study was undertaken on cross and thin section samples.

4.1.1.4 Nature of the plaster material and plaster layers

The nature of the plaster materials used at Çatalhöyük has already been studied (Mathews 2005a,b, Doherty 2006, 2007, 2008, Tung 2008, Wiles 2008). One of the main questions asked during this research was if true (burnt) lime plaster was used for the production of wall paintings, supported by the evidence of some early wall plasters with burnished red and yellow ochre surfaces that were found in the South Area at the base of the Space 181 sequence (Pre-level XII). These were recorded as being "very hard" textured (see Chapter 3, Section 3.2.1) and were considered true lime plasters by Matthews (2005a, 129).

Fig.35 A multi layered plaster with white and pale brown layers, CH01/Bach/U.8203/S5.

Fig.36 A single layered plaster with harder texture,
CH99/South/U.5325/S6.

Macroscopic observations helped to define that there were two different types of painted plasters: 1) Softer textured/multi layered with fine (wash) and coarser (base) layers, 2) Harder textured/single layered (Figs. 35, 36). Due to the level of deterioration further microscopic analysis was pursued to investigate whether there was any evidence of true lime plasters in the context of wall paintings, the nature of the plaster matrices and layers.

4.1.1.5 Application tools and possible techniques

During the macroscopic study some of the painted plaster surfaces and stone tools were observed to have distinctive striations or scratch marks (Fig. 37). In order to understand the nature of these marks and if they were related to the possible painting tools, i.e. animal hair brushes, cloth, skin, bone tools, wooden sticks, stone tools or to any surface

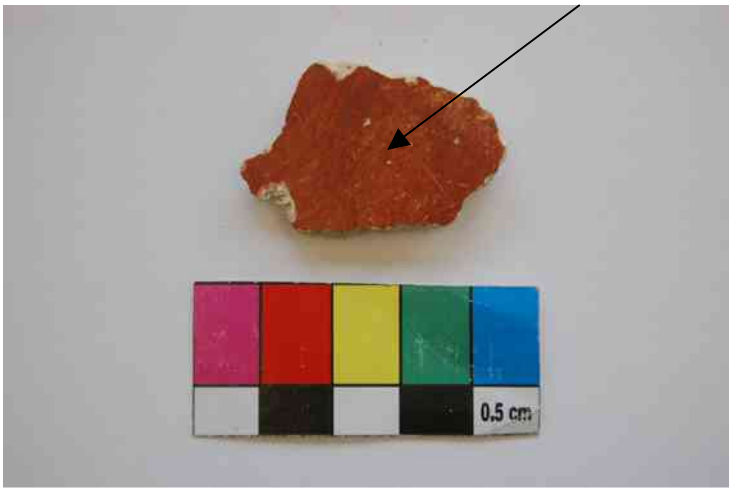


Fig.37 Red painted plaster with striations on the surface,
CH99/South/U.5294/S6.

deterioration/artificial damage, high magnification surface imaging with SEM (EDAX) was undertaken.

4.1.2 Microscopic Study Results

The results explained in this section derived from the study of the raw painted plaster samples, cross-sections, thin-sections and pigment dispersion samples by stereomicroscopy, polarised light microscopy (PLM), reflected light microscopy (RLM), scanning electron microscopy (SEM-EDAX), Raman spectroscopy and via image analysis under SEM (EDAX).

4.1.2.1 Number of layers on painted plaster material

The painted plaster samples were divided into two groups in terms of their plaster application method: Multi layered and single layered application. Both forms consisted of either one or two types of plasters (Figs.38, 39).

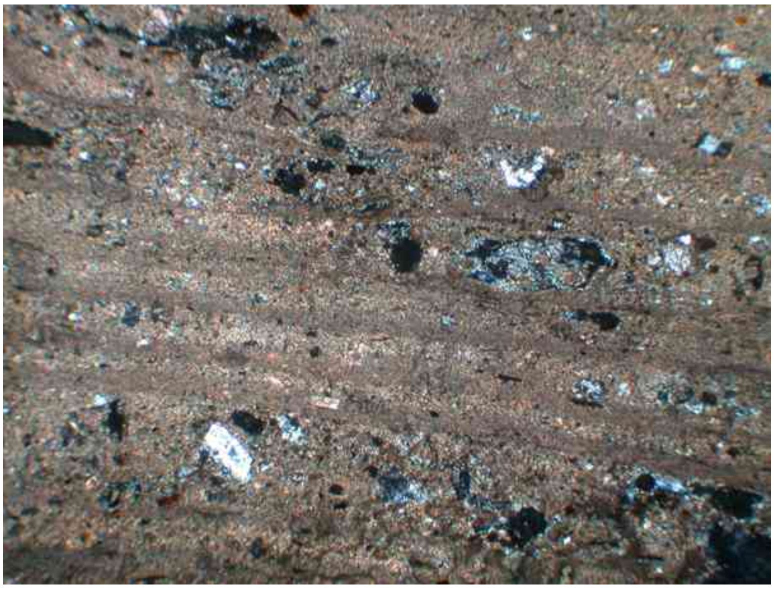


Fig.38. Multi layered plaster, CH06/4040/U.13669/S2 x400.

Fig.39 Single layered plaster with paint layer visible at the top of the section, CH99/South/U.5294/S6/x400.

4.1.2.2 Thickness of the layers on plaster material

Previous plaster analysis undertaken on the walls showed that each layer is between 200µm (white washes) and 5000µm (pale brown) (Mortimore 2004, 1180). However, due to preservation problems, it was difficult to take secure measurements from the layers on multi-layered plasters selected for this research. In most cases the layers had either lost their true thicknesses or were completely eroded into the plaster matrices. Nevertheless, the microscopic measurements taken on the well-preserved layers confirmed Matthews's work and indicated that the finely applied layers were generally less than 1000µm in thickness whilst the coarser layers could be 1000µm or more (Fig.38).

4.1.2.3 Nature of the plaster materials and plaster layers

The types of plaster materials and inclusions within the plaster matrices were identified by studying the thin-section samples both under PLM and SEM (EDAX). The most distinctive mineral inclusions and the nature of fabrics, i.e. silty/sandy with plant inclusions, were recorded in order to gain a general idea about the nature of plaster materials used for the paintings as well as to understand their possible sources.

4.1.2.4 Identification of pigments

The pigment samples taken both from wall paintings and consolidated masses of pigments were identified under PLM and Raman spectroscopy. The main colours used, the colour mixtures and the nature of pigment processing were recorded.

4.1.2.5 Application of paint layers

The long-term burial, surface erosion and deterioration made it difficult to observe the nature of application and the number of pigment layers on raw samples. However the cross-sections and thin sections of the painted plaster samples enabled to identify the layers clearly.

4.1.2.6 Thickness of paint layers

Like the previous point the thickness of the pigment layers has been affected by the state of preservation. However the rough measurement under x100 magnification shows that the pigment layers were in general around 500µm thick or thinner.

4.1.2.7 Particle size of pigments

The particle size varies within the samples. Even though the pigment particles were clustered together in most samples and therefore it was difficult to measure the individual particle size, the measurements of the largest and the smallest particles were taken in order to gain a general idea about the level of pigment preparation and application.

4.1.2.8 Paint application tools and possible techniques

Following the macroscopic examination both with the naked eye and stereomicroscopy, the raw painted plaster samples, as well as selected stone tools with possible tool marks were examined under SEM (EDAX) in order to determine the use of tools and possible application techniques. High magnification surface images were taken (>X50) and compared with modern painted plaster samples made during the experimental work.

4.2 Identification of Painted Plasters and Pigments used at Çatalhöyük

The analysis of painted plasters and pigment samples under RLM, PLM, Raman spectroscopy and SEM (EDAX) provided qualitative and semi quantitative mineral identification of materials and enabled the understanding of the type of plasters and pigments used for wall paintings production, as well as how the use of these materials was distributed throughout the site.

4.2.1 Plaster materials

Before examining the nature of the painted plaster materials, it is important to re-emphasise what I mean by “plaster” in terms of the Çatalhöyük wall paintings. As explained in Chapter 2 Section 2.3, the material that covered the mudbrick walls of the houses was analysed to be a naturally available product called “marl” (clay based and rich in calcium carbonate content). Marl would have been mixed with water to achieve either a slurry or a putty like product for covering the walls. Other materials were also mentioned by Matthews (2005a,b), i.e. soft lime and burnt (true) lime (Chapter 2, Sections 2.1, 2.3 and 2.4). The analysis undertaken for this research aimed to clarify the nature of this “wall covering” material particularly in relation to the paintings, and to identify if there is only one type or the varieties present different chemical and physical properties.

Table 4.1 below and Table 4.2 (in Appendix 10) show the typology of painted plasters available on the site (cross and thin-section analysis under PLM). Five possible types of plaster material were identified in relation to the painted surfaces. These types seem to have silty and/or sandy fabrics in general and all of them contain mineral inclusions and rock fragments derived from the Çarsamba and May rivers (see Chapter 2, Section 2.3) with inclusion sizes between 10µm-3000µm (x100). The elemental analyses results of the SEM (EDAX) analysis and the percentage distribution of individual elements within the plaster matrices can be seen in Appendices 27-202. Fig.40 presents the percentage distribution of the plaster types sampled.

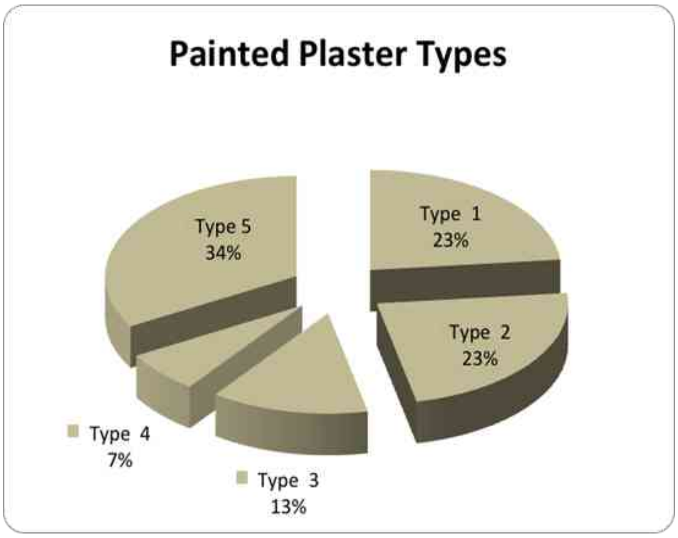


Fig.40 The percentage distribution of the plaster types.

Plaster Type	Texture	Colour under naked eye	Colour under optical microscopy	Structure	Inclusions	Plant material (Base)	Paint layers
1	Fine,silty	Pale brown	Brown	Multi-layered?	Sparse	Rich	One or more
2	Fine, silty	Pale brown and white layers	Brown	Multi-layered	Moderate	Rich	One or more
3	Fine, silty / Coarse, sandy	Pale brown	Brown	Multi or Two-layered?	Moderate to rich	Moderate	One or more?
4	Coarse, sandy	Brown	Bright brown	Single-layered	Rich	None	One
5	Fine, silty	White	Yellowish grey	Single-layered	Sparse	None	One

Table 4.1 The summary of the five forms of painted plaster identified under PLM via cross and thin-section analysis.

The details of these five plaster types are explained below:

4.2.1.1 Type 1

Type 1 consists of fine, silty, mottled/brown (10YR 6/3 pale brown, Munsell Soil Colour Chart, 2000) texture under optical microscopy. The colour is pale brown under the naked eye. It is not very clear if it is non-layered or the layers have diffused into the fabric. Its optical activity is variable, ranging between weak to moderate. It is generally sparse in inclusions and mainly has small quantities of feldspar, plagioclase feldspar, quartz, hornblende, *Unio sp.* shells, mica, gypsum, calcite and iron oxide particles (all generally subangular). In some cases there are a few fragments of sandstone, pitchstone?, andasite (rounded) and sparite (crystalline lime stone). Calcium levels in these plasters were measured by SEM (EDAX) to be less than 50% (40-46%). This type of plasters presents either one or multiple paint layers. The rich evidence of planar voids indicates the inclusion of plant materials in the plaster matrix. The inclusion size ranges between 20-750μm (x100) (Figs.41, 42, 43, 44). Type 1 painted plasters cover 23% of the available plaster types within the samples analysed and are mainly found between Levels IX and IV/South K, O, 4040 G, BACH G and are evident all throughout the site, South (B.2, B.17, B.79), 4040 (B.1, B.49) and BACH (B.3). However, as mentioned above, it is not clear that these types of plasters were multi layered or not, due to the level of deterioration/erosion which they present. Since they have the same fabric as Type 2 (see below) it may be possible that Type 1 and Type 2 are the same type of plaster.

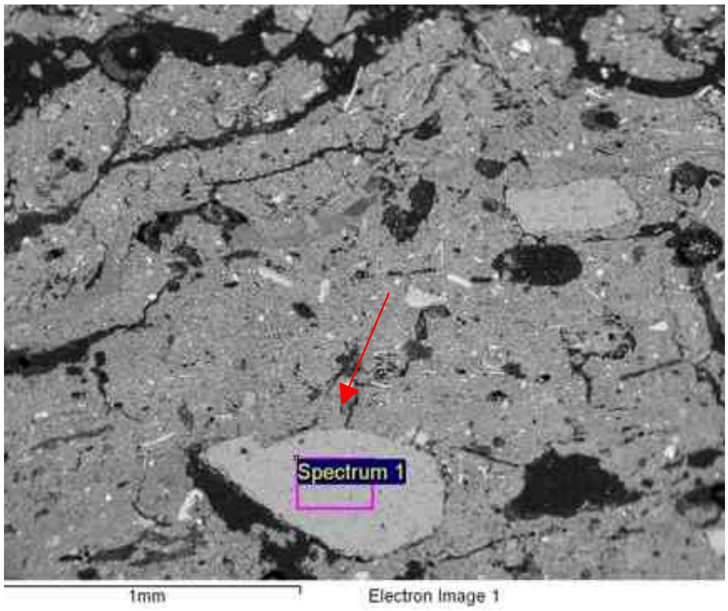


Fig. 41 SEM (EDAX) image of a Type 1 painted plaster, CH98/Bach/U.8203/S3, presenting quartz.

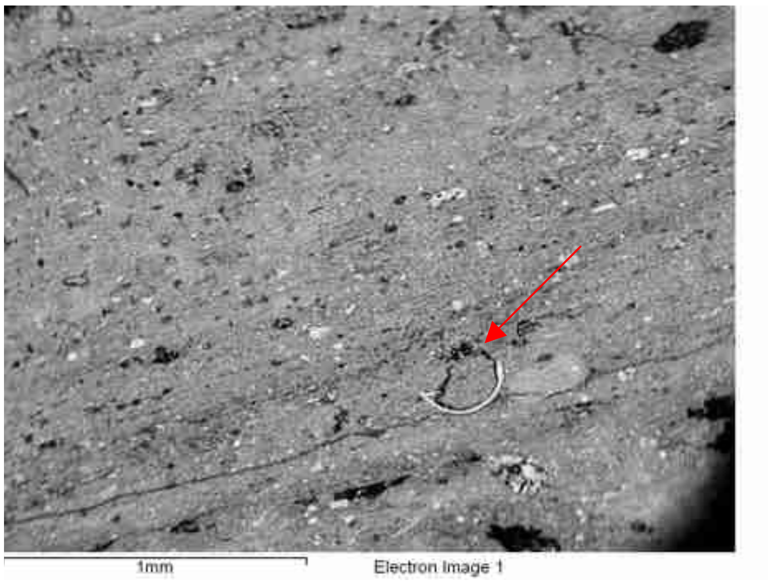


Fig. 42 SEM (EDAX) image of a Type 1 painted plaster, CH04/South/U.5383/X3, presenting an *Unio sp*. Shell.

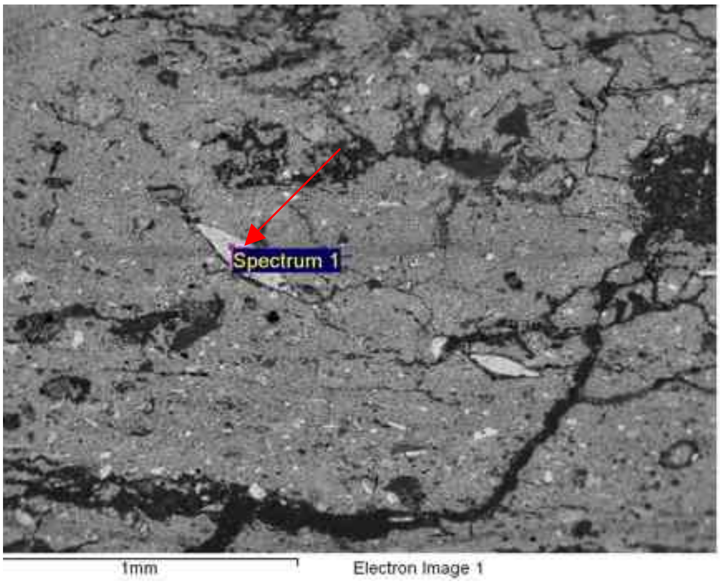


Fig. 43 SEM (EDAX) image of a Type 1 painted plaster, CH96/North/U.1309/X1,2, presenting fish shaped gypsum inclusions.

Fig.44 Feldspar and hornblende inclusions in Type 1 plaster, thin section image by PLM, CH96/North/U.1309/X1,2, x100.

4.2.1.2 Type 2

The same as Type 1, Type 2 consists of fine, silty, mottled/brown (10YR 6/3 pale brown, Munsell Soil Colour Chart, 2000) texture under optical microscopy. The colour is pale brown under naked eye. The main difference between Type 1 and 2 is that the latter is non-homogeneous with clearly defined multiple layers of pure white wash "soft lime" and impure pale brown "marl" in different thicknesses (soft washes are <1000µm, pale brown marl layers 1000µm or more, x100). Thinner, soft lime layers are finer/silty with only a few inclusions whilst thicker (pale brown) marl layers are mottled/sandier with more clusts and inclusions. Its optical activity is variable, ranging between weak and moderately. It is generally moderate to rich in inclusions and mainly has feldspar, plagioclase feldspar, quartz, hornblende (brown/green), *Unio sp.* shells, mica, gypsum, calcite and iron oxide particles (all generally angular to subangular). In some cases there

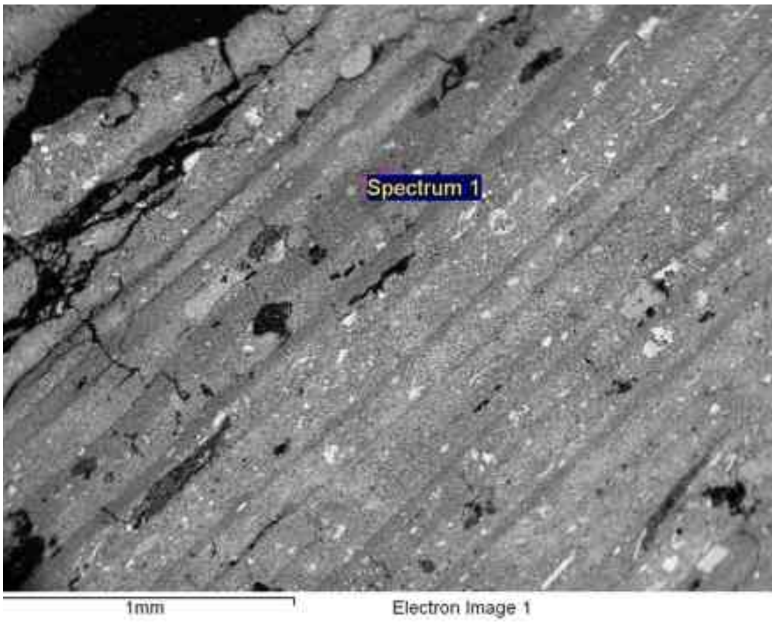


Fig.45 SEM (EDAX) image of a multi layered structured Type 2 plaster with finer and coarser plasters and the inclusions of shells, CH05/4040/U.10349/S7

are a few fragments of sandstone, andasite, piemontite (generally subangular to subrounded) and micritic lime stone (rounded). Type 2 plasters have calcium levels of less than 50% both in finer, soft lime and coarser marl layers (30-45%). Moreover, soft lime wash layers present around 20-30% magnesium content which is an indication of them having a dolomitic nature. The inclusion size ranges between 30-1000µm (x100). Similar to Type 1 this type present either one or multiple paint layers and the rich evidence of planar voids indicates the inclusion of plant materials in the plaster matrix (Figs.45-50).

This type of painted plasters are mainly found between Levels VII and III/4040 G, H, I/South O, P, M/BACH G, evident all throughout the site, South (B.8, B.75, B.79), 4040 (B.49, B.55) and BACH (B.3). Coincidentally, they also consist of 23% of the total number of the painted plaster samples.

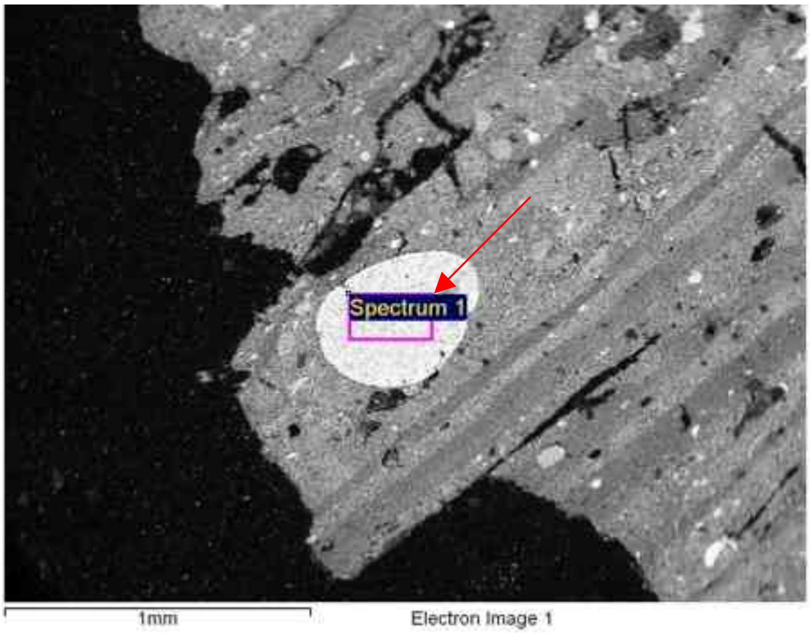


Fig.46 SEM (EDAX) image of a Type 2 plaster, CH05/4040/U.10349/S7 with a calcite inclusion derived from the river.

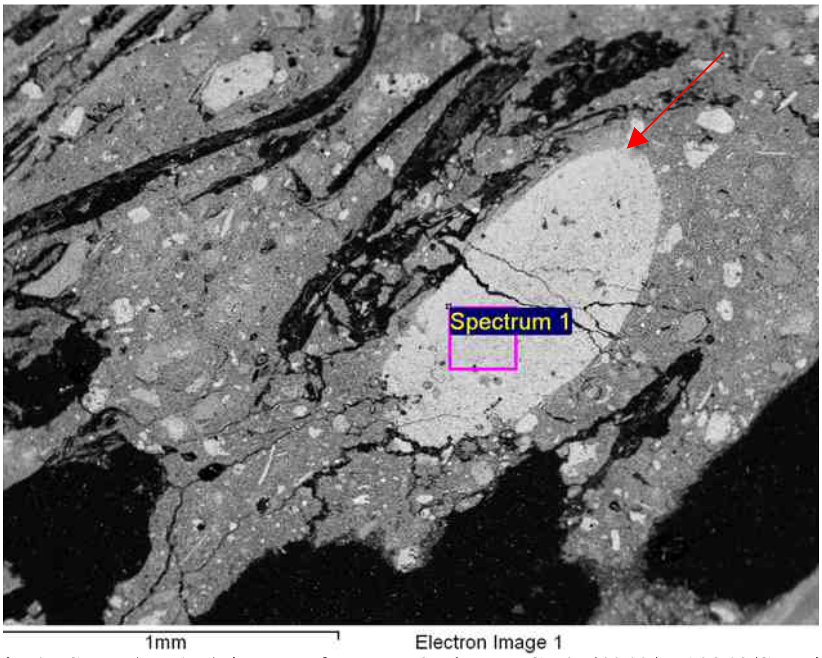


Fig.47 SEM (EDAX) image of a Type 2 plaster, CH05/4040/U.10349/S7 with a rounded micritic lime stone inclusion.

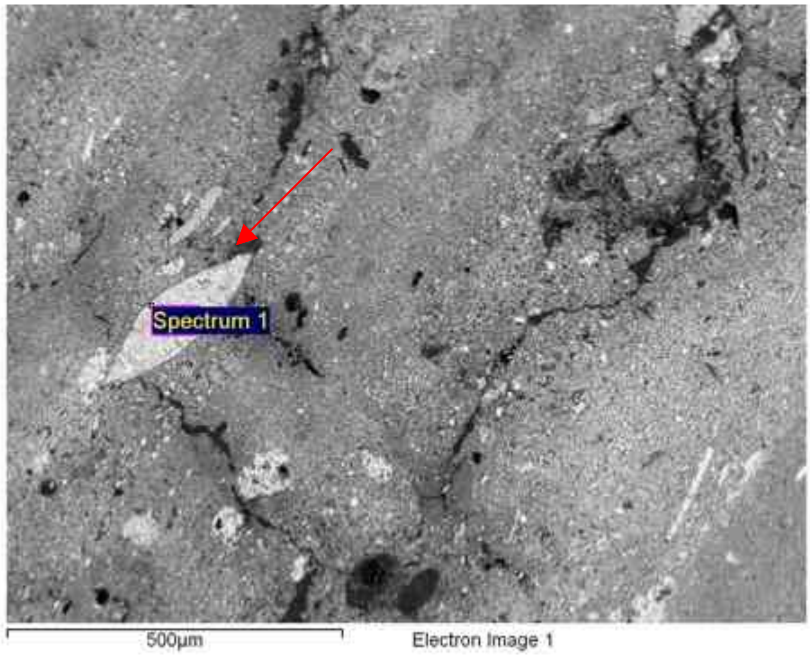


Fig.48 SEM (EDAX) image of a Type 2 plaster, CH06/4040/U.13669/S2 with a fish shaped gypsum inclusion.

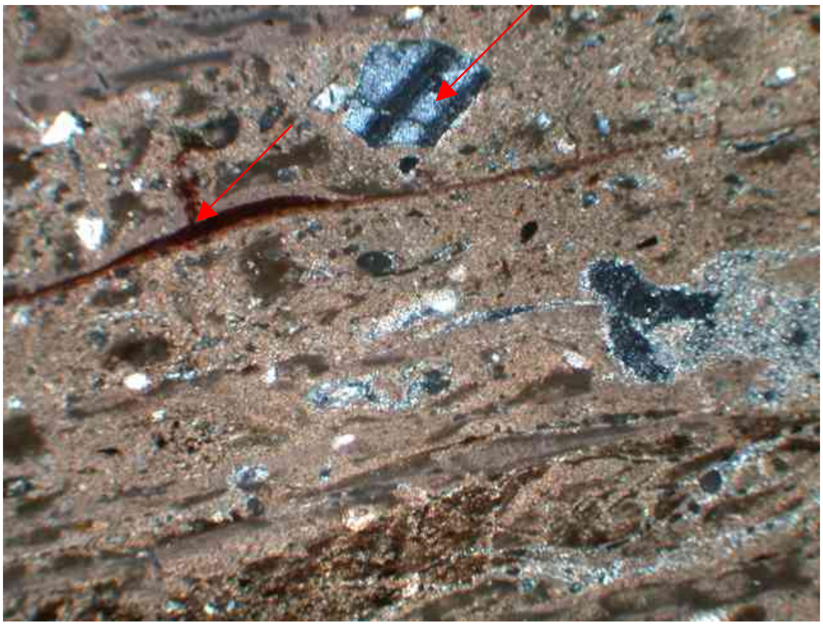


Fig.49 A thin section image of Type 2 plaster by PLM, CH05/4040/U.10349/S7, with plagioclase feldspar inclusion and a pigment layer, x400.

Fig.50 A thin section image of Type 2 plaster by PLM, CH01/Bach/U.8226/S3 with green hornblende inclusion, x400.

4.2.1.3 Type 3

Like Types 1 and 2 this type is silty and sandy with a non-homogeneous texture. The distinction between the silty and sandy parts is clear in some samples, almost composing two separate layers. Under optical microscopy there is an upper layer of brown (under naked eye 10YR 6/3 pale brown, Munsell Soil Colour Chart, 2000), fine, mottled, silty fabric with fewer clusts and inclusions, followed by a bright brown lower layer formed by the clay rich, sandy, mottled/coarser fabric with bright coloured clasts and inclusions (which may have resulted in the bright brown colour), indicating that this is impure marl plaster. In some samples the coarser/sandy parts are distributed throughout the fabric rather than as a clearly divided layer. Like Type 1, there seems to be some diffused layering in the silty part but it is not really clear. It is generally moderate to rich in inclusions and mainly has feldspar, quartz, hornblende (brown/green), cherts, *Unio sp.* shells, mica and iron oxide particles (all generally angular to subangular). In some cases there are a few fragments of andasite, sparite (crystalline lime stone) and devitrified obsidian (generally rounded to subrounded). Calcium levels in Type 3 plasters are less than 50% both in silty and sandy layers, being particularly low in the coarser sandy layers, i.e. <20%. This type has either one or multiple paint layers. The moderate evidence of planar voids indicates fewer inclusions of plant materials in the plaster matrix as compared to Types 1 and 2. The inclusion size ranges between 30-3000μm in coarser, sandy layers (x100), and between 10-650μm in finer, silty layers (Figs. 51, 52, 53).

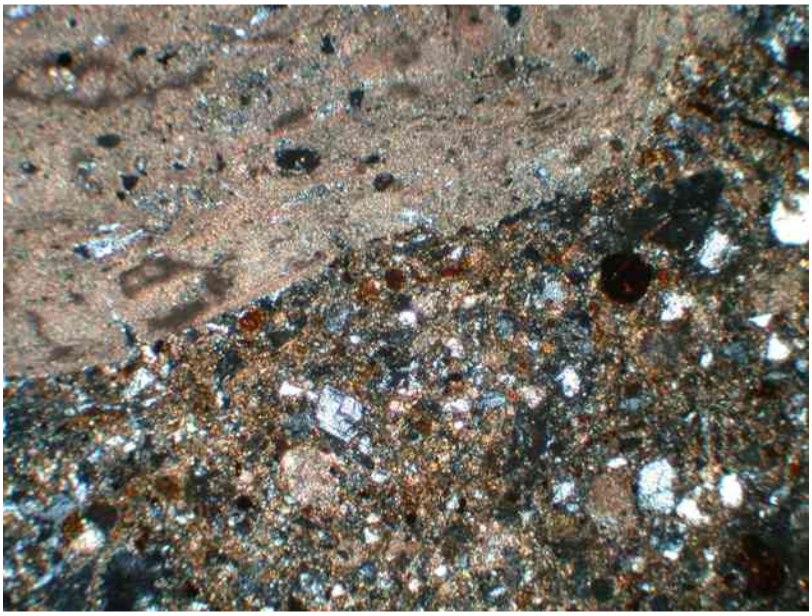


Fig.51 A thin section image of Type 3 plaster by PLM, CH06/4040/U.13481/S3, showing the finer and coarser layers, x400.

Type 3 painted plasters cover 13% of the painted plaster samples collected and are mainly seen between Levels VII and III/4040 G-H and evident only in the 4040 area (B.49, B.55, B.59).

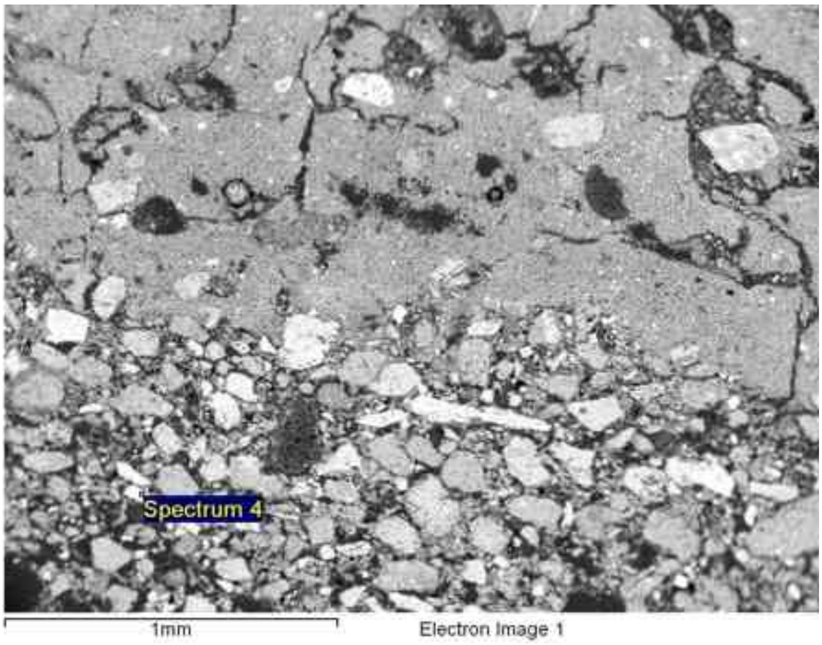


Fig.52 SEM (EDAX) image of a Type 3 plaster, CH08/4040/U.17494/S3, showing the finer and coarser layers together.

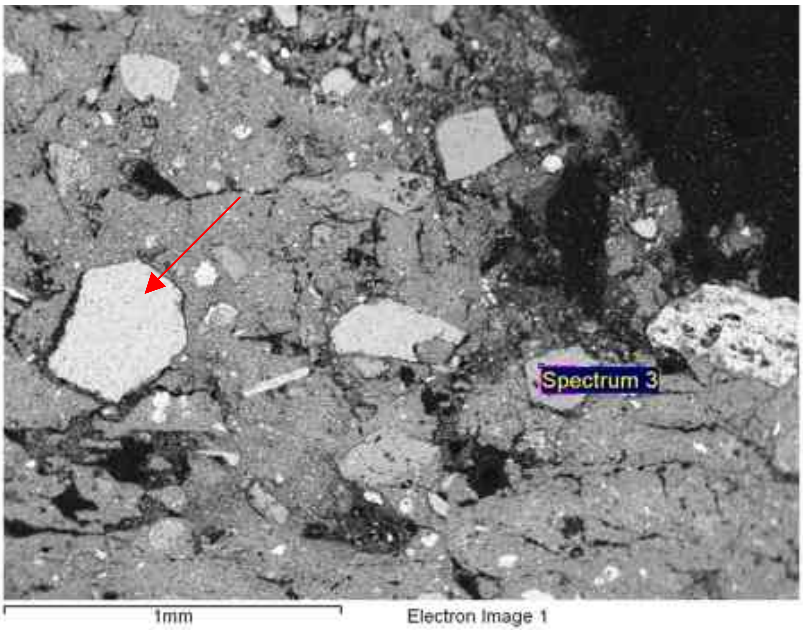


Fig.53 SEM (EDAX) image of a Type 3 plaster, CH05/4040/U.12313/S1, showing a potassium feldspar (indicated with a red arrow) and quartz inclusions.

4.2.1.4 Type 4

Different to Types 1, 2 and 3 this group consists of coarse, homogeneous texture with no layering. Under optical microscopy it has bright brown, sandy, mottled fabric that is rich in bright coloured clasts and inclusions (which may have resulted in the bright brown colour) indicating that this is impure marl plaster. The colour is brown under the naked eye. It is optically very active. It mainly has feldspar, quartz, hornblende (brown/green), volcanic lithic fragments and iron oxide particles (all generally angular, subangular to subrounded). Calcium levels in this plaster type are measured to be less than 20%. This group of plasters has only one paint layer. No evidence of planar voids indicates that the inclusion of plant materials might not have existed in the plaster matrix. The inclusion size ranges between 30-1300µm (x100). (Figs.54, 55, 56).

This type of painted plaster seems to be very rare (only 4%) and mainly seen in Pre-Level XII /South G (Space 181) and in Levels III/South R (B.56), evident only in the South area.

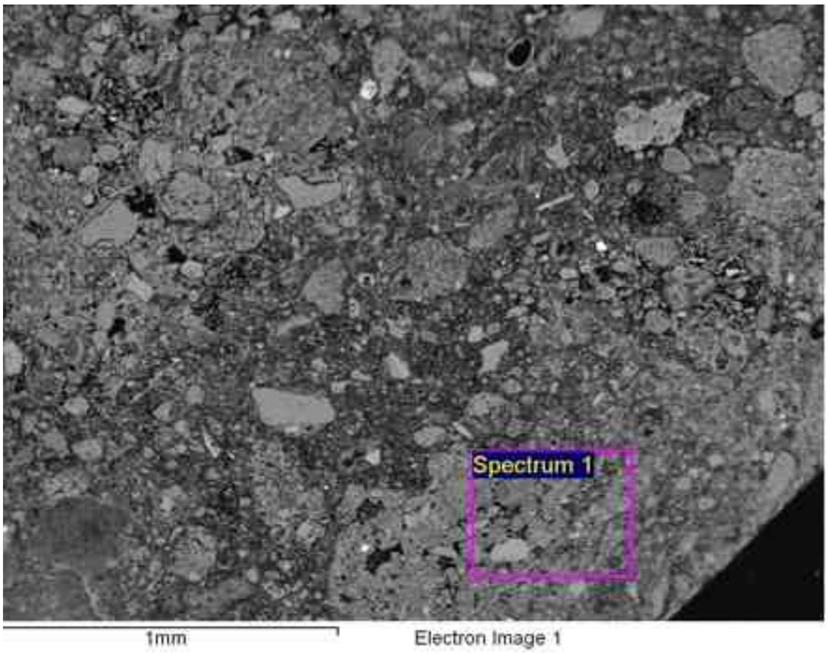


Fig.54 SEM (EDAX) image of a Type 4 plaster, CH99/South/U.5328/S13.

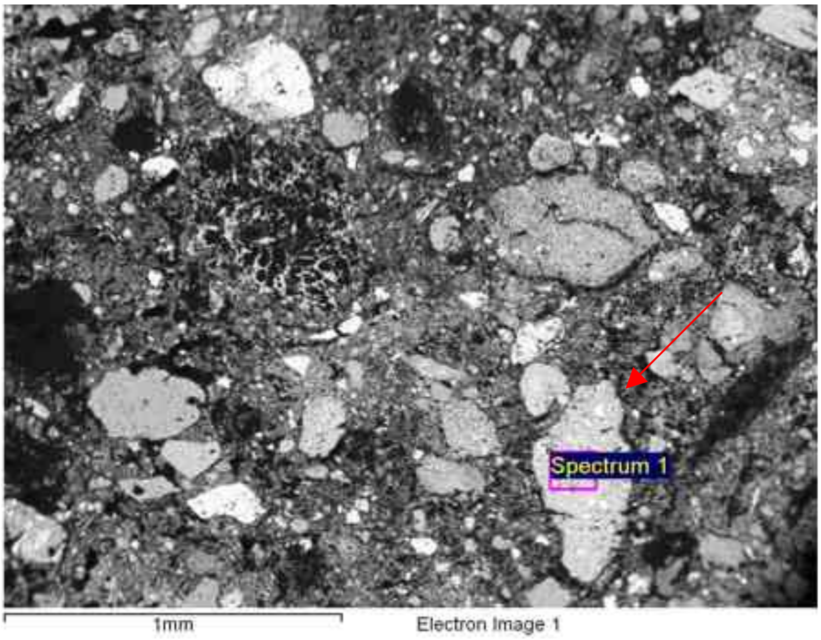


Fig.55 SEM (EDAX) image of a Type 4 plaster, CH06/South/U.13352/S22 showing a volcanic lithic fragment.

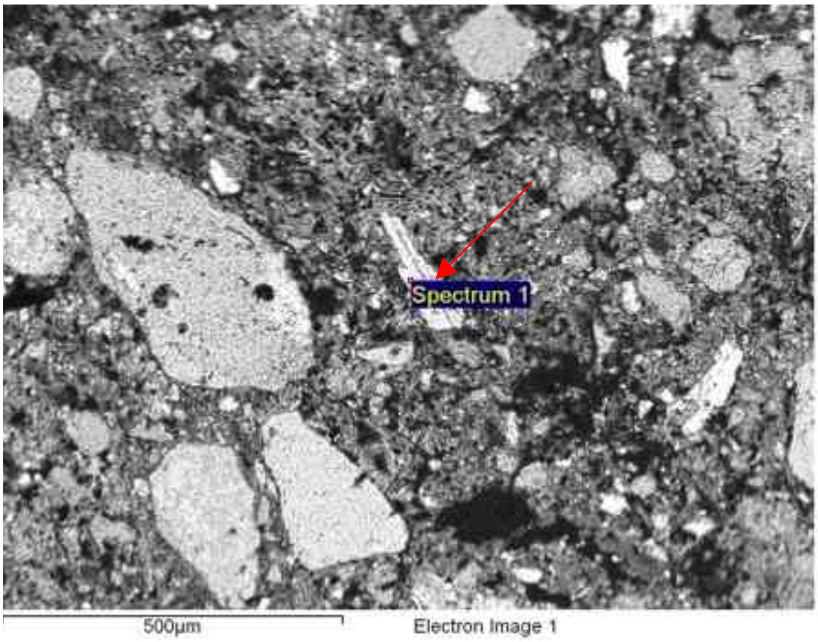


Fig.56 SEM (EDAX) image of a Type 4 plaster, CH06/South/U.13352/S22 showing a hornblende inclusion.

4.2.1.5 Type 5

Different from all the types explained above, Type 5 consists of fine, homogeneous texture with no layering. It looks “white” under the naked eye, but has a greyish white colour with a yellow hue under optical microscopy (5Y 7/2 light grey, Munsell Soil Colour Chart, 2000). It has a mottled, speckled fabric with fewer clasts and inclusions. Its optical activity is moderate. It mainly has large marl particles (subrounded), feldspar, plagioclase feldspar, quartz, hornblende (brown/green), *Unio sp.* shells, cherts, calcite, carbonates and iron oxide particles (all generally subangular to subrounded). In some cases there are medium and large particles of andasite, sandstone and micritic limestone (generally subangular to subrounded). Calcium levels in Type 5 plasters are more than 50%, at around 80-87%. There are some fragments of painted plaster material mixed with the fabric and this is present only in this group. This may indicate that old wall painting fragments might have been used as aggregates (recycled) during the preparation of plaster grounds for the later wall paintings (also see Matthews 2005b, 366). Like Type 4 this type also has only one paint layer. Very sparse evidence of planar voids indicates that the inclusion of plant materials might not have existed in the plaster matrix. The inclusion size ranges between 20-2200µm (x100) (Figs.57-66). This white plaster material seems to be different from the white “soft lime” washes used in Type 2 plasters. Soft lime washes being dolomitic, contain around 20-30% magnesium and less than 50% calcium. Type 5 painted plasters contain either none or very little magnesium, i.e. <5%, indicating that they are marl.

This type of painted plasters seems to be very common (34%) and was used particularly in Pre-Level XII/South G (Sp.181), Level X/South J (B.23), Level IX/South K (B.17), Level VIII/South L (B.43) and only evident in the South area.

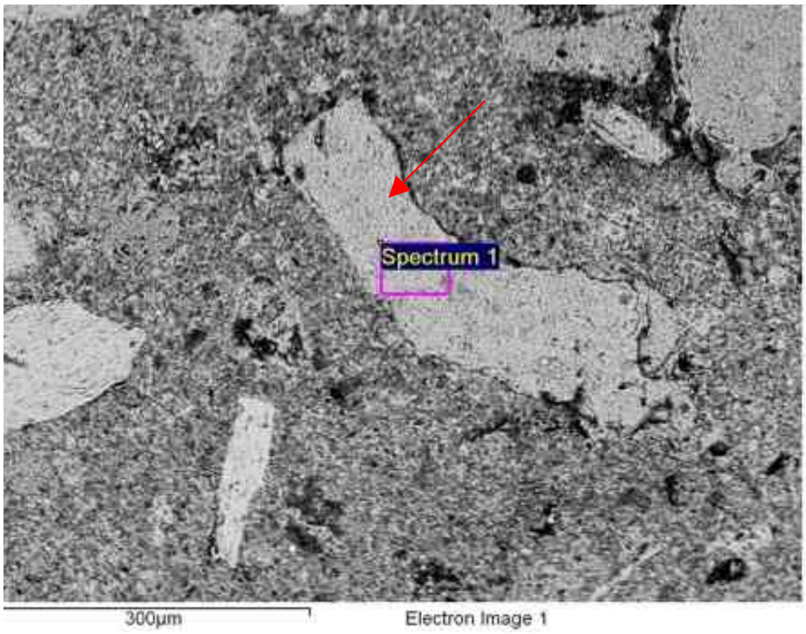


Fig.57 SEM (EDAX) image of a Type 5 plaster, CH99/South/U.5325/S6 showing a feldspar inclusion.

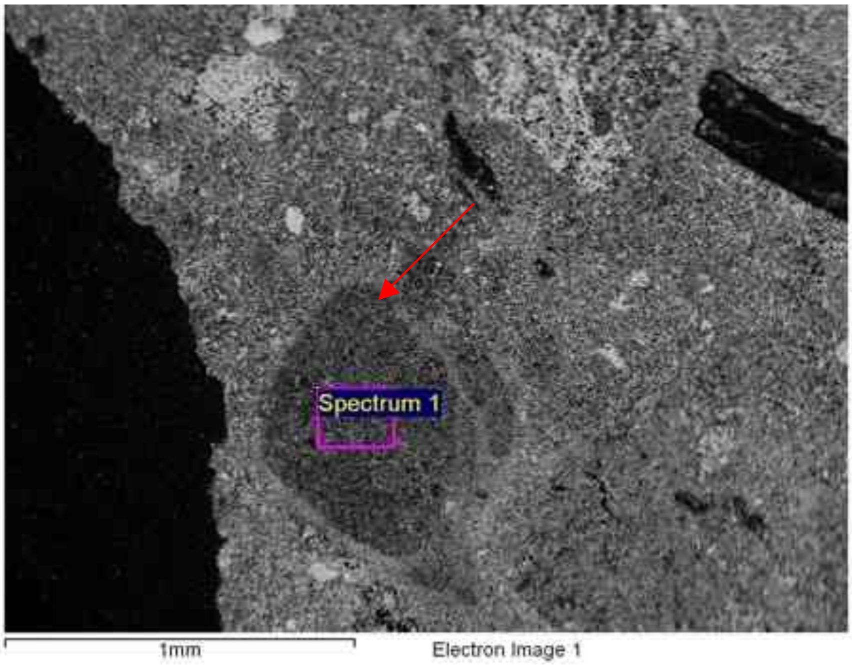


Fig.58 SEM (EDAX) image of a Type 5 plaster, CH99/South/U.5273/S2 showing a carbonate inclusion.

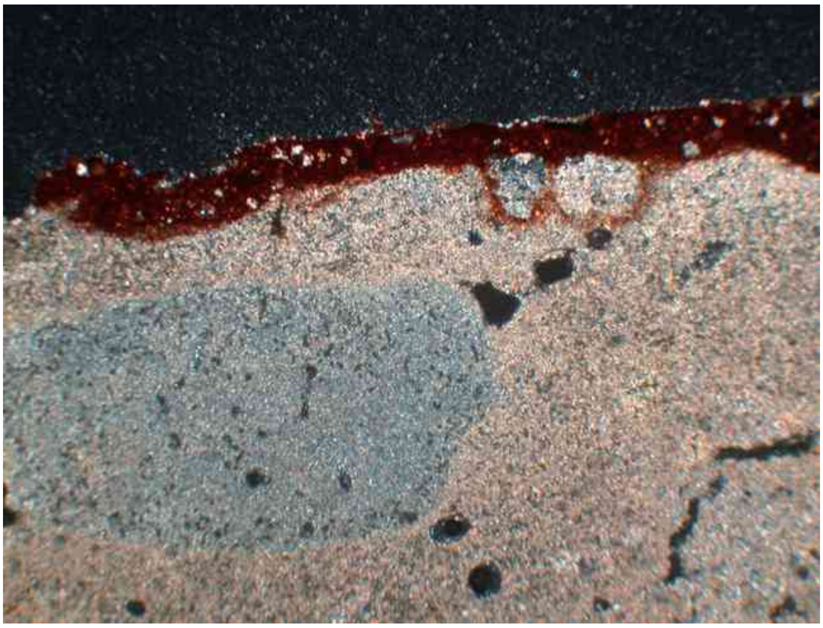


Fig.59 A thin section image of a Type 5 plaster by PLM, CH99/South/U.4629/S1 showing the single layered fine plaster with the red pigment layer above, x400.

Fig.60 A thin section image of a Type 5 plaster by PLM, CH99/South/U.5273/S2 showing an evidence of recycled painted plaster fragment being used as added inclusions, x400.

Fig.61 A thin section image of a Type 5 plaster by PLM, CH99/South/U.5273/S2 showing an evidence of recycled painted plaster fragment being used as added inclusions, x100.

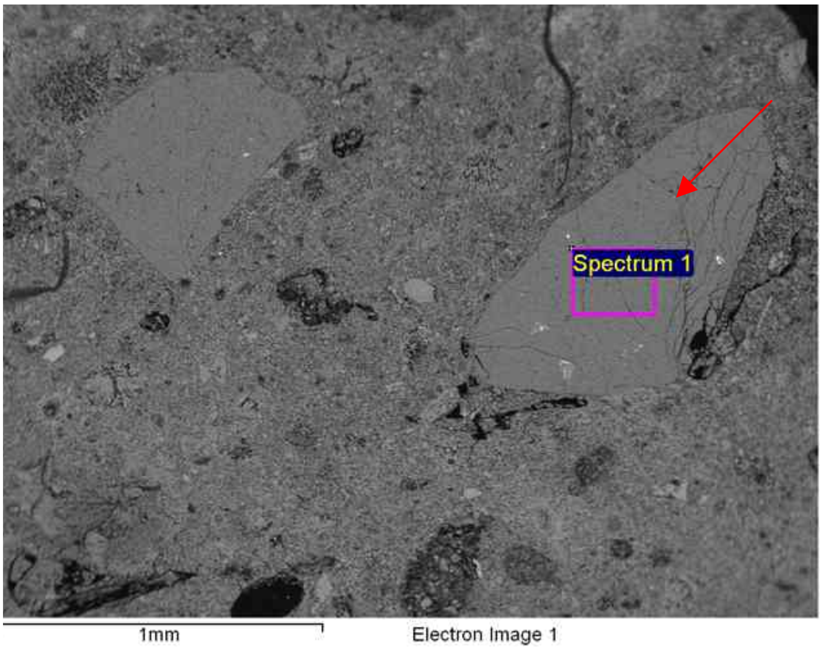


Fig.62 SEM (EDAX) image of a Type 5 plaster, CH99/SouthU.5315/S7 showing quartz inclusion.

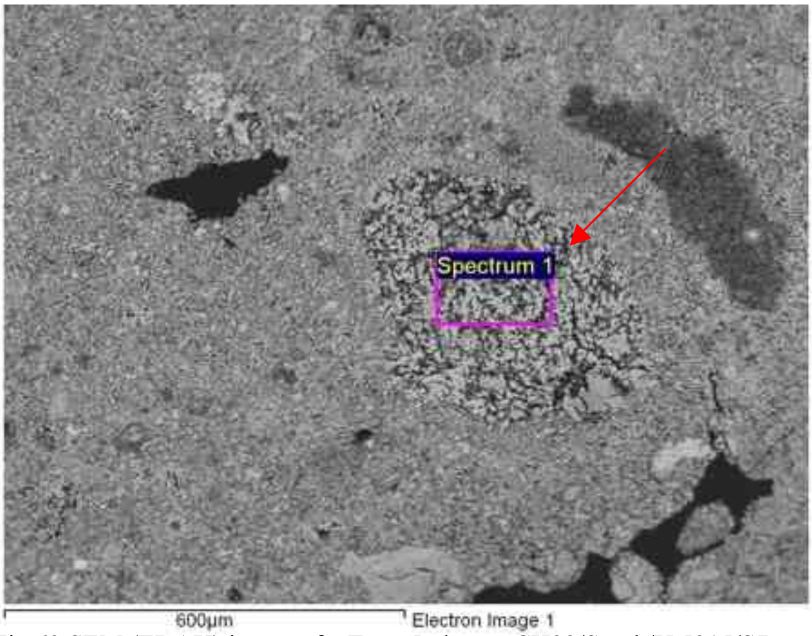


Fig.63 SEM (EDAX) image of a Type 5 plaster, CH99/South/U.5315/S7 showing a cherty limestone inclusion.

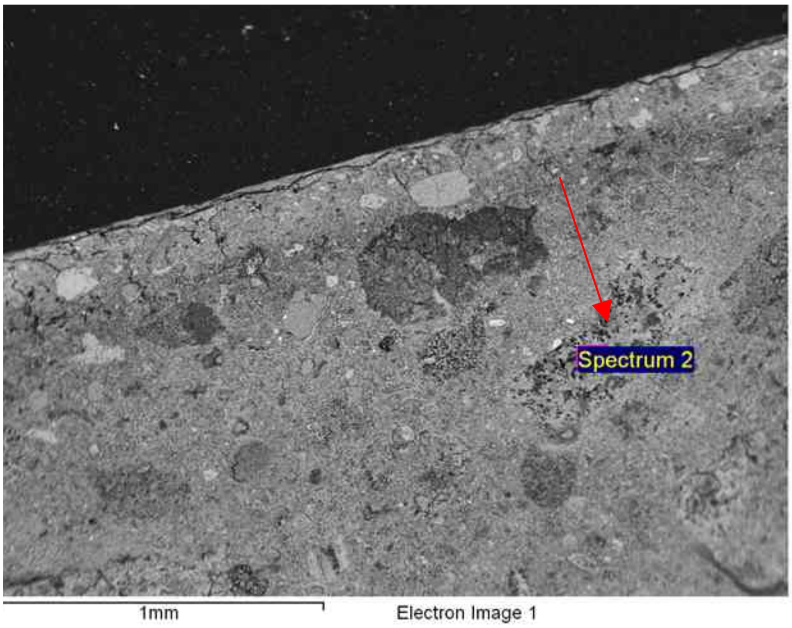


Fig.64 SEM (EDAX) image of a Type 5 plaster, CH99/South/U.5315/S7 showing possible clay inclusions.

Fig.65 A thin section image of a Type 5 plaster by PLM, CH99/South/U.4844/S3 showing an evidence of recycled painted plaster fragment being used as added inclusion, x400.

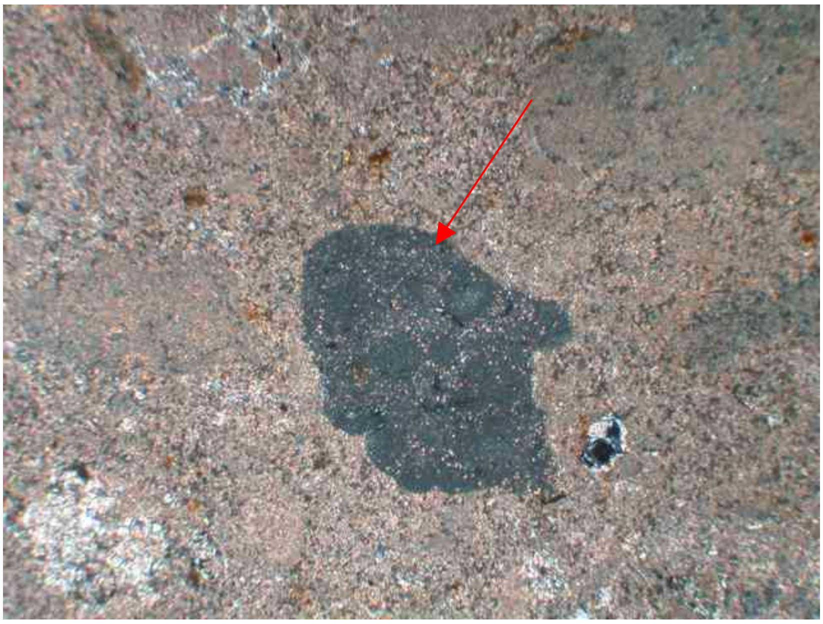


Fig.66 A thin section image of a Type 5 plaster by PLM, CH99/South/U.5294/S6 showing an andesite inclusion, x400.

4.2.2 Pigments

Red, yellow, blue, green and black pigments were found at Çatalhöyük (see Appendices 203-217). The pigments from both wall paintings and from consolidated masses of pigments were examined using PLM and Raman Spectroscopy. The aim of applying these combined methodologies to the analysis of pigments is as follows:

1) The classification of different shades may be related to a single mineral phase or a mixture of mineral phases. This may be observed using PLM, and the compositions of individual phases may be confirmed using Raman microspectroscopy.

2) Analysis under PLM of the particle size and shape can provide evidence of pigment processing.

3) The application method of pigments can be examined on surfaces at a macroscale using both PLM and RLM. Tables 4.3 and 4.4 present the results of the pigments analysed.

Colour	**Colour ID**	**Shades**	**Particle shape**	**Particle size (x100)**	**Location**
Red	Red ochre (Haematite, Fe_2O_3)	Light orangey red, dark orangey red, dark red, dark browny red **(see below for Munsell soil chart references for the different shades**)	Subangular to subrounded	8µm-100µm	Wall paintings/ burials, midden, fills
Red	Cinnabar (HgS)	None	Angular to subangular	5µm-100µm	Wall paintings/ burials
Yellow	Yellow ochre (Goethite (FeO[OH])	None	Subangular to subrounded	2µm-300µm	Middens, fills
Blue	Azurite ($Cu_3[CO_3]_2[OH]_2$)	Bright/dark blue	Angular	1µm-200µm	Burials
Green	Malachite ($Cu_2[CO_3][OH]_2$)	None	Angular	20µm-200µm	Burials
Black	Carbon/bone black	Black/brown	none	10µm-80µm	Wall paintings

Table 4.3 The summary of colours at Çatalhöyük
(also see Appendix 2 – Table 4.4 for the detailed analysis of the pigments found at Çatalhöyük).

Results of the analyses are below:

4.2.2.1 Red

Microscopic examination using PLM and Raman spectroscopy indicates that the red pigments can be divided into two types of pigment 1) red ochre (the earthy form of iron oxide composed mainly of clay) and 2) cinnabar (mercury sulphide).

4.2.2.1.a Red 1

Fifty nine red pigment samples were analyzed and fifty six of them (66% of the total pigment samples) were found to be red ochre (red iron oxide, Fe_2O_3) (Figs.67-72). Under the PLM all red ochre particles seem to be finely ground, generally subangular to subrounded, and are mainly clay coated, earthy, with carbonate minerals possibly mixed in from the plasters, or from a particular red ochre source. Other minerals such as quartz, gypsum, feldspar are evident in some samples. PLM and Raman spectroscopy revealed that some red ochre samples contained both iron oxide haematite and iron oxide hydroxide types, lepidocrocite and/or goethite which enhanced the orange-red colour of the pigment. Whilst the nature of the particular haematite source might be the reason for the different shades of red ochre, this may also have been achieved by the preparation processes, i.e. fine grinding or mixing some yellow ochre into red ochre. By observing the different tones of red, it was possible to group the red ochre pigments according to their shades (by microscopic observation and Munsell Soil Colour Chart, 2000): dark browny red (dusky red, 10R 3/2), light orangey red (red, 10R, 5/8), dark red (10R 3/6), dark orangey red (dark red, 2.5YR, 3/6). Fig.67 shows the percentage distribution of the different shades of red ochre.

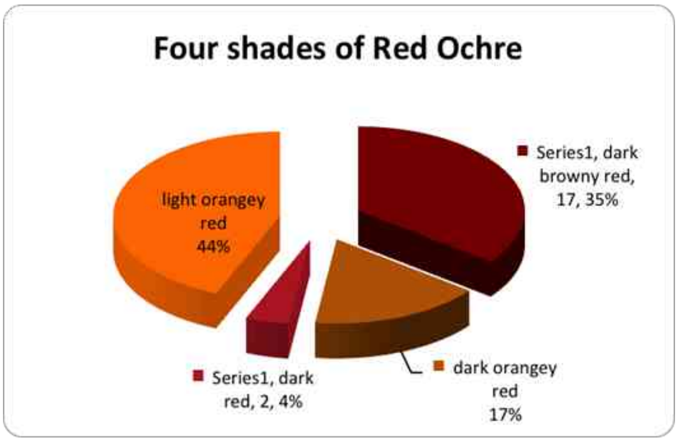


Fig.67 Four shades of red ochre and their percentage distribution.

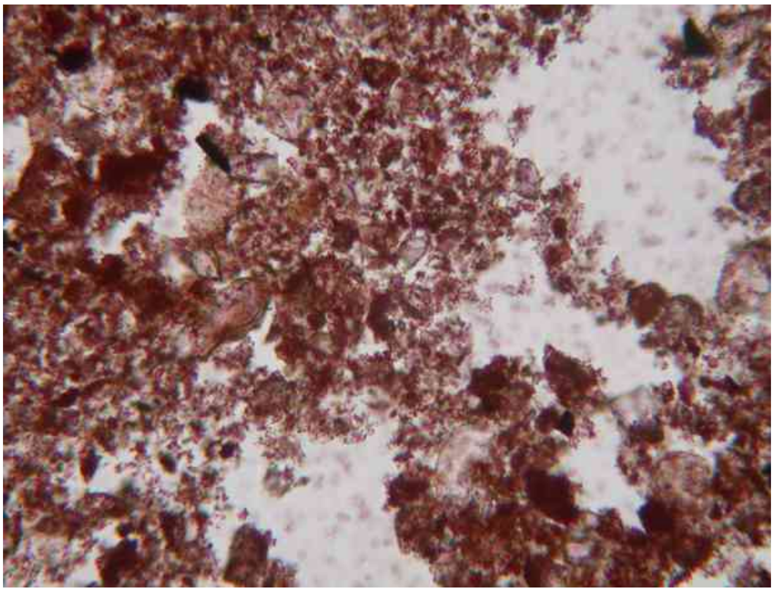


Fig.68 A PLM image of red ochre (dark red, 10R 3/6), CH05/4040/U.10396/S19, x400.

Red ochre is particularly common on wall paintings (sometimes mixed with cinnabar, see 2.2.1.b.) as well as in the burial contexts at Çatalhöyük from the earliest levels (Pre-level XII, from 7300 cal. BC) onwards. An important example of red ochre found in a burial context is the painted plaster skull U.11330, analysed by Dr Tristan Carter with portable X-Ray Fluorescence (PXRF) (Fig.69) (Carter 2009, 126).

Fig.69 Painted plastered skull CH04/South/U.11330.

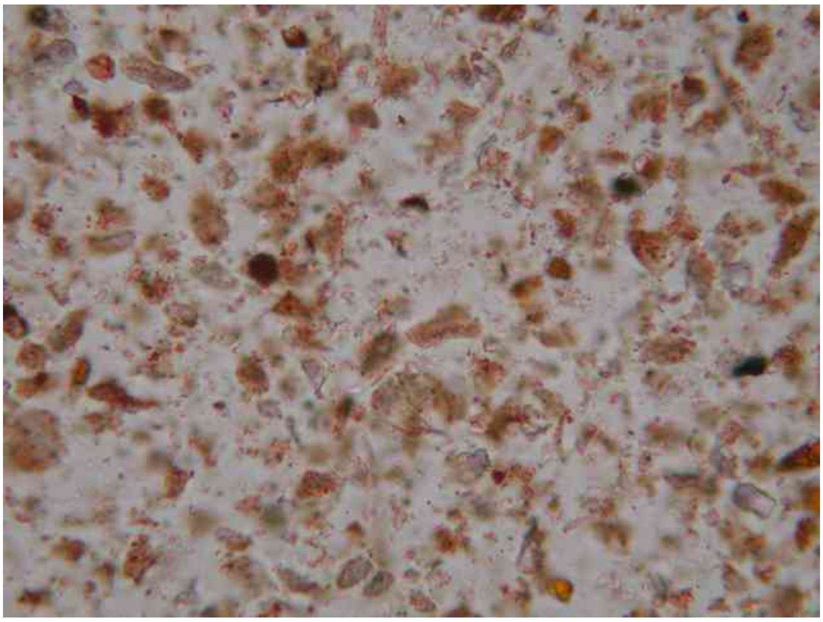


Fig.70 A PLM image of red ochre (lepidocrocite/goethite?, orangey red,10R, 5/8), CH99/South/U.5325/S19, x100.

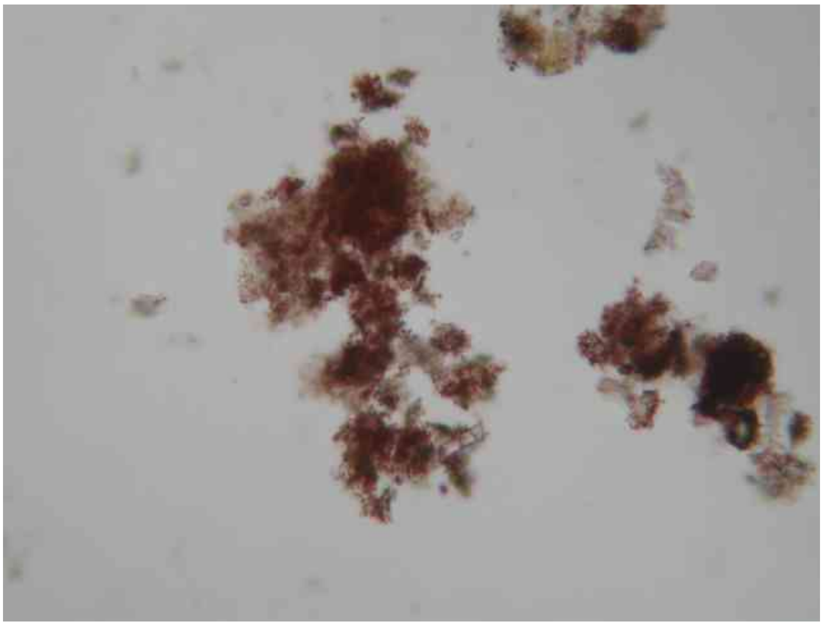


Fig.71 A PLM image of red ochre (dark orangey red, 2.5YR, 3/6), CH06/4040/U.13669/S2, x400.

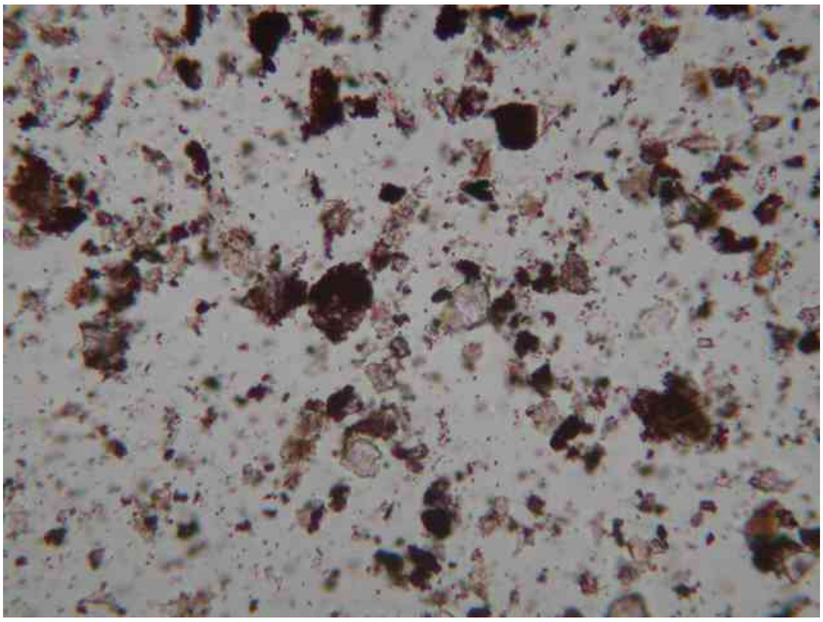


Fig.72 A PLM image of red ochre (dark browny red, 10R 3/2), CH09/South/U.17390/S4, x400.

4.2.2.1.b Red 2

Fifty nine red pigment samples were analyzed and three of them (4%) were found to be cinnabar (HgS) (Figs.73-78). Both under PLM and Raman cinnabar particles seem to be finely ground, very bright, vivid red and easily distinguishable from the red ochre particles. They are angular/subangular particles, clay coated with carbonate minerals possibly mixed in the plaster or from the particular cinnabar source. Other minerals such as quartz, gypsum or feldspar are evident in some samples. In one painting (CH06 4040 13669 in Building 49) Raman analysis detected that red ochre and cinnabar were used together as a mixture, which might indicate that cinnabar may have been added to red ochre to achieve a brighter red colour and/or to enhance the symbolic meaning. Also in B.49/Space 100 the different painting layers on wall 1661 (with geometric designs) were analysed to be painted either in red ochre or cinnabar. The evidence of cinnabar was also supported by the 1960's paintings by X-Ray Florescence (XRF) analysis undertaken by in the Ankara Anatolian Civilizations Museum (Zararsız *et al.* 2008).

It is not the earliest example of cinnabar use, since there is earlier evidence of cinnabar (possibly used in burial contexts and for trade) in Kfar HaHoresh in the Near East (Goring-Morris, Horwitz 2007, 914), however it may be the earliest use of cinnabar as a pigment in Anatolia. Both PLM and Raman analysis proved that cinnabar was used both on wall paintings and in burial contexts from Level VIII onwards (approx from 6700 cal. BC).

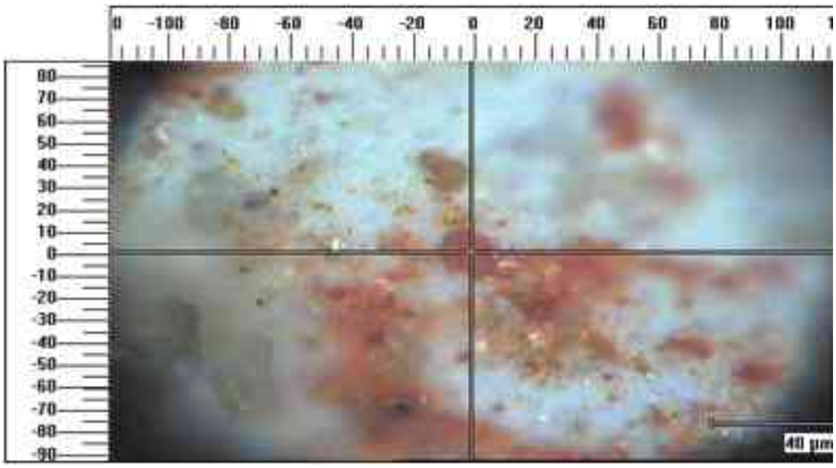
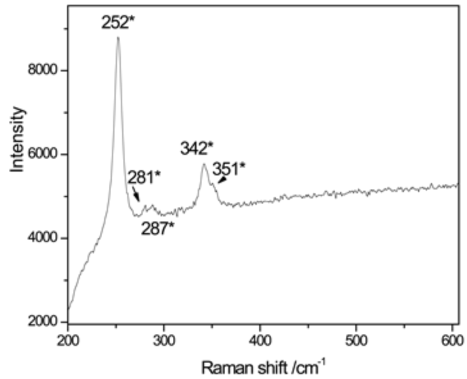


Fig.73 Raman analysis of cinnabar, CH06/4040/U.13453/S3 (Courtesy of Dr Sonal Brown).



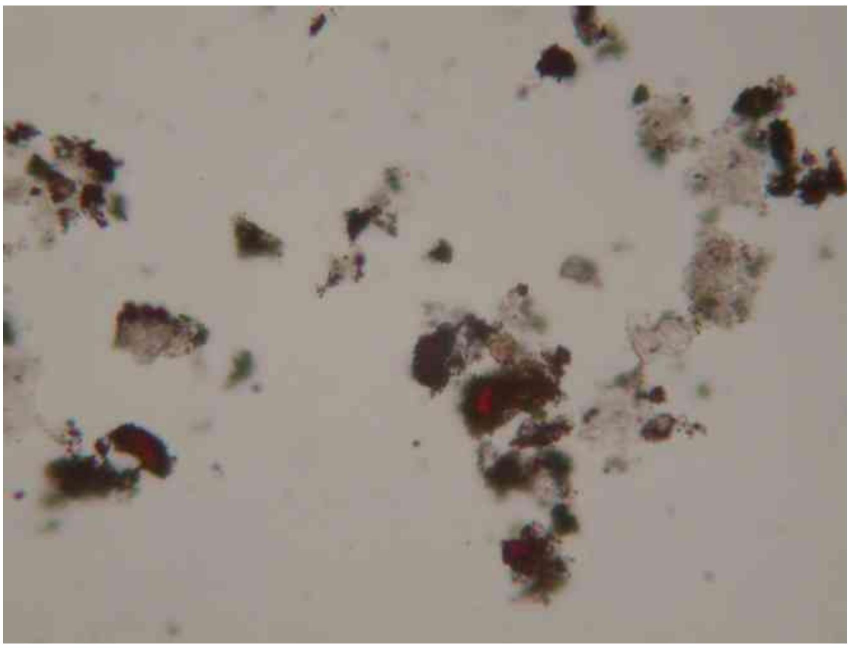


Fig.74 A PLM image of cinnabar, CH06/4040/U.13453/S3, x400.

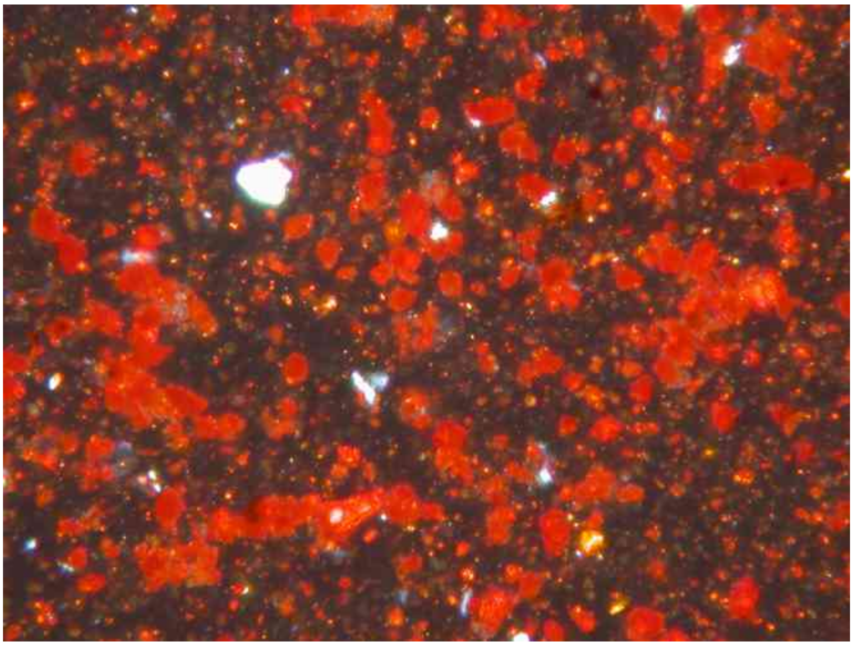


Fig.75 A PLM image of cinnabar, CH08/4040/U.17535/S1, x400. Under cross polarized light.

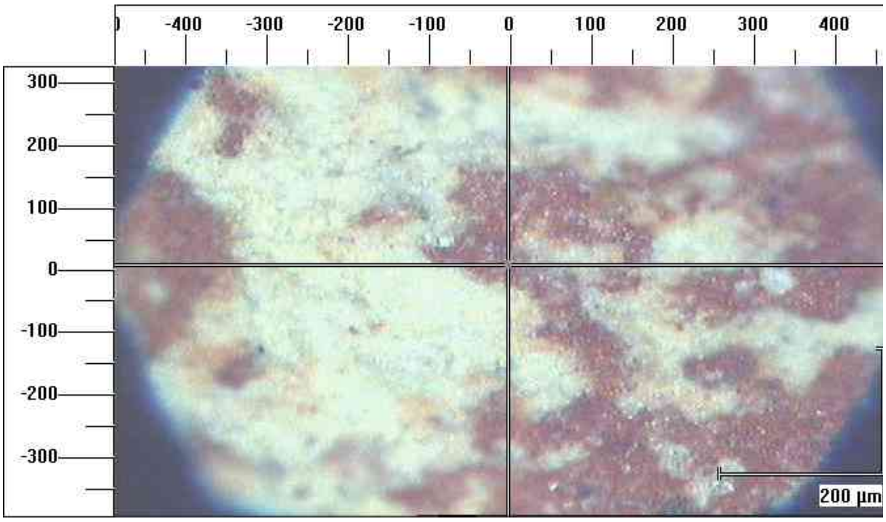
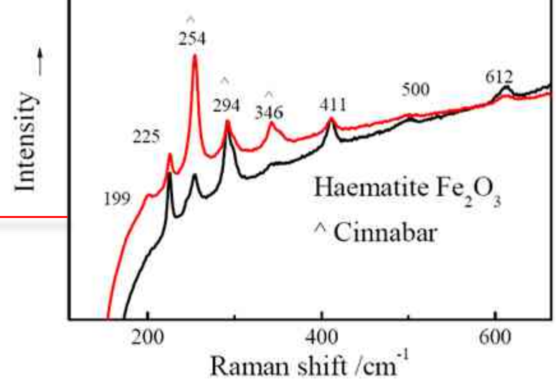


Fig.76 Raman analysis of cinnabar and haematite mixture, CH06/4040/U.13669/S2 (Courtesy of Dr Sonal Brown).

Raman spectra indicate the mixture of haematite and cinnabar peaks.



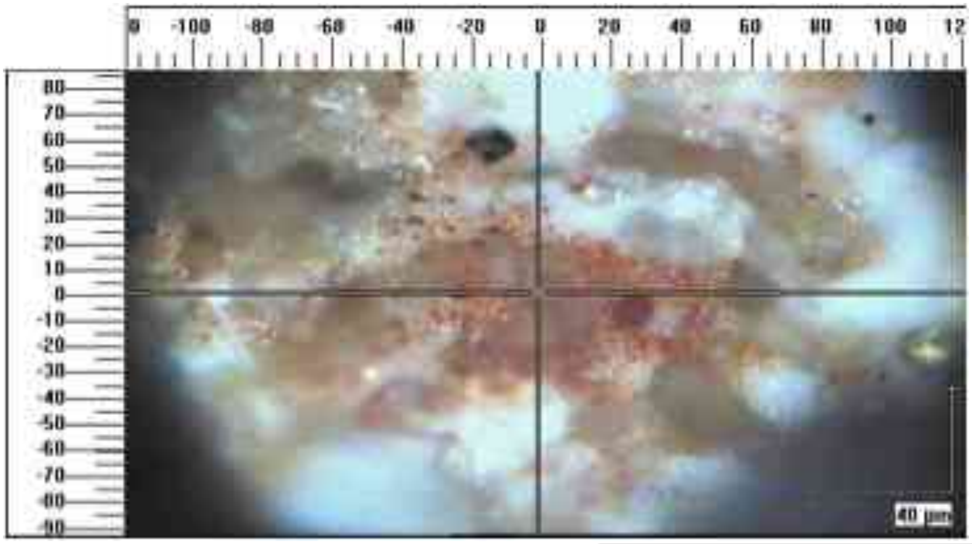
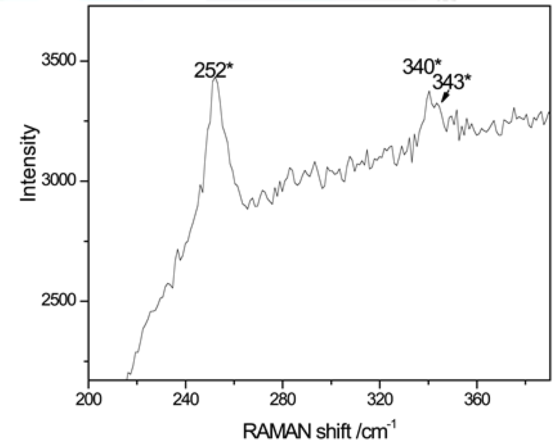


Fig.77 Raman analysis of cinnabar,
CH08/4040/U.16694/S1
(Courtesy of Dr Sonal Brown).



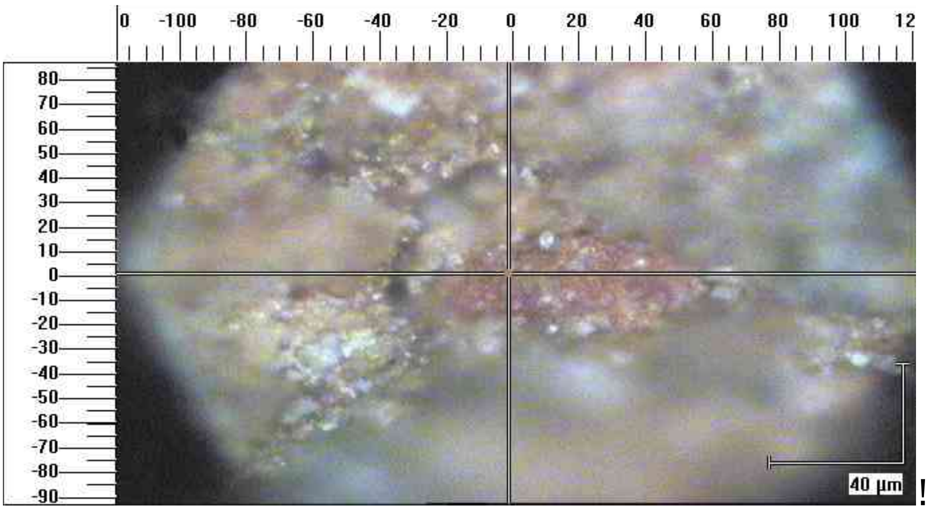
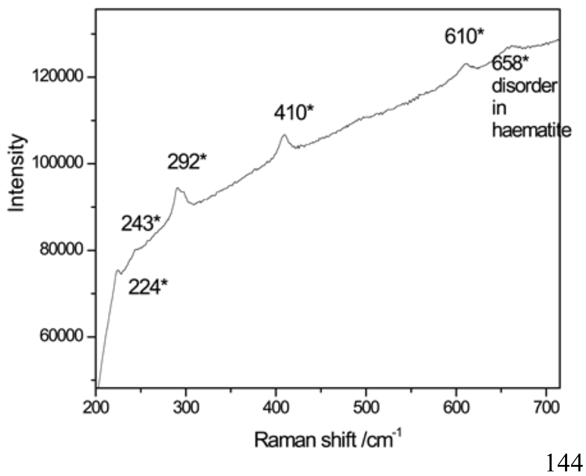


Fig.78 Raman analysis of haematite,
CH08/4040/U.16694/S1
(Courtesy of Dr Sonal Brown).



4.2.2.2 Yellow

Eight samples were analyzed in total (Figs.79-82). PLM and Raman analysis showed that the yellow pigment used at Çatalhöyük was yellow ochre (goethite) and was mainly used on wall paintings during the earlier levels (Pre-level XII, Levels XII-VIII 7300-6500 cal. BC) consisting of 12% of the total number of pigment samples. Under PLM, the clay coated particles were finely ground and crumblike, orangy yellow in colour, with a subrounded shape. They were mixed with fine grained carbonates (micrites) in some cases. This may be related to the geological source of the yellow ochre.

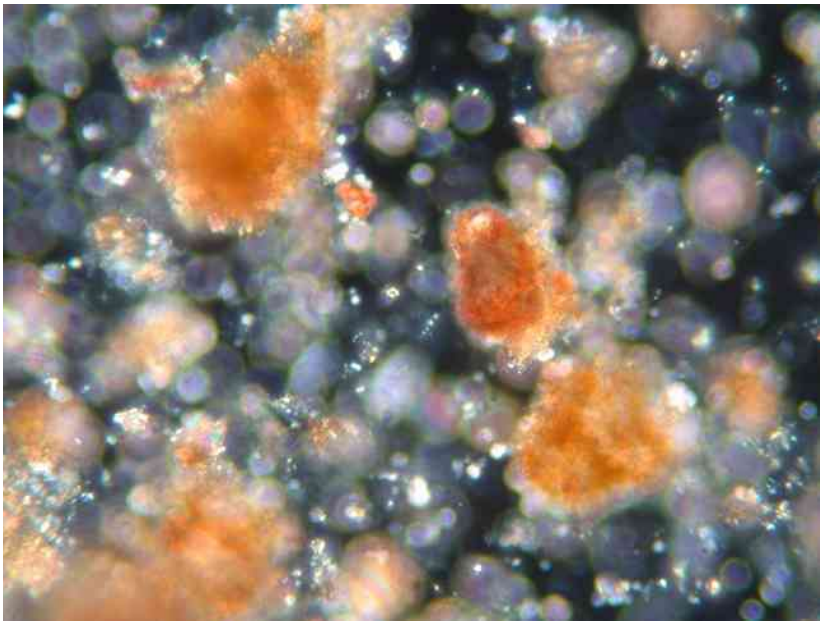


Fig.79 A PLM image of yellow ochre, CH99/South/U.4629/S1, x400.
Under cross polarized light.

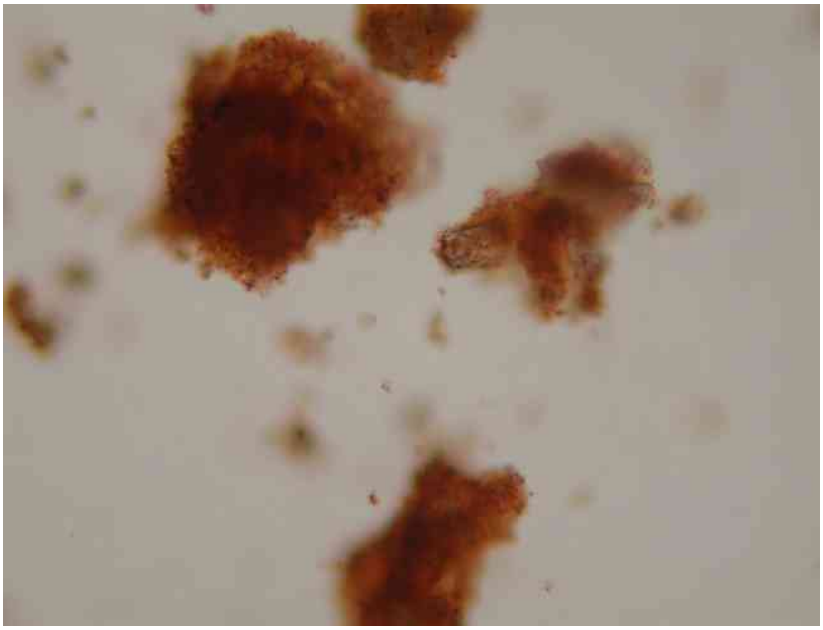


Fig.80 A PLM image of yellow ochre, CH99/South/U.4709/S3, x400.

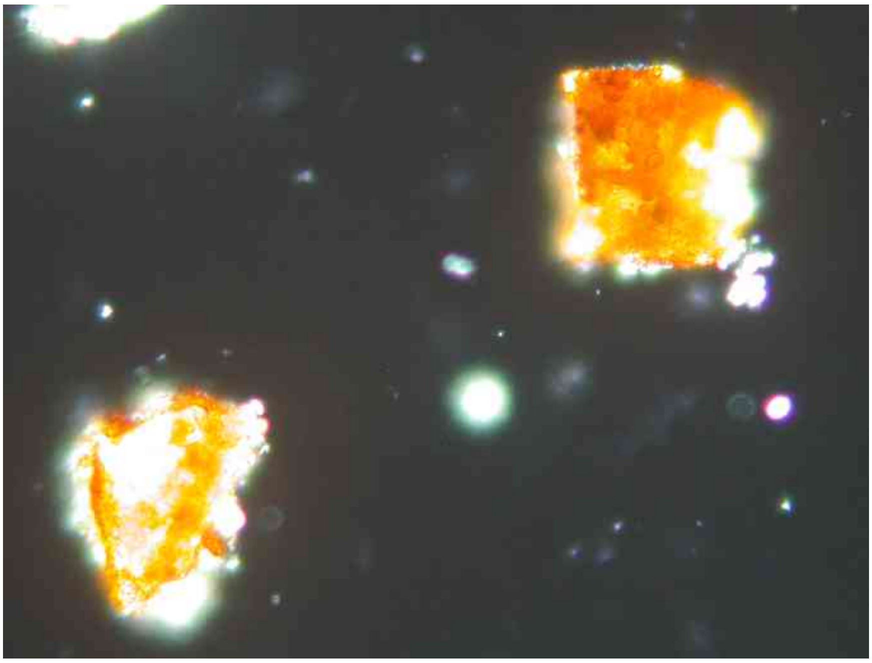


Fig.81 A PLM image of yellow ochre, CH99/South/U.4849/S3, x400.Under cross polarized light.

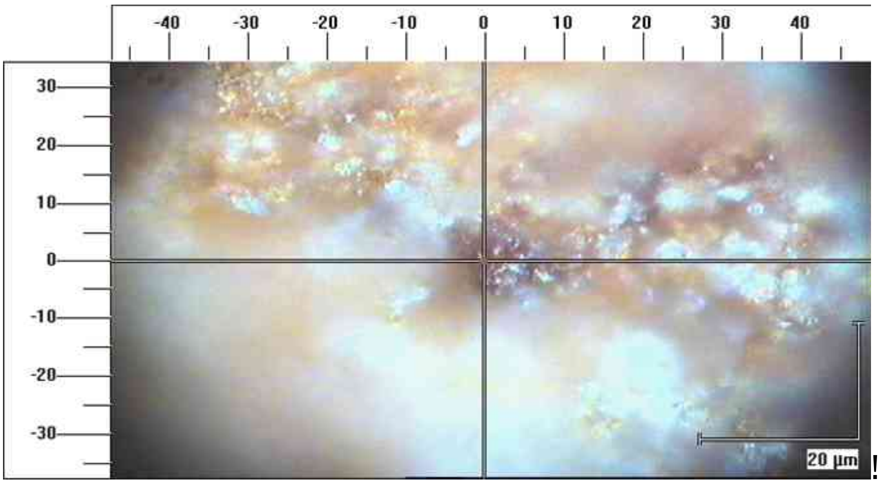
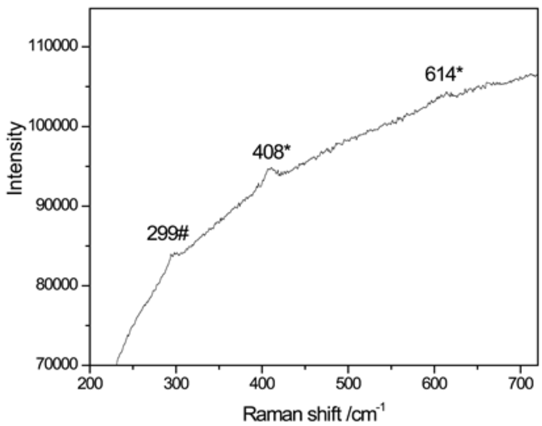


Fig.82 Raman image of the mixture of yellow ochre and red ochre, CH04/South/U.5383/S2, (Courtesy of Dr Sonal Brown).



4.2.2.3 Blue

Six blue pigment samples (7%) were analyzed in total (Figs.83-86). Both under PLM and Raman all were identified as Azurite ($Cu_3(CO_3)_2(OH)_2$) which could be the earliest known example of Azurite in pigment form. It is coated with clay and iron oxide particles and the particles are bright, light blue when finely ground and darker, greeny blue when coarsely ground. Other minerals such as quartz, gypsum, feldspar are evident in some samples. Angular and subangular shapes indicate that the pigment might have been hand ground. Azurite was only found as grave goods in burial contexts (particularly female and infant burials) not on wall paintings at Çatalhöyük and it was mainly available from Level VII and above (approximately from 6700 cal. BC).

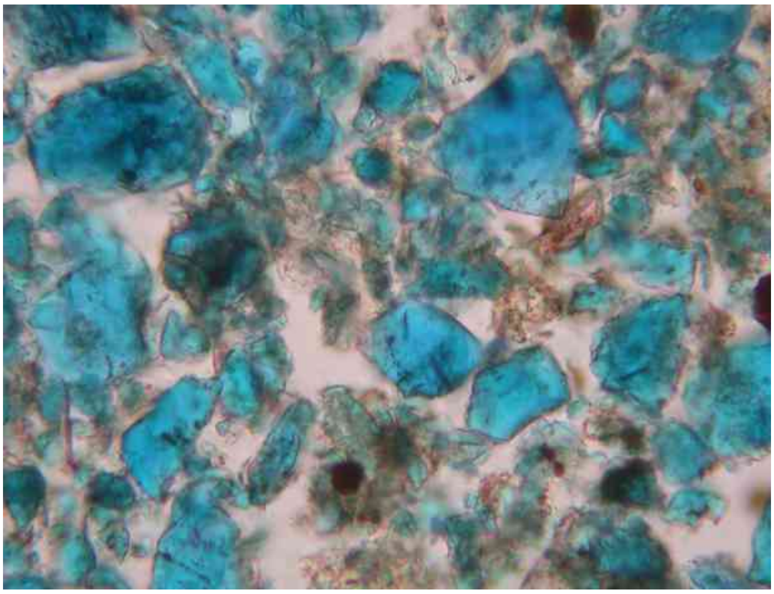


Fig.83 A PLM image of azurite, CH03/4040/U.7597/X1, x400.

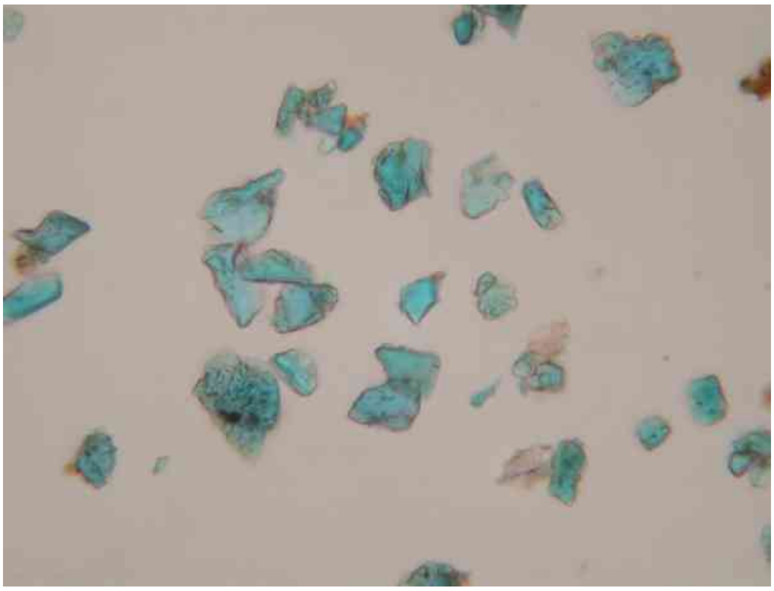


Fig.84 A PLM image of azurite, CH95/South/U.1007/S1, x400.

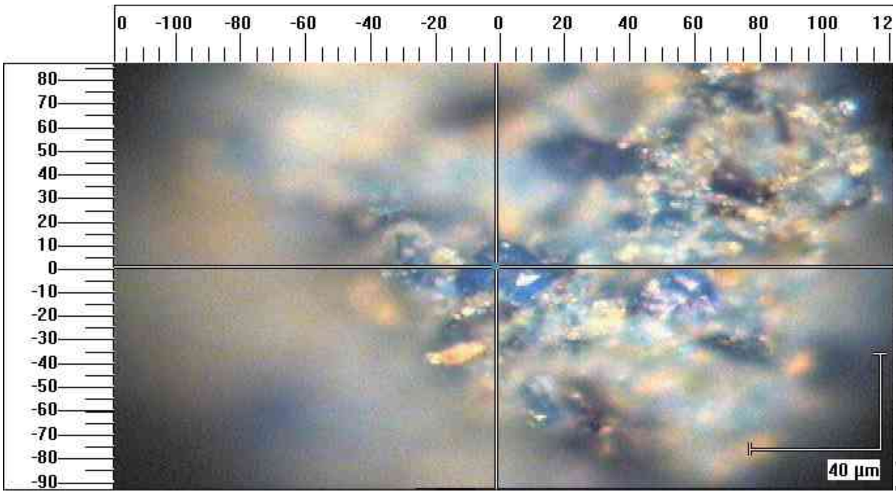
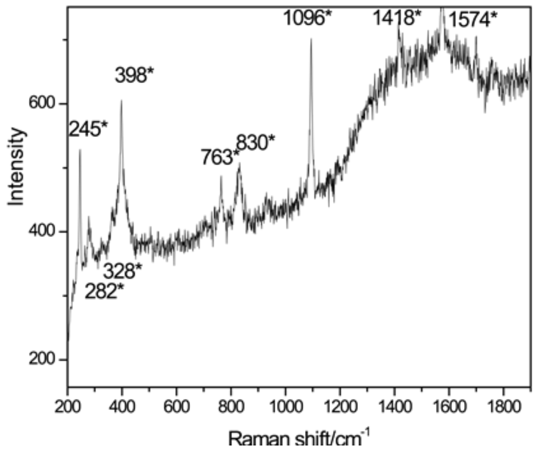


Fig.85 Raman image of azurite, CH03/4040/U.7575/X19 (Courtesy of Dr Sonal Brown).



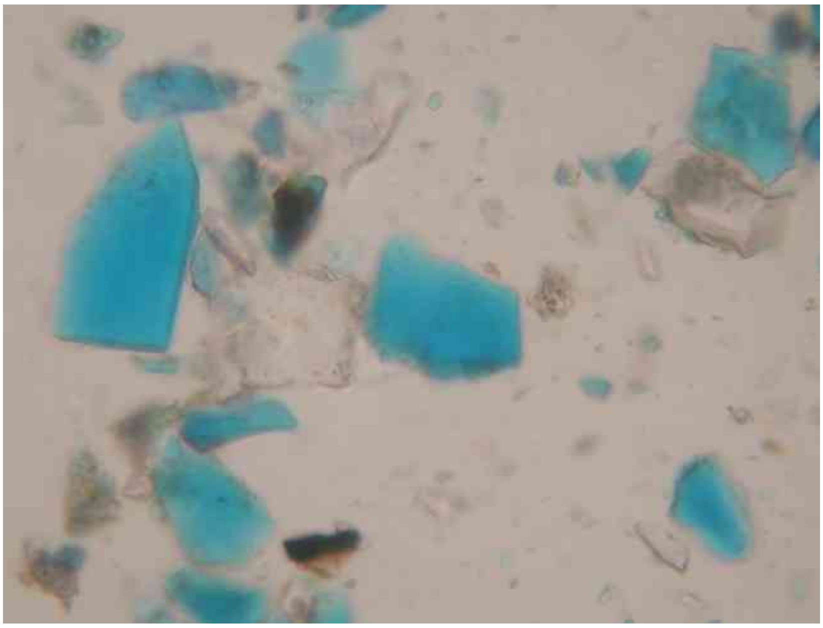


Fig.86 A PLM image of azurite, CH07/4040/U.16308/X2, x400.

4.2.2.4 Green

One green pigment sample was analyzed (Fig.87). Under PLM it was identified as Malachite $Cu_2(CO_3)(OH)_2$) which could be the earliest example of Malachite in pigment form. It is coated with clay and iron oxide particles. Quartz is also evident. It is composed of very fine, fibreous dark green malachite and has been ground down. Angular shapes also indicate that the pigment might have been hand ground. It seems to be pure malachite with no azurite particles. Malachite was only found as grave goods in burial contexts (particularly female and infant burials) and, like blue, was not on the wall paintings at Çatalhöyük and it was found from Level VII and above (approximately from 6700 cal. BC), consisting of only 1% of the total pigment samples. However the significance of the use of this colour can not be determined from a single occurrence.

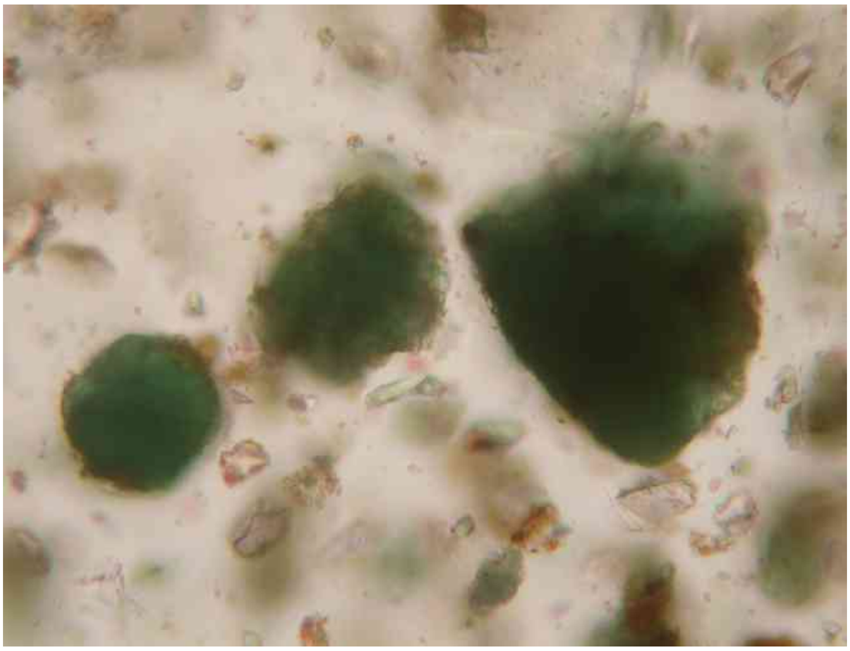


Fig.87 A PLM image of malachite, CH07/4040/U.16308/X2, x400.

4.2.2.5 Black

Nine black pigment samples were analyzed in total (Figs.88, 89, 90). All black pigments seem to have been carbon based as seen under PLM and Raman. However, a few samples presented possible evidence of bitumen both under PLM and GC-MS (U.8226, U.17494), but this result is not conclusive. Under PLM clay coated particles gave the indication of carbon black which is opaque, browny/black in colour, blotchy with a crumblike nature (Eastaugh *et al.*2004, 82-84). They were also mixed with carbonates, possibly coming from the plaster. However, no indication of phosphate was detected under Raman, which might be due to the reasons explained in Chapter 3, Section 3.3.5. In order to check that the black pigments were bone based, routine micro-chemical spot testing was undertaken. The result showed that all the black pigments selected for this study contained phosphate and therefore suggested that they are most possibly bone black. The black pigment is only used on wall paintings at Çatalhöyük from Level VII and above (approximately from 6700 cal. BC) and consisted of 10% of the total number of pigment samples.

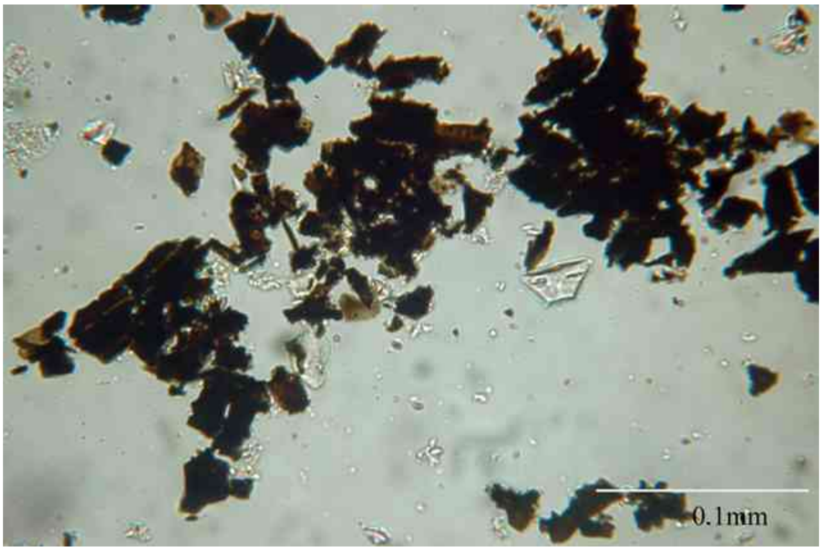


Fig.88 A PLM image of carbon black, CH06/4040/U.13669/S2, x400.

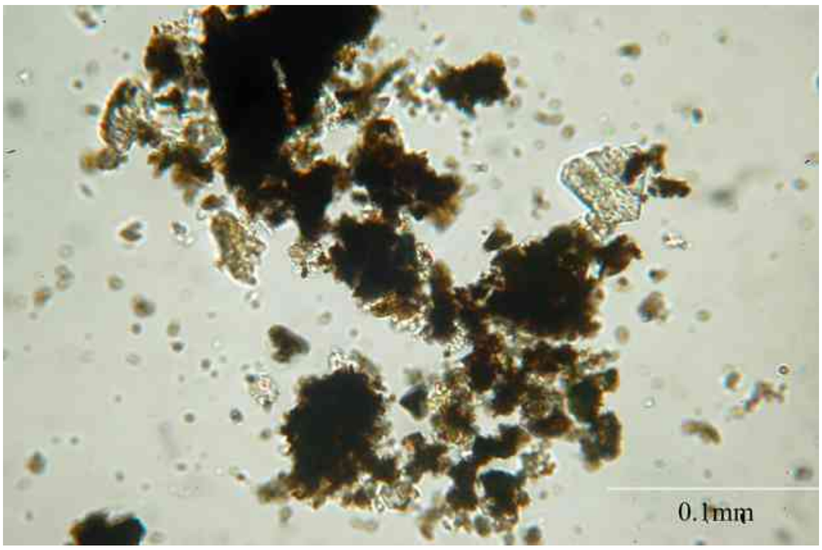


Fig.89 A PLM image of carbon black, CH08/4040/U.16694/S1, x400.

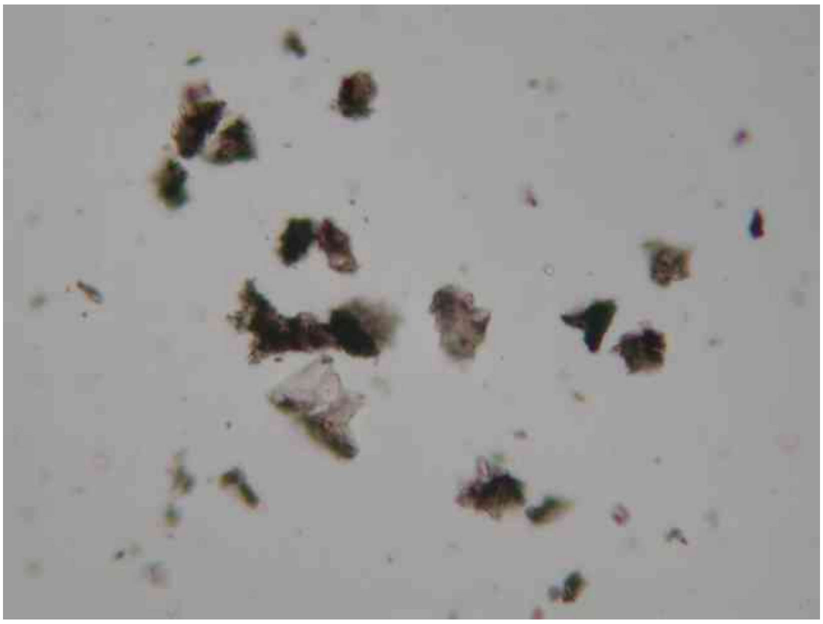


Fig. 90 A PLM image of carbon black, CH08/4040/U.16695/S1, x400.

4.2.2.6 White

There is no evidence of white pigments on the wall paintings at Çatalhöyük. Nevertheless the white coloured marl plaster (Type 5) background seems to provide a white, bright colour, which acts as a paint when the paintings are particularly decorated with shapes and figures. The Raman analysis of the white marl plasters did not present reliable results due to the fluorescing problems in general. PLM and SEM (EDAX) study of the marl plaster backgrounds also did not present any evidence of white pigment. If a calcium carbonate based white pigment (Gettens *et al.* 1993, 203-226) was used on the marl plaster surfaces (calcium carbonate rich) it would be difficult to detect and separate from the marl itself. It is most possible that if the white pigment was used, it would possibly have been used over the red and/or black painted areas to indicate a different design or a colour, rather than over the white marl plaster backgrounds.

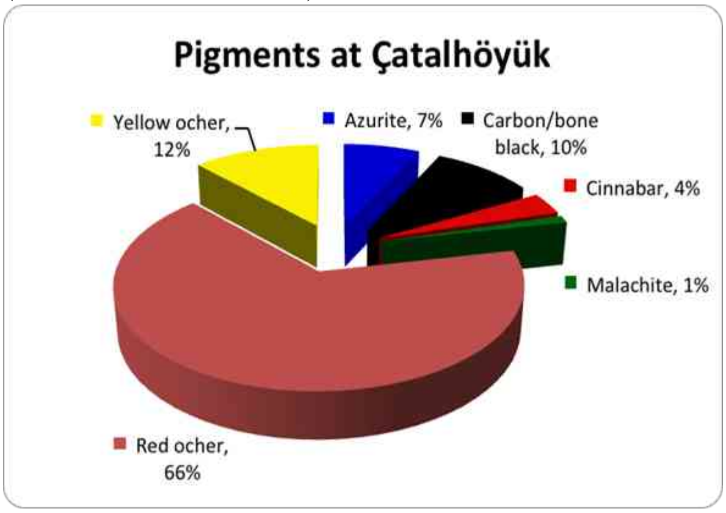


Fig. 91 The percentage distribution of pigments found at Çatalhöyük.

One of the inconsistencies in this research was the number of samples available from individual contexts. This meant that some contexts (buildings and burials) and habitation levels provided more painted plaster and/or pigment samples than others, i.e. there were 12 samples came from Building 49 (4040 Area, Level G) whereas Building 60 provided only 3 (4040 Area, Level H) (see Chapter 1, Table 1.2a). Also some pigments were very rare and found in only one or two contexts. This unfortunately affected the consistency of the overall results across the site, since there was too little information to make a reliable comparison between the individual contexts as well as to apply it to individual habitation levels.

4.3 Application Methods and Tools

Macroscopic and microscopic observations showed that the pigments were often ground very fine to achieve vibrant colours as well as being mixed with other colours to obtain the desired shades. There were some samples (particularly from the Pre-level XII, Space 181) that had a smooth, burnished surface and a few samples presented a glossy appearance under Raman spectroscopy (Fig.92).

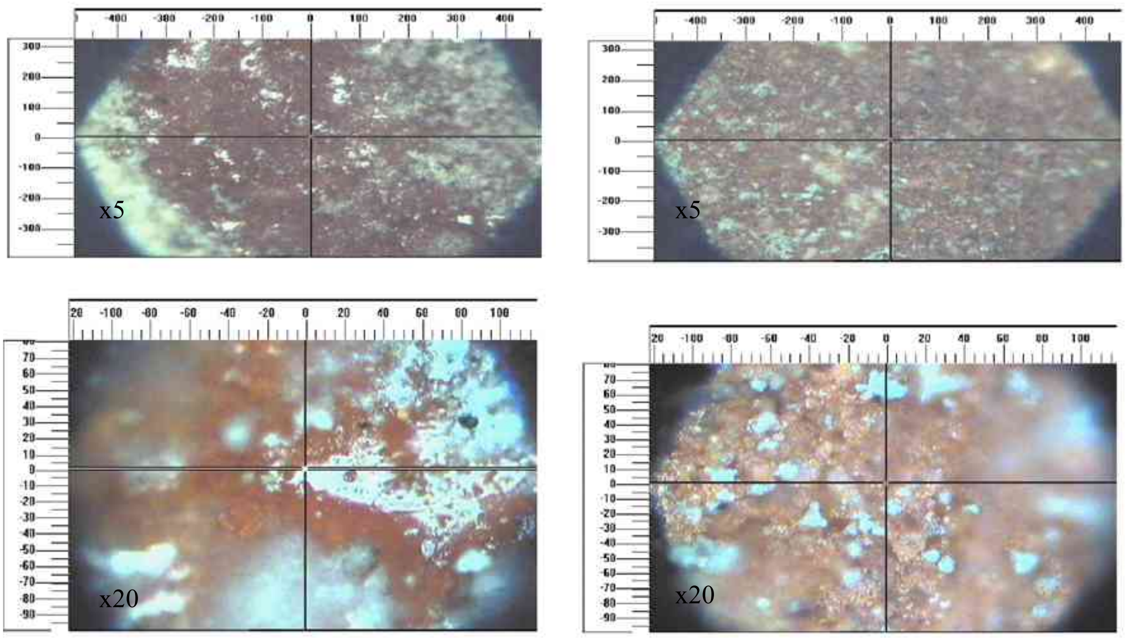


Fig.92 CH07/4040/U.15932/S3, showing top (left) and lower (right) layers indicating the glossy (finer) and matt (coarser) surfaces achieved via finer and coarser pigment grounding (Courtesy of Dr Sonal Brown).

The reason for this is not clear, however it may indicate the level of fine pigment and surface preparation and application. It may also be possible that the effects of the lime-saturated groundwater (see Chapter 3, Section 3.2) affected the painted surfaces, causing the loss of their original surfaces. The paint layers were applied generally in <1000μm in thickness and there was more than one paint layer on some painted plaster samples. However, the long-term burial, surface erosion and deterioration made it difficult to observe the nature of application and the number of pigment layers on raw samples. Cross-section and thin section samples provided more useful information which indicated that most commonly the paint layers have been applied onto white/fine soft lime wash (Type 2) layers, although in some cases, they were applied onto pale brown, coarser marl plasters with no plant inclusions. The analysis of this data indicates that there is no clear pattern in this practice between the different areas and the levels of the site. Starting from Level VII and continuing through the later levels paint application on pale brown marl plasters (Types 1, 2 or 3 but with no plant inclusions) was practiced as often as on the white soft lime washes. Before Level VII, paint application was only on white, fine soft lime washes. On some walls the application of paint on both types of plasters, i.e. on soft lime washes or pale brown marl with no plant inclusions, which were applied as different layers on the same wall was also evident (Table 4.5). The cross-section and thin section analysis showed that most often there was a smooth and sharp boundary between the paint and the underlying plaster layers, indicating that the plaster layers were most probably dry when the paint was applied with or without organic binders (if the paint was applied on damp/wet plasters, the paint would seep into the plaster layer and set to form an uneven and gradational boundary upon drying) (Figs. 93-97). The results of experimental work on the methods of paint application onto plaster also support the analytical results (See Chapter 5, Sections 5.2.4.1 and 5.2.4.2).

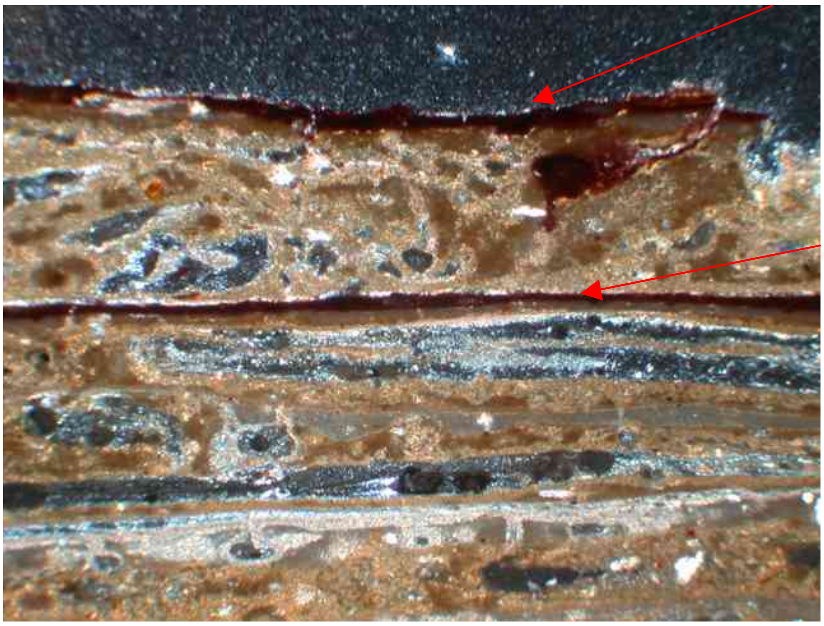


Fig.93 A thin section image of pigment layers by PLM,
CH09/South/U.18568/S1, x400.

Fig.94 A RLM image of pigment layers, CH08/4040/U.16695/S1, x400.


Fig.95 A RLM image of pigment layers, CH05/4040/U.10396/S1, x400.


Fig.96 A cross section image of pigment layer by RLM, CH99/South/U.4844/S11, x400.

Unit No	Location	Mellaart/Hodder Level	Paint application on plaster (Type 2)
8203	B.3, F160+F174. Insitu	Level IV-VII/Bach G	White, fine soft lime
8226	B.3 Sp.86. Collapse.	Level VII-VI/Bach G	Pale brown marl (no plant inclusions)
5383	B.2 F64. Insitu.	Level IX/South K?	Pale brown marl (no plant inclusions)
7913	B.49, Sp.100. Room fill	Level VII-VI/4040 G	Pale brown marl (no plant inclusions)
10501	B.43. Backfill.	Level VIII/South L	White, fine soft lime
10349	B.55, Sp.256, Insitu? Wall plaster collapse.	Level IV-III/4040 G	1 layer on white, fine soft lime, 2 layers on pale brown marl
10396	B.55, Sp.268	Level III?/4040 H	1 layer on white, fine soft lime, 1 layer on pale brown marl
11966	Burial fill	Level IV-III/4040 H	Pale brown marl (no plant inclusions)
12313	B.55, Sp.256 In situ? Wall plaster collapse	Level IV-III/4040 G	Pale brown marl (no plant inclusions)
17348	B.17, Sp.170, F566. In situ	Level IX/South K?	White, fine soft lime
13481	B.59, Sp.311, F2374. In situ	Level VI-V/4040 G	Pale brown marl (no plant inclusions)
13669	B.49, Sp.100, F1661. In situ	Level VI-VII?/4040 G	White, fine soft lime
13352	B.56, Sp.121	Level IV-II? South R	Pale brown marl (no plant inclusions)
13453	B. 60 F.2215. In situ.	Level V-VI?/4040 H	White, fine soft lime
16694	B.49 F1661. Insitu.	Level VI-V/4040 G	White, fine soft lime
17494	B49, Sp. 335, F1491 and F1661	Level VII-VI/4040 G	White, fine soft lime
18145	Sp.132. Fill of pit	South P	White, fine soft lime
18523	B.79 Sp.134	South O	White, fine soft lime
18568	B.79 Sp.134 F.5027. Insitu	South O	Pale brown marl
4221	B.8 F413/415. Insitu.	Level VII/South M?	White, fine soft lime
1309	B.1 Sp.188. Room fill	North G?	3 layers on pale brown marl, 1 layer on white fine soft lime.
2270	B.3, Sp 86. Room fill	Level VII-VI/Bach G	White, fine soft lime

Table 4.5 Paint application on white soft lime and/or pale brown marl plaster (Type 2) throughout the site.

Fig.97 A cross section image of pigment layer by RLM, CH99/South/U.4709/S2, x400.

During the macroscopic study, some of the painted plaster surfaces were observed to have distinctive striations and/or scratch marks. In order to understand the nature of these marks and whether they relate to possible painting tools, i.e. animal hair brushes, cloth, skin, bone tools, wooden sticks, stone tools, or to any sketching practices before painting, i.e. drawing, incising, engraving, or to any surface deterioration and damage, SEM (EDAX) was chosen for high magnification surface imaging to observe materials such as fibres or finer tool marks which could have given clues on the painting tools which may have been used. Painted plaster surfaces were aimed to be studied at very high magnifications (i.e. > x500) under SEM (EDAX). However the different sizes and thicknesses of the samples resulted in using much lower magnifications (i.e. > and < x50) which I had not anticipated before starting the analysis. Even though I realise that the optical binocular microscopy would have produced the same results, I wanted to try using the SEM (EDAX) as part of my personal learning process, and get more familiar with the imaging aspect of the equipment.

Experimental work was also undertaken in an attempt to replicate the surfaces observed on the archaeological plasters and to aid in the understanding of the painting and plastering tools which might have been used (see below). The close up study presented inconsistent data, which was not very surprising due to the age and deterioration levels of the painted plaster samples. There were also other limitations preventing the achievement of consistent results such as:

1) The size and thickness of the samples as well as their uneven topographies resulting in the need to set different magnification levels under the SEM.

2) The deterioration level of the surfaces affecting the clarity and the image quality of the possible tool marks.

3) The size and the weight of the samples resulting in them being unstable in the chamber of the SEM and therefore images moving during capturing and measuring.

Only twelve painted plaster surfaces presented possible evidence of tool marks and it proved to be difficult to define what kind of tools/brushes these marks could be derived from. However, some tentative conclusions can be drawn. Table 4.6 shows the classification of the different type of marks seen on the painted surfaces.

Number of samples	Tool Marks	Nature of tool marks	Possible tool
4	Deep Scratching	Scratched lines	Hard edged tool?
3	Sharp striations	In the same direction with inconsistent thickness	Thick brush?, cloth? , hard edged tool?
5	Softer striations	In the different direction with inconsistent thickness	Softer brush? cloth?

Table 4.6 The classification of tool marks on the painted surfaces.

4.3.1 Scratch marks

Four samples (U.4844 s3, U.5286 s11, U.5290 s28, U.5328 s13) presented some lines/striations in the form of deep scratching (Figs.98a,b, 99). However, it is not clear if these scratched lines were made deliberately by a tool with a hard surface or whether they occurred due to deterioration processes both during and after burial or related to the excavation process, i.e. non-careful excavation, scratching or brushing after exposure.

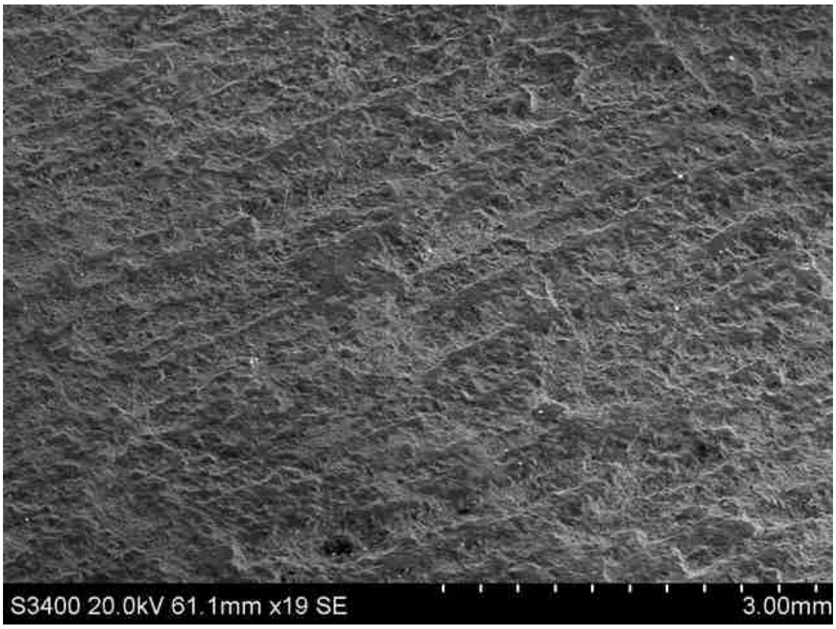


Fig.98a SEM image of the scratch marks on a painted surface, CH99/South/U.5286/S11.

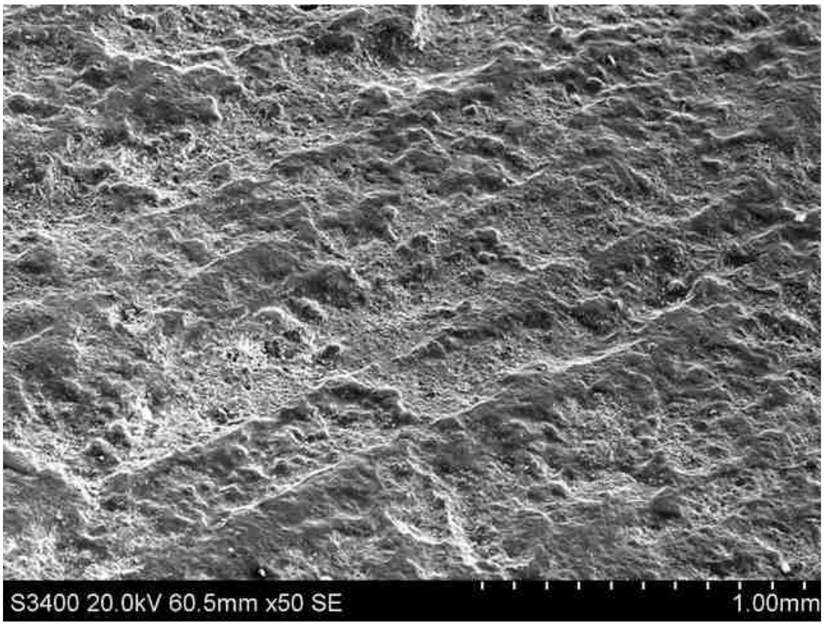


Fig.98b CH99/South/U.5286/S11. SEM image of the same sample above at a higher magnification, showing details of the scratch marks.

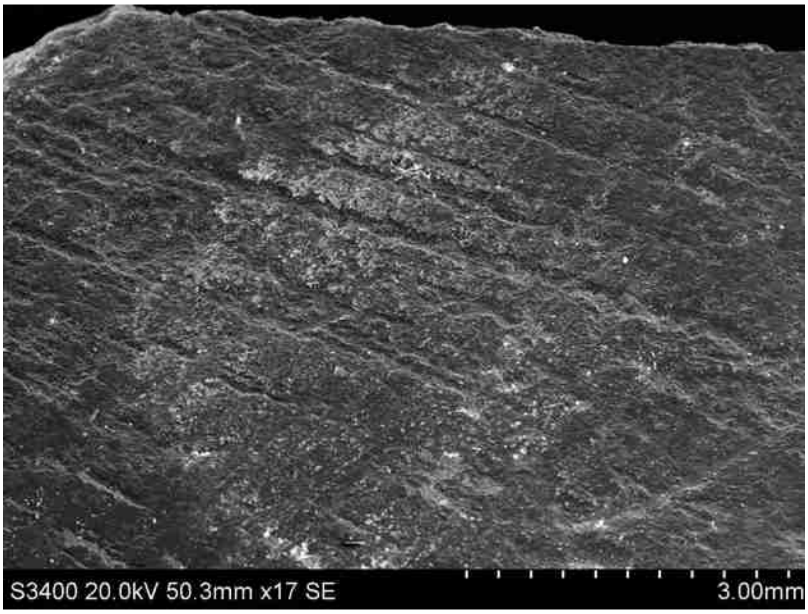


Fig.99 SEM image of the scratch marks on a painted surface, CH99/South/U.4844/S11

4.3.2 Sharp striations going in the same direction

Three samples (U.11966 s3, U.13669 s2, U.5315 s7) presented sharp striations, which seemed to have been painted in the same direction (Figs.100a,b, 101a,b, 102). The thickness of the lines is inconsistent. The curvature and clarity of the lines may suggest that either a thick strong brush, a thicker cloth or a tool with a hard edge might have been used to create these lines.

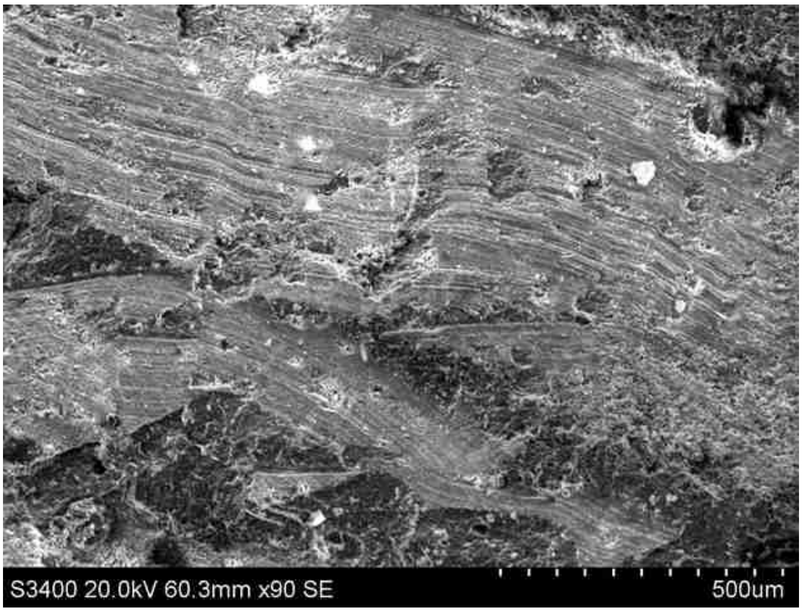


Fig.100a SEM image of the sharp striations going in the same direction, CH06/4040/U.13669/S2.

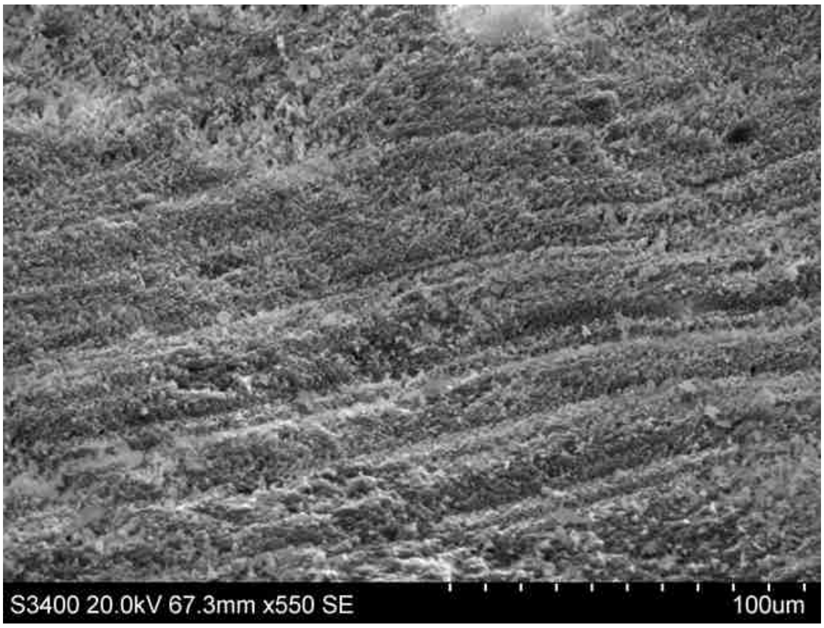


Fig.100b CH06/4040/U.13669/S2. SEM image of the same sample above at a higher magnification, showing details of sharp striations going in the same directions.

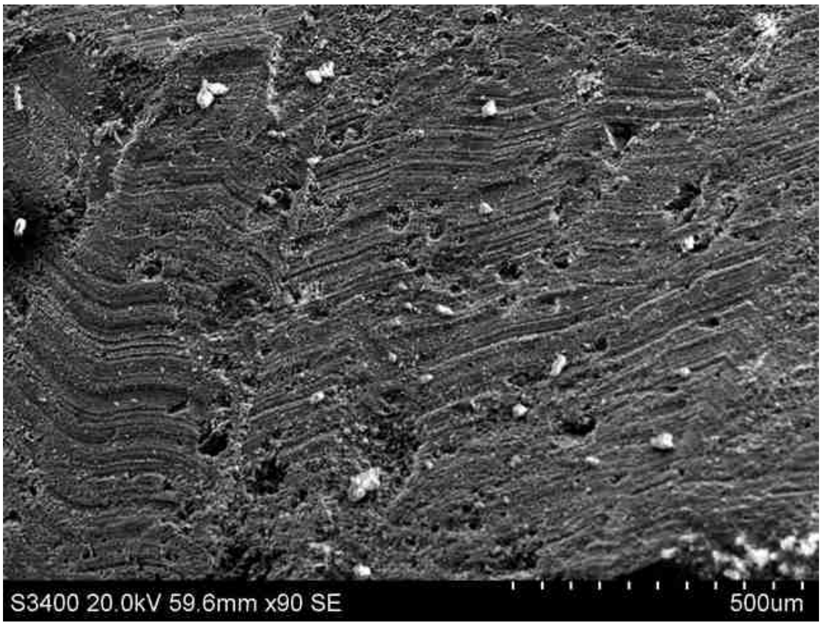


Fig.101a SEM image of the sharp striations going in the same direction, CH05/4040/U.11966/S3.

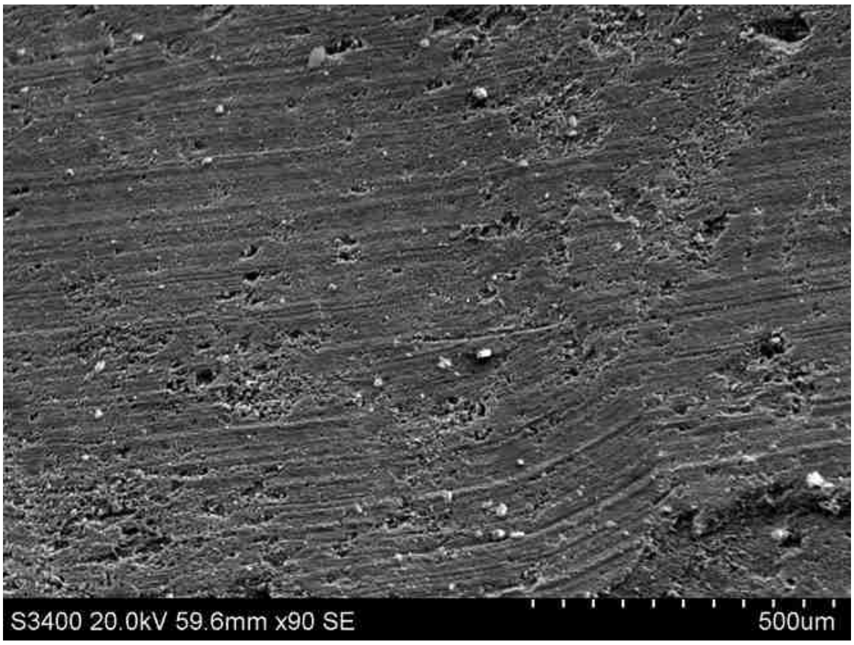


Fig.101b CH05/4040/U.11966/S3. Another SEM image of the same sample above, showing sharp striations going in the same direction.

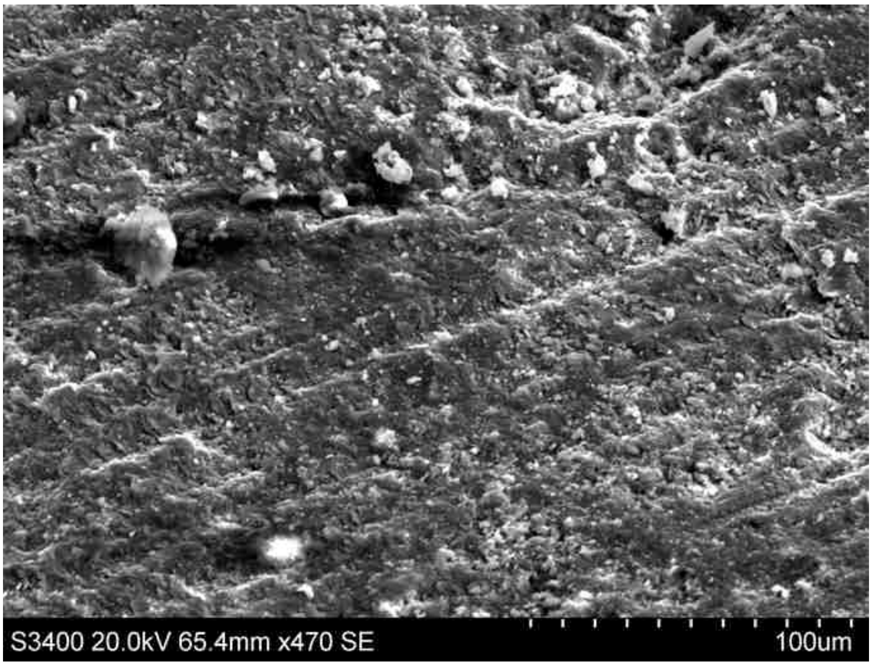


Fig.102 SEM image of the sharp striations going in the same direction, CH99/South/U.5315/S7.

4.3.3 Softer striations going in different directions

Five samples (U.4291 s10, U.4709 s3, U.5290 s28, U.5291 s10, U.5294 s6) presented softer striations, which seemed to be going in different directions, i.e. from left to right and vice versa (Figs.103a,b, 104, 105). The lines are irregular with a softer nature and the thicknesses are inconsistent. While this may depend on the type of tool, which might for example have incorporated soft animal hair, it may also be the result of artificial surface damage during or after burial.

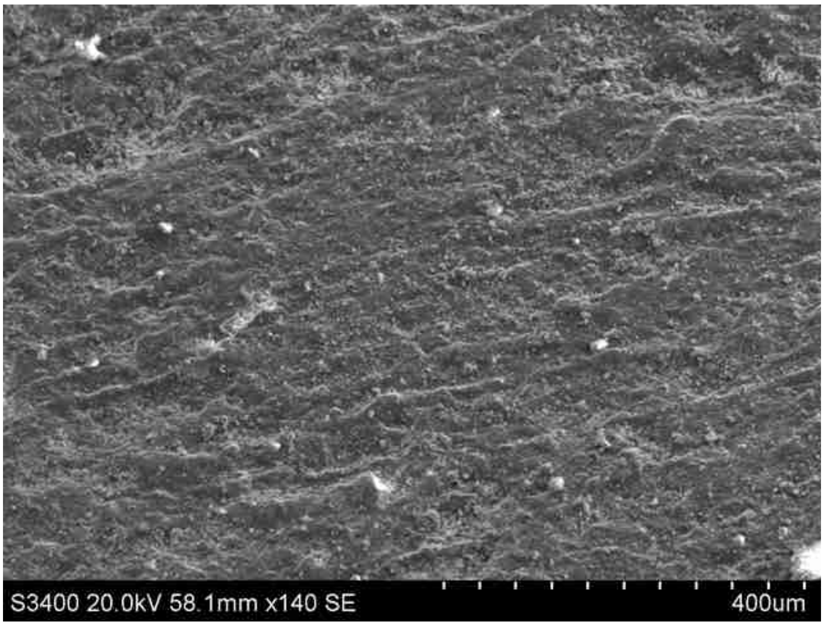


Fig.103a SEM image of the softer striations going in different directions CH99/South/U.4709/S3.

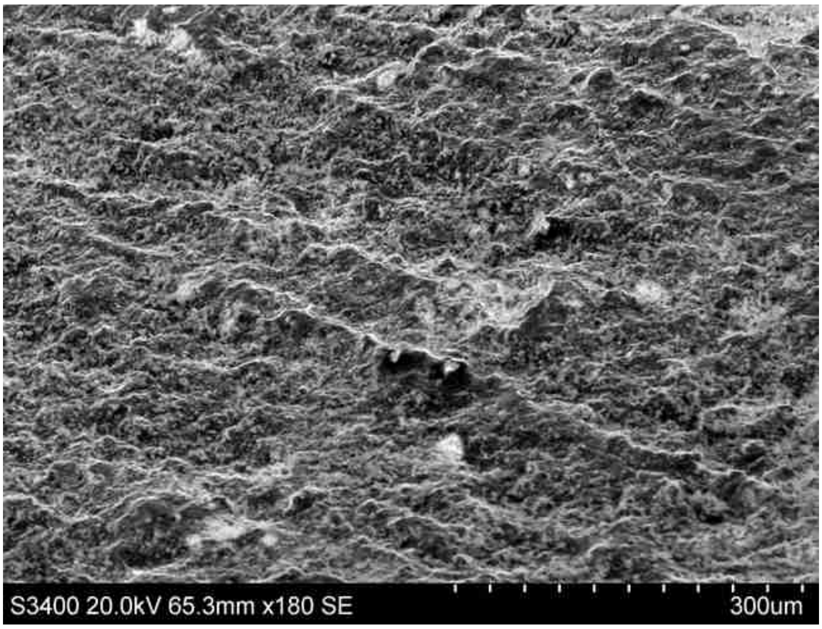


Fig.103b CH99/South/U.4709/S3. SEM image of the same sample above at a higher magnification, showing details of softer striations going in different directions.

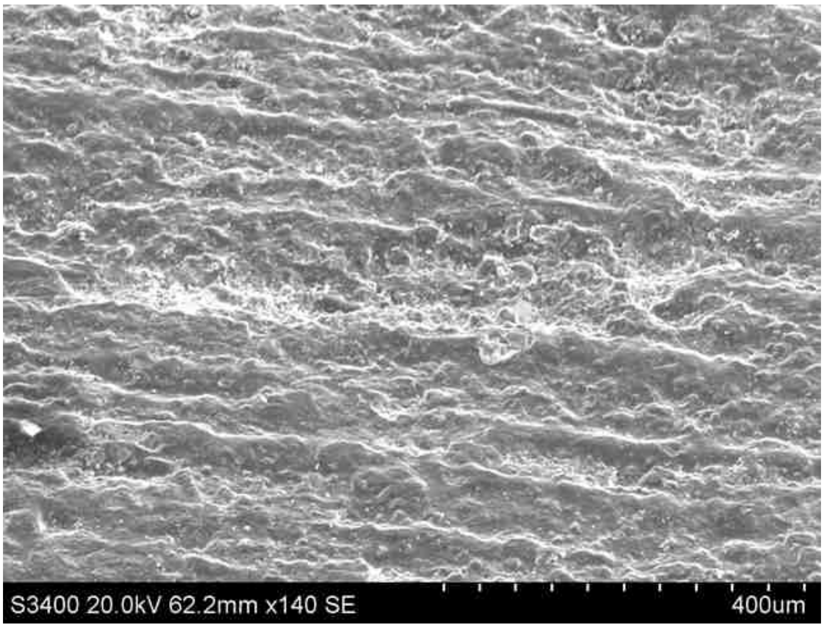


Fig.104 SEM image of the softer striations going in different directions CH99/South/U.5290/S28.

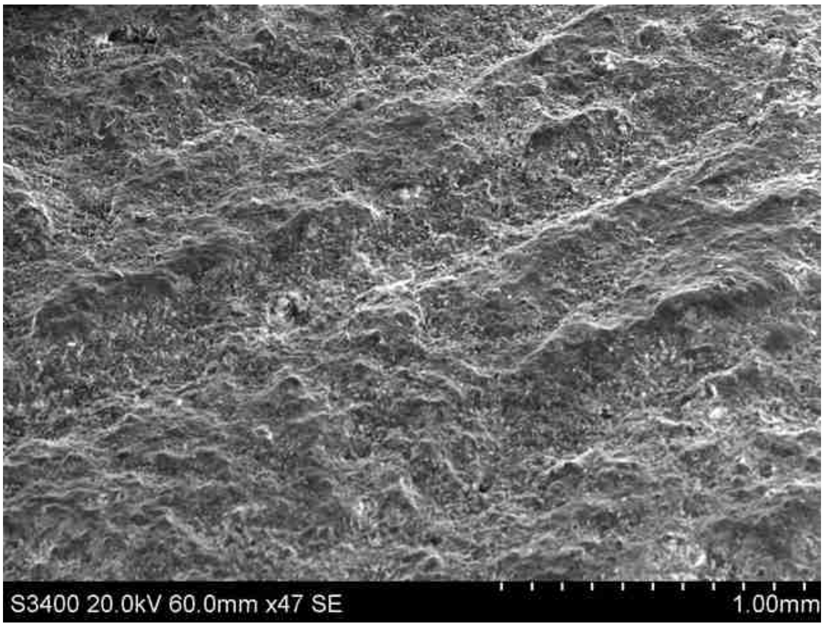


Fig.105 SEM image of the softer striations going in different directions CH99/South/U.5291/S10.

However, it is important to note that the interpretation of surface features is always problematic and cannot necessarily be directly related to paint application techniques. Particularly on these very old and deteriorated painted plaster samples it was very hard to spot obvious marks, any evidence of drawing or incising of the designs, which may have indicated the use of certain tools and sketching techniques before painting would have taken place. Therefore, I tried to describe what I observed on the surfaces as clearly as possible even though my interpretations are subjective.

Experimental work has also helped with the interpretation of painted plaster surfaces and was a very useful part of this research. I used my own observations and methodology to create experimental samples (the methodology and results of the experimental work are detailed in Chapter 5). The analyses of the experimental samples by PLM and SEM (EDAX) enabled me to observe the different tool marks/application techniques achieved by different painting tools and binders. It also helped examining the similarities or differences on any traces of tool marks/application methods both on the experimental and archaeological samples which provided some ideas on the possible tools used on the wall paintings. Table 4.7 below shows the results of the binders and tools used on the experimental samples. These results are presented here (rather than in Chapter 5) to be in conjunction with the analyses of tool marks on the original samples.

Binder mixed with pigment	**Tool marks (brush/cloth)**
Water	distinctive
Egg white and yolk	unclear
Milk	unclear
Rabbit skin glue	unclear
Linseed oil, Olive oil	unclear

Table 4.7 The results of the experimental binders and tools used.

As seen on Table 4.7, SEM (EDAX) analysis of the experimental samples showed that when a brush was used as a painting tool with a pigment and various organic binder mixtures such as egg white/yolk, milk and rabbit skin glue, brush marks were unclear (Figs.106, 107, 108).

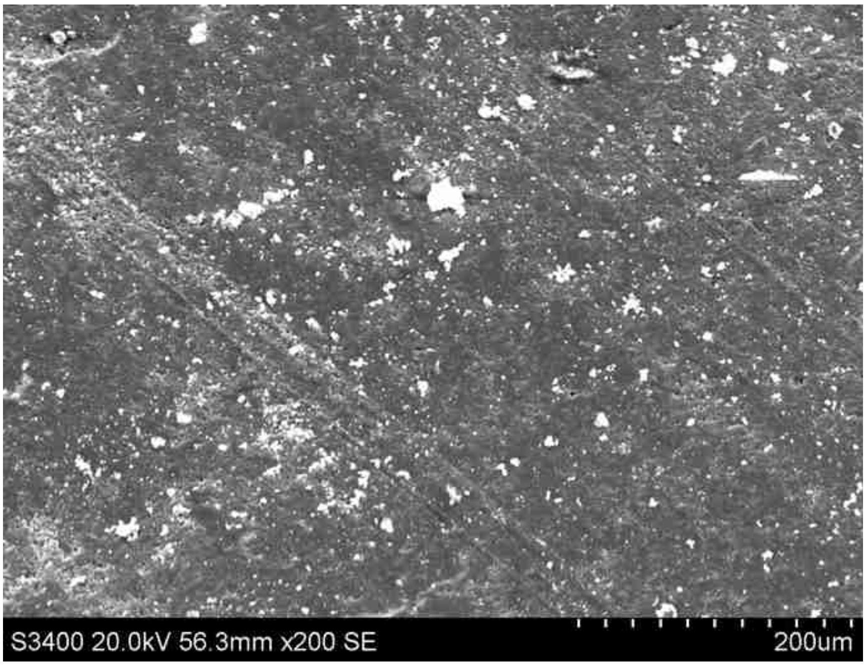


Fig.106 SEM image of the unclear brush marks via brushing with egg white. Experimental sample.

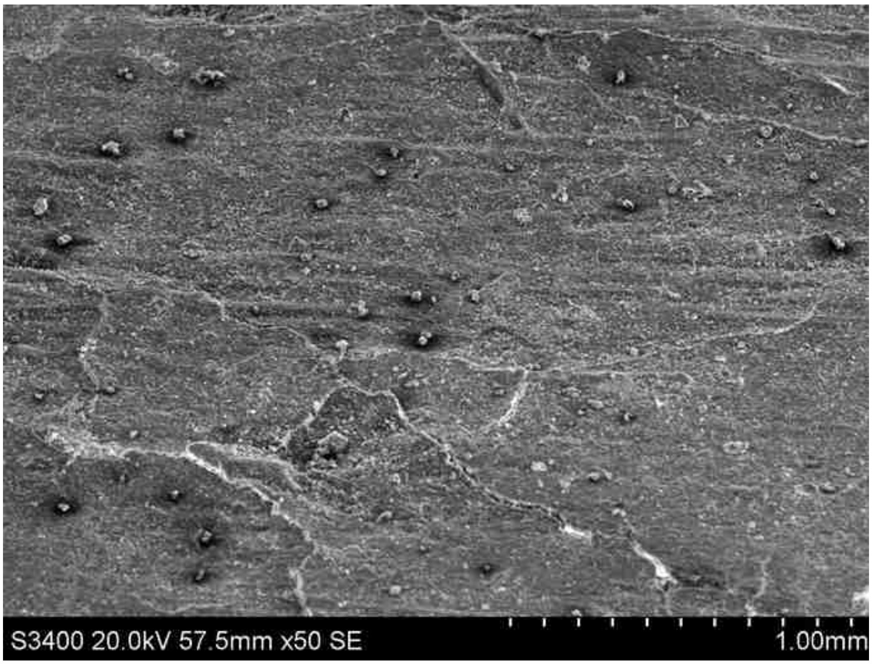


Fig.107 SEM image of the unclear brush marks via brushing with milk. Experimental sample.

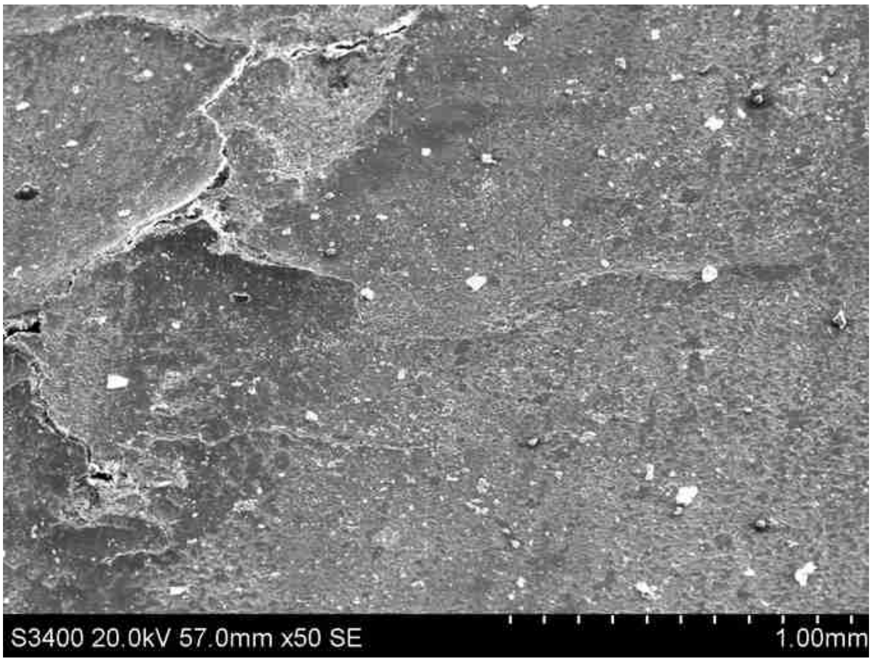


Fig.108 SEM image of the unclear brush marks via brushing with rabbit skin glue. Experimental sample.

However when used with a pigment and water mixture the brush marks were very clear, and went in different directions i.e. from left to right and vice versa (Figs.109, 110).

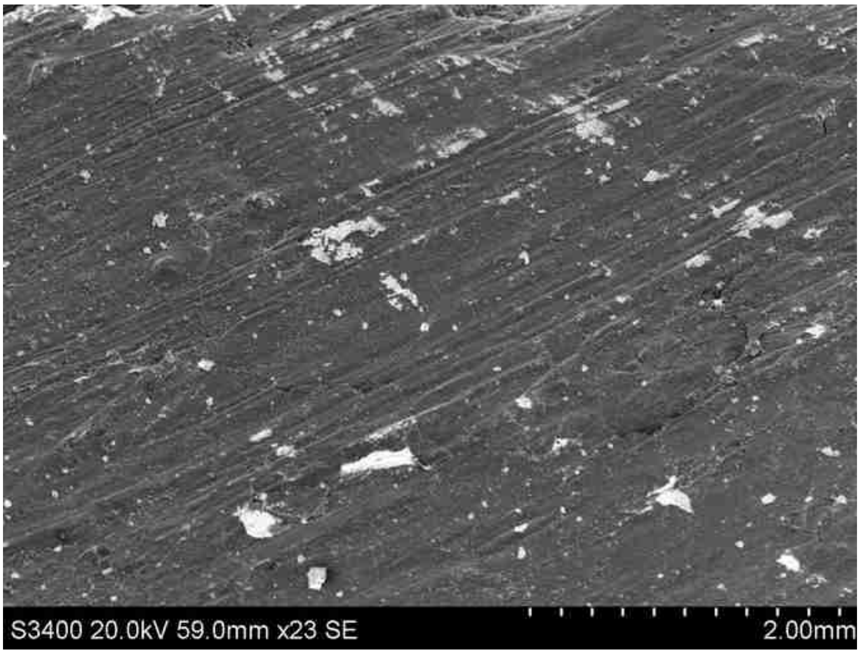


Fig.109 SEM image of the clear brush marks via brushing with water. Experimental sample.

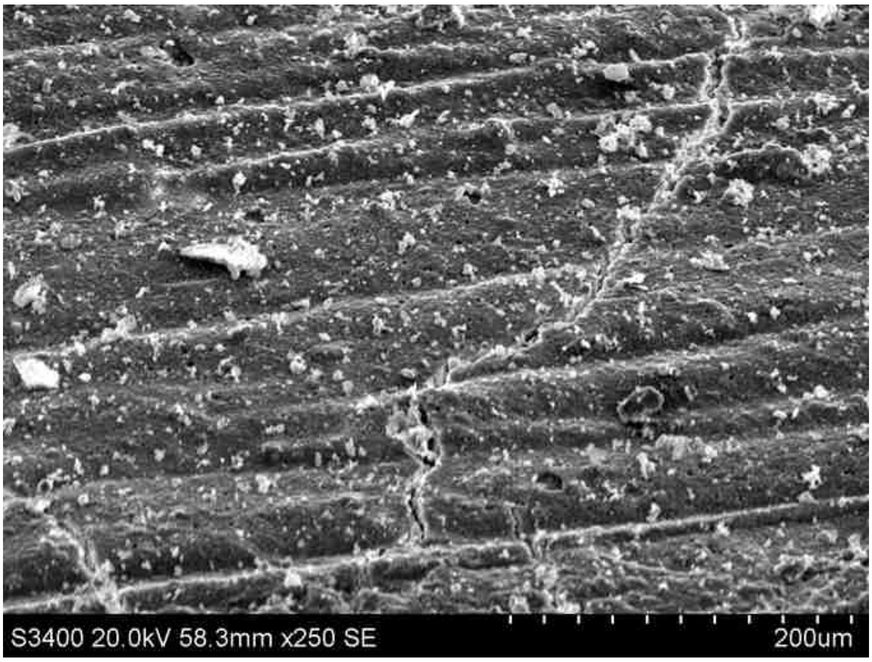


Fig.110 SEM image of the clear brush marks via brushing with water, close up. Experimental sample.

The paint application with a cloth and water also created very clear striations over the surface, but only showed “some” striations when used with pigment and organic binder mixtures, even though the nature of application was still easy (Fig.111). It is not clear what the reason may be for this, but the viscosity of the binder used, the time taken for the setting of the binder and the settling of the paint on the plaster surface are all possible explanations.

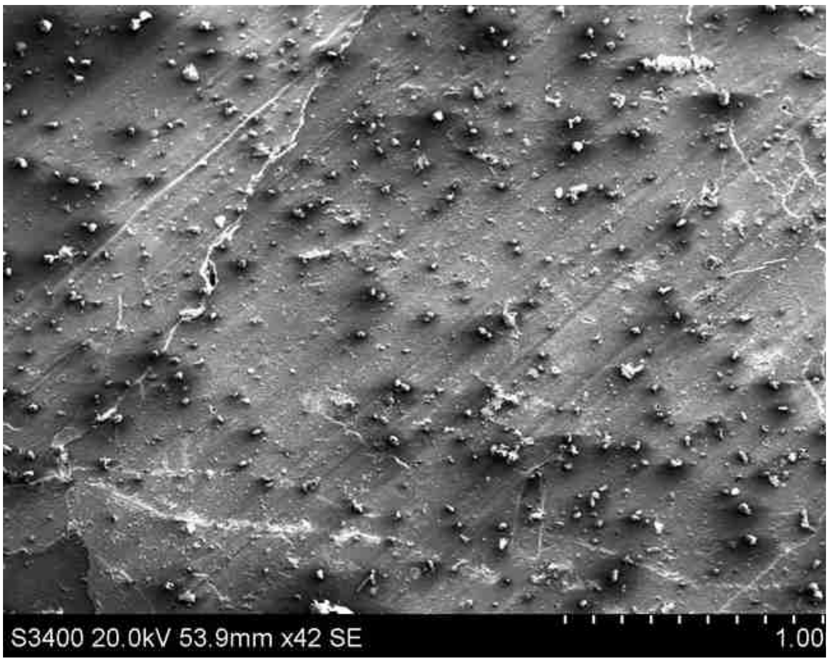


Fig.111 SEM (EDAX) image of the clear striations via the application with cloth and water. Experimental sample

The tool marks/striations on the original painted plaster samples were compared to the striations on the experimental samples under SEM (EDAX) via surface imaging and even though it was not really possible to gather reliable data due to the nature and deterioration levels of the samples, interesting similarities were observed. For example the softer striations going in different directions were present on some painted plaster samples and looked similar to the striations created with a brush on the experimental samples (Figs.112, 113). The only difference was that it was not very easy to detect the stroke direction of the striations on the original samples due to the surface deterioration, whilst the experimental samples had clear brush strokes in different directions, i.e. from left to right and vice versa. Also on the experimental samples, the paint application with cloth resulted in sharper lines going in the same direction (see Fig.111), which were similar to the sharper striations on some of the original samples (Fig.114). The striations which go in the same direction also suggested that the actual painting work was made using straight movements mainly in one direction, i.e. from left to right, as opposed to circular movements.

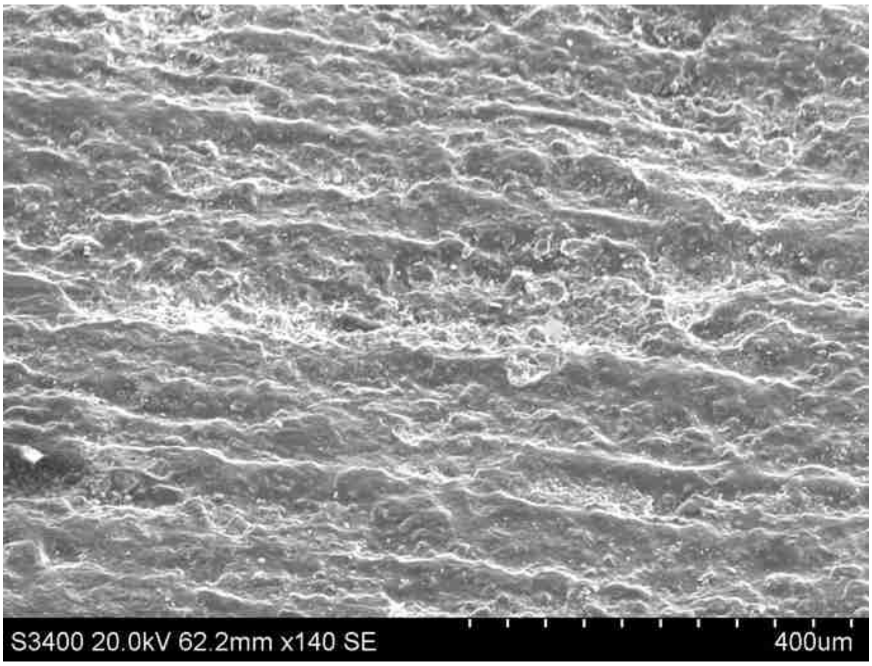


Fig.112 SEM image of the softer striations going in different directions, CH99/South/U.5290/S28.

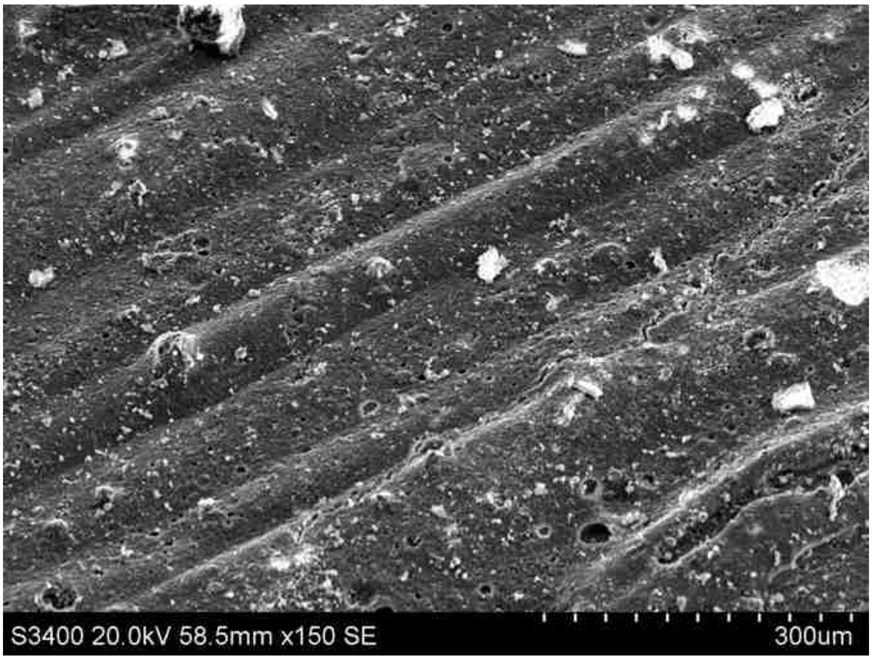


Fig.113 SEM image of the clear brush marks via brushing with water. Experimental sample.

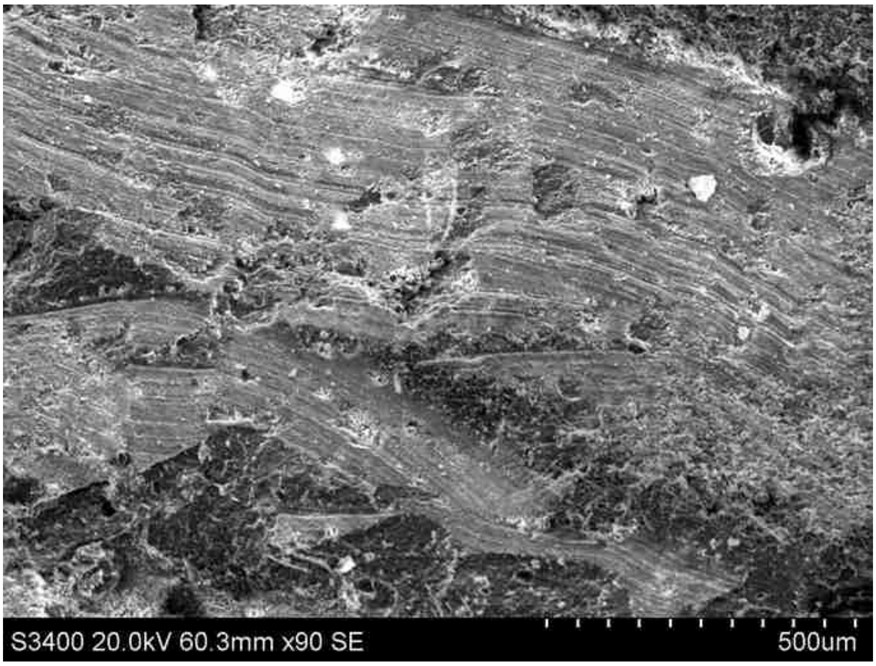


Fig.114 SEM image of the sharper striations going in the same direction CH06/4040/U.13669/S2.

4.4 Organic Binding Media

Chemical analysis of possible binders which may have been used for the paint application was attempted using Gas chromatography–Mass spectrometry (GC-MS) and was undertaken by Dr Rebecca Stacey who specialises on organic materials at the Department of Conservation and Scientific Research at the British Museum. Six painted plaster samples were chosen for analysis (see Table 4.8). The paint was sampled by scraping from the plaster surface using a clean scalpel blade. An area of paint approximately $5mm^2$ was removed from each sample.

Sample no.	Context no.	Paint layer on plaster
1	U.4844 s11	Thick fine-grained red
2	U.1309 x1	Thin, red
3	U.5383 x2	Fine-grained red
4	U.8226 s3	Large-grained black
5	U.4709 s3	Thick yellow paint layer with red stripe
6	U.7913 s6	Thin fine-grained red

Table 4.8 The details of the samples for the organic binder analysis.

Each of the samples was divided into two sub-samples for preparation in two different ways prior to analysis as follows:

4.4.1 Sugars (monosaccharides): for detection of gum media

Stacey describes the process as follows:

> "The samples were placed in clean glass micro-vials and hydrolysed by the addition of 100 µl of 0.5M methanolic HCl followed by heating at 80 °C for 18 hours. They were then dried under a stream of nitrogen and derivatised by the addition of 100 µl of Sigma-Sil A (1:3:9 ratio of trimethylchlorosilane (TMCS), hexamethyldisilazane (HMDS) and pyridine) followed by heating at 80 °C for one hour. This procedure is based on the method described by Bleton *et al.* (1996) for analysis of plant gums" (Stacey 2011, 2).

4.4.2 Lipids and amino acids: for detection of protein and oil/fat media.

Stacey describes the process as follows:

> "The samples were placed in clean glass micro-vials and hydrolysed with 100 µl of 6N HCl, heated overnight at 105 °C and then dried under nitrogen. The samples were dried again after agitation with 100 µl of deionised water and 100 µl of denatured ethanol.
>
> Prior to analysis, the samples were derivatised with N-(tert-butyldimethylsilyl)-N-methyltrifluoroacetamide(MTBSTFA)+1%tertbutyldimethylsilylchloride (TBDMCS). In both cases a procedural blank (no sample) was prepared alongside to monitor for laboratory contamination" (Stacey 2011, 2).
>
> "As a result of the analysis, no trace of sugar or uronic acid compounds characteristic of gum binding media could be detected in samples 3–6. Samples 1 and 2 both contained a few traces of sugar compounds but these could not be linked to the characteristic sugar profiles expected from gum binding media. No amino acid or lipid compounds were detected in the protein/lipid extracts. However, some of the samples (3, 4 and 5) contain hopane and sterane compounds that are characteristic of bituminous materials. This result for the black paint (sample 4) might indicate that bitumen might have been used as a pigment or as a mixture with the carbon black, but this result is not conclusive, since only one black pigment sample presented a vague evidence of bitumen (U.16647, S3) (see Fig.45). The red (sample 3) and yellow/red (sample 5) paints also indicate the presence of bitumen which is less obvious and this may suggest that contamination from other sources of bitumen at the site is also a possibility" (Stacey 2011, 2).

Essentially it was not possible to detect any evidence of gum, protein, oil or fat-based painting media. This is probably due to the age and deterioration levels of the samples. This means that the nature and use of organic binders at Çatalhöyük is still unknown and therefore needs to be investigated further.

4.5 The Study of possible Ground Stone Painting Tool kits

Studies of ground stone tools at Çatalhöyük indicate that such tools might have been used for food production and for possible crafts such as pigment grinding, plaster polishing, pottery, figurine and bead making, etc. (Wright, Baysal 2005, 307, Wright *et al.* 2013, 355-408). The studies also indicate that most evidence for ochre processing was found on small, fine sandstone/schist slabs (palettes) and less commonly on fragmentary handstones. In a few cases these came from grinding features, i.e. Building 1, and are considered to be related to a number of activities, i.e. possibly for painting walls or preparing pigments as grave goods. The ground stones data suggests that people used very small, fine grained abrading tools made of schist and sandstone in order to grind ochre and other minerals to various degrees. Sandstone abraders, fine marble/limestone polishing tools and schist palettes also had evidences of plaster and paint residues, which led to a further investigation of the possibility of a ground stone tool kit for wall painting production at Çatalhöyük.

During this research I examined some of the selected ground stone tools with possible pigment and plaster residues to be able to understand if they might have been used in relation to painting production. Wright and her team also supported my study by looking at the ground stone tools as possible painting/plastering tools and asking whether it would be possible to identify any evidence of specialism in ground stone tools by comparing the residual evidences on tools with the distribution of tools and the painted plasters within houses throughout the site.

The ground stone data shows that the most common artefacts used for ground stone tools were volcanic rocks, such as andesite and basalt. The dominance of andesite and basalt was due to the large percentage of broken querns and handstones. Other common materials were schist, diabase, dolerite, metabasalt, limestones, sandstones and marble. In terms of technological typology, Wright classified tool types according to the ways they were shaped, i.e. battering, flaking, pecking for initial shaping, followed by rough abrasion and coarse grinding. Then a finer abrasion to even out remaining roughness, followed by polishing to create finer polish on other materials or the actual tools used (Wright *et al.* 2013). Other classes were miscellaneous worked items, i.e. pigments, cores and debitage, and unworked stones.

The ground stone specialists studied 37828 unwashed stone items and identified the tools that may be related to wall paintings production throughout the ground stone data. They were particularly:

1) Fine abrading tools: Tools used for fine abrasion and made of fine grained or fine textured materials. These consist of small abrading slabs (often sandstone), small sized palettes (schist), small abrading knives (schist and sandstone), hand abraders (Wright *et al*. 2013 for definitions of individual tool types, Figs.115, 116a,b).

2) Polishers: Tools used for polishing and made of very fine grained materials. These often consist of small, hand held pebbles (limestone and marble) (Figs.122a,b).

3) Pigments: Unworked lumps and abraded pieces possibly used for producing paint and residues found on artefacts.

The latest excavation data studied by Wright and her team provides stone tool assemblages containing many small and/or broken artifacts as well as complete and large-sized ground stone tools (Wright *et al.* 2013, 355-408). According to the study most of the ground stone artifacts come from inside buildings, including both broken and complete examples. External areas produced only 8.4% of tools and most of them were broken. Wright mentions that even though the numbers are small, the types from external areas are similar to those found within houses.

Wright explains that:

> "small schist palettes were the one artefact type that consistently displayed pigment residues. Whilst not all palettes displayed pigment residues, and whilst such residues were occasionally seen on other artefact types (quern fragments, small sandstone abrading slabs, quartzite abraders), pigment traces were most commonly seen on the palettes by a significant margin" (Wright 2013, *pers.comm.*).

Therefore, Wright suggests that:

> "larger abraders/tools may also have been used for pigment milling. However, the association pattern between the small schist palettes and the pigment residues is outstanding and it is surprising that the pigment residue

evidence from larger tools was so rare. This may be due to the very coarse texture of the larger grinding tools making it difficult to create finely ground pigments. However there remains a possibility that levels of preservation played a role and the evidence from Çatalhöyük West Mound (Chalcolitic period) may be different" (Wright 2013, *pers. comm.*).

Below are the possible tools types identified for wall smoothing and pigment processing.

4.5.1 Fine Abrading Tools

The ground stone tools which suggest the closest relationship to wall painting production are the fine abrading tools (class C) and they seem to be the third most common artefacts (9.2% of all tools) within the whole ground stone assemblage (Wright *et al.* 2013). They are used for fine abrasion and are made of fine grained rocks, i.e. sandstones and schists (Figs.115,116a,b). They were small, easily held in one hand and were able to be transported from place to place. The sandstones used vary in texture and they may have been used for three different levels of abrasiveness. Coarser sandstone is often seen in sanding, cutting and sharpening slabs whilst very fine-grained sandstone seem to be used for producing abrading slabs small enough to be held in one hand for finer abrasion. Small sized pebbles and fine grained sanders with very flat surfaces are some of the forms that the handheld abraders are found as (Baysal, Wright 2005). Possible pigment residues and plaster were also observed mainly on small abrading slabs (palettes) and abraders. It is not always the case that red areas on schist palettes are actual pigment residues; in these cases they are either a part of the natural colour of the stone or a result of burning. However there are definite cases of fine pigment residues on these palettes and these are clearly identifiable by the fact that the pigment is fugitive. Abrading slabs include complete tools, fragments, sanding slabs, sanding/cutting slabs and palettes which all have certain shapes and purposes of use. The study of the ground stone data suggests that eleven abrading slabs (palettes) and six general abraders (one being the abrader/knife type)

Fig.115 CH05/South/U.11372/K1, an abrading slab (sandstone) with possible pigment residues (Courtesy of Dr Karen Wright).

contained pigment residues indicating the possibility of small grinding slabs and fine hand grinders which might have used in order to grind/produce pigments.

Fig.116a CH06/4040/U.13103/K1, an abrading stone type (schist) with possible plaster residues indicating evidence for the use for plastering application (Courtesy of Dr Karen Wright).

Fig.116b CH06/4040/U.13103/K1, same abrading stone from side view with plaster residues (Courtesy of Dr Karen Wright).

According to Wright's description a palette is a very small (larger forms are also evident) fine grained abrading slab that can be held in one hand, with one or more shallow, concave grinding surfaces (Wright *et al.* 2013). It was possibly used as a base to hold the raw mineral which would be finely or coarsely ground with a fine, medium or coarser grained abrasive stone (abrader). In terms of materials, sandstone and schist were used both for the abrading slabs and abraders. Green schist, phyllite and mica schist were most commonly used for palettes (Figs.117, 118, 119), general abraders and knives with abraded surfaces and sharp edges.

Fig.117 An example of a schist palette with definite pigment residues. Mellaart excavations. No contextual information is available (Courtesy of Dr Karen Wright).

Fig.118 CH06/4040/U.13127/K1, an example of a schist palette with possible pigment residues (Courtesy of Dr Karen Wright).

Fig.119 CH08/South/U.17058/K5, an example of a schist palette with possible pigment residue (Courtesy of Dr Karen Wright).

Wright explains that the abrading slabs and abrader knives which were possibly used for painting and plastering are often small and can be held in one hand showing that a fine level of pigment processing could be possibly made by using palettes (as bases) and abraders (as grinders) in a small scale production (Wright *et al*. 2013). Abrading knife types (with abrading surfaces and edges showing use for rough cutting) might also have been used as spatulae in order to apply and/or smooth the wet marl plaster once on the wall (Figs.120, 121).

Fig.120 An example of an abrader knife (Courtesy of Dr Karen Wright).

Fig.121 An example of an abrader knife (Courtesy of Dr Karen Wright).

4.5.2 Polishing Tools

The study by the ground stone specialists show that the polishing (burnishing) tools consisted of only 3.1% of all tools and come in the forms of polishing slabs (Figs.122a,b), polishers (Figs.123, 124, 125, 126) and tools with functions such as percussion or cutting (Wright *et al.* 2013).

Fig.122a CH97/North/U.2525/K1, an example of a polishin slab (Courtesy of Dr Karen Wright).

Fig.122b CH04/South/U.11400, an example of a polishing slab (Courtesy of Dr Karen Wright).

Fig.123 CH99/South/U.5721/X3, an example of a polisher (Courtesy of Dr Karen Wright).

Fig.124 CH02/South/U.5578/X3, an example of a polisher (Courtesy of Dr Karen Wright).

Fig.125 CH07/South/U.16239/K1, an example of a polisher (Courtesy of Dr Karen Wright).

Fig.126 CH05/South/U.11648/X2, an example of a polisher (Courtesy of Dr Karen Wright).

These seem to be made mainly of hard limestone or marble. Polishers are explained by Wright as small hand tools which were in round, oval or rectangular shapes with at least one even, polished side (Wright *et al.* 2013). Even though there is no evidence of plasters or pigments on the surfaces, their shiny and flat surfaces with scratch marks in all directions may indicate that they may have been used for polishing plaster surfaces on walls before painting took place.

4.5.3 Pigments

At Çatalhöyük pigments were found mainly in three forms; raw, as abraded nodules and as pigments found on tools as residues. Raw form is possibly the raw minerals, which the pigments were processed from via washing, grinding and sieving (Figs.127a, b, c, d, e).

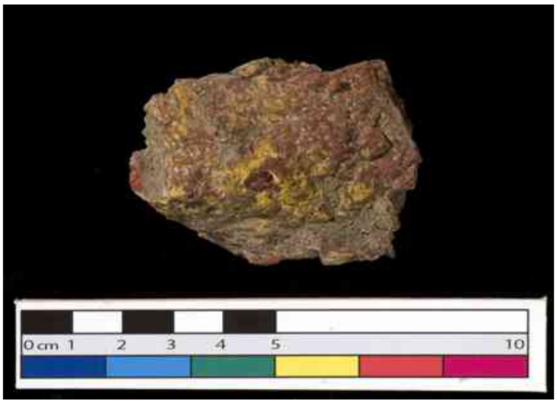


Fig.127a CH06/South/U.12553/X5, an example of a pigment in a raw form (Courtesy of Dr Karen Wright).

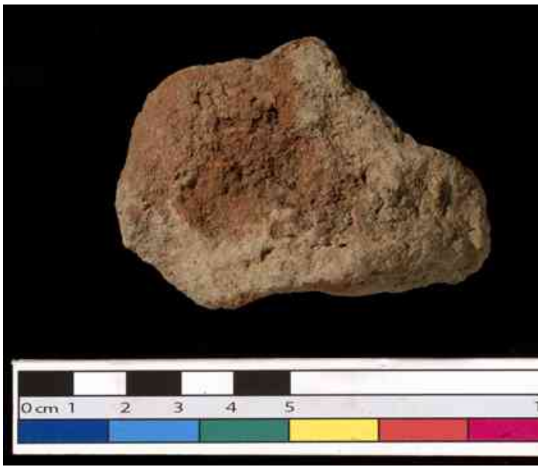


Fig.127b CH97/Bach/U.2209/X1 an example of a pigment in a raw form (Courtesy of Dr Karen Wright).

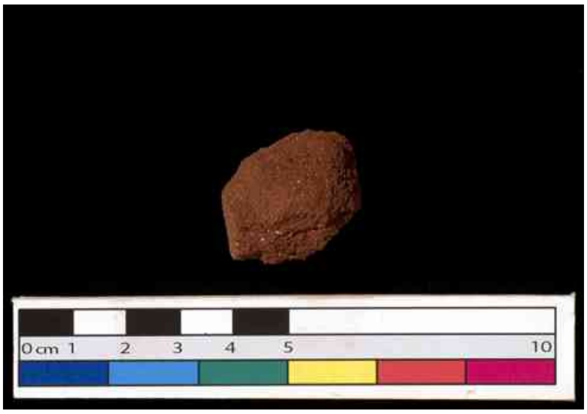


Fig.127c CH04/4040/U.10231/X1, an example of a pigment in a raw form (Courtesy of Dr Karen Wright).

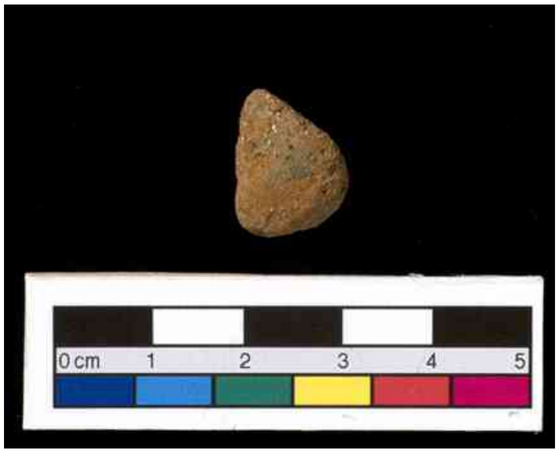


Fig.127d CH02/South/U.5848/K2, an example of a pigment in a raw form (Courtesy of Dr Karen Wright).

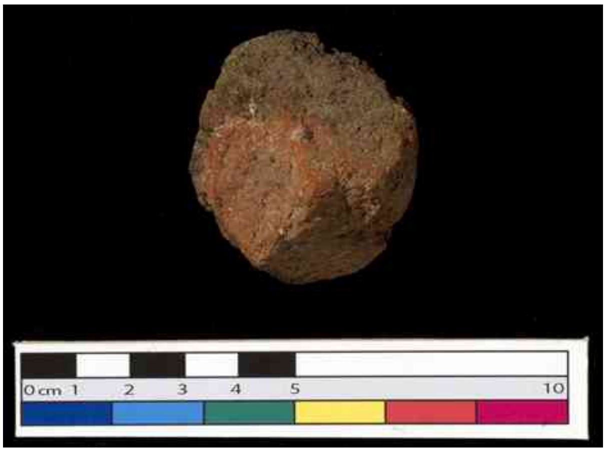


Fig.127e CH04/South/U.11295/K5, an example of a pigment in a raw form (Courtesy of Dr Karen Wright).

Abraded nodules, with one or more abraded surfaces, indicate pigment lumps that were possibly being used either as actual painting tools to rub on the walls or being used on the palettes in order to mix pigments with binders before applying onto the walls (Figs. 128a,b,129, 130, 131).

Fig.128a CH06/South/U.12631/K1, an example of a pigment in an abraded form (Courtesy of Dr Karen Wright).

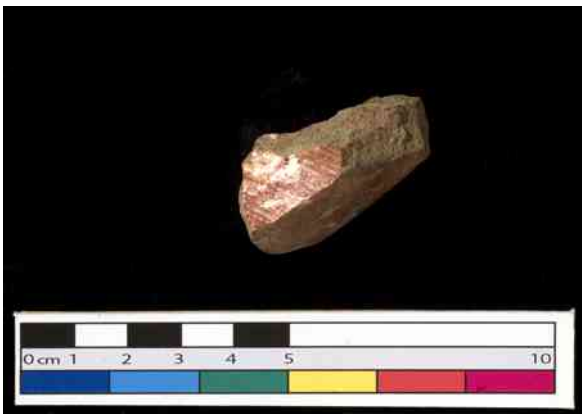


Fig.128b U.12631, side view (Courtesy of Dr Karen Wright).

Fig.129 CH06/4040/U.13177/K3, an example of a pigment in an abraded form (Courtesy of Dr Karen Wright).

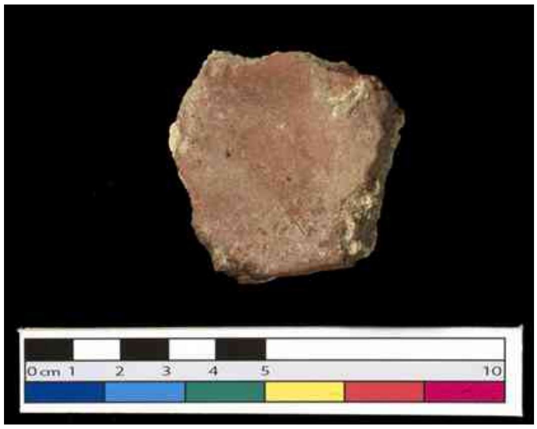


Fig.130 CH07/4040/U.14684/K1, an example of a pigment in an abraded form (Courtesy of Dr Karen Wright).

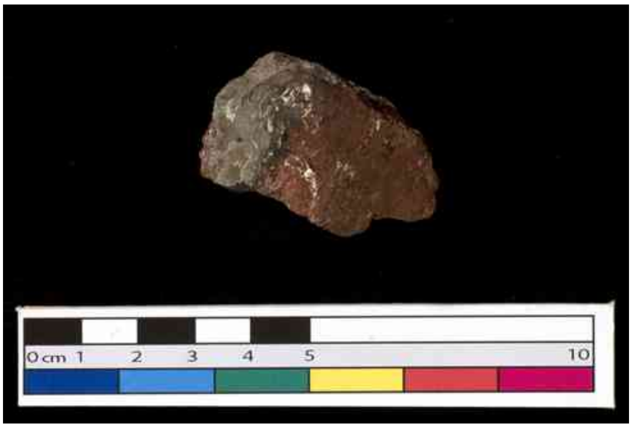


Fig.131 CH08/South/U.17040, an example of a pigment in an abraded form (Courtesy of Dr Karen Wright).

As seen on Table 4.9 (Appendix 218) abraded nodules are one of the most interesting aspects of the pigment data related to the ground stone painting tool kit. Their flat surfaces have striations similar to those observed on the painted surfaces (Figs. 132a,b)

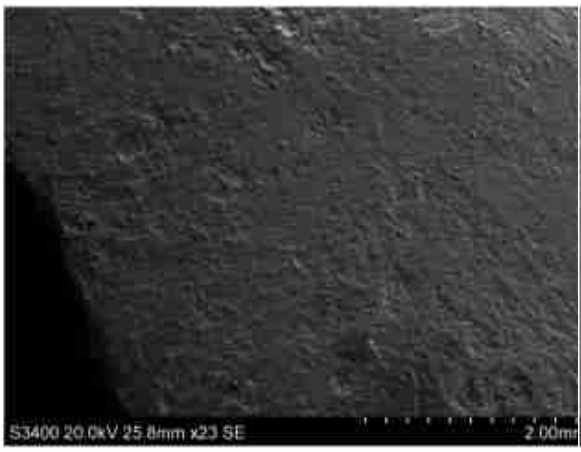


Fig.132a CH06/4040/U.13177/K1, the evidence of striations on the surface of an abraded nodule (see Fig.129).

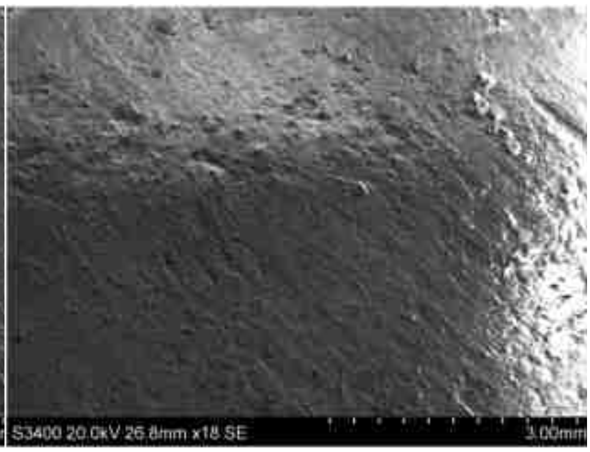


Fig.132b CH06/4040/U.13177/K1, the evidence of striations on the surface of the same abraded nodule (see Fig.129).

and their waxy/compact nature may still give clues about their possible use for producing paint by rubbing either on the walls (similar to crayons, Leroi-Gourhan 1982, 12) or on the schist palettes.

According to the ground stone study undertaken in relation to the houses, ground stone tools mostly came from inside buildings (Wright *et al.* 2013). Wright explains that middens and external areas have also produced data (broken and complete artefacts), but in small quantities. The study showed that the ground stone tools in general were crafted, used and discarded inside houses (particularly in the making of crafts and food) (Wright *et al.* 2013). Also all the large and heavy stone tools/artefacts that are complete were found only inside houses and it seems that they may not have been used communally in outside spaces. This may be explained as the heavy nature of these tools might have made it less practical to carry them in and out of houses and therefore any shared activities between different households using these tools might have been undertaken inside the houses.

The study also shows that the number of ground stone tools is different between houses (Wright *et al.* 2013). Even though the large and elaborately built multi burial "history houses" seem to contain large assemblages of artefacts, this is not always the case, as seen in Buildings 3 and 68. One of the aims of this research is to see if some houses had a better access to ground stone tools and specific tool kits than others. For example, in order to investigate whether the "wall painting tool kit" was available to most or all households or whether there is any evidence of specialization in wall paintings production, i.e. only special houses/workshops? containing specific tools in relation to the wall painting toolkits, it is important to look at the distribution of wall painting related ground stone tools within buildings throughout the site. Tables 4.10 (Appendix 219) and 4.11 (Appendix 220) present all the ground stone tool types that may be related to wall painting production and their distribution inside the buildings in the South and 4040 Area. They include materials from floors, but also from fills within buildings. Study of the distribution of the painting tools shows that in general most abrading tools, polishers and pigments came both from within buildings and from middens/external areas whilst the small, coarser grinding tools such as handstones were found in middens. Table 4.10 shows that in the 4040 Area all of these tools were found in most buildings, but their numbers were higher in buildings where wall paintings existed, i.e. Buildings 3, 49, 55, 77. In the South Area (Table 4.11) the data presents a similar pattern to the 4040 Area, in that tools are found within most buildings, but this time there is no clear difference between the houses with and without paintings. The painting tools distribution through the different phases of the South and the 4040 Areas (Table 4.12, Appendix 221) also shows that the number of painting tools increases in the later levels, i.e. South P, Q, R, S, T and 4040 G, and this may be linked with the higher number of tool accumulated in certain houses with more paintings, i.e. as clearly seen in the 4040 Area buildings (see above). Further discussion of these results is made in Chapter 6 in order to investigate if it is possible to detect a pattern in relation to "specialised" or "communal" wall paintings practices.

4.6 Conclusion

This chapter has presented the analytical results which were obtained from using the most suitable investigative techniques for this research on plasters, pigments, possible application methods, possible use of organic binders and the ground stone tools which may have been used for pigment and plaster application. As explained in Chapter 1, Section 1.6.3.4, the analytical results also helped to set up the experimental work which was undertaken as a support for the former and enabled a better understanding of how materials may have combined to create wall paintings. Unfortunately the archaeological samples for this research did not always enable one to gather conclusive information via the analytical study, i.e. it was not really possible to get clues on the use of possible tools and application techniques. Therefore the experimental work mainly focused on using modern materials, i.e. natural marl, commercial red iron oxide pigment, crushed carbonized wood (with reference to the original ones identified by the analytical work) and selected media as binding materials, to test how individual materials would react with each other (rather than the individual materials themselves) and the practicality of using possible painting tools as well as the application techniques in order to get a feel of the most basic methods of creating paintings, while also complementing the results of the analytical study. Whilst the results of analytical work are discussed within the analytical framework of this chapter, further discussion takes place in chapter 6 where the results are placed into the broader context of wall painting production at Çatalhöyük. They are also supported by the results of the experimental work which are presented in the next chapter.

Chapter 5

The Methodology and Results of the Experimental Work for Plastering and Painting Practices at Çatalhöyük

5.1 Introduction to the Experimental work

This chapter presents the designed methodology and results of the experimental work, carried out in support of the analytical study in this thesis in order to better understand, as well as to better compare and complement some of its results. Experimental archaeology is a useful method for exploring the material under study when technology is investigated both from the perspective of the maker and the object itself (Brysbaert 2004). Millson explains that today experimental archaeology plays an important role "between data and theory i.e. between science and arts" (Millson 2011, 4) and it is not only considered to be replication work as in the past, instead it is recognised to also investigate past methods of the manufacture of objects together with the main ideas behind them. It can also involve the application of experimental methods "in the areas of data collection, description and interpretation while testing, evaluating and replicating techniques, assumptions, hypotheses and theories at any level and all levels of the archaeological research" (Ingersoll *et al.* 1977, xii, Millson 2011, 4). While some scholars may focus on finding answers about the material pasts and the methods and technologies used via analysing the material using a variety of instruments or undertaking typological studies, others may be more interested in putting themselves into past people's circumstances and reproducing their actions to be able to understand their abilities and choices for producing materials of the past (Coles 1979, 2). Moreover, throughout experimental work one can also make links with archaeological information gathered by undertaking analytical work on how the materials were made and the steps of art/craft production within communities (Brysbaert 2004, 187). In other words, experimental archaeology can help archaeologists/specialists to see technological aspects in detail while helping them to understand the object's social context (Brysbaert 2004, 187, Ingold 1999, xi).

Ingersoll *et al.* (1977) explain that there are four categories of experimental archaeology:

> "**1)** controlled replication of objects or known activities. **2)** testing the methodological assumptions against a known data and/or gathered results. **3)** contextual, **4)** those dealing with ethnographic data" (Ingersoll *et al.* 1977, xii).

The suitability of these categories depends on the context and nature of material and the amount of information or data available in relation to the methods of production and use (Millson, 2011, 3).

A scientific methodology can also be combined with experimental archaeology when professionals may need to recreate objects to achieve a close association with the original objects by using the most similar materials available. This is important in terms of gathering reliable data throughout the experimental work. Each step of the experiments must be documented, so that it can be re-replicated or re-developed if and when necessary. It is also important that the results are related to the broader archaeological context, easy to understand and usable by other scholars and studies in the field (Millson 2011, 3).

The results of much experimental work undertaken within the archaeological field can support archaeological knowledge (Skibo 2000, 200). However, it is crucial to be aware that experimental work is often only a guide for understanding the main aspects of technology, since it is impossible to imitate the original contexts in which people undertook their work (Dobres 2000, 150, Brysbaert 2004, 185). People who created objects in their own contexts might have experienced different social interactions, religious beliefs and had a different symbolic understanding of their surroundings as opposed to us, who undertake experimental work within our present and contemporary contexts. Therefore we can say that the actions are dependent on the contexts within which they are undertaken.

During this study the need for conducting experimental work occurred when it was realised that the analytical data was not reliable enough to answer some of the questions asked, i.e. material interactions, application techniques and possible tools. I also wanted to test some of the analytical results against the experimental work, i.e. the application techniques, to see how physically practical they would be in the context of plastering and painting walls. It was not possible to use original painting materials for the experimental work and I was aware that the modern materials I chose, i.e. pigments and binders, were only modern representatives of the original ones and would not act the same as those used in the archaeological context. Nevertheless, the entire plastering and painting practice gave me some ideas on the use of painting materials, techniques, tools and how materials reacted with each other, even though the results I gathered might not be scientifically conclusive.

While conducting my research it was pointed out to me that in the village of Küçükköy the locals regularly plastered the walls and I held a few informal conversations with villagers and workers employed to work at Çatalhöyük to improve my understanding of how plastering practices can work in a predominantly pre-modern context. It was not an ethnoarchaeological survey and the conversations were not formal interviews but it did widen my appreciation of possible factors surrounding plastering practices that had not been covered in the academic literature. A detailed survey of wall painting ethnographies was beyond the scope of this research.

My main questions for the experimental work were:

1) How could the plaster layers have been prepared and applied onto mudbrick walls as well as onto each other before the paint application?

2) What kind of tools might have been used to prepare the plaster surface before or after the painting takes place, i.e. polishing pebbles, hand sized stone tools, cloth, skin, hands?

3) What kind of tools might have been used to prepare the pigments, i.e. grinding/abrading stones, hand stones, schist palettes?

4) What kind of painting methods might have been used, i.e. on a dry or a wet surface, with or without binders?

5) What kind of tools might have been used to apply the pigments on the walls, i.e. brushes, bone, stone, wooden tools, cloths, skin, bare hands?

6) Which of the application/painting methods were the most successful in terms of use and durability?

Each section of the experimental work is discussed below. The selection of materials and the methodology used emerged from the archaeological and analytical data. Natural marl was used as the closest material to the original plastering material. Pigments and binders were modern, commercially sourced materials. I was aware that these will not have behaved the same way as the original materials and the purpose of the experimental work was designed to understand more about the application methods and how people could prepare and paint their walls as well as to observe interactions between marl, pigments and binders. With the ideas inspired by the local information collected from the villagers of Küçükköy it was also aimed to develop a technological and social understanding of plastering and painting practices both from a Neolithic craftsman's and the villagers' point of view.

5.2 Experimental Work:

5.2.1 Materials

The materials used for the experimental work were selected according to their immediate availability and their similarities to the original materials that were identified through the analytical study. Table 5.1 shows the materials used for the experimental work.

Materials	Use
White marl	Plastering
Off white (pale brown) marl	Plastering
Commercial red iron oxide pigment	Painting
Modern charcoal remains for black pigment	Painting
Brushes	Painting
Pieces natural of textiles	Plastering/painting
Pebbles in various sizes	Grinding, plastering, burnishing
Straw	Plastering
Sheep scapulae	Plastering
Wooden sticks	Painting
Fingers, hands	Plastering/painting
Wooden boards (15cmx24.5cm)	Plastering

Table 5.1 The materials used for the experimental work.

5.2.1.1 Terminology Used during the Experimental Work

Marl plaster: Marl is a naturally occurring, clay based material, which was used to cover the walls of the mudbrick houses at Çatalhöyük (see Chapter 2, Sections 2.3 and 2.4, Chapter 4, Section 4.2.1). It can be used in a slurry or putty form depending on the amount of water added and the final product is defined as "marl plaster".

Single layered painted wall plasters: Painted wall plasters made from one thick layer of white marl plaster (5000μm or less) with a single layer of paint applied.

Multi layered painted wall plasters: Painted wall plasters which are made of several thin layers of white and pale brown (off white) marl plasters with either one or more paint layers applied.

Foundation layer: The thick layer of pale brown marl plaster (5000μm) which would be applied onto the mudbrick walls, followed by the application of thinner plaster layers.

Base plaster layers: Thin layers of pale brown (off white) marl plaster with the addition of plant material (1000μm or more).

Final wash layers: Thin layers of white marl plaster without the addition of plant material (<1000μm).

(All colours described above have been recorded visually as well as under optical microscopy).

Wet plaster: When dry marl lumps are mixed with water to form marl plaster and applied in wet state.

Damp plaster: The state of marl plaster as it dries but before it becomes leather-hard.

Leather-hard plaster: The state of marl plaster before it completely dries (sets).

Dry plaster: When marl plaster is completely dry.

5.2.2 Marl Plasters:

As the analysis showed natural marl clay (Types 1,2,3,4 with <50% and Type 5 with >50% calcium content) has slight differences in nature/colour (Doherty 2006, 2007, 2008, see Chapter 2, Section 2.3 and 2.4, Chapter 4, Section 4.2.1). There is a general method of application observed by the scholars on the ancient site: **1)** a 5000μm thick foundation layer of pale brown silty clay with 50% vegetal stabilisers. **2)** The subsequent plaster layers then consisted of repeated application of thinner layers: 1000µm or more, pale brown (base) marl plaster with vegetal additives and <1000µm very fine, white soft lime (final wash) without additives, which were very smooth and most probably burnished (See Chapter 4, Section 4.2.1, Matthews 2005b, 366, Doherty 2007, 372,373, Tung 2008). As mentioned in Chapter 4, Section 4.2.1 during the sampling work of the painted plasters a different type of painted plaster was recorded, mainly found in the lower levels of the East Mound (South area, Space 181, Pre-level XII and levels X, IX, VIII) with red and yellow painted surfaces. These plasters were composed of a single, thick layer of white plaster (colour observed visually, 5YR 8/1, Munsell Soil Colour chart, 2000) and were considerably compact. Under optical microscopy they looked greyish white with a yellow hue (5Y 7/2 light grey, Munsell Soil Colour Chart, 2000). The analysis showed that they were white marl with fine marl and limestone inclusions (see Chapter 4, Section 4.2.1.5).

As explained in Chapter 4, macroscopic observations showed that there are two different types of painted plasters (multi layered, softer texture, and single layer, harder texture) with one or more paint layers applied. However, it was difficult to investigate these plaster/paint layers due to the effects of long-term burial, surface erosion and deterioration. Further microscopic analysis was pursued to observe the nature of these painted plasters (see Chapter 4, Section 4.2.1). According to the microscopic study, the painted plaster samples were divided into two groups in terms of their plaster application method: single layered and multi layered application. Single layered plasters mostly consisted of white marl (Type 5), whilst multi layered plasters were made up with pale brown (impure) marl and white soft lime (Type 2) in different thicknesses. The total thicknesses of the multi plaster layers has changed due to their preservation problems, i.e. they have lost their true thicknesses or been completely eroded.

Following both macroscopic/microscopic observations, the experimental work aimed to test these different types of plasters and their applications. Marl being a natural product (See Chapter 2, Sections 2.3 and 2.4) and available in the close surroundings of the site, it is still used in the region for plastering mudbrick walls/floors and apparently applied in a similar way to in the Neolithic by mixing it with large amounts of straw and water for the thicker layers and as a thin white wash for the final one. The villagers are aware that its colour varies from pale brown (off white) to white and it has a very sticky nature (Matthews 1996, 304, Doherty 2007, 372, 373). For the experimental work, locally available marl was collected from a ditch in the nearby village of Dedemoğlu, 6km east of Çatalhöyük (Fig 133a,b).

Fig.133a The locally available marl piled up along a ditch in Dedemoğlu village, 6km east of Çatalhöyük.

Fig.133b Mustafa the site guard, helping to collect the marl.

A hydraulic ditch (channeled naturally by the pressured water) is located on the eastern border of the current alluvial fan, cutting it and digging into the underlying marl deposits. From here, marl is collected for use in plastering in the surrounding villages. Stevanović mentioned that this was also the source for the marl used in the making of the experimental house at Çatalhöyük in 1999 (Stevanović 2005, 1-72, Stevanović 2008, *pers. comm.*).

The marl deposits are of two types, white and off white. The off white colour equates to pale brown under the visual examination of the painted plaster samples (10YR 7/3 very pale brown, Munsell Soil Colour chart, 2000) as well as under the optical microscopy (10YR 6/3 pale brown, Munsell Soil Colour Chart, 2000) and therefore will be described as "pale brown" in the further text. Pale brown deposits (though it looked "whiter" when dry) were located near the surface of the ditch and therefore were easier to obtain. In order to extract white marl deeper coring was necessary (for the colour differences in marl, see Chapter 2, Sections 2.3 and 2.4, Chapter 4, Section 4.2.1, Chapter 6, Section 6.1). Fortunately, some of the white marl that was previously obtained from the same ditch for plastering the experimental house (Stevanović 2005, 1-72) was already available on site and was used for the experimental work (instead of soft lime washes on multi layered applications). Soft lime was not available for this experimental work, since it was not feasible to obtain it at the time of the experiments. Also, the same plaster materials used for plastering the experimental house (Stevanović 2005, 1-72) was tested in order to better understand today's plastering practices in the nearby villages.

Following the observations above, two different combinations of plaster application were tested:

1) Layered application of pale brown and white marl plaster

2) Single, thick layer of white marl plaster

5.2.2.1 Preparation of marl plaster before application

The marl was extracted in the form of medium to large, hard lumps, which were left to dissolve in water for 24 hours (Fig.134). Small wooden boards (15cm x 24.5cm) were used as a backing support for the application of plaster layers (Fig.135). Finely sieved

Fig.134 Soaking the marl lumps in water.

Fig.135 The wooden backing boards for the experimental plaster application.

straw was used as plant stabilisers, as the optical microscopy work showed the impressions of fine vegetal stabilisers in marl plasters (approximately 50%) to reduce shrinkage upon drying and increase flexibility (Fig.136)

Fig.136 Finely sieved straws to add into marl plaster.

Ryan (2010, *pers.comm.*) mentions that her phytolith analysis presented some finely chopped plant impressions in plasters (possibly sedges, chopped leaves, stems of monocots) but due to the poor preservation of phytoliths in marl which has a high pH, they were not able to be fully identified. However, in bricks a number of samples were successfully analyzed (Ryan 2006, 2007, 2008). The specialists found a considerable variability in the amounts of plant material present in burnt bricks ranging from little or no plant material to an abundance of visible phytoliths. Some appear to be chaff and/or thin monocot stems and others are thicker monocot stems. Their initial results show the use of cereal chaff and leaves/stems of wild grasses, reeds and sedges from wetland plants in brick temper (Rosen 2010, *pers.comm*). At Çatalhöyük the extensive quantities of plants suggest that they were collected in large quantities and also possibly stored to be used in house constructions (Stevanović 2008, 211, Ryan 2008, 150). However, none of these examples were clearly visible in the plasters.

For plastering work, bare hands, cloths and pebbles in small to medium sizes were experimented with as plastering and burnishing tools, since they were available and are used in villages nearby Çatalhöyük. Following discussion with the animal bone specialist Nerissa Russell sheep scapulae were also experimented as plastering tools (Fig.137a), since some of the scapulae analysis at Çatalhöyük showed deliberate abrasion on the surfaces (Figs.137b-d) even though there is no evidence of plaster on them (Russell 2010, *pers.comm.*, Russell 2005, 347, 348).

Fig.137a A modern sheep scapula.

Fig.137b An archaeological sheep scapula, U.13370, X9 (Courtesy of Nerissa Russell).

Fig.137c An archaeological sheep scapula, U.14522 (Courtesy of Nerissa Russell).

Fig.137d An archaeological sheep scapula, U.6512, F127 (Courtesy of Nerissa Russell).

According to the villagers, the pale brown base marl plaster that is applied as primary layers over the mudbrick walls, shrinks and cracks upon drying if not mixed with straw. This makes the plaster very thick in consistency and it is constantly watered down to achieve a thinner wash. After mixing with coarser straw (50:50 straw/plaster V/V) the pale brown marl plaster is usually left for a day or two in order to settle it and bring it to a "putty" consistency, before it can be applied onto the walls. Generally it is applied around 1000µm or more. Once the layer of pale brown plaster has set, a thin layer of white marl plaster with no straw is applied as a final wash (<1000µm), either by using a brush, hands or a cloth and constantly smearing/burnishing the plaster until it starts drying (Fig.137e).


Fig.137e Fatma re-plastering a wall in Building 5, 4040 Area.

Following the information given by the villagers as well as by the microscopic and macroscopic observations, two types of plaster application were tested:

5.2.2.2 Layered application of pale brown and white marl plaster:

Painted plaster analysis showed that the marl plaster layers consisted of repeated application of layers as the approximate thicknesses were mentioned above. Microscopic observations also indicated that the surfaces of the white washes are smooth and compact, indicating that they may have been deliberately burnished, possibly using limestone or marble polishing stones/pebbles found on site (Mellaart 1962, 48, Wright, Baysal 2005, 324, Wright *et al.* 2013).

Following the information mentioned above base layers were made by mixing the pale brown marl with finely sieved straw (50:50 straw/plaster V/V) in order to observe the ease of preparation/application as well as the level of cracking and shrinkage upon drying. The locally available coarser straw was first chopped with stones (as suggested by the villagers) (Fig.138) and then was sieved with a 0.3milimicron sieve and the fine straw obtained was added to the marl with some water to achieve a putty texture (Fig.139). During this work some villagers who I worked with at Çatalhöyük helped me with the preparation of the materials.

Fig.138 Nevriye chopping the coarse straws with stone.

Fig.139 Mustafa and İbrahim mixing the sieved straw into marl.

It was observed that the plaster became very thick and difficult to work with as the straw was added. However, the addition of more water thinned out the plaster and made it easier to apply (Fig.140).

Fig.140 Application of marl plaster after thinning out with water.

A preparatory base layer (1000µm or more) was applied quite thinly over the surface of the sanded and lightly wetted wooden boards (Fig.141).

Fig.141 The first (preparatory) marl plaster layer with mixed straw.

The addition of straw also created a slightly rough textured surface to which the following washes of thin (<1000µm) white marl plaster with no straw inclusions would be applied onto (Matthews 2005, 366) (Fig.142).

Fig.142 The second (finer) white marl plaster layer without straw, applied onto the first layer.

The white, thin wash layers were alternated with thin layers of pale brown marl plaster (with no addition of straw). A small sheep scapula (worked and prepared by chopping the ends and filing the edges) proved to be the ideal tool to spread the plaster (Figs.143a,b).

Fig.143a Working the sheep scapulae into shape before plastering.

The side and the top of the scapula bone acted as a spatula. Once the plaster was roughly spread onto the mudbrick by using a scapula bone it was possible to get a very smooth surface by using hands, a very thin cloth or pebbles wetted with water (Fig.144).

Fig.143b Spreading marl plaster onto mudbrick using a small sheep scapula.

Fig.144 Smoothing out marl plaster by hand.

Even though there is no evidence of plaster on any animal scapulae from Çatalhöyük the possibility of their use for plaster application is strong due to its practicality and the wear marks observed on some of the examples, as noted by Russell (Russell 2008, *pers.comm,* Russell 2005, 347,348)

The experimental work showed that the marl plaster layers cracked while drying and the level of cracking depended on the thickness and method of application (Fig.145).

Fig.145 Marl plaster layers cracking during the drying process.

For instance, when applied very thin and smeared continuously with a cloth, hands or a pebble during application the marl plaster does not crack even without the addition of straw. However, if the marl plaster is applied thicker (1000µm or more) then the addition of approximately 50% plant stabilisers (this would be calculated by eye which would require a skill gained through experience) and smearing the surface with a flat pebble or a cloth during drying is necessary to prevent cracking. This practice also burnishes the surface and further prevents the occurrence of cracks.

5.2.2.3 Single, thick layer of white marl plaster:

The microscopic examinations showed that the painted plaster samples from Space 181 (Pre-level XII, Levels X,IX, VIII, South Area) were made up of a single, thicker layer (<3000-4000µm) of white marl plaster with fine lime and other mineral inclusions (see Chapter 4, Section 4.2.1.5) as well as no addition of plant materials. These plasters were also very distinctive due to their highly burnished surfaces. As discussed above the experimental work showed that when a single thicker layer of marl plaster was applied without adding any stabilisers it cracks severely during setting (Fig.145). However the original samples did not show any evidence of cracking. The possible reasons for this are discussed in Chapter 6, Section 6.1.

5.2.3 Preparation of the marl plaster surface before painting

5.2.3.1 Burnishing

Burnishing is a form of treatment in which the surface of the plaster is polished using a hard smooth tool such as a wooden or a bone spatula, stones or pebbles by rubbing the surface gently while it is in a leather-hard state, i.e. before drying. Following the results of previous observations on the marl plastered surfaces (Mellaart 1962, 48, Matthews 2005b, 366, Wright, Baysal 2005, 324) the experimental work and the study of the ground stone data indicated that the marl plastered walls might have been burnished before the paint was applied possibly by using limestone or marble, hand sized polishing stones or pebbles of different shapes (Wright *et al.* 2013). Apart from adding vegetal stabilizers to create strength and flexibility in the marl plaster, burnishing the leather-hard surface tends to smear out the surface and seems to make it harder, stronger and smoother before the paint is applied (Fig.146).

Fig.146 Marl plaster layer after burnishing with pebbles during drying.

After burnishing the surface becomes compact. During the experimental work the marl plaster surfaces (both pale brown and white) were either left unburnished or burnished at three stages before the painting process in order to observe the best conditions for burnishing: **a)** while the marl plaster was still wet/damp **b)** when leather-hard **c)** when dry.

The experimental work showed that leaving the surface unburnished was not really an option due to shrinkage and cracking. However, the continuous burnishing during the application of thin layers of wet marl plaster minimizes the need for final burnishing (before the paint application) while controlling the occurrence of cracks (Fig.147).

Fig.147 Marl plaster layer after burnishing with hands during application.

Hands or a piece of cloth used with light pressure seemed to work well for burnishing thin layers of wet marl plaster during the application process. Burnishing after the application of marl plaster (either thin or thick layers) could only be done when the plaster was leather-hard. Burnishing the wet/damp surface was unsuccessful due its softness and the plaster was peeled off by the burnishing tool (pebbles in this case). The dry marl plaster surface was also not practical to burnish as the result was a very white powdery/matt surface, not suitable for painting. When both type of marl plaster (pale brown and white) were burnished leather-hard, their surfaces looked compact, shiny and “off white” in colour (Fig.148).

Fig.148 Marl plaster layer after burnishing when leather-hard.

As a result of the experimental work burnishing was considered to be best achieved during the marl plaster application (both white and pale brown), when the plaster was wet and applied in the form of very thin layers. Burnishing was also successful when the plaster was leather-hard and it helped to remove any cracks before the application of paint. Hands and a piece of cloth used with light pressure were suitable for burnishing wet plaster, whilst the pebbles or small hand sized stones (in various sizes) with flat surfaces worked very well with a hard pressure for burnishing the plaster when leather-hard.

5.2.4 Painting the marl plaster surfaces

Following the burnishing process the marl plaster surface was compact and smooth, ready to paint (Fig.149).

Fig.149 Marl plaster layer after burnishing, ready for painting.

The type of pigments experimented for painting were not as natural as the ones used for the archaeological paintings. The red colour was obtained from a modern commercial red iron oxide powder pigment and black was obtained by grinding burnt wood fragments collected around the site (Fig.150). It is recognised that the properties of the modern paints will not be the same as those used in the archaeological context. Unfortunately, the natural ochre pigments were not available to me during my experimental work and therefore I decided to experiment with the commercial type, which gave some indication of the painting/colouring techniques and the interaction between the pigment and the marl.

Fig.150 Grinding commercial red ochre pigment with a modern mortar and pestle.

The literature on prehistoric pigments (Delamare, Guineau 2006, 16, Pomies *et al.*1999, Ruspoli 1987, 192, Chalmin *et al.* 2003) mentions that after collection, the pigments in the mineral form were possibly dried in the sun, ground to various degrees, sieved to reduce impurities and then re-ground to powder, before being cleaned and dried. Further grinding allowed a finer granulation to be obtained. A number of fine abrading slabs, hand stones and schist palettes found at Çatalhöyük with possible residues of pigment may indicate the possible use of these tools for pigment preparation (Wright, Baysal 2005, Wright *et al.* 2013) (See Chapter 4, Section 4.5). PLM analysis on pigments showed that the particle shapes (angular to subrounded) and sizes of the original pigment samples vary within the samples and the size ranges between 5µm-300µm (X100) indicating that the pigments were generally finely ground (angular shapes indicating hand grinding) and maybe sieved through a fine cloth to achieve brighter, purer colours and therefore smoother applications as observed by the Raman spectroscopy (see Chapter 4, Section 4.3). The different shades of pigments, i.e. in red ochre and azurite, may also be related to the preparation processes (as well as the different geological sources) as the pigments become brighter and more vivid when they are finely ground and darker if coarsely ground.

During the analytical study the cross-section and thin section of the painted plaster samples showed that most often there was a smooth, sharp boundary between the paint and the underlying plaster layers (See Chapter 4, Section 4.3). This indicates that the plaster layers were most probably dry when the paint was applied with or without organic binders. If the paint had been applied on damp/wet plasters the paint would seep into the plaster layer and set to form an uneven and gradational boundary upon drying. In order to test the practicality of different application techniques and to compare it with the analytical results three methods were tested: painting on wet, leather-hard and dry marl surfaces both on single, thick and multi, thin layered plasters. As opposed to the plastering tools there was no information or evidence on the painting tools used at Çatalhöyük. Following technical studies on Palaeolithic cave paintings, I experimented with small brushes, fingers, hands, wooden sticks, cloths and pebbles as painting/burnishing tools (Fig. 151).

How these worked for applying pigments onto marl plaster is explained in Section 5.3, the Summary of Results.

Fig.151 Painting/burnishing tools used during the experimental work.

5.2.4.1 Application of paint on a single, thick layer of white marl plaster

5.2.4.1.1 Painting on a wet surface (unburnished) (Fig.152)

When the paint was applied onto a wet, unburnished marl plaster surface, the pigments mixed with the water in the plaster. In this case the pigments were applied onto a 3000-4000µm thick, white marl plaster surface with no straw additives (to imitate the Space 181, Pre-level XII, South Area plasters) and no burnishing in order to test the ease of paint application, and the resistance of the paint against burnishing. A small amount of bleeding occurred when the red and black pigments were applied with water and if more water was used, bleeding increased. Carbon black was less dense than the red ochre and it bled more during application.

Fig.152 Painting experiments on wet marl plaster.

Upon drying, the pigments seemed to be held by the marl plaster and the pigments only came off lightly when touched. However, since the marl plaster was applied without any straw inclusions and surface burnishing it severely cracked while drying and this made the application of paint onto a wet surface an unsuitable method (Fig.153).

Fig.153 Wet marl plaster cracking upon drying.

5.2.4.1.2 Painting on a dry surface (burnished when leather-hard): (Figs.154a,b)

Following the unsuccessful result of the paint application on wet marl plaster, application on a dry marl plaster surface was tested. This method generally involves mixing pigments with a binder to apply onto a dry plaster ground ("*tempera*"). Scholars explain that the powdered pigments and the binder would be mixed together and left for several days to achieve a fine pigment dispersion (Mora *et al.* 1984, 72, Barnett *et al.* 2006, 452, Helwig 2007, 40). This seemed to intensify the colour on the painting. For the experimental work, the marl surface was firstly burnished when leather-hard and any cracks were removed.

Fig.154a Painting experiments on dry marl plaster (burnished leather-hard) with six binders tested with red ochre pigment.

Fig.154b Painting experiments on dry marl plaster (burnished leather-hard) with six binders tested with carbon black pigment.

Fig.155 Commercial red ochre pigment mixed with milk (left), egg white (middle) and water (right).

Six types of binding media (readily available on site and potentially available in antiquity) were selected: water, egg white/yolk, linseed oil, olive oil, milk and animal glue (rabbit skin glue) to mix with red iron oxide and carbon black pigments (Fig.155). After the pigments had set, they were also burnished with small pebbles to observe how they would react with the burnishing process.

The results are discussed below:

5.2.4.1.2.a Egg white and yolk: Protein based egg white and yolk are similar to each other mainly in protein composition with egg white containing more water (87%) than the yolk (Masschelein-Kleiner 1995, 60). Despite their brittleness and insolubility upon aging, egg white and yolk have been used since the prehistoric times as a binder, a retouching medium and a varnish (Masschelein-Kleiner 1995, 61). During the experiments, egg white and yolk (tried separately) were easy to mix with red ochre. However, they did not mix well with the carbon black, possibly due to the nature of the pigment or the level of grinding. This resulted in the addition of more black pigment into the binder. When applied on the marl surface, it was possible to achieve good paint coverage on the burnished surface. Upon drying, the pigments adhered well onto the plaster. Once both pigments dried, they were burnished by a small hand sized pebble. The result was good with no loss of pigments.

5.2.4.1.2.b Water: When the pigments were applied onto a burnished surface with water they were easy to mix and apply. The paint coverage of red ochre was good, but the carbon black was not so good. It seems that the carbon black and the binder did not mix well, as in the case of egg white and yolk. Upon drying, the pigments did not adhere to the marl plaster and came off easily. It was possible to burnish both pigments when dried using a small pebble. However some loss of pigment occurred in carbon black as the black turned into a greyish tone.

5.2.4.1.2.c Milk: Milk is another protein based binding medium. It was easy to mix with carbon black and apply with a good coverage, but not so easy with the red ochre. It seems that the red ochre and the binder did not mix well during application. Upon drying both pigments adhered well to the marl plaster and they burnished adequately with some loss of pigment.

5.2.4.1.2.d Rabbit skin glue: Rabbit skin glue is a refined rabbit collagen and contains about 25% to 30% of collagen. Collagen is the main protein in the skin, bone and tendons of mammals and is the only source for the substances known as gelatin and animal glue. It is produced from rabbit skin shavings, which are mixed with water and then heated. This gelatin based animal glue is known to have strong adherence qualities and a distinctive colour and smell. One of the important properties of a gelatin solution is to form a gel state by cooling (Masschelein-Kleiner 1995, 57). During the experiments rabbit skin glue was easy to mix with red ochre and apply with a good paint coverage. However, the carbon black and the glue did not mix well during application. It was also not easy to use this binder due to its “gelling” properties, since it needed to be kept warm constantly in order to increase its working time and to be easily mixed with the pigments. Upon drying, the pigments adhered well to the marl plaster and burnished well.

5.2.4.1.2.e Linseed oil and Olive oil: Linseed oil is a drying vegetable oil and is extracted from the seeds of the flax plant from which linen is obtained. It dries faster than other oils, possibly due to its high concentration of linoleic acid. Studies show that the oil content varies between 35-40% (Masschelein-Kleiner 1995, 37, Gettens, Stout 1966, 33). Olive oil was also experimented with as an available fruit oil on site, even though it was not known as a binder that was used during the Neolithic, however it was used during the Bronze Age in the Aegean and Eastern Mediterranean (Brysbaert 2004, 173). Both linseed and olive oil were tested separately. Both oils were not easy to mix with both pigments and the paint coverage was not good on the burnished marl plaster surface. Upon drying the pigments did not well adhere to the marl plaster surface and loss of pigments occurred while burnishing.

5.2.4.1.3 Painting on a dry surface (burnished when dry):

All binders tested behaved the same as above when applied on a dry, burnished surface which looked powdery/matt and was not really suitable for painting.

5.2.4.2 Application of paint on multiple, thin layers of marl plaster

Following the painting experiments on a single, thick layered marl plaster, the same methodology was applied onto a multiple, thin layered marl plaster.

5.2.4.2.1 Painting on a wet surface (unburnished) (Fig.156)

Pigments mixed with water were applied when the thin layers (<1000μm) of pale brown and white marl plaster were still wet. However this application did not work, since the marl plaster layers started drying immediately following their application. It was also difficult to capture the leather-hard state of the plaster due to the faster rate of drying. For these reasons the pigments had to be applied onto a dry marl plaster surface which was burnished during application by mixing them with the binders listed above.

Fig.156 A thin layer of marl plaster burnished during application.

All binders behaved the same as described above when applied onto a thin layer of dry, burnished marl plaster surface. Linseed and olive oil were not tested on the thin layers as they proved to be unsuccessful throughout the experimental work. Also when the pigments were mixed with milk, egg white/yolk and rabbit skin glue they appeared to be darker and matt in colour after drying. In contrast, when mixed with water and oils, the colours looked brighter and vivid.

Tables 5.2, 5.3, 5.4a, b and 5.5a, b below summarize the results of the experimental work, which were explained above.

Plaster application	Wet (unburnished)	Wet (burnished during application)	Burnished when leather-hard	Burnished when dry
Single, thick layer of white marl plaster (no straw)	Poor surface	Good surface	Good surface	Poor surface
Multi, thin layers of pale brown/white marl plaster (with/without straw)	Not applicable	Good surface	Good surface	Poor surface

Table 5.2 The results of the burnishing experiments.

Tools	Ease of application	Binder
Brush	Easy	Water/organic
Cloth	Easy	Water/organic
Hands	Difficult	Water/organic
Wooden stick	Difficult	Water/organic
Pebbles	Difficult	Water/organic

Table 5.3 The results of the tools for applying the paint.

Plaster application Single,thick layer of white marl plaster (no straw)	**Red Ochre+Water**	**Red Ochre+Egg white and yolk**	**Red Ochre+Milk**	**Red Ochre+Rabbit skin glue**	**Red Ochre+ Linseed/ Olive oil**
Application	Easy	Difficult	Easy	Difficult	Easy
Coverage	Good	Good	Poor	Good	Poor
Burnishing	Poor	Good	Moderate	Good	Poor

Table 5.4a The results of the red ochre pigment and binders mixed when applied onto a single, thick layer of white marl plaster.

Plaster application Multi,thin layers of pale brown/white marl plaster (with/without straw)	**Red Ochre+Water**	**Red Ochre+Egg white and yolk**	**Red Ochre+Milk**	**Red Ochre+Rabbit skin glue**	**Red Ochre+Linseed /Olive oil**
Application	Easy	Difficult	Easy	Difficult	Easy
Coverage	Good	Good	Poor	Good	Poor
Burnishing	Poor	Good	Moderate	Good	Poor

Table 5.4b The results of the red ochre pigment and binders mixed when applied onto a multiple, thin layers of pale brown/white marl plaster.

Plaster application Single,thick layer of white marl plaster (no straw)	**Carbon Black+Water**	**Carbon black+Egg white and yolk**	**Carbon Black+Milk**	**Carbon black+Rabbit skin glue**	**Carbon black+Linseed/ Olive oil**
Application	Easy	Difficult	Easy	Difficult	Easy
Coverage	Poor	Good	Good	Good	Poor
Burnishing	Poor	Good	Moderate	Good	Poor

Table 5.5a The results of the carbon black pigment and binders mixed when applied onto a single, thick layer of white marl plaster.

Plaster application Multi,thin layers of pale brown/white marl plaster (with/without straw)	**Carbon black+Water**	**Carbon black+Egg white and yolk**	**Carbon black+Milk**	**Carbon black+Rabbit skin glue**	**Carbon black+Linseed/ Olive oil**
Application	Easy	Difficult	Easy	Difficult	Not tested.
Coverage	Poor	Good	Good	Good	Not tested.
Burnishing	Poor	Good	Moderate	Good	Not tested.

Table 5.5b The results of the carbon black pigment and binders mixed when applied onto a multiple, thin layers of pale brown/white marl plaster.

5.3 Summary of Results:

Several observations were made during the experimental work in relation to the preparation and application methods of different types of marl plaster, the use of binders, the durability of plaster and paint, and how the pigments reacted with the different applications of plaster and types of binders. Mainly marl plasters in slightly different shades and fabrics (see Chapter 4, Section 4.2.1) were used at Çatalhöyük for producing wall plasters and paintings, but for the experimental work only white and pale brown (off white) coloured marl plasters were available.

From the results of the experimental work, it may be concluded that:

1) Paintings were made on marl plasters which were applied onto the walls in two different forms; single, thick layered and multi, thin layered.

2) Painted plaster fragments from Space 181 (Pre-level XII, South Area) were composed of a thicker layer (<3000-4000μm) of white marl plaster with no plant inclusions. The experimental work indicated that when the marl plaster was applied thicker than 1-2mm, even mixed with plant inclusions, it shrinks and cracks whilst drying and this makes the application of paint on a wet or dry plaster surface an unsuccessful process.

3) For thicker application of plasters continuous burnishing during the application of wet plaster is necessary to prevent or minimize shrinkage and cracking as well as to achieve a suitable surface for painting. This may be the reason for the high level of surface burnishing evident on the samples from Space 181 (Chapter 6, Section 6.1).

4) Most painted plaster samples observed on site were made up of thin layers of pale brown and white marl plaster. During the experimental work, thin marl layers dried very quickly following application and it was not possible to paint them when the surface was still wet. Painting had to be done either on a leather-hard (if possible to capture) or on a dry surface.

5) Experiments showed that paint application was possibly made on dry surfaces by using organic binders and/or water, since the application on a wet surface did not work well, even though the pigments were held better by the marl plaster upon drying and lost less after burnishing.

6) Burnishing was required either during the plaster application when the plaster was still wet, or when the plaster was leather-hard to remove any cracks prior to painting. Burnishing after the plaster dried made the surface powdery/matt and therefore was not suitable for painting.

7) When burnished leather-hard, the surface became compact, smooth and shiny on which the pigments looked more bright and vivid.

8) Burnishing when the plaster was damp (the state before it becomes leather-hard) did not result in a good surface, since the burnishing process peeled off the damp plaster.

9) The burnishing process has provided a good surface for paint application. Ground pigments (red ochre/carbon black) were applied both on pale brown and white marl plasters, covered with a new layer of plaster (Fig.157).

Fig.157 A thin layer of marl plaster applied over a painted layer.

10) Both red ochre and carbon black mixed well with most of the binders tested, apart from linseed and olive oil. Carbon black also did not mix well with egg white/yolk and rabbit skin glue, however this may be due to the amount and the fineness of the pigment grinding.

11) Red ochre did not achieve a good coverage when mixed with milk or oils, whilst carbon black did not colour well when combined with water or oils.

12) In terms of paint adhesion, water and oils did not present good results as the pigments came off very easily when touching and burnishing with a pebble. Both pigments worked well with the rest of the binders on a dry surface and did not come off.

13) It was observed that when used with strong binders such as egg white, egg yolk, milk and rabbit skin glue any bleeding of pigments might depend on the proportions of the binder to the pigment. Further problems occurred when a new layer of plaster was applied over the paint layer, since the pigment bled into the fresh layer (in varying amounts depending on the binder used) (Fig.158).

Fig.158 Bleeding of red ochre layer into the subsequent marl plaster layer.

It seems that the amount of binder used and the time between the applications of the layers are important. The paint needs to integrate enough into the plaster layer below in order not to bleed into the new layer. Matthews mentions that the wall paintings might only have been exposed for a short duration, which may have been enough for paint to settle into the plaster (Matthews 2005, 366). Another possibility might be that after some time, the painted surfaces became covered with layers of grease and soot and this effectively sealed the paint and prevented it from coming off. As opposed to these possibilities, the bleeding of paint may have been one of the practical reasons for painting walls, since if the paint bleeds into the fresh layer of plaster, it would be logical to paint the new layer to hide the bleeding. Experimental work showed that one solution to prevent this problem might be to apply a new plaster layer, thick enough to cover the bleeding paint (Fig.159). It was observed that the plaster is thicker when the pale brown marl is mixed with plant inclusions and therefore covers the surface better than the thinner, white layers. Following this thick layer, a thin wash would be applied before paint application.

Fig.159 Pale brown marl plaster layer mixed with plant inclusions creating a thicker layer to cover the paint layer below.

14) Sheep scapulae worked very well for the application of plaster. Once the plaster was roughly spread onto the experimental boards using a scapula bone, it was possible to get a very smooth application by using hands, a very thin cloth and pebbles wetted with water.

15) Simple brushes worked well for mixing and the application of paint. Fingers and hands did not work well for painting designs or larger areas (red walls), since the paint dried very quickly when in contact with skin.

16) Wooden sticks were also tested to draw designs but again the paint dried very quickly when in contact with the wood. Using a wooden tool required the use of large amounts of pigment, which may not have been very practical in terms of the efficient use of pigments.

17) Painting with a cloth worked very well and it showed that it would have been very easy to paint the larger areas (red walls) in this way. It acted as effectively as a thick brush, while leaving striations, and was possible to paint a large surface very quickly. However, certain types of binder, i.e. animal glue, might have been difficult to use in large quantities to mix with pigments, as they set very quickly and become sticky making the paint application difficult.

18) Experiments showed that the pigments mixed with different binders often burnished well after drying, however the paint also came off depending on the binder used. Even though there is no clear evidence of “paint burnishing” on site, i.e. on pebbles or burnishing/polishing stones, it may have been possible to burnish colours to enhance them and make them look brighter.

5.4 Conclusion

This chapter presented the methodology and the results of the experimental work, which aimed to support the analytical work. Chapter 6 will further interpret these results by placing them within the context of wall painting production at Çatalhöyük.

By undertaking this experimental work, I better understood the practical side of plastering/painting walls with the help of the villagers of Küçükköy who are very familiar with local materials around Çatalhöyük and developed their own practices and customs in order to plaster their houses. I observed how some of the wall painting materials and the application techniques would work and interact with each other, that otherwise would not be possible to understand only by investigating these materials individually. Even though it was not possible to create the same conditions or to obtain the closest materials and tools to the originals, it enhanced my personal understanding of painting practices in the context of Çatalhöyük. I became more familiar with the use of marl, how it works in different forms and modifications, how it reacts with red ochre and carbon black pigments and with the different organic binders that I tested. Moreover, I gained a good understanding of the possible painting tools and how practical they would be for painting, and how organic binders might work with pigments as opposed to water. By designing and undertaking this experimental work myself, I felt that I also became more familiar with the thought processes of a person who selects, prepares and experiments with the materials and finally paints a wall for the first time to see how it all works. It is, of course, clear that there were some gaps within my experimental work, the most important ones being the repetition of experiments with the correct materials (original pigments/binders or the materials closer to original) in various different combinations as well as the analytical study of the experimental samples and their comparison with the archaeological ones. However, this study was an initial attempt to experiment with the painted/plastered surfaces and it was the first time I undertook such experimental work after which I realised that it needed more detailed work and more focus on the individual materials. Unfortunately I do not have access to the archaeological material anymore, but any future attempt would be very useful to complete the gaps in the methodology and making more reliable comparisons with the archaeological samples.

Chapter 6

Interpretation and the Discussion of Results

In this final chapter the results of the technological and experimental study on the wall paintings of Çatalhöyük (presented in Chapters 4 and 5) will be discussed in detail to investigate each step of wall painting production within Neolithic Çatalhöyük.

6.1 The Nature of Plasters at Çatalhöyük and the Different Methods of Wall Plastering prior to Painting

The current research has supported the previous studies on Çatalhöyük plasters, as it shows that the wall paintings were generally applied onto very fine, soft, dolomitic (high calcium and magnesium) soft lime washes as well as onto clay and calcium carbonate based marls in different colours with a silty/sandy particle size. Both of these materials were available naturally around the site. During the analytical work the observation of the marl plaster fabrics and the character of the mineral/organic inclusions enabled me to gain a clearer idea of the five types of marl plasters used for the paintings from the earlier levels onwards, as well as determining their potential sources around the region where Çatalhöyük was located (Konya Basin). As explained in Chapter 2, Section 2.3, marl was sourced from the extensive marl beds of the Konya basin, which lay below the site as a natural resource and was possibly collected "wet" from pits as well as along the different sections of the palaeolake Konya. Current SEM (EDAX) analysis showed that the pale brown (impure) marl plasters studied for this research have a calcium content of less than 50% whilst white (purer) marl has a calcium content of more than 50% (see Chapter 4, Section 4.2.1), making them durable enough to cover mudbrick walls. They are also of smectitic (volcanic) origin and contain silica, aluminium, iron and magnesium (see Appendices 27-202) which makes the marl behave very similarly to clay. Clay and silt particles are the binding elements in marl and when it is exposed to atmosphere damage can occur due to the changes in moisture levels (Balderrama, Chiari 1984, 110). Therefore marl based plasters would require regular repairing and maintenance. Marl found around Çatalhöyük seem to show slightly different characters, i.e. in colour and fabrics, because of being obtained from the different sedimentary sections along the Çarşamba alluvial fan (Matthews 2005b, 364-373, Doherty 2007, 371, 372. Tung 2008, 252-257, Doherty 2006, 309). The results of the painted plaster analysis showed that the colours of the marl plasters ranged between white to pale brown (under the naked eye), where they were used to make up both multi and single layered wall plasters. The distinctive examples of the latter came from some early levels, i.e. the Pre-level XII in Space 181 and the Levels X, IX, VIII in B.17, B.23 and B.43 in the South Area. Four out of the five marl plaster types discovered (Types 1,2,3,4) have fine, silty and/or coarse, sandy fabrics in general and they show a colour range from pale brown to bright brown (under optical microscopy, see Chapter 4, Section 4.2.1.1-4.2.1.4) as the fabric gets coarser and sandier, rich in bright coloured inclusions. Type 5 plasters seem to be very different than the rest with their greyish white colour under optical microscopy (see Chapter 4, Section 4.2.1.5) and very few inclusions.

As explained in Chapter 2, Section 2.3, raw marl consists of impure (sandier) and purer (siltier) forms due to the depositions of facies at different sections along the paleolake Konya and the evidence of the purer (siltier) forms was rare (Doherty *et al.* 2007, 382-390). Sands, silts, mineral inclusions (inclusion sizes between 10μm-3000μm), rock fragments, i.e. feldspar, quartz, hornblende, calcite, marl, andasite, sandstone and limestone, as well as any organic matter, i.e. bone, *Unio sp*. shells, were brought by the catchments of the Çarşamba and May rivers which may also indicate the differences in geology where these inclusions might have been brought from. The main mineral inclusions within the marl fabrics, together with a few fine-grained marl and limestone inclusions as well as the particles of volcanic origin suggest the use of a Çarsamba-May clay. The inclusions within plasters are of sparse or moderate density in finer, silty fabrics (Types 1, 2, 3, 5) but as the fabrics get coarser and sandier (marl plaster Types 3 and 4), the inclusions become more plentiful (Doherty 2007, 372). According to Doherty, these sandier facies may have formed near the surface at the time of occupation and contained more clay impurities. These marls are olive green in colour when they are first exposed on a high water table but the colour changes into brown when mixed with sands and silts in areas where the water table is low. Doherty explains this difference as due to “the oxidation state of the small iron-rich clay component of the marl” (Doherty 2011, *pers.comm*). The purer form of marl is greyish white in colour and as opposed to the sandier marl it may have formed further from the shoreline and contained only minor inclusions of reddish clay (in marl plaster Type 5). These differences in the plaster fabrics that were used for the paintings may indicate changes in the locations from where the marl was obtained at different times and periods throughout the life of the settlement. It also shows that with time and experience the people may have developed a good understanding of the marl and how and where to obtain it from, in order to modify it according to their needs. Thus they could have made deliberate choices in what form and purpose they wanted to use it for.

While most of the mineral inclusions observed in the different types of marl (see Chapter 4, Section 4.2.1) would have come via the active Çarşamba river, gypsum which is particularly found in the coarser (base) layers on Type 1 and 2 plasters, was possibly formed in situ and is considered contemporary with the pale brown marls, indicating that the gypsum sources might have been nearer than Hotamış, in the east of Çatalhöyük (Doherty 2011, *pers. comm.*). The studies also showed that there were clear differences in colours and fabrics between the wall and floor plasters used at Çatalhöyük. The colours range from white to pale brown tones (under the naked eye) in the wall plasters, while the floor plasters have grey and brown tones (Matthews 2005b, 364-373, Doherty 2007, 371, 372. Tung 2008, 252-257). In terms of the marl fabrics both wall and floor plasters have silty/sandy marls with a variety of inclusions. Having the higher calcium carbonate content (80-87%) white marl plasters in particular do not contain any plant material when used on the walls. However Doherty mentions that the white marl plasters do contain high proportions of plant material (50%) when they were used on the floors, the same as the pale brown plasters (Doherty 2007, 371). He also found some plasters that had a high magnesium oxide and low alumina levels, indicating that these plasters have a dolomitic nature (soft lime) and are not clay based. They would be found far away from the lake edge, possibly 5km north of Çatalhöyük, as opposed to being sourced along the paleolake Konya (Doherty 2007, 373, Matthews 2005b).

The current study showed that, particularly on Type 2 painted plasters, the final white layers where the paint was applied were composed of "soft lime" (mentioned by Matthews) with up to 95% pure carbonates of calcium and magnesium (Roberts *et al.* 1999, 624, Matthews 1996, 304, Doherty 2011). As Doherty mentions (2009, 115) "they derive from the relicts of freshwater limestones that are very similar to weathered pure lime plasters in composition" (Doherty 2011, *pers.comm.,* De Ridder 1965, 235).

The presence of the weathered limestone inclusions within Type 5 marl plasters brings clarification to another question: if true (calcined) lime plaster was also available for the production of wall paintings. Distinct from the marl plasters both Mellaart's excavations (Mellaart 1966, 169) and Matthews's micromorphological work have argued the presence of true (calcined) lime plaster in the earlier levels (Pre-Level XII, Level X, IX and VIII) (Cessford, Near 2005, 179, Matthews 2005b, 371, Kingery *et al.*1988, Garfinkel 1987, 70,71), but the clear evidence of its use has not yet been established. As mentioned in Chapters 2 and 4, some white plasters with highly burnished red and yellow ochre surfaces (Type 5) were recorded in the South Area (Pre-level XII/Space 181 and in Levels X, IX, VIII) which had hard textures and therefore were described as "burnt lime plasters" (Matthews 2005a, 129). However, Doherty explains that the low water table levels would provide the right conditions for the groundwater affecting these plasters (Doherty 2006, 309) and causing a "very hard" texture (see Chapter 3, Section 3.2.1). He also explains some factors, which question the possibility of these plasters being "calcined lime plasters" (Doherty 2009, 115). Some of these are:

1) There is no clear evidence for lime production on the site so far.

2) The lime burning process requires a lot of fuel (wood) and limestone. Both of these sources need to be sought and brought to the site as well as activities such as building kilns and finding the tools for making lime plaster, all of which can be very labour intensive.

3) The presence of "very fine clay impurities (primary) and subangular limestone fragments" (Doherty 2009, 115) in the plasters from Space 181 (analysed by Optical Microscopy and SEM-EDAX) indicate that these plasters were not fired up to high temperatures. Otherwise these inclusions would not have survived.

4) Non-evidence of (secondary) fired lime impurities within the Space 181 plasters such as "calc-silicates, glass, part-burnt limestone etc." (Doherty 2009, 115) show that these plasters were not fired. The impurities above are mainly found in burnt lime plasters, particularly when they are made by inefficient firings (Doherty 2009, 115).

5) Naturally available marl and soft lime seem to provide a nice, white background colour which is desirable for painting as well as for covering

> walls to brighten the inside of houses in order to create cleanness and more light. In this case, it would seem that calcining limestone to make plasters would have been unnecessary and less practical in the context of Çatalhöyük.

Affonso (1996) also pointed out that the calcined lime matrix can be very similar to the matrix of marl, and when the slaked lime (lime putty, CaOH) has been subjected to re-carbonation process calcium carbonate ($CaCo_3$) is produced that is almost the same as the raw sedimentary calcite both mineralogically and chemically (Affonso 1996, Barnett 1991, Karkanas 2007). True lime plaster would present high amounts of lime inclusions (burnt, over burnt or unburnt) that are well reacted with the surrounding matrix. "It also would not present large gypsum fragments, since they would be broken down at 150°C and recrystallise in a very fine grain size" (Siddall 2013, *pers.comm*). It is evident that Space 181 plasters contain only low amounts of very fine mineral inclusions, a few limestone inclusions and some organic inclusions, i.e. shells and bones. This indicates that they were not subjected to a firing (or a high firing) process. Moreover, Doherty mentions that "many of the Space 181 painted plasters showed localized yellow staining under stereomicroscopy" (Doherty 2013, *pers.comm.*), which could be the explanation of the yellow hue observed under PLM (Chapter 4, Section 2.1.5). He adds that "this is a typical characteristic of the local marl (oxidation of trace iron impurities along dessication cracks and root-hair channels) (Doherty 2013, *pers.comm.*).

Therefore, it is safe to say that the microscopic analysis of the Space 181 painted plasters (Type 5) does not support the claim for the use of calcined lime plaster on the walls of the early levels, i.e. Pre-Level XII and in Levels X, IX, VIII of the East mound. Instead, they were made of white marl with some fine-grained marl and limestone inclusions. Later on, pale brown (impure) marls and soft lime (in the form of base and wash layers on multi layered plasters) appeared and was commonly used for plastering/painting house walls throughout the Neolithic Çatalhöyük.

Unlike other archaeological settlements in Anatolia and the Near East (see Chapter 2, Section 2.2) true lime or gypsum plasters do not seem to have been used for plastering the floors and walls of houses at Çatalhöyük and this is currently evident throughout the life of the settlement. The reasons for not employing true lime plasters are still being investigated, since there are available limestone sources around the surroundings of the site, i.e. northwest and southwest of the Konya Plain as well as along the Konya basin

(Doherty 2011, *pers.comm*, De Ridder 1965, 225-254). Moreover, when lime plaster sets it provides a harder and waterproof surface, which is more durable than marl plastered surfaces that are soft and easily damaged by moisture due to their clay like properties. However, making lime plaster requires a considerable amount of fuel to produce, whereas marl plaster simply involves mixing marl with water.

Marl and soft lime, as mentioned above, are easier to process than lime plasters, since they do not require any calcining. Prior to the preparation and the application onto mudbrick walls some stages in sourcing and processing are suggested by Doherty (2006, 307). These stages could have been similar to the current practice undertaken by the villagers such as:

1) Finding marl and soft lime sources near the site.

2) Planning how to extract and transport to the site, i.e. organizing tools, containers, means of transport.

3) Keeping the material wet or dry, in a pit or in a container.

4) Preparing the material, i.e. cleaning from impurities, collecting inorganic and organic additives, water and old plasters from previous walls, to add to the mix.

5) Getting containers/tools together for preparing marl/soft lime.

6) Repeating certain activities due to the practicalities of marl/soft lime when prepared, i.e. quick setting time and deciding how much to prepare each time.

It could have been possible that following extraction, wet marl/soft lime was stored in a wet/damp environment until it was used, i.e. in a pit filled with water in order to minimize the time spent dissolving dry lumps of marl as experienced during the experimental work (see Chapter 5, Section 5.2.2.1). Following the possible stages suggested above by Doherty, the plasters would have been prepared and applied onto mudbrick walls in two forms: **1)** a single, thick layer, **2)** multi layers: a fine, soft lime wash onto coarser marl plasters. Analysis on the painted plaster samples showed that single, thick layered marl plasters were mainly evident in earlier levels (Space 181/Pre-level XII, B.17, B.23, B.43/Levels X, IX, VIII) but some was also observed between

Levels V-III (see Chapter 1, Table 1.1 for the chronology of the different levels). They seem to be 5000μm or less in thickness and made of white marl with fewer inclusions naturally occurring in its fabric (Type 5). Some of the single, thick layered marl plasters however have very sandy fabrics indicating they were more impure (Type 4) (see Chapter 4, Section 4.2.1.4). One of the most distinctive features of the Type 5 marl plasters is the evidence of small, single layered painted plaster fragments being mixed into the plaster fabric. This may indicate that earlier wall painting fragments (only single layered) might have been used/recycled as aggregates during the preparation of the plaster grounds for the later wall paintings and this practice may have had a symbolic and/or a practical meaning. Matthews suggests that these earlier painted wall fragments might have come from the houses that may have carried "symbolism and memory" and when they were mixed into the plasters of other houses this may have indicated "a way of transferring and encapsulating these essences and establishing links, perhaps ancestral, with people/structure which the plaster was taken" (Matthews 2005b, 366). Another important feature of these plasters (Types 4 and 5) is that they have only one layer of paint (<1000μm). However, in the later levels (Level IX and above), this pattern changes into thinly applied, multi layered soft lime/marl plaster combinations (Type 2) with one or more layers of paint (<1000μm), indicating that the painting and plastering practices inside the houses changed through time which can be seen mainly in the South Area, since the 4040 area only has the evidence of multi layered plasters (see below Tables 6.1 and 6.2).

South Area	**Mellaart/Hodder Level**	**Change in Plastering practice**
Sp.181	Pre-Level XII/South G	Single layered form
B.23	Level X/South J	Single layered form
B.2	Level IX/South K	Multi layered form
B.17	Level IX/South K	Single and multi layered form
B.43	Level VIII/South L	Single layered form
B.8	Level VII/South M	Multi layered form
Sp.168	Level VII/South M	No samples available
B.79	Level VIA/South O	Multi layered form
B.75	Level V/South P	Multi layered form
B.65	Level IV/South Q	Multi layered form
B.56	Level III/South R	No samples available
B.44	Level II/South S	No samples available

Table 6.1 Change in plastering practices in the different phases and buildings of the South Area.

4040 Area	Hodder Level	Change in Plastering practice
B.1	4040 G	Multi layered form
B.77	4040 G	No samples available
B.49	4040 G	Multi layered form
B.59	4040 G	Multi layered form
B.55	4040 G	Multi layered form
B.60	4040 H	Multi layered form
B.67	4040 H	No samples available
B.47	4040 J	No samples available
B.3	Bach G	Multi layered form

Table 6.2 Change in plastering practices in the different phases and buildings of the 4040 Area.

Multi layered marl plasters (Types 1? and 2) were made of pale brown (base) and white (wash) layers (see Chapter 4, Section 4.2.1). They were applied in different thicknesses, which may not have been planned in advance to the actual plastering work, but it may have been that the thicknesses were determined via many practices of plastering and experimenting. As explained in Chapter 4, single layered Type 5 plasters seem to be the most common plaster type, especially in the early levels (Pre-Level XII/South G, Level IX/South K, Level X/South J, Level VIII/South L). Multi layered, Types 1? and 2 are present to a similar extent and in use after Level IX and up to Level III (Levels 4040 G, H; Levels South O, P, M; Level BACH G). Types 3 and 4 are the least common plaster types used at Çatalhöyük. Type 3 is different than the rest of the plaster types and it looks like it consists of both fine/silty and coarse/sandy pale brown marl plasters which could relate to the nature of the marl fabric from where it was collected. It is only present in the 4040 Area (Levels VII and III; Levels 4040 G, H), whilst another single layered marl plaster, Type 4 is present both in the earlier and later levels in the South Area (Pre-Level XII/South G, Levels III/South R).

The preparation processes for these plaster types seems to differ between the two forms of application. The analytical work showed that the single layered painted plasters (Types 4 and 5) do not contain any plant inclusions for additional strength and flexibility, unlike the multi layered plasters. The reason for this is still unknown, since the nature of the plasters used for both applications is similar. The non-evidence of plant inclusions in these earlier, single layered marl plasters might be explained in two ways:

1) The higher quality of white marl was used for making single layered painted plasters and its nature did not require the inclusion of plant additives to prevent cracking during drying.

2) As observed during the experimental work severe cracking occurred due to the lack of plant additives both in white and pale brown marls (see Chapter 5). This may be why the surfaces of the painted plasters from Space 181 (made of white marl plaster) were heavily burnished to mitigate cracking. Marl plaster surfaces must have been burnished before the paint application and the very fine layers of paint show the burnished marl surface below. It is therefore clear that single, thick layered white marl plasters were prepared following a different methodology than the multi layered soft lime/marl plasters, not mixing with any plant inclusions but instead burnishing continuously during the plaster application (exactly the same way as it was experimented with white marl washes on multi layered plaster applications, see Chapter 5). It may have been possible that paint layers on some paintings could also have been burnished to reduce cracking (although there is no clear evidence of this). If at all practiced, however, paint burnishing may only have been applied on "certain" paintings, since there are clear evidences of tool/brush marks on some painted surfaces which would have been lost if burnished (see Chapter 4, Section 4.3). The burnishing process could also have been an important part of the painting ritual to enhance and brighten the painted surfaces in order to emphasis the meaning of the paintings, which may possibly have been related to certain events within the life of inhabitants. This may also indicate why "certain" paintings might have been burnished.

As indicated above, it is crucial that the plant inclusions are added into the marl plaster fabrics in order to prevent them from shrinking and cracking whilst drying (see Chapter 5, Section 5.2.1). According to Rosen and Ryan, finely prepared plants such as thin or thicker monocot stems, i.e. chaff, stems of reeds and sedges (see Chapter 5, Section 5.2.2.1), may have been mixed with marl plasters to achieve this (Ryan 2010, *pers.comm,* Rosen 2010, *pers.comm*). Both analytical and experimental work supported the conclusion that the ratio of plant inclusions to plasters is required to be almost 50:50 (V/V) in order to control shrinkage and to increase flexibility of the material. However, burnishing is still necessary but less rubbing seems to be enough to achieve a smooth surface without cracking. Also the thickness of the plaster layers and the method of application are very important in order to reduce cracking, i.e. applying very thinly

(1000µm or less) and burnishing continuously during the application and setting. During the experimental preparation of plasters (see Chapter 5, Section 5.2.2.1), it was also noticed that the addition of plant inclusions made plasters very thick in consistency and therefore it was necessary to thin them down by adding water to enable easier application.

From observation of current plastering practices in the nearby villages, multi layered plasters might have been applied as the plaster layers were roughly spread onto the walls and smoothed/burnished by using hands, abrader knives, a very fine textile (or a skin?) and possibly with polishing stones wetted with water during the application. As explained in Chapter 5 (Section 5.2.2.1) animal scapulae (when the sides were cut and worked into shape) was a very practical tool to apply lumps of wet marl plaster and to spread them onto the mudbrick walls in layers. Particularly the side and top of scapula bone could have been used in a very similar way to the modern spatulas used today (Fig. 160). Once the base layer of pale brown marl plaster has set, a very fine, thin layer of soft lime with no plant material would be applied over the surface as a wash either by using a brush, hands or a cloth and constantly smearing/burnishing until the plaster starts setting.

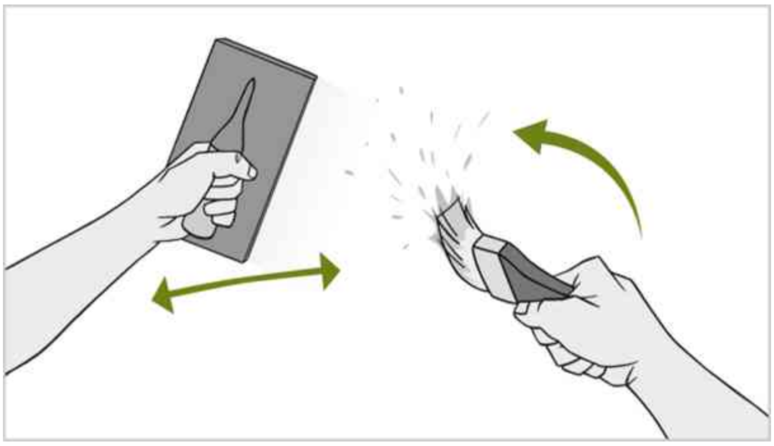


Fig.160 Modern plaster burnishing practices (www.channel4.com/4homes/how-to/diy/how-to-plaster-a-wall).

Based on her study of later painting/plastering practices, Matthews suggests that there were monthly or even one to two year gaps between the individual paintings before they were covered with layers of marl plaster and white soft lime wash (Matthews 2005a, 136). These time periods may have been long enough for paint to settle into the plaster layer which is probably important so as to prevent paint coming off when applied with certain binders, i.e. water (see Chapter 5, Section 5.2.4.1.2). Today, plastering work inside the village houses is repeated annually and particularly Today, plastering work inside the village houses is repeated annually and particularly undertaken during the dry summer months. This could have been the same in Neolithic Çatalhöyük. In winter, the heavy use of hearths and ovens inside the houses might have generated a lot of soot and grease (Matthews 2005a,b) which might have covered the surrounding plastered walls more than in the summer and create a reason to maintain/renew the plastering and painting once the "dirty" season ends. In additon, grease and soot could have sealed the paint layer, possibly preventing it from coming off throughout the winter, extending the life of the painting until it is required or desired to be re-plastered for a new painting.

Once the plasters were prepared and applied onto the walls, they were ready for painting. Burnishing was a crucial step for the plaster application and it seemed that the further burnishing to prepare the surfaces for painting needed to be done either during the plaster application or when the plaster was leather hard, as burnishing a completely dry surface results in a powdery/matt surface which is not very suitable for paint application. The experimental work, together with the study of the ground stone tools throughout the buildings across the site, suggested that bare hands, textiles and small, hand sized polishing tools that are made of limestone and marble might have been used for the plastering/burnishing practices throughout the earlier and later phases. Particularly the shiny and flat surfaces of the round and rectangular polishing stones may indicate that they might have been very practical tools for buffing/polishing plaster surfaces on walls before painting would take place, and that they were commonly used in general plastering practices like today's polishing wheels or spatulas. These tools were distributed throughout most buildings both in the South and 4040 Area and found in most phases. The data shows that their use increased particularly in the later phases with the evidence of higher number of wall paintings (see Chapter 4, Section 4.5).

The use of stones for polishing walls is still a part of the continuing plastering tradition in the villages nearby Çatalhöyük as well as some of the modern plastering practices today, specially seen in particular styles of wall plastering, i.e. Tierrafino Stone Tadelakt (www.tierrafino.com) plastering (Figs.161a,b).

Fig.161a Polishing Tierrafino plaster with small hand held semi-precious stones (www.tierrafino.com/stone_tadelakt_gallery/material%20and%20workshops//).

Fig.161b Polishing Tierrafino plaster with small hand held stones (www.tierrafino.com/stone_tadelakt_gallery/material%20and%20workshops//).

6.2 The Nature of Pigments and their Modification/Application in relation to Painting practices at Çatalhöyük.

The painting process would have consisted of many stages some of which might have mostly involved collecting/preparing materials and tools prior to the actual painting work. The analytical work showed that Çatalhöyük pigments mainly derived from common minerals and they were mainly inorganic based. Doherty explains that the main pigments used for paintings might have been obtained locally and therefore the inhabitants may not have needed to travel far in order to collect minerals to produce pigments (Doherty 2011, *pers.comm.*).

Siddall (2014*, pers.comm)* explains that in a geological context iron rich earth, red or yellow ochres may be found either directly overlying the ore, which they have derived from, or they may be transported via rivers, streams etc. This means that it is very difficult to identify sources as the ochres travel thousands of kilometres from their original sources before being re-deposited. Similarly, geological changes in the landscapes, i.e. 10,000 years of modification of Konya landscape, the agriculture and climatic changes make it difficult to provenance pigments used during the Neolithic period. Sidall also mentions that primary ochre sources around the Konya plain might be directly associated with volcanic activity of Karadağ or alternatively with the mineralisation in higher grounds surrounding the Konya plain (Siddall 2014, *pers.comm*). According to Doherty and his study of the surroundings of Çatalhöyük, low purity red and yellow ochre are available within limestone deposits around the north and southwest of Konya plain (near Beyşehir) whereas high purity volcanic-derived (primary) red ochre sources are present around the Erenler Dağı, southwest of Konya (Appendix 223). Doherty further adds that mercury deposits (as the source of cinnabar) are often related to past volcanic activity which was mainly situated in the southwest and north of Konya region as well as around Niğde in the east (Appendix 224a). The largest of these deposits is at Sızma, about 30km north of Konya (Appendix 224b). Mellaart thought that this area was the main source of cinnabar that was used at Çatalhöyük, but no study has been undertaken to prove this hypothesis (Doherty 2011, 92). Moreover, azurite and malachite sources, associated with copper mineralisation can be found either in the northwest of Konya or within the same limestone deposits in which red and yellow ochre are present (Appendix 223). Even though this information provides an indication of the closest pigment sources around Çatalhöyük (within a radius of 40km), a more detailed and systematic study is required, i.e. isotopic analysis and field sampling to understand the exact provenances of the pigment sources (Doherty 2011, *pers. comm.).*

During the study no evidence of plant based pigments were found, however this may be due to the preservation issues of the organic pigments. The only organic based pigment was carbon black which seems, in some cases, to have been obtained mainly by burning animal bones and woody plant material (though two samples of black pigment presented a possible evidence of bitumen both under PLM and GC-MS, this result is not conclusive and may be due to various contamination on site, see Chapter 4, Section 4.2.2.5). White marl or "soft lime" washes seem to have provided a bright background after burnishing which helped to create more light inside the dark Çatalhöyük houses (see Chapter 2, Section 2.4). It may have acted as the equivalent of a white paint, when the paintings were decorated particularly with shapes and figures. Also when the bottom part of the walls were painted with solid red colour, white plaster surfaces on the upper parts of the walls might have been prepared/burnished to create a contrast which would have helped to brighten the red painting below. Moreover, finely ground pigments were applied very thinly (<1000µm) on white marl plasters and soft lime washes, maybe to allow the white colour of the plaster to shine through and to create a contrast between the painting as well as the rest of the plastered wall. As opposed to this, pale brown marl wash layers on which the paint was applied in some paintings seems to have created slightly paler (duller) tones of red (Figs.162a, b).

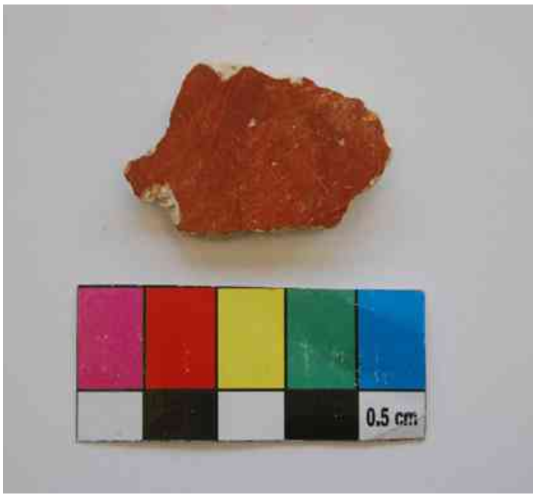


Fig.162a Red paint applied on white plaster, CH99/South/U.5294/S6 (Duygu Çamurcuoğlu).

Fig.162b Red paint applied on pale brown plaster, CH04/4040/U.7913/S6 (Duygu Çamurcuoğlu).

The latest study by Anderson et al. also mentions the evidence of small obsidian grains in the paint layers found in Building 49 at Çatalhöyük. They explain that the obsidian inclusions in the paint may have reflected the light inside the house more efficiently and brightened the red colour against the white background (Anderson *et al.* 2014, 373-383). However, this PhD research did not find any evidence of obsidian grains within the number of painted plaster samples (including the samples from Building 49) that were examined via different techniques, i.e. thin-section, cross-section and dispersion analysis under optical microscopy and SEM (EDAX) and therefore this subject is open to discussion.

The analysis of the pigment samples showed angular to subrounded shapes in general and the particle sizes mainly range between 5µm-300µm (x400 magnification) indicating that the preparation of colours prior to painting would involve finely grinding the pigments (angular shapes indicating simpler hand grinding), possibly sieving to remove impurities to achieve brighter purer colours and consequently smoother applications which seem to have been a general practice at Çatalhöyük and have not been changed through time. Some samples (particularly from the Pre-level XII, Space 181) had smooth, burnished surfaces with glossy appearance observed under Raman spectroscopy which may indicate the level of fine pigment and surface preparation and application.

As mentioned above, the pigments in mineral form may have been prepared initially by washing/sieving the raw minerals to remove any impurities (Delamare, Guineau 2006, 16). All the pigments analysed at Çatalhöyük seem to have been rich in clay, carbonate, gypsum or quartz minerals which may indicate contamination from the plasters but may also be potentially associated with the geological source of these materials, showing that the minerals may not have been washed/sieved thoroughly. Another explanation could be that the pigments might have been mixed with extenders such as clay, calcite or quartz (Chalmin *et al.* 2003). Once the washed minerals were dried they were ground into powders and if necessary modified in several processes, i.e. the further grinding and filtering to produce brighter colours, mixing different pigments or the transformation of the colours by heating. At Çatalhöyük, different shades and tones of colours seem to have been common and they are present both in the early and later levels. Particularly the red colours used on wall paintings –mainly red ochre (haematite, Fe_2O_3) which was the most commonly used pigment at Çatalhöyük– was found in four shades; dark browny red, light orangey red (the most used), dark red (least used), dark orangey red (see Chapter 4, Section 4.2.2.1a). These different shades might be strongly related to the nature of the particular haematite source indicating the collection of pigments from different geological sources (Siddall 2010, *pers.comm*). However, they may also be related to the preparation processes, i.e. how finely the pigments were ground or the mixing of red and yellow ochre in some cases. The second red pigment– cinnabar– was either used on its own or mixed with red ochre for paintings to achieve brighter tones and/or maybe to enhance the symbolic meaning of the painting. However, it was not extensively used and was particularly found on the decorative scenes. PLM and Raman spectroscopy revealed that some red ochre samples contained both iron oxide haematite and iron oxide hydroxide types, i.e. lepidocrocite and/or goethite, which might have enhanced the orange-red colour of the pigment.

The transformation of colours by heating was a prehistoric practice (see Chapter 2, Section 2.1.1), but its use at Çatalhöyük could not be investigated during this research. However the rich availability of both red and yellow ochre sources around Çatalhöyük may give an indication that this practice may not have been very popular to use as it may not have been very practical and necessary to undertake. The pigment data suggests only a slight evidence of heat transformation in red ochre pigments, however this result is not conclusive. Moreover, pigment lumps were mostly found in relation to fills or burial contexts as opposed to being found around hearths and ovens, possibly not presenting an evidence of pigment heating.

The data shows that pigment use and technology at Çatalhöyük did not change much through time as all the pigments (except azurite and malachite) that were used on paintings showed only a few possible varieties of pigment preparation (see Appendix 4, Tables 6.3 and 6.4).

South Area	Mellaart/Hodder Level	Change in Pigment modification
Sp.181	Pre-Level XII/South G	none
B.23	Level X/South J	none
B.2	Level IX/South K	none
B.17	Level IX/South K	none
B.43	Level VIII/South L	none
B.8	Level VII/South M	none
Sp.168	Level VII/South M	Finer hand grinding on azurite?
B.79	Level VIA/South O	none
B.75	Level V/South P	none
B.65	Level IV/South Q	none
B.56	Level III/South R	none
B.44	Level II/South S	none

Table 6.3 Change in pigment modification in the different phases and buildings of the South Area.

4040 Area	Hodder Level	Change in Pigment modification
B.1	4040 G	none
B.77	4040 G	none
B.49	4040 G	Heat treatment on red ochre?
B.59	4040 G	none
B.55	4040 G	none
B.60	4040 H	Finer hand grinding on cinnabar?
B.67	4040 H	Finer hand grinding on azurite?
B.47	4040 J	Heat treatment on red ochre?
B.3	Bach G	Finer hand grinding on azurite?

Table 6.4 Change in pigment modification in the different phases and buildings of the 4040 Area.

Carbon black and yellow ochre are used only on wall paintings whilst red ochre and cinnabar were seen both on paintings and in burial contexts, the latter being used very rarely (see Chapter 4, Section 4.2.2). The azurite and malachite may be the earliest evidence of these minerals used in a pigment form both in Anatolia and the Near East (Gettens, Fitzhugh 1966, 54, 1974, 3). They were found only as grave goods in burial contexts (mainly in female and infant burials), ground into powders and in two cases associated with a bone spatula and possibly placed in a skin pouch, i.e. U.8184 green pigment, U.16308 blue pigment, Figs. 163a,b. The fact that these colours were not found on wall paintings but were specially prepared and placed in graves as burial goods suggests a few possible interpretations:

1) It might be possible that the sourcing and preparation of azurite and malachite pigments was a difficult process, therefore making these pigments prestigious and meaning that they were only used for ritual/symbolic purposes, i.e. as facial or body paint, relating the specialty of these pigments with certain individuals or ritual events.

Fig.163a CH07/4040/U.16308/X2 Blue azurite pigment with a bone spatula (Jason Quinlan, Çatalhöyük Research Project).

2) It is known that these pigments are fugitive when applied on wet (*fresco*) plasters of high alkalinity, i.e. lime plasters, and therefore they are often applied on dry (*secco*) surfaces with organic binders (Lindsey 2005, 7, Gettens, Fitzhugh 1966, 55, 1974, 5-7). Both pigments are quite stable when reacting with light and normal atmosphere, however they darken when exposed to sulphuric fumes and other pigments. Azurite also darkens and changes into malachite resulting from the binding media being aged and developing a yellowish/browny colour. As

Fig.163b CH01/BACH/U.8184/X4 Green malachite pigment with a bone spatula (Jason Quinlan, Çatalhöyük Research Project).

explained in Chapter 5, the experimental work suggested that the paint at Çatalhöyük was possibly applied to burnished, dry surfaces possibly with the help of water and/or organic binders. For this reason, it may be possible to say that azurite and malachite could also have been used on paintings like the other colours, but they may have been considered "special" and therefore the choices might have been made to use them only for special events and for special people within the burial contexts.

Another important pigment that is used at Çatalhöyük is cinnabar. Its use at Çatalhöyük is one of the earliest evidences of cinnabar use in pigment form following Kfar HaHoresh (Goring-Morris, Horwitz 2007, 914) in the Near East, and it seems to be the earliest use of cinnabar found in Anatolia. Later evidence of cinnabar in Neolithic Europe is found on human bones (in Spain, Martin-Gil *et al*. 1995) and on decorative pottery (in Serbia, Mioć *et al.* 2004) from c. 5000 cal. BC onwards. Cinnabar at Çatalhöyük is evident both on paintings and in burial contexts. Even though the cinnabar samples analysed for this research indicate that it started being used much later than red ochre which is seen from Pre-level XII onwards, this assumption may not be conclusive due to the limitations of sampling (see Chapter 1, Section 1.5.4) which did not permit investigating if the cinnabar was used earlier than Level VIII. It is particularly found on the decorative designs, i.e. geometrical paintings in B.49, see Appendix 2, as opposed to used for solid red paintings, either mixed with red ochre or on its own, maybe to brighten up the red ochre with its vivid colour and/or to attach some special meaning to the paintings. A number of the renowned red painted skulls from the 1960's excavations, including one from Level VI that had a large frontal area of a bright red pigment were analysed by the portable X-ray Fluorescence (PXRF) and the analysis confirmed Mellaart's original claim that this vibrant colour was cinnabar (Carter 2009, 127) (Fig.164). Previous research on cinnabar that was found on some Neolithic human bones from the burial site of La Velilla in Osorno (Spain) considered the toxic "preservative properties" of

Fig.164 A cinnabar painted skull from Mellaart E.VI.20 (Scott Haddow, Çatalhöyük Research Project).

this pigment to be closely related to the preservation of human bones as part of unique ritual practices (Martin-Gil *et al.* 2004, 759-761). Martin-Gil (*et al.* 2004) also suggested that the methods of cinnabar processing, i.e. washing and fine grinding, which would create brighter tones of red, may have added other meaning than preservative purposes such as "giving back the warm colour of blood and life to the bones" (Martin-Gil *et al.* 2004, 761).

Apart from the ritual attributions that might have been given to this pigment, there are some practical reasons which might also have caused its very scarce use, such as:

1) The collection of the raw mineral (cinnabar) being a painstaking process[2] and therefore being collected only at certain times and in certain amounts, sometimes causing the unavailability of the pigment for paintings and burials.

2) The poisonous nature of mercury, i.e. via vapor and dust during grinding, and the instability of the pigment in the longer term (cinnabar may turn black when exposed to light (McCormack 2000, 796-798) makes the use of cinnabar very selective and may have prompted the use of more available and safer red ochre as a substitute.

Unlike red ochre azurite, malachite and cinnabar have not been found in middens and fills so far and this may indicate the rarity and importance of these pigments, as they would not be regularly discarded, but only specially treated and used in certain contexts. Red ochre was also very common in burial contexts however it was not possible to find a clear pattern between the choice of red ochre or cinnabar within the burials. Red ochre was found on a very special object –the painted/plastered skull U.11330 in the South Area (Carter 2009, 126, see Chapter 4, Section 4.2.2.1.a)– indicating that although cinnabar may have been used as a symbolic and unique pigment, the choices of which of these two different reds was used are not clearly distinguishable at this point. It is highly possible that practical/logistical reasons might have affected the selection of these pigments, i.e. the unavailability of cinnabar or red ochre at a particular time or the impracticalities and difficulties of sourcing/preparing pigments.

[2] Cinnabar ores are formed underground when warm mineral solutions rise towards the earth's surface under the influence of volcanic action. They occur in concentrated deposits located at or near the surface. About 90% of these deposits are deep enough to require underground mining with tunnels. The remaining 10% can be excavated from open pits" (www.enotes.com/mercury-reference/mercury-192066).

6.3 Painting the Neolithic Çatalhöyük: Possible Painting Techniques and the Painting Tool Kits

The analysis across the site, as well as the experimental work, showed that the painted surfaces had no evidence of artificial carbonation which would have been possibly caused by the application of pigments when the plaster was wet and the effects of environment during burial[3]. The plasters (marl and soft lime) were most probably dry and already burnished when the paint was applied with water or organic binders. As explained before, unless burnishing takes place during application, the marl plaster surfaces crack during drying, making paint application impossible. Further burnishing might have been undertaken on dry marl plasters in order to smooth any irregularities on the surface before painting, however the experimental work showed that this practice makes the surface matt and powdery, creating a rough surface which might have been inappropriate for painting. As opposed to previous interpretations of paint application on plasters, my analysis provided more interesting information, indicating that the pigments were not only applied on white/fine soft lime washes, but also on pale brown/fine marl plaster washes with no plant inclusions (see Appendix 5 and Table 4.5 in Chapter 4). However, it is not possible to detect a clear pattern of this practice between the different areas and levels of the site. It looks as if the paint application on pale brown marl washes was practiced as often as on the fine soft lime washes, starting from Level VII and continuing through the later levels. Paint application on white, fine marl plasters seems to have been the general practice only in the earlier levels prior to Level VII, indicating that the different colours of plasters that were used for creating wall paintings might have been selected according to the needs and desires of the individuals in the household, i.e. wanting a specific tone of red colour on the walls, but it could be that it was not easy to obtain white soft lime at a specific time and instead pale brown marl plaster would have been used. These practical and/or aesthetical (maybe even symbolic) approaches in relation to re-plastering practices seem to have taken place during the later phases of Çatalhöyük. It is also possible to see the paint application on both types of plasters (soft lime and marl) on different layers of the same walls (see Chapter 4, Section 4.3, Table 5).

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[3] In the *fresco* technique, pigments are applied on a fresh lime plaster surface whilst it is still wet. The pigments are fixed by superficial carbonation of the lime as the water begins to evaporate and the saturated calcium hydroxide comes to the surface from inside the plaster, reacting with the carbon dioxide from the air, changing into calcium carbonate. This reaction stabilizes the pigments in place as if they are part of the limestone walls (Mora *et al.*1984, 72, Brysbaert 2004, 3, Lindsey 2005).

Unfortunately, it was not possible to detect any evidence of organic binders, i.e. protein, oil, fat or gum based on the painted surfaces during this research (see Chapter 4, Section 4.4). Nevertheless, the experimental work suggested that most possibly water and/or organic binders must have been used to fix pigments onto plasters. However, the poor durability of paint when used with water and plant based oils was clearly evident during the experimental work. The evidence of surviving paintings after thousands of years may indicate that stronger organic binders might have been preferred for painting practices. Moreover the experimental work showed that the organic binders tested, such as egg white/yolk, milk and rabbit skin glue resulted in almost no tool marks on the marl plaster surfaces when mixed with pigments. Only water seemed to cause very clear striations when the pigment was applied by a brush or a piece of cloth. The reason for this is not clear but the viscosity of the binder used, the time taken for the setting of the binder and the settling of the paint on the plaster surface may be effective in not resulting in any tool marks. Considering that only twelve samples provided clear striations/tool marks, which may be the result of paint application with water, it may be said that both water and the organic binders with strong adhesion properties might have been used depending on their availability and the practicality of use at times. Experimental work showed that during re-plastering, the paint that was applied with water and plant based oils bleeds into superimposed white wash layer. This may be the reason why thicker layers (1000µm or more) of pale brown marl plaster (with plant inclusions) were applied onto the previously painted layers in archaeological samples, before the application of a new wash layer. The thicker layer of marl plaster would completely seal the paint layer below and enable a fresh soft lime wash to be applied over it for the new painting.

In regards to the painting tools used it was not possible to gather reliable and consistent results due to the age and deterioration of the samples, but it is possible to make a few assumptions by using the results of the experimental work as well as the ground stone data. Even though there is little surviving archaeological evidence, the comparisons between the tool marks on both original and modern painted plaster samples (via experimental work) showed that tools such as animal hair brushes (soft/hard) and cloth (or maybe skin) may have been the most practical tools for painting, which would have resulted in some form of striations (see Chapter 4, Section 4.3). The preparation of the pigments prior to painting is an important process involving pigment grinding to achieve brighter colours as well as to ensure a smooth paint application and this practice does not seem to have changed through time. The work on the ground stone tools in relation to wall painting production may show that the pigments might have generally been ground on small sized, fine abrading slabs (palettes) –often made of schist– by using small sized fine abraders (handheld grinders or abrader knives). The pigments may also have been rubbed (in the case of abraded nodules) onto these palettes to produce powder pigment throughout the different phases of the settlement. These fine abrading slabs (palettes) and hand grinders seem to have been small and easily held in one hand. Because of the generally small sizes of the abrading palettes it seems likely that pigments were prepared in small quantities and applied onto walls accordingly, i.e. small amount of pigments would be enough for painting detailed designs. This might indicate that the painter prepared and/or used only small quantities of pigments at a time. However, preparing small amount of pigments for each painting might have been a time consuming process and therefore it is possible that a stock of pigments might have been prepared in advance and stored until the painting took place when small quantities of pigments would be used. Unfortunately there is no surviving evidence of wooden, basketry, ground stone or ceramic bowls with distinctive pigment residues, which could have been used for storing or for mixing the pigments and binders.

No evidence of sketching practices, i.e. drawing, incising or engraving, was observed on the samples even under the high magnification of SEM (EDAX) (either due to the deterioration of samples or because such practices did not exist). Because of permit restrictions (see Chapter 1, Sections 1.5.1 and 1.5.4) the complete Mellaart paintings at the Ankara Anatolian Civilizations Museum could not be studied with analytical methods to investigate this aspect in detail. For painting the larger areas, i.e. red walls, the experimental work showed that it is practical to mix small amounts of ground pigment with a binder to achieve a large amount of paint. The paint in this form is very easy to apply by using a cloth (or a skin?) in order to cover large areas quickly. The experimental use of cloth in particular proved to be effective for painting larger surfaces. The evidence of abraded pigment nodules with burnished/flat surfaces may also suggest that they may have been used for painting directly onto the walls or for spreading pigments onto schist palettes (as mentioned above) before mixing with a binder. Their flat surfaces show striations which go in the same direction as was observed on the painted surfaces (see Chapter 4, Section 4.5.3) whilst their waxy/compact nature may give clues about their direct use on the walls for painting. These abraded pigment nodules might also have been used to burnish the wall surfaces while painting to make them more compact and durable as in the case of lime plastered walls being burnished with red ochre (see Chapter 2, Section 2.2). While using hands to apply paint onto plaster has not proved to be an easy method, the practice of hand painting and making impressions of hands on the plastered walls seems to have continued during the later levels, i.e. Buildings 77, 49 and 55 in the 4040 Area. The experiments showed that the pigments mixed with different binders generally burnished well after application, but some paint came off during burnishing, depending on the binder used, i.e. the stronger the binder, the more durable the paint. Even though some painted surfaces look possibly burnished (Space 181, Pre-level XII, South Area), distinctive striations are still evident on them. If the paint layers were burnished, there would be no evidence of tool marks or straight striations (see Section 6.1). It is possible that the marl plaster layer below was heavily burnished and this affected the paint layer, making it look shiny and burnished. If that is the case, it would have been possible to see some circular marks as a result of the plaster burnishing, however these are not evident. Also as there is no evidence of "pigment" residues on the polishing (burnishing) stones, the paint layers may not have been burnished in general (only the plaster layers were burnished), but as mentioned previously paint layers on "selected" paintings may have been burnished in order to enhance their colours visually and symbolically.

The sharper and softer striations were evident on twelve painted plaster surfaces and two possible abraded pigment nodules. This may indicate that the actual painting work was made by using straight movements as opposed to circular movements (particularly when painting a solid red wall). This is interesting, since the experimental work suggested that plastering and burnishing work is easier to do in circular movements, which is a quicker way to smooth the wet marl plaster. When the painting took place (mainly in relation to red walls) it was observed that paint needed to be applied in straight movements from one direction to other, i.e. left to right, when mixed particularly with an organic binder. Water made the paint application easier in many directions, but generally in straight movements from left to right. Unfortunately it was not possible to detect any tools marks on the decorative paintings, i.e. hand motives or geometric designs, possibly due to the level of deterioration on the samples. Therefore, no information could be retrieved on the painting techniques of individual designs.

The experimental work also suggested a clue towards the nature of tool marks and the possible tools, which might have created the paintings, but the levels of deterioration on the original samples and the comparisons with the experimental samples did not provide reliable results. It seems that there are two clearer types of striations on the original samples, i.e. sharp striations going in the same direction and softer striations going in different directions, which looked very similar to the striations that harder or softer brushes would create as well as textile clothes on the experimental samples. Only the brushes and the textile cloths were found to be easy to use and created clear lines on the painted surfaces. There was no archaeological evidence for possible tools made from organic materials, i.e. wood or bone, however the experimental work proved that these tools might not have been overly practical for painting due to their porous, paint absorbing nature (see Chapter 5, Section 5.3).

Table 6.5 below shows the summary of results on the steps of the wall painting production at Çatalhöyük.

Steps of wall painting production	**Materials used**	**Technique used**	**Tools used**
Plastering	Marl (pure/impure, with/without plant additives). Soft lime (purer, without plant additives).	Application of wet plaster in single or multi-layered forms. As a final wash layer on multi-layered forms	Hands, animal scapulae Brushes, hands, a fine textile/skin cloth?
Burnishing on wet marl (during application)	-	Less burnishing on marl with plant additives. Circular movements are easier for burnishing marl/soft lime surfaces.	Hands, stone abrader knives, a fine textile/skin cloth?, polishing stones, pebbles.
Burnishing on leather-hard marl prior to painting (during drying)	-	Circular or straight movements to make the surface very smooth/shiny without any cracks.	Hands, a fine textile/skin cloth, hand sized, round polishing stones (limestone, marble).
Painting	Finely ground impure red ochre (in various forms i.e. haematite, lepidocrocite and/or goethite), cinnabar, bone (and carbon?) black. Azurite and malachite were only evident in burials.	On dry marl/soft lime surfaces by using binders i.e. water or possibly organic origin. No evidence of sketching prior to painting. Straight movements in different directions are particularly easier for painting red bands. Circular movements would be easier when brushes were used.	Soft/hard animal hair brushes, textile/skin? cloths, hands, abraded pigment nodules (abraded pigment nodules may have also been used for burnishing walls while painting).
Pigment burnishing	-	unclear	unclear

Table 6.5 The summary of results on the steps of the wall painting production at Çatalhöyük.

6.4 Painting the Neolithic Çatalhöyük: Was it a "communal" or a "specialist" practice?

Several definitions of craft specialization in relation to archaeological context have been suggested by scholars (Rice 1981, Clark 1995, Costin 1991, 2001, Cross 1993). One of the simplest explanations by Miller (2007, 30), focusing on the idea as a general practice, was "developing an expert knowledge and a method of organization in producing crafts". According to Flad and Hruby craft specialization would also "emphasize the social aspects of productive behavior and the importance of specialized production in the creation and perpetuation of social ties" (Flad, Hruby 2007, 3). As opposed to these general ideas, some scholars argue that a craft specialism is closely related to the individuals and therefore should be explained as the specialist production undertaken by "an individual who hold a position or vocation because he (sic) controls a set of skills that most of his communal fellows do not control" (Rodgers 1966, 410, see also Flad, Hruby 2007, 4). This view is also defined as the "producer specialization" which describes an individual who only specializes in a certain activity (Muller 1984, 90) whereas the "craft (product) specialization" refers to a product which is produced for others (outside of one's own household) meaning that "any production occurs with the intention that the product be consumed by non-dependants" not "by the members of one's own household" (Flad, Hruby 2007, 4-5), (also Clark 1995, 279, Clark, Parry 1990). Flad and Hruby (2007) further explain that producer specialization and product specialization are interrelated within the area of craft specialization and "they emphasize critical distinctions in the production activities of individuals within social groups". (Flad, Hruby 2007, 5). They also suggest that while producer specialization forms a subset within the general area of product specialism, a continuum takes place between these two perspectives (Figs.165a, b).

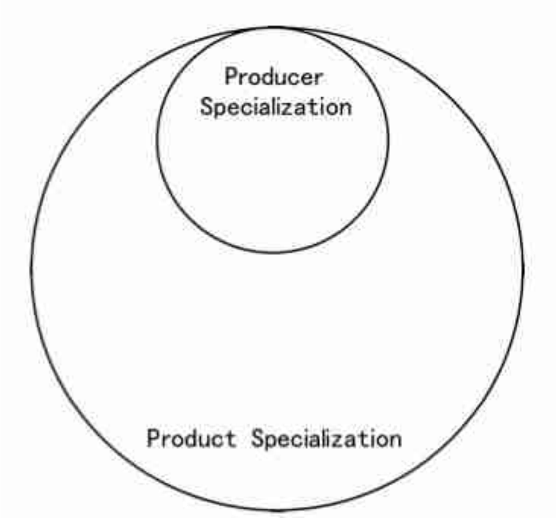


Fig.165a The interrelationship between producer and product specialization (Flad, Hruby 2007,5).

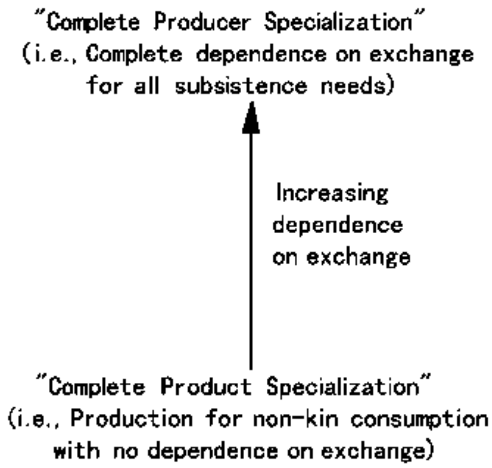


Fig. 165b The continuum within the craft specialization (Flad, Hruby 2007,5).[4]

In order to determine whether or not there may be specialist practices within a community, various criteria need to be looked at. As Costin (1991,8) and Flad and Hruby (2007, 6) mention these are:

1) Context of production, i.e. the study of production areas.

2) Concentration/distribution of the production material.

3) Scale of the production, i.e. large or small.

4) Intensity or the time in which the production takes place, i.e. full-time, part-time, seasonal.

Even though it may not be easy to identify the level of production in an archaeological context, other factors can be examined by studying the areas in which the production took place (such as the buildings where wall paintings, pigments and the related tools were found, their concentration and sizes) in order to gather clues about the scale of the production processes.

[4] "Complete product specialization indicates production for non-kin consumption with absolutely no dependence on the exchange of these products for satisfying subsistence needs, while complete producer specialization involves the complete dependence on the exchange of products. The middle part of the continuum indicates varying degrees of dependence on the production for subsistence." (Flad, Hruby 2007,5).

According to the study of the painted plasters, only a small number of wall painting samples came from primary/in situ contexts (36 out of 121 painted plaster and pigment samples) in various buildings both in the South and the 4040 Area (see Appendices 4, 5 and 222 for the building plans/locations of samples). Most painted plaster and pigment samples seem to come from the fills, i.e. infill, room and back fills, and middens throughout the site. Figures 166a and 166b present the distribution of painting related materials throughout the different levels, areas and buildings of Çatalhöyük.

Fig.166a shows that red/yellow ochre were found throughout the most phases in both areas of the site and there was no significant change in their technological modifications as seen in Tables 6.3 and 6.4 (in Section 6.2). Following ochre pigments, multi layered wall plasters with white soft lime/pale brown marl also seem to be used in most phases, but 4040 G in the 4040 Area seems to have provided the highest numbers both for the use of ochre and the multi layered wall plasters. Single layered wall plasters with white marl appear to be very common only in the early phases of the South Area (South G, J, K, L) and after that the use of multi layered plasters seems to have taken over.

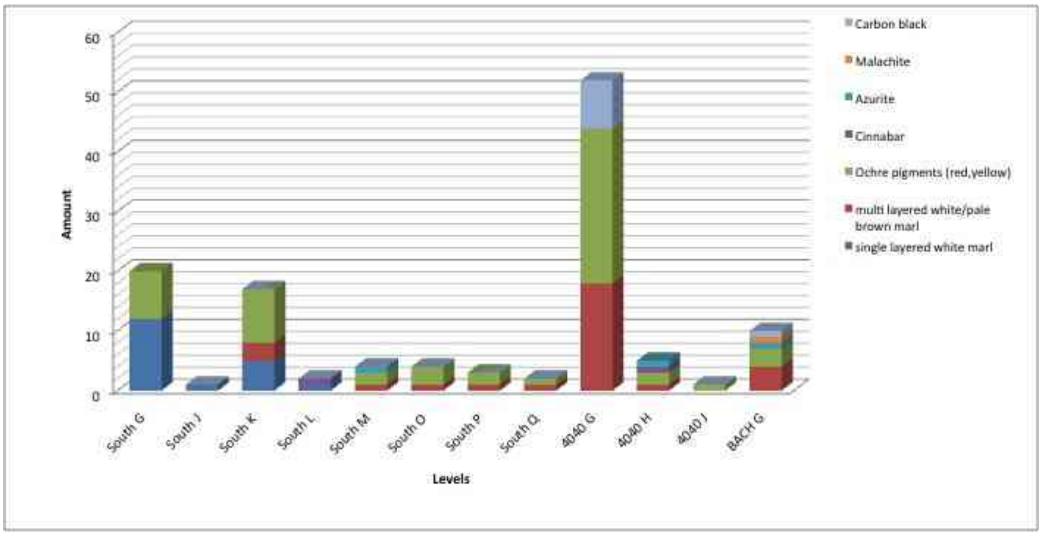


Fig.166a The amount of painting related samples throughout the different phases and areas of Çatalhöyük.

The study of the available samples showed that carbon black was mainly found in 4040 G and BACH G and it was possibly not a widely used pigment like azurite and malachite. It might have been used only for certain paintings, i.e. with designs in B.49 and B.55 in the 4040 Area, which may have been painted for certain occasions. Cinnabar, also a very rare pigment, was only evident in the 4040 Area in phases G and H where the buildings with painted designs were present.

It is hard to know how often azurite and malachite pigments were placed in burial contexts, since we do not have enough samples coming from the various levels/phases and buildings across the site. Nevertheless, Fig.166a shows that azurite was available from BACH G phase and its use continued in the later phases of South and 4040 Areas, i.e. 4040 H and South M, with no change in its technological processing (see Tables 6.3 and 6.4). Fig.166b below shows that painting related materials came from most buildings in the earlier phases and they continued to be used throughout the life of the settlement both in 4040 and the South Area. It is therefore possible to say that painting walls at Çatalhöyük might have been a general practice involving the whole community and might not have been a specialist craft only undertaken by individuals or individual households. As the study of Wright's data suggests possible wall painting related ground stone tools, i.e. abraders, polishers, palettes, and pigments, seem to be found in most houses across the site in varying forms and combinations. This may indicate that there was no "specialization" or any evidence of "special houses/households" involved in the wall paintings production at Çatalhöyük (Figs.167, 168, 169).

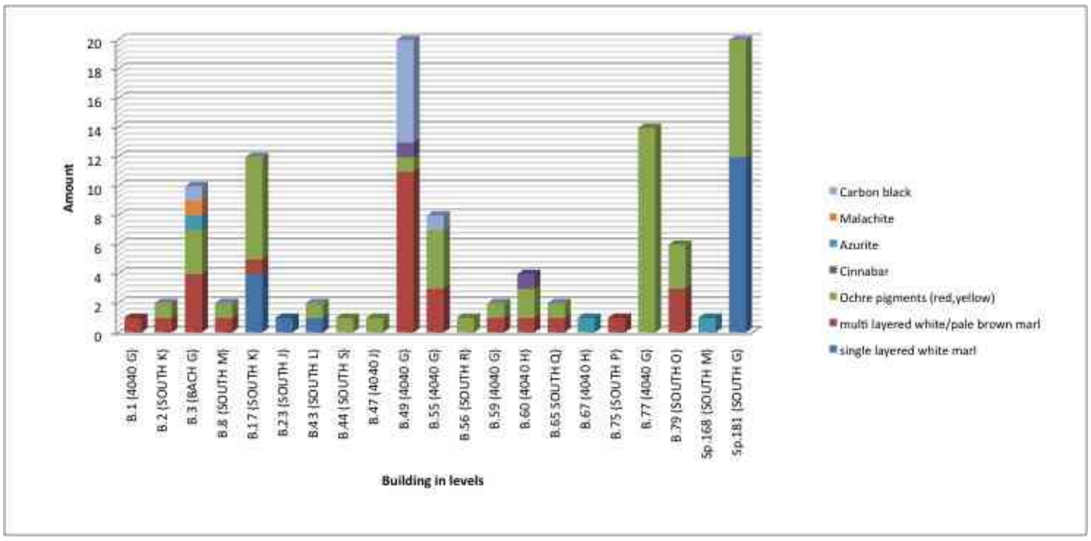


Fig.166b The amount of painting related samples throughout the different phases, areas and buildings of Çatalhöyük.

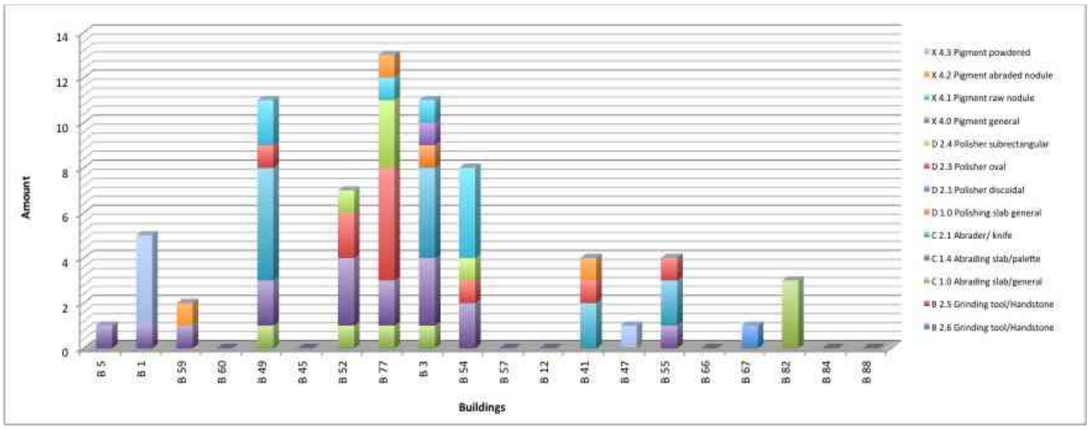


Fig.167 The amount of painting related groundstone tools throughout the different buildings in the 4040 area of Çatalhöyük.

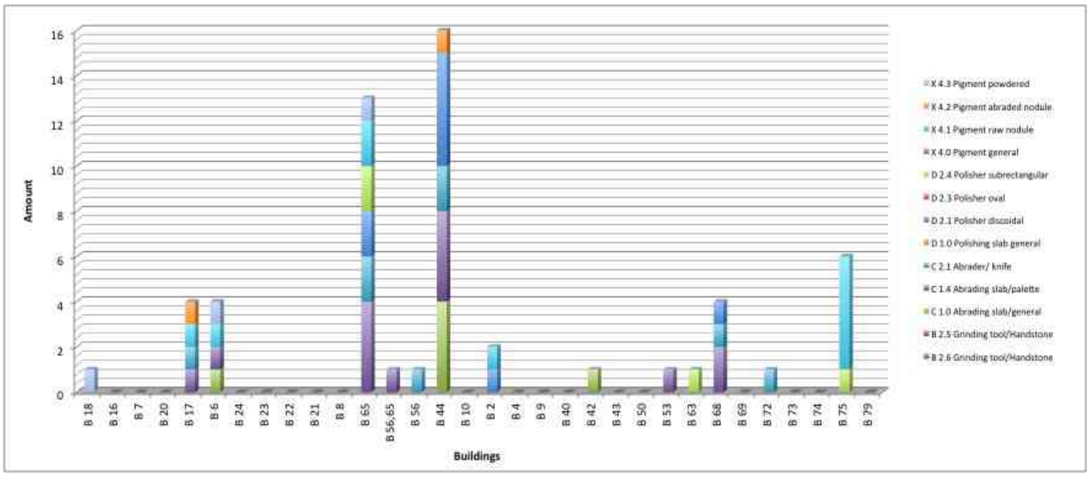


Fig.168 The amount of painting related groundstone tools throughout the different buildings in the South Area of Çatalhöyük.

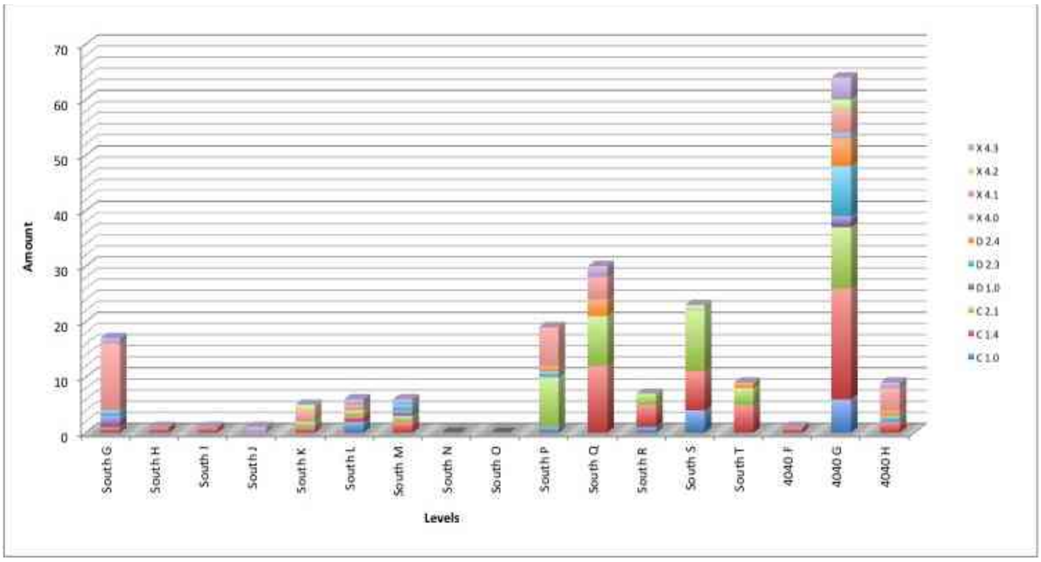


Fig.169 The amount of painting related groundstone tools throughout the different phases in the South Area and the 4040 area of Çatalhöyük.

The painting production involving ground stone tools seems to have been undertaken mainly inside the houses. This idea however is mainly based on the assumption that the ground stone tools studied during this research might really have been used for paintings. The tools were found in both the earlier and later levels, but their numbers increased slightly in the buildings of the later levels where more wall paintings were found, which is clearly seen in the 4040 Area (see Chapter 4, Section 4.5). In the South Area this pattern was the same, but the painting related tools were found in the houses both with and without paintings. This again may indicate that each house may have produced their own tools to plaster/paint their walls rather than the existence of special "painters' houses" which would have distinctively presented high numbers of "painting tools" as evidence. Even though the later levels/phases show higher number of painting tools in certain houses with paintings (see Appendices 219, 220 and 221), this may be linked to the accumulation of plastering/painting tools in these houses as more paintings were produced through the time rather than a reason to consider them "special". While these results are interpreted via the current excavation data, it is known that not all the buildings have been fully excavated in certain levels both in the South and 4040 Area and therefore it is not possible to do a more significant cross level comparison between the earlier and the later levels across the site.

The above information suggests that there seems to be no significant variation in plastering/painting techniques and tools used at Çatalhöyük between the different areas, buildings and levels that it was possible to investigate during this study. Despite the very aged and deteriorated nature of the pigment, painted plaster and the ground stone samples, certain techniques and methods could be identified via investigative, experimental and analytical work (see Chapter 4 and this Chapter). The nature of the wall painting production generally seems to have been the same across the site with some changes, particularly in plasters and plastering techniques, between the earlier and later levels/phases. This indicates the possible evidence of common practices being undertaken by most households who may have plastered and painted their walls via experimenting and finding the most practical methods and tools. Some of these practices may have had additional symbolic meanings along the way, i.e. while sourcing the materials, deciding the colours for paintings, preparing the materials and combining them with the meanings of imagery that they created.

This finding also supports Hodder's entanglement idea (see Chapter 2, Section 2.4) in conjunction with operational and behavioural sequences which is a consistent pattern seen in the production of "things" at Çatalhöyük houses. The need and reasons to paint walls, deciding designs and materials, obtaining resources, preparing/modifying materials, choosing techniques and tools, organizing time and labour would be the parts of a production line and the whole process would involve following each step thoroughly to achieve the desirable result. The life histories of "things'', as well as the social and environmental changes would also need to be responded to and may have strongly influenced people' choices and practices when producing things. During the sequence people would also experiment with the ideas, materials and techniques to learn what works best and what is possible for the individual cases and thus develop better practices according to their needs. Things would get influenced by and interrelated with each other too, i.e. repetition or imitation of forms and decorations on various media such as wall paintings, pottery, basketry, textiles. As a result, people become things and things become people, which closely depend on the "house", on each other and on their social and natural environment.

Matthews has suggested that re-plastering and painting practices might have been connected with significant occasions in the lifetime of inhabitants/buildings (Matthews 2005b, 367) and that is probably why they would choose certain rooms and walls inside the houses as well as selecting the most durable materials and techniques to create paintings (see Chapter 2, Section 2.4), a skill that might have been developed by practical experiences. This study shows that without paintings, the walls would simply be plastered and this would be enough to insulate the mudbrick walls for several reasons, i.e. to cover the uneven surface of the mudbrick, to reflect more light inside the houses and/or to absorb unwanted odours (marl is known to have mild antiseptic properties due to its alkalinity, Doherty 2006, 306). Making paintings, however, might have added a special meaning to the walls and therefore the painting processes (including obtaining and preparing materials) might have been treated as a communal (and maybe a ritual) practice in which every household would be involved. They might also have helped each other and celebrated the new painting. This may be true for certain paintings, i.e. red walls and daily scenes, but there is a possibility that more elaborate designs may have been developed and painted by more skilled people. It was, unfortunately, very difficult to clearly recognize these actions as well as the painters' individual styles during this study due to the deterioration of the samples available.

More focused research on the individual styles and techniques of painters would provide a more detailed approach to understand the nature of these practices.

6.5 Conclusion

This research has presented new information on the technological processes behind the wall painting production at Neolithic Çatalhöyük. It also looked briefly at the possibility of craft specialism within the making of paintings, by using the technological and archaeological data collected from the analytical study. During the research, it became clear that the wall paintings of Çatalhöyük (and Neolithic wall paintings in general) possibly share certain similarities with other object forms and decorative media in terms of designs and technologies, i.e. pottery, textiles, basketry, cave paintings. It was also interesting to see that similar painting materials, techniques and imageries were developed and used throughout the different eras and different regions regardless of what they may have meant for the people. How these practices and information became common is unknown and requires further investigation.

One of the most interesting areas which became apparent during this research was the significant gap in painting production during the central Anatolian and the Near Eastern Paleolithic (particularly between upper and Epi-paleolithic, c. 45,000 cal. BC-10,300 cal. BC) (Bar-Yosef 1997, 163). Decorating walls and expressing symbolism via wall art first started occurring during the early and middle PPNB. Artistic and/or symbolic expression through the creation of decorative art objects and paintings was scarce until this period. The reason for this is unknown. However, even though the settlement and population sizes increased during the PPNB, the wall art was still restricted in terms of scale and occurrence. Some scholars made suggestions on the possible reasons for this slow development (see Chapter 2, Section 2.2.1), but like some aspects of the wall painting production, this question is still open for further study and research.

As Düring and Marciniak explain "in the initial central Anatolian Neolithic, settlements composed of neighborhood clusters acted as the basic constituent elements of society, creating clearly bounded neighborhood groups and local communities" (Düring, Marciniak 2006, 182). The idea of "autonomous households" was first suggested in relation to the central Anatolian Neolithic and are considered an important part of the early Neolithic "neighbourhood clusters". According to Düring and Marciniak these households helped in developing "the social, ceremonial and economic foundations of the neighbourhood communities" (Düring, Marciniak 2006, 182). Çatalhöyük had one of these neighborhood communities particularly in the earlier levels (X–VI), where it was also clear that there were "more or less discrete household residences in which a standardized set of features associated with domestic activities were found" (Düring, Marciniak 2006, 183).

Hodder (2006) and Cessford (2004) suggest that the houses at Çatalhöyük were fundamental in terms of forming a tradition which was based on the household experience, both through "a spatial and temporal organization" (Tung 2008, 288). Hodder also argues that "the repetition of the ordering of social space within the house sequences is remarkable and leads to the hypothesis that social life was organized at least partly through the routines and practices of domestic socialization" (Hodder 2007, 108). He also explains that the daily practices within Çatalhöyük houses determine the social world and "the continuities in these practices and functions based in the houses can be seen specially in the art and symbolism" (Hodder 2007, 109), i.e. on paintings where repetitive imagery, traditions and techniques continue through time and steadily transforming these houses into "dominant households" (Düring 2006, Hodder 2006). Since these particular activities were crucial for the continuity of the settlement, some households may have had more control or may have had a leading role in passing around their traditions/practices in the settlement. This would then make them the "autonomous" households.

Tung mentioned about the "intimate knowledge, which is born and maintained through the interaction of people to things, places, and themselves where the only constant is movement and gradual transformation" (Tung 2008, 288, 289). Tung's research on Çatalhöyük plasters has suggested that people were very enduring in their practices and traditions at Çatalhöyük. This is a good indication of how deeply they were involved in their surrounding environment and its resources "a knowledge that was maintained and experienced outside of the buildings through the everyday and cyclical interactions of people" (Tung 2008, 290). Throughout this research, one thing became clear; wall painting production also involved long-lived practices and traditions in which the materials and techniques did not show much change through time. Imagery, painting styles, material selection and the ways that the materials were modified/used were persistent and only changed slightly whilst generally the same patterns continued across the site in certain contexts and paintings. Even though the idea of "autonomous houses" fits in with the idea of certain houses with wall paintings leading the painting production throughout the settlement, the archaeological data suggests the opposite, indicating that the preparation/modification of wall painting materials (mostly based on the ground stone evidences) mainly took place inside the houses and each household was possibly producing their own paintings where the interaction of individual households would also be very likely.

In summary, mainly due to the sample limitations, this study focussed on the detailed investigation of the technological make up of Çatalhöyük wall paintings, i.e. resources, materials, material interactions, tools and techniques, using analytical and experimental work. The former made it possible to understand the application and use of different scientific instruments in the context of archaeological pigments and painted plasters as well as to evaluate the whole analytical process. In some cases, the limitations of the samples and the analytical equipment available for the study proved that we cannot safely answer every question we ask and the results we gather may not always be reliable and conclusive, unless we have plenty of resources and ideal conditions to build up our research in. For this reason, the wider themes such as linking iconography with the material/technical choices, detailed study of the pigments found in burial contexts and the organic binders could not be pursued. This research showed that experimental study worked well in some of these cases, by looking into specific areas from a craftsman's point of view, providing possible clues for practical questions as well as confirming both archaeological and local knowledge (which is still being put in practice today).

As the secondary aim of this research, the contextual and material study on the paintings as well as on the ground stone tools helped to observe whether certain areas of the site were producing more paintings and/or painting related materials such as pigments and tools. Thus, the study made it possible to evaluate if the wall painting production was a special craft, only engaged in by specialist people and/or households, or was a communal practice in which most households were involved. It is hoped that this research made it possible to gain a little insight into these social questions by following the material evidence from Çatalhöyük, since it is very difficult to draw certain conclusions about these activities when we deal with very old and deteriorated archaeological material.

6.6 Future Research

One of the questions which remained unresolved during this research was if organic binding media was used for the painting processes. Unfortunately the time restrictions, unavailability of the required techniques for analysis, as well as the deterioration levels of the painted plaster samples have not enabled this area to be pursued, even though this study argues that organic binding media may have been used on the paintings. For this reason a detailed analytical research on the investigation of possible organic binders should be undertaken in the future.

There is also the question of black pigments containing bituminous materials. GC-MS analysis on one black pigment sample (U.16647, S3) indicated a possible use of bitumen as a pigment or as a mixture with the carbon black. This result is not conclusive and could not be investigated further during this study. It is suggested that this area should be examined in detail by studying the availability and use of bitumen within the central Anatolia and the Near East.

Another area of research which could not be covered during this study was the study of Çatalhöyük pigments in the context of burial practices. The prehistoric pigments within social/ritual practices raise the question of the significances and the meanings of colour. In order to understand the symbolic connections in the use of pigments both between the daily lives of people and the burial practices as well as with wall paintings, a more detailed study is necessary, as well as to examine practical or ritual reasons for choices.

Provanencing pigments would also be an important part of this area to find out about the sources of the minerals used to build a better understanding of the raw materials, their ways of processing and use within the different contexts at Çatalhöyük. Reconstruction of pigment sources and the Neolithic landscapes is not a straight forward process. This work would have needed a detailed field sampling and provenance analysis as well as looking into trades and how people connected during the Neolithic period, which could not be achieved during this research.

One of the pigment related questions of this research was if the variety of ochre colours was achieved via heating. As mentioned in Chapter 2, Section 2.1.1, it is possible to change their original colours from yellow to brown, brown to red and red to black by heating iron oxides between 575-650^{o}C (Chakraborty 1999, Abdouni *et al.* 1988). Apart from being found in burial contexts as well as room and infills Matthews mentions that sometimes red and yellow ochre were observed in the northern areas of main rooms as well as in the southern areas of the rooms where they were sprinkled around hearth/ovens (Matthews 2005a). Whilst this may give clues that heating iron oxides to obtain different shades may have been a practice, it would also raise the question of whether red ochre was achieved through heating yellow ochre or it was found as a natural rock and processed (Minzoni-Dèroche 1995, 157, Pomiès *et al.* 1999). Studies indicate that this aspect could be investigated by analyzing red ochre (hematite) samples with techniques able to elucidate crystal structure, i.e. X-Ray Diffraction (XRD), Transmission Electron Microscopy (TEM) and, to a certain extent, spectroscopy techniques including Raman and FTIR spectroscopy (Pomiès *et al.* 1999, 275-285, Lopes, Faria 2007, 117-121). This was not possible within the scopes of this research. However, future researchers should consider undertaking this analysis which would be a very important study concerning the nature of red ochres used at Çatalhöyük.

Even though studying the related groundstone tools presented some initial ideas on the possible use of a stone tool kit for the painting practices, the result of this study is not entirely conclusive. Only a few samples/examples gave obvious evidences of use, i.e. polishing stones and some of the abrading tools with pigment residues. It would be very interesting particularly to focus on the abraded pigment nodules and their use, however this research did not have enough time to look into this aspect. A comparative study between the abraded nodules, other pigments lumps and the pigments on the paintings may provide more detailed information on the use of pigments and their processing.

Examining painting skills in detail and the different styles between individual painters at Çatalhöyük would be another area to focus on. For example, the well-studied Paleolithic paintings from Western Europe present more elaborately painted/drawn figures and designs than the Neolithic wall paintings from central Anatolia and the Near East, where they seem to be executed more crudely (the skills can be observed via the sophistication of imagery). This, in fact, may be an important indication of different skill sets in painting practices existed within the different eras and communities. Did Paleolithic people have better (more specialist?) painting skills whereas the Neolithic people did not? The fact that the painting skills on the Çatalhöyük paintings were not intricate this could also be an indication that there were no special “painters/artists” in the community who created these paintings, but instead everybody painted.

It is also vital that an efficient database for painted plasters and pigments is developed at Çatalhöyük and integrated into the electronic site database. Currently the samples are only registered on the finds database and they do not contain any detailed information. Unfortunately this research could not create this database due to time restrictions and the workload on the site. I hope that following this study a more systematic database can be developed for the Çatalhöyük painted plasters and pigments, which can help future researchers providing clearer and more accurate information.

6.7 The Parameters for safe conservation practices for the future study of the wall paintings and related materials

As explained in Chapter 3 the wall paintings and the related materials such as marl plasters, pigments and possible plastering/painting tools have been subjected to the deteriorating effects of the long burial conditions. Following exposure, these materials will be in danger and the archaeological information which they hold can be lost in a very short time if they are not excavated, handled and treated with particular care. During this study, the condition of the material studied made it clear that they needed a more careful approach in terms of excavating, recording and storage to make them more accessible for future studies. Below are the suggested criteria for the safe preservation of the wall painting materials:

1) When found in situ wall paintings should be exposed under the supervision of an excavator and a conservator who will provide tools and advice on how to remove very thin plaster layers without damaging the painted surfaces and recording the archaeological information in a systematic way.

2) Exposure of mudbrick walls and the painted, marl plastered surfaces needs to be controlled as the excavation continues. Conservation materials such as Geotextile fabric (permeable fabric made from polypropylene or polyester) must be used to cover and protect the wall surfaces and tops between work hours. Damage to paint and plastered surfaces can occur very quickly upon excavation due to the severe temperature and relative humidity (RH) changes in the environment.

3) Pigments are mainly found in burial contexts as well as within buildings, in fills and middens. When coloured materials are found, it is important to consult the conservator or a pigment specialist to understand the nature of the pigments and in order not to cause confusion with other materials such as coprolites or colour variations within the soil.

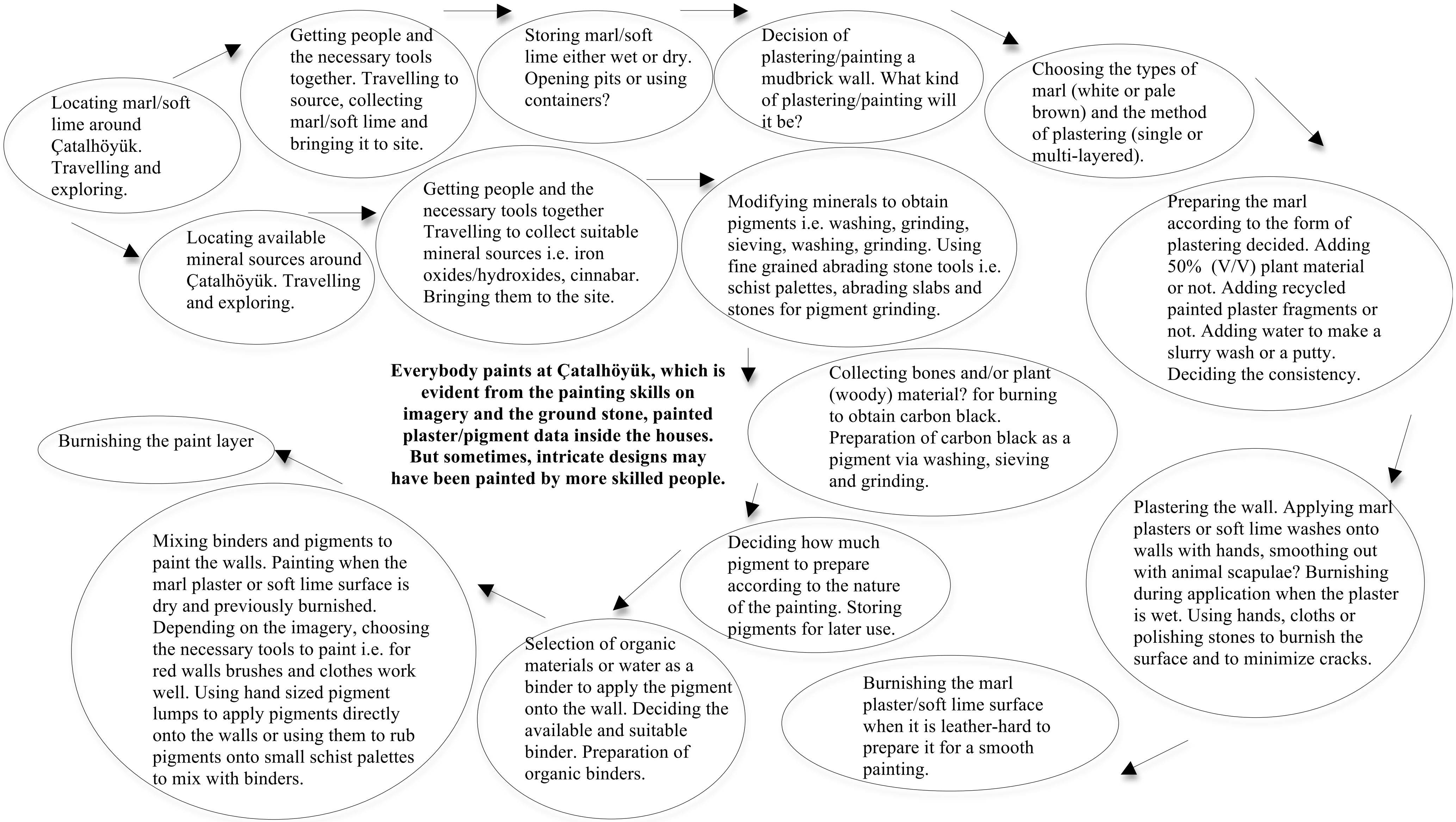
4) Before applying any conservation materials on painted plasters and pigments it is crucial that relevant samples are taken and recorded systematically on the site database with the contextual information. Consultation with the conservators, pigment and plaster specialists is also required not to hinder any scientific analysis in the future. No brushing or washing should be applied to plaster, pigments or ground stone tools as this practice might damage the material and result in the loss of archaeological information.

5) Painted plaster samples should be packed in acid free tissue and kept in small polyethene food boxes as placing these friable samples in plastic bags causes them to move about and get damaged, i.e. causing powdering and breaking. Pigment lumps and nodules should be stored in the same way, whilst in powder form they must be placed in small sample tubes. All samples must be labelled carefully with accurate description and contextual information.

6) Ground stone tools (see Chapter 4, Section 4.5) possibly related to wall paintings must be examined carefully upon excavation since they may have pigment residues on them as well as deliberate abrasion/use or tool marks. If any of these found, the information must be recorded on the site database. These objects should not be washed, however very light brushing with a soft brush can remove soil and reveal marks and surface residues, which can provide important information on possible wall paintings tool kits.

6.8 Final conclusion

As the final conclusion of this thesis, the operational chart on the next page describes the possible stages of the wall paintings production at Çatalhöyük. During this research, it became clear to me that wall paintings certainly had a symbolic importance for the people of Çatalhöyük, though they seem to have adapted it into the practicalities of their houses and daily lives. People seemed to have had a good knowledge of their surrounding environment as well as its resources, and like the other object technologies at Çatalhöyük, wall painting production seemed to have involved long-lived practices and traditions in which the materials and techniques were formed by experimenting and deciding the most suitable and practical approaches. Whilst this PhD study tried to understand the nature of these practices/traditions, further research on the wall painting materials will enable to close some important gaps, which were explained under Section 6.6 above.


Locating marl/soft lime around Çatalhöyük. Travelling and exploring.
Getting people and the necessary tools together. Travelling to source, collecting marl/soft lime and bringing it to site.
Storing marl/soft lime either wet or dry. Opening pits or using containers?
Decision of plastering/painting a mudbrick wall. What kind of plastering/painting will it be?
Choosing the types of marl (white or pale brown) and the method of plastering (single or multi-layered).
Preparing the marl according to the form of plastering decided. Adding 50% (V/V) plant material or not. Adding recycled painted plaster fragments or not. Adding water to make a slurry wash or a putty. Deciding the consistency.
Plastering the wall. Applying marl plasters or soft lime washes onto walls with hands, smoothing out with animal scapulae? Burnishing during application when the plaster is wet. Using hands, cloths or polishing stones to burnish the surface and to minimize cracks.
Burnishing the marl plaster/soft lime surface when it is leather-hard to prepare it for a smooth painting.
Locating available mineral sources around Çatalhöyük. Travelling and exploring.
Getting people and the necessary tools together Travelling to collect suitable mineral sources i.e. iron oxides/hydroxides, cinnabar. Bringing them to the site.
Modifying minerals to obtain pigments i.e. washing, grinding, sieving, washing, grinding. Using fine grained abrading stone tools i.e. schist palettes, abrading slabs and stones for pigment grinding.
Collecting bones and/or plant (woody) material? for burning to obtain carbon black. Preparation of carbon black as a pigment via washing, sieving and grinding.
Deciding how much pigment to prepare according to the nature of the painting. Storing pigments for later use.
Selection of organic materials or water as a binder to apply the pigment onto the wall. Deciding the available and suitable binder. Preparation of organic binders.
Mixing binders and pigments to paint the walls. Painting when the marl plaster or soft lime surface is dry and previously burnished. Depending on the imagery, choosing the necessary tools to paint i.e. for red walls brushes and clothes work well. Using hand sized pigment lumps to apply pigments directly onto the walls or using them to rub pigments onto small schist palettes to mix with binders.
Burnishing the paint layer
Everybody paints at Çatalhöyük, which is evident from the painting skills on imagery and the ground stone, painted plaster/pigment data inside the houses. But sometimes, intricate designs may have been painted by more skilled people.

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