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MATERIALS SCIENCE APPLIED TO TRACE ANCIENT TECHNOLOGIES
IN THE AEGEAN WORLD

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Painting biographies

Ann Brysbaert

Introduction

Past and recent scientific analyses of plaster and pigments by means of a wide range of techniques have enabled the study of Aegean wall paintings in a more detailed and contextualised way, so that archaeologists no longer need to rely solely on stylistic studies to argue matters of chronology, origins (if this is indeed a valid question) and workshops. This paper aims to provide a brief critical overview of technological studies while also emphasising their contextualisation beyond their purely scientific studies in order to avoid approaching this rich material from a singular perspective. As argued a decade ago, both archaeological scientists and archaeological theorists attempt to understand past societies by means of investigating material culture, so both approaches should go hand in hand; thus also in painted plaster studies. It seems, however, that scientists emphasise the behaviour and properties of objects while the theorists are more concerned with the study of subjects through the study of objects, while both deal with material culture. Therefore, it is useful to investigate why artefacts (or ‘features’ when less portable) are socially and culturally constructed and to consider the physico-chemical and biological construction and properties of these artefacts or features (Jones 2004, 327, 329). While scientific analyses of painted plaster contribute to a broader understanding of socio-economic and political issues at play in the regions under study, these results only become useful when integrated with iconographic, stylistic and contextual studies of this material, and when discussed from a social theory perspective. From an iconographic perspective, the work, by F. Blakolmer, on Aegean prehistoric painted plaster stands out. ‘In the Aegean Bronze Age, architectonic walls, pottery, seals, figurines, dresses as well as the human body could have functioned as bearers of distinct information and thus underline the complexity of the artistic

construction of images. [The symbolic marks on these] ... demonstrate the close interrelation of this vocabulary of signs, as well as a symbolism, “working” on different levels of semantic meanings’ (Blakolmer 2012, 332). A rich source of information is out there in the shape of these paintings and the more varied ways these are approached, and especially also combined, the more messages will come towards us and hopefully be understood. It is necessary to integrate technological but also scientific analyses into iconographic and stylistic studies on the large, rich and varied LBA repertoire of painted plaster of the Aegean and surrounding regions with which contacts of many types were clear (Brysbaert 2008, 160–185). Such trends are becoming more common even though the more traditional approach that carries out scientific analyses *as an end in itself* still exists, and the same applies for iconographic overviews without the integration of technological data in a social-theoretically informed discussion. The latter type of studies whether purely technological/scientific or purely iconographic, however, may not forward archaeological enquiry into the rich complexity of the human past and may not answer wider questions about these paintings’ biographies, which essentially turn them into social actors themselves. Questions about *why* specific materials and techniques were chosen and by *whom*, how they developed or changed over time, what the socio-economic and cultural drivers were for these changes, if any took place, whether any influences from beyond the Aegean were noticeable on Aegean paintings and vice versa, how this was implemented, and why such craft forms eventually disappeared, are not addressed by scientific analysis per se. These questions, however, reach out to the core of what people were doing and how they were living their daily lives; and as archaeologists, that remains our main line of interest. Such

traditional scientific analyses may contribute to the *al fresco-al secco* debate – and it has done so over the last decade and earlier – but not always in a very constructive way beyond the strict debate. Therefore, analytical results need full integration into a wider theoretical discussion, addressing the archaeological questions, which in themselves are based on specific research debates that motivate these analyses (see Jones 2004). Only then will multidisciplinary approaches to painted plaster, based on both scientific approaches and theoretical frameworks of analyses, provide the relational aspects of the material qualities and properties, how these may have shaped past people's views of their own cosmos, and how such views of their world may, in turn, have shaped these paintings.

Past painted plaster studies, a short overview

Technological studies on Aegean painted plaster are as old as its first finds. People such as Evans' earliest material scientist, N. Heaton (1910), studied the Knossian pigments and painting technologies, and later also the material found at Tiryns and Orchomenos (Heaton 1912). The latter results were published as addenda in the wall painting volume by Rodenwaldt (1912). In 1942 Duel and Gettens published a synthesising paper about what was hitherto known on the technologies and materials of Aegean paintings. In terms of pigment studies, a new wave of laboratory studies started in the 1960s in the Dimokritos laboratory by a strong collaboration between S. Philippakis, R. Jones, V. Perdikatsis and M. Cameron (e.g. Philippakis *et al.* 1976 and many more). V. Perdikatsis continued this line of study through the IGME laboratories, first, and subsequently, at the University of Crete at Chania. Around the same time, the work on the plaster from the Pylos excavations was published (Lang 1969), and M. Cameron's PhD (1975) formed a monument to his work done at Knossos. A scientific paper resulted from the laboratory analyses conducted on these fragments and is still one of the main papers to consult on Knossian analyses of plaster and pigments (Cameron *et al.* 1977). Not only had these early studies recognised most of the mineral-based pigments but they also asserted, in my view correctly, that various painting techniques were likely combined in executing most of the painted scenes on these lime plaster surfaces. They suggested that *al fresco* was the attempted or intended technique and formed the majority of the painted surface. When the plaster became too dry, the artists would continue with adding on paint via *al secco* methods.

The 1990s saw another concentration of plaster studies by the scientific work done on the Mallia materials (for example Dandrau 1999; 2000; 2001; Jones 1999), while V. Perdikatsis wrote an updated synthetic paper in 1998, and R. Jones another update in 2005. More work was now also carried out and published from the site of Akrotiri where

decades of great conservation work had been undertaken (e.g. Perdikatsis *et al.* 2000). L. Chryssikopoulou and her team were the first to analyse murex purple applied as an organic material on the lime plaster surfaces there (Chryssikopoulou and Sotiropoulou 2003). Moreover, she carried out very insightful experimental trials in the environment in which these paintings would have been carried out originally (Chryssikopoulou *et al.* 2000) and this was a useful improvement of the experimental work earlier carried out by M. Cameron back in Canada. Other relevant experiments were carried out by Hatton and team (2008) at Oxford where he reproduced the Egyptian blue pigment, one of the most common blue pigments in Aegean painted plaster next to Riebeckite. Since this was a synthetic or man-made pigment rather than a mineral-based one, insights in this technology aids in understanding the level of efforts that people went through to reach the colours they wanted to employ, and what these may have meant, both the pigment and its composition, and the efforts needed to produce it (see earlier: Philippakis *et al.* 1976; Kakouli 2002; Brysbaert 2011b; Vlachopoulos and Sotiropoulou 2012). Very recently, a useful experimental study was carried out by Angelidis *et al.* (2018, esp. 365) which indicated that the *sinopie* or underdrawings at Akrotiri, also known from the much later Renaissance paintings, for example, were carried out on damp plaster. A thin white lime layer/wash was then applied to cover the *sinopie* but this wash was likely still transparent (because it was still damp) while the final scene was painted, and, as such, it left the *sinopie* visible under the thin white damp plaster layer. In effect, this strongly suggests *al fresco* painting for at least the scenes that show evidence for *sinopie* presence (Brysbaert 2008, 116). Finally, the experimental work by A. Vlavogilakis (2017) has taken on specific small-scale experiments on plaster and its fillers and was carried out in the correct environment again. In asking questions about the technology itself but also on the practice of carrying out the individual steps of the painted plaster *chaîne opératoire* takes the study of experimentation to yet another level and such work can only be encouraged since it also may help to provide insights in the practices and processes that the artisans themselves came across while at work (see also Brysbaert 2004; 2008 with refs).

What is perhaps the most important in experimental and analytical work for archaeology is its reproducibility of the experiment or the analysis. Being thus fully informed by all scientific and archaeological data concerning these materials, but also each step in their experiment or analysis, while being firmly placed within their context, is essential conduct for this type of research. All too often, and specifically in considering Aegean painted plaster, statements such as potential Egyptian (implied by Brecolaki *et al.* 2012, 2874, 2876; and repeated by Vlachopoulos 2020, 408) and other cultural influences are rather decontextualised if these cannot be corroborated by other substantial evidence, or

if other similar material from the local traditions already indicated that specific techniques existed in earlier times anyway (Brysbaert 2008 on the MBA materials analysed indicating that no *al fresco* seemed to have existed then).

In early 2000, a PhD started under the direction of R. Jones and B. Knapp at Glasgow University resulted in a large comparative technological study of painted plaster material from 17 sites from the Aegean (10: Knossos, Myrtos-Pyrgos, Palaikastro, Monastiraki-Amariou, Phylakopi, Mycenae, Tiryns, Thebes, Gla, Orchomenos) and the east Mediterranean (7: Miletus, Hattusha, Alalakh, Tel Kabri, Qatna, Tell Sakka and Tell-el Dab'a) where similar iconography and stylistic themes were recognised (for Tell-el Dab'a: Brysbaert 2002 on pigments and technical considerations). The drive of the study was based on these premises but the methods employed were scientific analysis and small-scale experimentations, combined with a strong theoretical framework. This PhD study did not aim to add to the volume of already known analytical data from many sites, but to *explain* the results in terms of various phenomena of social interconnections between elites and artisans in the LBA east Mediterranean. This work (Brysbaert 2004; 2008 both with full references) thus employed a more holistic combined approach that comprised scientific analysis, replicative experiments, social-anthropological theory and contextual-iconographic/stylistic selection of the material. It discussed issues of crafting and producing, and aspects of travelling craftspeople, then hotly debated (e.g. Hitchcock 2005). Networks of interlinked social actors and relationships were recognised while painted plaster *chaînes opératoires* were no longer presented as lists of analytical results. Such holistic approaches were already achieved by the very good work carried out, e.g. at the Fitch laboratory for ceramic studies earlier on. As such, the obtained results became fully integrated in theoretical debates that tackled social questions. Work on painted plaster continued in the 2000s with material studied from Greece and beyond (e.g. the Menelaion (Jones 2009); Plakes House at Mycenae (Brysbaert 2013); Pylos (Brecoulaki *et al.* 2008; 2012); Akrotiri (Sotiropoulou *et al.* 2016); Qatna in Syria (Brysbaert 2011a; von Rüdén *et al.* 2018); Tel Burak in Lebanon (Bertsch 2019)). These studies offered insights in organic pigments (murex at Pylos) and traces of organic binding media, suggesting the use of *al secco* painting techniques on various groups of material, and while doing so, unfortunately also denying that the *al fresco* technique was also employed as many, earlier on, testified. Often in scientific work, one has to react first by promoting the complete opposite before a middle way is found and accepted. As a result this debate, therefore, has been a dead end for some time as it forms the only topic discussed, together with more data presentation, rather than taking up the archaeological questions, beyond a materialist perspective. Finally, in an otherwise very useful iconographic overview

of painted plaster, Vlachopoulos (2020) used several technological terms wrongly ('frescoes': e.g. 407–409, 420, 'fresco technique': 421, 'fresco painters': 422, 'EIA frescoes': 422), while Brysbaert emphasised already in 2000 to avoid the use of the term 'frescoes' because it implies a specific technology applied on a specifically prepared surface (wet lime plaster only). Instead, she suggested 'painted plaster' because this would be in line with the ICCROM terminology of 'architectural surfaces' and would avoid pitfalls over 'floor' or 'wall paintings' and painted objects (offering tables, sarcophagi, or plastered heads, all of which are known from Aegean Bronze Age contexts).

Fortunately, new technologies also brought about new ways of looking at and studying the material itself and removed the attention from the (still) ongoing *al fresco-al secco* debate a little. C. Papaodysseus and team (Papaodysseus *et al.* 2008, 403, 407) investigated the geometry of several curves that had been observed on the figures of the Akrotiri material. They postulated that these were likely drawn and painted with the aid of premade templates, therefore suggesting that artisans were familiar with a high level of geometric design and that they strived to produce a well understood level of symmetry in the figures they depicted. What is not clear to the current author is whether the team has also studied such potential phenomena beyond Akrotiri itself. This would be a very worthwhile exercise to carry out so that meaningful comparative studies of technical transfer and skill transfer can follow. Through the investigation of potential technological transfers between sites we may obtain further insights in the travelling aspects of artisans, a concept now much more accepted, even for earlier periods too (Muhly, this volume).

Both 2D and 3D scanning and modelling recently also made an entrance in the study of painted plaster with some fabulous results, not only for publication (see e.g. Bietak *et al.* 2007 for Tell el-Dab'a for an early example) but also to be able to use the high resolution imagery towards the reconstruction of fragments that joined, purely on the basis of the matching algorithms (Brown *et al.* 2008; Toler-Franklin *et al.* 2010). The advantages of such work have been discussed elsewhere (Brysbaert in press) and are clear, especially when the minute details of production technology traces can now be studied to a much larger extent, over prolonged periods of time away from the material, and without having to handle it constantly. An additional use of 3D recording of painted plaster scenes will allow the study of the social functions of such painted scenes, provided that these are large enough to work with. Again, Akrotiri proved a useful case study in applying a combined 3D modelling and GIS method for their socio-symbolic reading of the painted plaster within its architectural urban context. It highlights the potential relationship between spatial relationships in the town of Akrotiri through the communicative power of the paintings which may have enhanced the widespread

production of such painted murals all over the site (Paliou 2011). As such, these paintings in fact play an active role in their environment where people and things interact with each other on a constant basis (see Brysbaert 2008). A similar conclusion, and much more, was also reached by the team of J. Maran, A. Papadimitriou and U. Thaler when working with the well conserved fragments of painted plaster from Tiryns that were originally both located in the Tiryns apothiki and in the National Archaeological Museum in Athens (Maran *et al.* 2015).

Finally, the conservation of painted plaster found its way into the literature in the form of separately published papers (Tsitsa 2013) and this is a very positive and welcome development since most of this work, unfortunately, remains under the radar of academia. For far too long, conservators who were often highly trained scientifically, were seen as technical handmaidens to excavators. If their work received any attention in publications, it usually sat tucked away in large appendices. Therefore, Tsitsa's paper on her work done on the Heraklion Museum painted plaster, clearly indicates the amount of observations one can reach by working so closely to these paintings. As a science-based archaeologist and conservator, I hope this is a fast-moving forward trend and not just one that is concerned with groups of high profile materials (such as Knossos, Akrotiri).

However, conservation work still has some way to go in the right direction concerning some of its hands-on practices. For example, too many surfaces of painted plaster fragments found in older excavations are embedded in (sometimes equally) old plaster-of-Paris blocks (materials from Knossos, Mycenae, Tiryns, Orchomenos, Tell el-Daba, and many more), and even more recent ones seem to have been consolidated this way. The point of embedding fragments into the blocks is clear: the frail fragments are set solidly in relation to each other and are safe from further crumbling. However, this does not outweigh the many disadvantages of using this technique of saving the material. Often, joining fragments are found later on and cannot be entered easily in the reconstructed blocks. Mistakes can occur too when later studies show the wrong relation between joins made in the embedded blocks. Equally alarming is the fact that the plaster-of-Paris blocks are stronger and sturdier than the fragments of painted plaster. This clashes with one of the main conservation principles in hands-on conservation, namely that any new material introduced to the archaeological materials should be softer and weaker than the state of the original so that, if the added materials need removal, this will not be at the cost of the archaeological material. The work carried out at Akrotiri seems to be the notable exception since they use a softer mixture which can be removed easily if needed. Even with high dexterity and lots of patience, plaster-of-Paris blocks cannot be cut away without severely damaging the original painted plaster. Another problem is that the back and sections of

these fragments are no longer accessible for further study. Finally, such work takes up large resources in terms of human input and, to some extent, cost because they weigh a lot; and do not always contribute to the aesthetic display of the paintings themselves. Instead, they often distract. This is why 3D scanning is greatly useful because all sides can be scanned and material can be reconstructed *ad infinitum*, while newly found fragments can be added in later as well. Changing displays are possible and no continuous handling is required after all fragments are scanned.

In terms of the destructive nature of research through sampling, conservation plays another role as well. For example, the paper by Papliaka *et al.* (2015) discussed the continuously improving sampling strategies in relation to past conservation treatments. Often such treatments mask past original organic compounds and degradation products, while more recent consolidation materials take the possibilities of past organic materials into account, and even that is a great way forward. It also suggests that past studies on organic materials should be read and understood with caution when reporting past organic materials easily (Sotiropoulou *et al.* 2015). This latter study on the implications of finding metal oxalates in painted plaster from the LBA until Roman times also considered ageing binders in fragments that were also submitted to conservation materials, confirming the care taken in investigating and subsequently accepting the results of organic binding media detection, a point I already made in 2008. As I suggested then, organic binding media were very likely used – we knew that the *al secco* method was already in vogue in the MBA on Crete since no signs of *al fresco* was seen on those much earlier materials (Brysbaert 2008, 150, group 1, table 7.1). The issue, therefore, did not sit with the *acceptance* of the partial use of *al secco* techniques (many did before me), but with how we go about finding unadulterated evidence for it. It seems now that Sotiropoulou and her team have achieved exactly this care in their sampling, methods of investigation and thoughtful presentation of their results, something which ends in taking a great middle-ground between *al fresco* and *al secco* and something that can and should be accepted by all parties in this debate (but see still the resistance against this: Vlachopoulos 2020, 408). Only time will tell if the discussion has finally moved on, that *al fresco* as a technique can also be accepted (either with pure water or limewater), and perhaps can, in some cases, take up its place as the *intended* (see many signs already outlined by Cameron's former work), but perhaps *not always achieved*, technique of painting. Denying any *al fresco* presence in these paintings despite century-long work by Bronze Age painting experts, s.a. Duel and Gettens (1940s), M. Cameron, M. Lang at Pylos, L. Chryssakopoulou at Akrotiri, and even Heaton much earlier on, in which everyone, including myself, accepted a combination of *al fresco* and *al secco* painting techniques, testifies of a lack of insights in

what are the important questions that need to be asked (see Introduction). The context of the paintings, however, and their socio-symbolic locations, presence and performative power will, no doubt, tell us a much more exciting story about how people went about their daily lives, whether as an elite person or as an artisan, or in any other social role.

The way forward: studies integrating paintings in their multiple contexts

Despite the abovementioned studies which form far from a complete overview (see more in Brysbaert 2008; in press; also von Rüden *et al.* 2018), there is still a lack of studies on materials found outside the pure elite contexts of palaces, villas and large complexes, in other words, the high profile sites, while these materials do exist outside these locales. Unfortunately, these materials are still misconceived as of secondary importance (see recently Vlachopoulos 2020, 419). Such necessarily collaborative work and its compulsory comparisons with the much better known elite-context materials is crucial in order to understand if there are different technical and social uses for plaster in different social contexts; the emphasis cannot just remain on elite iconography. Such work was suggested 15 years ago (Brysbaert 2004; 2008) and while it has not yet been taken up, despite such material being present in various excavation and museum archives all over Greece, it would form a very useful and necessary PhD topic. Many more conservation-related projects need to be brought to the attention of both archaeologists and scientific investigators of technological practices alike. A clear example of how much such work can reveal, due to the year-long experience of close observations, is the work by Angelidis *et al.* (2018). No one but conservators will have the luxury (perhaps) of studying the material in such great detail, so the time has come that we fully integrate such observations and that conservators take the initiative to publish their work (see also Tsitsa 2013). Another point already mentioned in 2008 is the lack of comparative work carried out between painted plaster scenes of large size versus miniature scenes in terms of the underlying technological practices of the *chaîne opératoire* of plaster production and subsequent painting. Are there differences in the plaster composition and pigment processing between both types of scenes? And what about the 3D or relief scenes we know from Knossos (e.g. Kaiser 1976), Palaikastro, Gla and Tell el-Dab'a (Brysbaert 2008)?

Furthermore, contextual studies of painted plaster are also on the rise and much needed. For example, many painted plaster scenes did not collapse from their walls at a given time in the past but, instead, they were purposefully stripped off and deposited, possibly (but not necessarily) to allow for a new painting programme on fresh plaster (e.g. plaster 'stack' found in House of the Frescoes in Knossos, and deposit at Gla: both Brysbaert 2003, 170). More detailed

studies since 2003 seem to confirm these practices (Shaw and Chapin 2006, 61–63 on the Knossian 'stack'), but how to match it with situations in which overplastering and overpainting existed as well? What about the reuse/recycling of materials of the same composition in new ones (Brysbaert 2003; also Vlagilakis 2017)? What was the reasoning for one or the other choice? Were decisions purely practical or was there more to them? Can we try, virtually at least, to reconstruct deposited material to the building/place in which it perhaps once belonged? And what about material deposited in crevices (Gla: Iakovidis 1998, 268)? As mentioned in earlier studies, an agency approach may help in at least thinking about these questions in a more nuanced way, especially since people are closely entangled (to use a hype term) not only with each other but also with materials and objects in their daily lives. Objects and features are crucial in forming, transforming and changing social processes and they change meaning constantly through varied contexts, uses and handling. As people change and are socially dynamic, so are the objects entangled with these people. People shape objects that shape people. Perhaps this expresses one of the most important characteristics of object's (or feature's) biographies. At the same time, objects and features also gather time, movement and change. They gather meaning and value because of their physical form which is in and of themselves via their producers, their material make-up, or simply their ageing. They also gather value and meaning over time through enactment and acts of performing which is a relational characteristic since people, in contact with such objects or features, may gather meaning and status too, because of their relation with these objects or features. That people and the painted plaster scenes, materials, compositions and values are entangled should be clear from a multitude of publications and needs no further repetition here. Further, there is still work to be done on the questions about how, when, where, especially if future studies hopefully will investigate non-palatial and non-elite materials too.

As may be clear from the above section, investigative work on the actual material combined with asking meaningful questions still has quite a way to go. There is always more material to study and different methods to study it, with different questions in mind. It is therefore delightful to see that some more recent work confirms many of the strands of my earlier work on the topic. For example, von Rüden *et al.* (2018, 13, notes 33–37 and 39) study material from several of the sites which I worked on over a decade ago and come up with similar but improved results when compared with Brysbaert (2004; 2007; 2008, 97–106). Also, my initial use of the *chaîne opératoire* and cross-craft interaction methodological approach combined with agency theory, has finally caught on, and is fully integrated by von Rüden's team. A similar situation occurs in the recent proceedings of a conference on painted plaster and ceramics in which

the first use of murex purple detected on painted plaster in Akrotiri was recognised as noted by E. Chryssikopoulou who had it analysed by S. Sotiropoulou (Chryssikopoulou and Sotirakopoulou 2003) over a decade ago. Brecolaki *et al.* (2008, 380), who initially pulled into doubt the use of Raman spectroscopy, later on recognised its advantageous usage and employed it herself as well (Brecolaki *et al.* 2017, 149). The point is that one does not *need* to agree on results. For example, Brecolaki *et al.* (2017, 158) argue out the *al fresco-al secco* debate (still) on Tell-el Dab'a images made by myself rather than studying the material itself. This goes against Brecolaki's own point of studying material with multiple methods. In this specific case, no scientific method is employed on the material at all. Where I do argue for travelling craftspeople and artisans, I do not do this as lightly as she suggests: *i.e.* on the *al fresco* evidence only, even though it does play an important role, but it also confirms the concept of travelling artisans mentioned by plenty of other studies on style, iconography and other combined approaches. Finally, Becker (2019) refines the observations on *al fresco* versus *al secco* at Tell-el Dab'a and, with this, he may have the most correct answer if his observations on lime water (rather than pure water) was employed to apply the pigments onto the wall, and how that is supposed to be seen in cross-sections versus the effects of carbonation.

In the end, it is the disagreements in research outcomes that make scientific research exciting after all, and we all learn from new and fresh looks at the same materials. What is, however, a prerequisite to good scholarship is the completeness of a literature study and the full recognition of what people have carried out before you. That way, one shows familiarity with the literature and respect for what others have investigated. Moreover, one then also avoids repetitive statements or 'short-cut' readings of people's statements which only confuses the reader who *is* fully familiar with the literature. Finally, reading 'everything under the sun' about a specific topic becomes harder and harder with the wealth of studies undertaken in the last decades. Gone are the days of Evans and Schliemann when they had endless time and only a fraction of the literature to read, and perhaps 'everything under the sun' may on occasion, also include ourselves, as was the case on January 12–14, 2018, on the beautiful island of Rhodes.

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plaster cannot be seen too far removed from its walls, as has been hinted at above. Therefore, this research is part of the ERC-Consolidator SETinSTONE project under the direction of Prof. A. Brysbaert, Leiden University, and funded by the European Research Council under the European Union's Horizon 2020 Programme/ERC grant agreement n° 646667.

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