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International Symposium Archaeology of Colour
Simpósio Internacional Arqueologia da Cor

I. Pombo Cardoso, M. J. Vilhena de Carvalho, S. Sá (Guest Editors | Editoras Convidadas)

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Editorial

Artigos Articles

Archaeology of colour – the production of polychromy in sculpture up to the 16th century

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Arqueologia da cor – a produção de policromia na escultura até ao século XVI

Polychrome sculpture has an extremely long production tradition in human history, testified by numbers and abiding production. These cultural objects embody the diverse cultural and material references that shaped their production across different periods and geographies. The production process of such objects involves a complex network of participants who, at the different production phases and among diverse possibilities, are responsible for making a number of choices regarding models, styles, materials and techniques. These choices encapsulate traditions, knowledge transmission, perception of materials, reputation of performances, moments of rupture and innovation, as well as reception and diffusion resulting from societies own history including the multiple cultural encounters. Ultimately, polychrome sculptures are tangible expressions of the cultural identity and diversity of the cultures that produced them.

As such, polychrome sculptures are powerful lines of inquiry, providing insights not only into the objects themselves but also into the societies who produced and used them. The archaeological and historical study of these sculptures – through the critical analysis of historical documentation and production processes, the physicochemical analysis of materials and techniques, as well as exercises in archaeological reconstructions – offers the opportunity to investigate and understand polychromy as a technology but also its cultural traditions and social embeddedness.

This special issue reunites research papers presented at the international symposium organized within the scope of the *Archaeology of Colour* project (PTDC/ART-OUT/5992/2020). This project is dedicated to the study of polychromy on medieval and early modern Portuguese sculpture, with a central research aim of achieving a comprehensive understanding of the significance and evolution of polychrome technology used to decorate/finish sculptures in Portugal during this period.

Therefore, the project *Archaeology of Colour* departed from the systematic research of a significant group of polychrome sculptures selected from the Museu Nacional de Arte Antiga and the Museu Nacional Machado de Castro, dating from the earliest known Portuguese examples (thirteenth century) still with remnants of polychromy, to those from the period when major changes in the Portuguese history occurred as a result from the new Atlantic explorations (c. 1525).

The project involved a comparative material culture study about the original polychromies used to decorate/finish stone and wooden sculptures in Portugal during this period. It included scholars from different disciplinary areas, merging humanities and natural sciences, in order to interpret data retrieved from the complementary sources of information.

The comparison and interpretation of the material, technical, experimental and documentary data evolves at multiple levels – within each sculpture, among sculptures attributed to the same workshop, and across different production centres – looking for trends and singularities. The findings are then critically interpreted within the relevant historical context, in relation to the extant European studies of this nature and further compared with studies related to other chronological and geographical contexts.

Although the primary focus is the polychromy in medieval and early modern Portugal, a key foundation of this project is to explore and cross-over disciplinary, geographic, and chronological boundaries in the search for more informed answers about our own subject. This is because we strongly believe that it is crucial to defy the contemporary phenomenon, where frequently, scholars concentrate on their area of specialization. In the specific case of material culture studies, by doing this, several opportunities are lost. One such opportunity is offered by the fact that often similar raw materials, techniques and motivations underlie various technologies. Therefore, through critical analysis and comparison of the *chaînes operatoires* and driving forces in neighbouring technologies, a lot can be learned.

The investigation of these systems requires consideration of multiple processes, including the selection, sourcing, transformation, or preparation processes of raw materials; application techniques; tools and sources of energy; labour and social organization; know-how involved; spatial arrangements; products and services delivered or discarded; as well as the actors involved, such as commissioners, producers and consumers. This approach favours to address broader research questions about the cultural and social context of polychrome sculpture. For instance, it helps understand factors influencing technological choices and styles such as material availability and preferences, possible cultural interactions and technological transfer, or the lack of those, as well as the development of skill specialisation, and the role of sculptures, sculptors, painters and commissioners in medieval Portuguese society.

In addition to bridging research disciplines, geographic and chronological boundaries are also crucial to cross with the aims of contextualizing and exploring the evolution of polychrome technology.

Ultimately, it is believed that this cross-boundary and bridging approach enhances the quality and sustainability of the research. Likewise, it promotes collaboration, sharing knowledge, questions, and methodologies among different scholars, professionals, universities, and other institutions (e.g. museums and industry).

Therefore, the symposium *Archaeology of Colour. The Production of polychromy in sculpture up to the sixteenth century* (April 2024), organized by the NOVA School of Science and Technology (Universidade NOVA de Lisboa) and the Museu Nacional de Arte Antiga, was deliberately designed to bring together contributions covering a wide range of topics, chronologies, and geographical contexts.

Contributions explored two key aspects, the use of colour and the role of polychromy, from multiple perspectives, objectives and methodologies. These included the analysis of documentation, choice of materials and techniques, knowledge transmission, workshops *modus operandi*, circulation of materials, techniques, artists, and artworks, as well as the meanings and reception of colour. Discussions also covered experimental archaeology, various analytical approaches for studying polychromy; and material and digital reconstruction proposals of past appearances.

Explored various periods up to the 16th century, with some contributions concentrating in specific periods (such as the Iberian Iron Age, the twelfth and thirteenth centuries, or the fifteenth century) while others covered a broader chronological scope ranging from the Chalcolithic to the Hellenistic Period, or the Middle Ages.

Geographical contexts were equally diverse, examples included the Iberian Peninsula, present-day England and Germany, the Adriatic region, Western Asia, ancient Iran, or Japan.

The aim was to engage scholars from diverse fields, specialized in different chronologies and dedicated to particular geographical contexts, to deepen our understanding of the production of polychromy before the sixteenth century. By fostering interdisciplinary dialogue and comparative studies, this symposium and the *Archaeology of Colour* project aim for a deeper understanding of polychrome sculpture and its place in the broader history of material culture.

Finally, the authors are deeply grateful to the Scientific Committee of the International Symposium Archaeology of Colour, for their active involvement in reviewing and selecting the contributions, as well as for their dedicated and inspiring participation in moderating the various panels. Their expertise, support, and dedication were truly invaluable!

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A escultura policromada tem uma tradição de produção longa na história da humanidade, testemunhada pelo número de exemplares e produção contínua. Estes objetos culturais incorporam diversas referências culturais e materiais que moldaram a sua criação ao longo de diferentes períodos e geografias. O seu processo de produção envolve uma rede complexa de intervenientes que, nas várias fases e entre múltiplas possibilidades, tomam decisões sobre modelos, estilos, materiais e técnicas. Essas escolhas refletem tradições, a transmissão de conhecimento, a perceção dos materiais, a reputação das execuções, os momentos de rutura e inovação, bem como a receção e difusão resultantes da própria história das sociedades, incluindo os múltiplos encontros culturais. Em última análise, as esculturas policromadas são expressões tangíveis da identidade cultural e da diversidade das culturas que as produziram.

Assim, as esculturas policromadas abrem linhas de investigação importantes, proporcionando o conhecimento não apenas sobre os próprios objetos, mas também sobre as sociedades que os produziram e utilizaram. O estudo arqueológico e histórico destas esculturas – através da análise crítica da documentação histórica e dos processos de produção, da análise físico-química dos materiais e técnicas, bem como os exercícios de reconstruções arqueológicas – oferece a oportunidade de investigar e compreender a policromia não só enquanto tecnologia, mas também do seu contexto cultural e social.

Este número especial reúne investigações apresentadas no simpósio internacional organizado no âmbito do projeto *Archaeology of Colour* (PTDC/ART-OUT/5992/2020). O projeto dedica-se ao estudo da policromia na escultura portuguesa medieval e moderna, com o objetivo central de alcançar a compreensão abrangente do significado e da evolução desta tecnologia utilizada para decorar/finalizar esculturas em Portugal durante este período.

O projeto *Archaeology of Colour* partiu da investigação sistemática sobre um grupo significativo de esculturas policromadas selecionadas do Museu Nacional de Arte Antiga e do Museu Nacional Machado de Castro, abrangendo desde os primeiros exemplares portugueses conhecidos (século XIII), ainda com vestígios de policromia, até aos datáveis do período em que ocorreram grandes mudanças na história de Portugal, decorrentes das novas explorações atlânticas (c. 1525).

O projeto envolveu um estudo comparativo da cultura material sobre as policromias originais utilizadas para decorar/finalizar esculturas em pedra e madeira em Portugal nesta lata cronologia. Contou com a participação de especialistas de diferentes áreas disciplinares, combinando as humanidades e as ciências naturais, com o objetivo de interpretar os dados obtidos a partir das fontes de informação complementares.

A comparação e interpretação dos dados materiais, técnicos, experimentais e documentais desenvolve-se em vários níveis – para cada uma das esculturas, entre esculturas

atribuídas à mesma oficina e entre esculturas atribuídas a diferentes oficinas – procurando identificar tendências e particularidades. Os resultados são depois analisados criticamente no contexto histórico relevante para cada uma e comparativamente com os estudos europeus existentes sobre o tema e, ainda, com estudos relativos a outros contextos geográficos e cronológicos.

Embora o foco principal seja a policromia na escultura medieval e moderna em Portugal, um dos princípios fundamentais deste projeto é explorar e transpor fronteiras disciplinares, geográficas e cronológicas, na busca de respostas mais informadas sobre o nosso objeto de estudo. Isto, porque acreditamos firmemente que é essencial desafiar o fenómeno contemporâneo da frequente concentração dos investigadores apenas na sua área de especialização. No caso específico dos estudos de cultura material, esta abordagem leva à perda de múltiplas oportunidades de conhecimento. Por exemplo, muitas vezes, os mesmos materiais, técnicas e motivações subjacentes são comuns a diversas tecnologias. Assim, a análise crítica e a comparação das *chaînes opératoires* e das motivações em diferentes tecnologias, resulta num efeito sinergético e holístico do conhecimento adquirido.

A investigação destes sistemas requer a consideração de múltiplos processos, incluindo a seleção, obtenção, transformação ou preparação de matérias-primas; as técnicas de aplicação; as ferramentas e fontes de energia; a organização do trabalho e da sociedade; o saber-fazer envolvido; o destino funcional e a implantação espacial; os produtos e serviços resultantes ou descartados; bem como os diversos agentes envolvidos, sejam eles encomendadores, produtores ou consumidores. Esta abordagem permite explorar questões de investigação mais amplas sobre o contexto cultural e social da escultura policromada. Por exemplo, ajuda a compreender fatores que influenciam as escolhas tecnológicas e estilísticas – como a disponibilidade e preferência por determinados materiais, possíveis interações culturais e transferências tecnológicas (ou a ausência destas), tal como o desenvolvimento e a especialização de competências – e o papel das esculturas, escultores, pintores e encomendadores na sociedade medieval portuguesa.

Além da promoção do diálogo entre diferentes áreas disciplinares, consideramos igualmente essencial transpor fronteiras geográficas e cronológicas com o objetivo de contextualizar e explorar a evolução da policromia enquanto tecnologia.

Em última análise, acreditamos que esta abordagem de transpor e interligar diferentes fronteiras contribui não só para a qualidade, mas também para a sustentabilidade da investigação. Da mesma forma, promove a colaboração e a partilha de conhecimento, questões e metodologias entre diferentes investigadores, profissionais, universidades e outras instituições, sejam eles museus ou mesmo indústrias.

Assim, o simpósio *Archaeology of Colour. The Production of Polychromy in Sculpture up to the 16th Century* (abril de 2024), organizado pela NOVA School of Science and Technology (Universidade NOVA de Lisboa) e pelo Museu Nacional de Arte Antiga, reuniu intencionalmente contributos que exploraram uma ampla diversidade de temas, cronologias e contextos geográficos.

As contribuições debruçaram-se sobre dois aspetos fundamentais – o uso da cor e o papel da policromia – a partir de diversas perspetivas, objetivos e metodologias. Estes incluíram a análise de documentação histórica, a escolha de materiais e técnicas, a transmissão de conhecimento, o *modus operandi* das oficinas, a circulação de materiais, técnicas, artistas e obras de arte, bem como os possíveis significados e a receção da cor. As discussões também incluíram a arqueologia experimental, diversas abordagens analíticas para o estudo da policromia e propostas de reconstruções materiais e digitais do aspeto original das peças.

Foram trabalhados vários períodos até ao século XVI, com algumas contribuições centradas em períodos específicos – exemplo são, a Idade do Ferro na Península Ibérica, os séculos XII e XIII, ou o século XV – enquanto outras cobriram um espectro cronológico mais amplo, desde o Calcolítico ao Período Helenístico, ou a Idade Média.

Os contextos geográficos discutidos foram igualmente muito diversos, incluindo por exemplo a Península Ibérica, a atual Inglaterra e Alemanha, a região do Adriático, a Ásia Ocidental, a antiga Pérsia, ou o Japão.

O objetivo foi envolver investigadores de diferentes áreas disciplinares, especializados em várias cronologias e dedicados a contextos geográficos específicos, para aprofundar a compreensão da produção da policromia até ao século XVI. Ao incentivar o diálogo interdisciplinar e os estudos comparativos, este simpósio e o projeto *Archaeology of Colour* pretendem a compreensão mais aprofundada da escultura policromada e do seu lugar na ampla história da cultura material.

Por último, as autoras gostariam de expressar o seu sincero agradecimento aos membros Comité Científico do Simpósio Internacional *Archaeology of Colour*, pela sua participação ativa na revisão e seleção das contribuições, bem como pelo seu contributo inspirador e dedicado enquanto moderadores dos vários painéis. A sua competência científica, o seu apoio e dedicação foram verdadeiramente inestimáveis!

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Visible materials, invisible meanings: colour-based hierarchies in the Middle Ages

Materiais visíveis, significados invisíveis: hierarquias baseadas na cor na Idade Média

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Abstract

The decision that oversaw the choices of pigments used in medieval artworks was based on multiple criteria. Among these was their economic value, often linked to the greater rarity of the raw material from which the pigments were derived, or to the lower availability on the market. Alongside the economic value, there was also the symbolic value attributed to materials and pigments from a symbolism often rooted in references found in the Holy Scriptures, in exegetical, theological, encyclopedic, or other texts. The case studies presented in this paper, based on works created with different media whose pigments underwent specific archaeometric analyses, show that throughout the Middle Ages, sometimes precise hierarchies were employed in the choice of pigments, and the most precious ones were reserved for the most important figures or the most significant details.

KEYWORDS
Medieval art
Hierarchy of materials and colours
Pigments
Lapis lazuli
Azurite
Colour symbolism

Resumo

A escolha dos pigmentos utilizados nas obras de arte medievais baseou-se em múltiplos critérios. Um deles, era o seu valor económico, muitas vezes ligado à raridade da matéria-prima de onde os pigmentos provinham, ou à menor disponibilidade no mercado. A par do valor económico, existia também o valor simbólico atribuído aos materiais e aos pigmentos, a partir de um simbolismo muitas vezes enraizado em referências encontradas nas Sagradas Escrituras, em textos exegéticos, teológicos, enciclopédicos ou outros. Os estudos de caso apresentados neste artigo, baseados em obras realizadas com diferentes suportes e cujos pigmentos foram submetidos a análises arqueométricas específicas, evidenciam que, ao longo da Idade Média, por vezes foram empregues hierarquias precisas na escolha dos pigmentos, sendo os mais preciosos reservados para as figuras mais importantes ou para os pormenores mais significativos.

PALAVRAS-CHAVE
Arte medieval
Hierarquia de materiais e cores
Pigmentos
Lápis-lazúli
Azurite
Simbolismo da cor

Introduction

Unlike later periods of art history whose artworks strive to imitate the appearance of other things, and the materials employed deliberately vanish from sight, medieval artworks prominently display the materials used in their making, by emphasizing the physicality of its constituent materials, as exemplified by typical medieval media such as mosaic, stained glass or enamel. To quote the opening words of Herbert L. Kessler's much-celebrated book, *Seeing Medieval Art*, "Overt materiality is a distinguishing characteristic of medieval art" [1].

This assertion is rooted in the so-called "material turn" that has characterized Medieval studies over the last 30 years [2-6]. Among the strategies that medieval artists employed to accentuate the material aspects of their works, there is also the combination of two or more materials, independent either by nature or expressive capabilities, meant to address a significant effect on the perception of artworks, especially in sculptures, be they in stone, wood, metal or other materials.

According to a recent proposal formulated by Fachechi [7], we can detect four different ways by which this polymateric effect was achieved, considering the way different materials were combined: "by superimposition", that is when one or more materials are hidden or at least obscured by others, "by insertion", when the various materials are in full view but none of them is essential for the understanding of the iconography, "by juxtaposition", when all materials are also in full view, but each of them plays a specific role in image description. Finally, a fourth category combines in one object all the three kinds of multi-material effect previously listed.

Reasons behind mixed media objects were many: the desire to dignify an object by using precious materials, sometimes even re-using and hoarding ancient objects, the need to confer objects an aura of sacredness, the varied interaction of different materials with natural light or candlelight [8], just to mention a few.

The richness of the materials employed could increase the effectiveness of images with high devotional content, according to widespread medieval beliefs. The Church's use of precious stones and metals was also linked to its self-promotion in the eyes of the faithful, being a clear sign of its economic and political power. The iconology of materials can supply useful tools to interpret these kinds of objects and reconnect them with their peculiar iconography.

According to Bernard of Clairvaux's *Sermones in vigilia nativitatis domini* [9], God's actions were characterized precisely by *admirabiles mixturae* (wonderful mixtures). Bernard observed that God wanted to mix and combine things different from each other so that his work was astonishing and disturbing but also inducing deep reflection [10-11].

Multi-materiality (and polychromy which often followed) satisfied several other needs, such as *varietas* – one of the pillars of medieval aesthetics [12-13] –, the emphasis on specific shapes and details that the artist sought to highlight (sometimes to achieve realistic effects) and, above all, the attribution of symbolic meanings to the images through the iconology of materials and colours. Coloured materials conveyed specific meanings [14]. The multiple symbolic meanings of colours were never unique but also depended on their context of use. These meanings overlapped, layered on top of those intrinsically possessed by the materials to which colours are added, as demonstrated by the studies in the iconology of materials [15-17]. From gold, likened to the divine because it is incorruptible, to silver, traced back to the eloquence of the divine word and the brilliance of the Lord's words; from parchment, often traced back to Christ's Incarnation and Passion because of its being "skin" and being often dyed with purple (as in *Codices purpurei* such as the famous *Codex Rossanensis*), to bronze, employed on several occasions by medieval popes and emperors because of its stability and durability, to visually express their concept of authority [18-19]. Vitreous arts such as stained glass and enamel – crafted from sand, pigments, and metal under intense heat – implied in the realization process itself a metamorphosis that "that mimicked the process of finding redolent Christian meaning in the literal Jewish accounts represented on them" [20].

The spiritual value ascribed to the materials from which works of art were made was often found in the raw materials used for the painter's pigments, in a combination of symbolic meanings upon which the meanings of matters and the meanings of colours layered. Such symbolic meanings added to the economic value of materials and pigments, which were deemed valuable because of their intrinsic qualities (like certain precious metals), rarity (like certain precious stones), or both.

Iconology of matter and colours: the case of lapis lazuli

A case that well exemplifies this layering of meanings is offered by lapis lazuli, a precious stone, renowned and employed since the times of Ancient Egypt. It is a mineral agglomerate of lazurite, which is responsible for the blue colour, calcite, and pyrite that gives the stone the characteristic gold-like sparkles. From the processing of lapis lazuli, in a very laborious and costly process, the pigment known as 'natural ultramarine' was made. The etymology of 'ultramarine', as it is well known, does not derive from a specification of its peculiar colour shade. Still, it comes from its distant eastern trans-Mediterranean origin (that is, ultramarine means "a mineral coming from very far, from lands beyond the sea"). Lapis lazuli, in fact, in ancient and medieval times was mined solely from the mines of Sar-e-Sang in the province of Badakhshan, in today's Afghanistan, and the stone was transported along the Silk Road to Persia, where it underwent initial processing, only to be traded from there, via the merchants' network, throughout the Mediterranean and Europe. This makes the lapis lazuli's rarity and, consequently, one of the reasons for its preciousness [21-22].

Ancient and medieval sources (scientific treatises, encyclopedias, lapidaries) and modern gemological studies agree that since Antiquity and at least until the thirteenth century the lapis lazuli's name was *saphirus*, in Latin, *σάπφειρος* in ancient Greek, and *sappı̄r* (סַפִּיר) in Biblical Hebrew (and it was similar in many other ancient languages).

Despite the similarity with the transparent blue gem that today we call "sapphire", the word *saphirus*, instead, indicated a different stone, lapis lazuli. The shift in meanings occurred sometime around the mid-thirteenth century when written sources such as Albert the Great's treatise on stones, *De mineralibus*, started to associate the word *saphirus* to a blue transparent stone, likely the blue corundum or modern sapphire, a stone that before that date was probably called *hyacinthus*. Gems' names, as we can see, have an intricated history, often very difficult to disentangle [23].

In the descriptions of the stone called *saphirus*, ancient and medieval authors refer to its extraordinary blue colour compared to that of a serene sky, its golden glow, its opacity as well as its distant origin, often connected with the land of the Medes.

However, before ancient treatises on precious stones or Medieval lapidaries, *saphirus* also has a long list of Biblical occurrences which help clarify its symbolism. In the Book of Exodus *saphirus* is mentioned several times. We find it twice, together with many other gems, in the description of the breastplate of Aaron: the first time in Exodus 28: "*Ponesque in eo quatuor ordines lapidum: in primo versu erit lapis sardius, et topazius, et smaragdus; in secundo carbunculus, sapphirus, et jaspis; in tertio ligurius, achates, et amethystus; in quarto chrysolithus, onychinus, et beryllus. Inclusi auro erunt per ordines suos*" ("Then mount four rows of precious stones on it. The first row shall be carnelian, chrysolite and beryl; the second row shall be turquoise, lapis lazuli and emerald; the third row shall be jacinth, agate and amethyst; the fourth row shall be topaz, onyx and jasper. Mount them in gold filigree settings", Ex 28, 17-20); the second time in Exodus 39: "*Et posuit in eo gemmarum ordines quatuor. In primo versu erat sardius, topazius, smaragdus. In secundo, carbunculus, sapphirus, et jaspis. In tertio, ligurius, achates, et amethystus. In quarto, chrysolithus, onychinus, et beryllus, circumdati et inclusi auro per ordines suos*" ("Then they mounted four rows of precious stones on it. The first row was carnelian, chrysolite and beryl; the second row was

turquoise, lapis lazuli and emerald; the third row was jacinth, agate and amethyst; the fourth row was topaz, onyx and jasper", Ex 39, 10-13).

The floor on which the Lord rests his feet is *opus lapidis sapphirini*: "*Ascenderuntque Moyses et Aaron, Nadab et Abiu et septuaginta de senioribus Israel. Et viderunt Deum Israel, et sub pedibus eius quasi opus lapidis sapphirini et quasi caelum, cum serenum est*" ("Moses and Aaron, Nadab and Abihu, and the seventy elders of Israel went up and saw the God of Israel. Under his feet was something like a pavement made of lapis lazuli, as bright blue as the sky", Ex 24, 9-10). A similar parallel between a stone named *saphirus* and the heavenly vault also recurs in Ezekiel's vision describing the throne on which the Lord sits as "*aspectus lapidis sapphirini similitudo throni*", ("a throne of lapis lazuli", Ez 1, 26). It occurs similarly in Ez 10, 1, "*Et vidi: et ecce in firmamento quod erat super caput cherubim, quasi lapis sapphirus, quasi species similitudinis solii, apparuit super ea*" ("And I looked, and there in the firmament that was above the head of the cherubim, there appeared something like a stone of lapis lazuli, having the appearance of the likeness of a throne"). Furthermore, in Ezekiel 28,13 *saphirus* is mentioned together with other gems, and in the Song of Songs, the bridegroom, later interpreted as Christ, is described with these words: "*Manus illius tornatiles, aureae, plenae hyacinthis; venter eius eburneus, distinctum sapphiris*" ("His arms are rods of gold set with topaz. His body is like polished ivory decorated with lapis lazuli", Song of Sg. 5, 14). In Isaiah 54, 11, in a prophecy on the future of Israel, *saphirus* is again mentioned in the foundations of the New Jerusalem: "*Paupercula, tempestate convulsa absque ulla consolatione, ecce ego sternam per ordinem lapides tuos, et fundabo te in sapphiris*", ("Afflicted city, lashed by storms and not comforted, I will rebuild you with stones of turquoise, your foundations with lapis lazuli"). The Old Testament tradition thus establishes a parallel between the colour blue, consistently traced back to *saphirus* and the concepts of durability and eternity.

Finally, in the New Testament, the description of the walls of the Heavenly Jerusalem in Revelation 21 places *saphirus* among the stones that dot the foundations of the Heavenly City: "*Et fundamenta muri civitatis omni lapide pretioso ornata. Fundamentum primum, iaspis, secundum sapphirus, tertium chalcedonius, quartum smaragdus*" ("The foundations of the city walls were decorated with every kind of precious stone. The first foundation was jasper, the second sapphire, the third agate, the fourth emerald", Rev 21, 19).

A long-lasting medieval tradition rooted the properties of precious stones especially in this biblical passage and set the importance of stones based on it. The Heavenly Jerusalem was a model for the earthly churches which ideally aspired to imitate the celestial model also by reproducing or imitating the same materials. In Christian Medieval art, the continuous search, through stained-glass windows, for a translucent polychrome decoration in which glass imitated coloured precious stones should be interpreted in exactly this sense.

Not only the Bible, but also Medieval exegesis expanded the meaning of lapis lazuli: early Christian commentators, such as Origen and Saint Jerome, explored the symbolism of the sapphire and its connection with the colour of the Heavens, making it one of the signs of Heavenly Life promised by God, in conformity with the contents of St. Paul's letter to the Philippians (Phil 3, 20).

In early Medieval Anglo-Saxon Britain, Bede the Venerable, writing a *Commentary on Revelation* glossed over the passage in the Book of Revelation insisting on the parallel between the stone, its colour, and the heaven, when clear: "the second, sapphire; Moses explained the colour along with the symbolic meaning of this stone, for in his description of the appearance of God he said: «under his feet as it were a work of sapphire stone, and as the heaven, when clear. Ezekiel also says that the place in which the throne of God stands looks like a sapphire», and that the glory of the Lord resides in this colour, which bears a likeness to the supercelestial realm. Even so, he who is like this can say with the Apostle: «But our conversation is in heaven. [The sapphire] when it is struck by the sun, emits from itself a blazing» flash" [24]. In the ninth century, Rabanus Maurus, in his *De Universo* (On the Universe) [25], took up the same interpretation of Bede, which he quoted verbatim.

Therefore, the colour of the *saphirus* stone, likened to the colour of the heaven when serene, based on Exodus 24, represented the glory of the Lord throughout all the early Middle Ages up to the twelfth century. Written around 1096, Marbode of Renne's lapidary, *De lapidibus* (*On stones*) described *saphirus* as a stone that defeats envy, appeases all fears, is apt to bring reconciliation and peace, propitiates divine responses, and, finally, makes it impossible for anyone who wears it to be deceived [26].

In the twelfth century, Hugh of St. Victor, in the *Didascalicon*, reiterated the parallel between the *saphirus* and by reversing the Old Testament metaphor handed down from the early medieval exegetical tradition: "What is more delightful to see in the sky when it is clear, which shines like a *saphirus*?" [27].

To sum up, Biblical exegesis and medieval lapidaries connected specific symbolic meanings to *saphirus*, which were influenced by the role it had in the Bible, where it is mentioned several times in connection with a variety of theological notions: sky, God, the Heavenly Jerusalem. All these connections became permanent iconographic attributes of the stone [14, 28-31]. The properties of lapis lazuli were also assumed by extension by the pigment obtained from the processing of lazurite, a component of lapis lazuli, i.e., ultramarine blue.

The case of lapis lazuli, which has been investigated in detail here, shows how the symbolic meanings attributed to materials, often rooted in Sacred Scriptures and imbued with theological interpretations, were then transferred to the pigments obtained from those materials, and by extension, to the colours made with certain pigments. The case of the colour blue-sapphire, here linked to the gemstone of the same name (sapphire/lapis lazuli), proves to be similar to that of other precious materials and pigments derived from these materials, such as the case of natural purple, used both as a dye for fabrics and as a pigment (for example in parchment), and the colours purple and pink, closely related to this pigment [32-33].

The analysis of other case studies drawn from medieval artworks created on various media (polychrome sculpture, illuminated manuscripts, mural painting, and panel painting), selected from works which underwent in the past years to scientific analyses that have provided valuable information on the pigments used, allows for the extension to other pigments and colours of what has so far been hypothesized for lapis lazuli and ultramarine blue, as will be shown in the following section.

Hierarchy of materials and pigments

In addition to biblical and exegetical references, the value of materials was also based on market value. Therefore, rare and less available materials, such as lapis lazuli and gold, were considered spiritually more valuable also because they were economically more valuable.

In complex buildings, for example, among the various marbles [34-35], the more precious ones emphasized the more sacred spots. It was the case of the Byzantine church of Hagia Sophia in Istanbul. The study of the piers and architraves of the doors of the Great Church has shown how sophisticated the choice of materials was, the preciousness of which increases as one enters the building. So, one can see Proconnesian marble in the portals of the exonarthex and in the western doors of the narthex, while in the nine doors leading from the narthex into the naos it is possible to recognize a ternary scheme with three portals in Pavonazzo marble (Pavonazzetto or Docimaean marble) at the ends and in the center two portals in verd antique (*marmor thessalicum* or ophite) framing the large bronze-covered portal below the mosaic of the lunette with Christ enthroned [36].

An interesting topic to focus on is about materials of the same colour. It is rather likely that less expensive and more available materials were considered spiritually less valuable than precious materials of the same colour, and yet, when they were used as their cheaper substitutes, they had to absorb their intrinsic meanings. This does not mean that sometimes artists use marbles, metals, stones, and pigments according to their tone rather than their

value; it happens, for instance, when two materials are used in chromatic combination rather than as alternatives. In contrast, it is possible that some hierarchical scheme was applied when two or more materials of the same colour were contextually used in the same work of art [37]. The focus is not on the hierarchy based on colours, here, that is a visual hierarchy, the principle of arranging elements to show their order of importance or to organize and emphasize them, an aspect pretty explored by scholars [38-39], but rather the hierarchy of the materials and, consequently, the hierarchy of pigments which they are made from. Scientific investigations prove fundamental to addressing this topic.

Scientific investigations to identify the pigments employed in medieval artifacts and different media have recently greatly boosted thanks to perceptive studies carried out by Raman microscopy. These important investigations provide art historians with a unique opportunity to reflect on the reasons behind the choice of two or more different pigments of the same (or similar) colour in the same artwork, painted in the same time, revealing hierarchical schemes where more precious materials were used for the most important characters (or related details of them), while ordinary, cheaper materials were used for less important details or secondary characters. These hierarchical schemes seem to be applied across time, place, and media boundaries; in the Middle Ages, one can prove this both in the early and late periods in the Eastern and Western artworks.

Figure 1. *Saint Barbara and Saint John the Baptist*, Lluís Borrassà, Harvard Art Museums, Cambridge (MA).

Rather often, contracts indicated exactly the pigments the artists committed to use. Some of these pigments were local, others were imported, generally at a much higher price. Contracts reflect on the brightness and durability of different pigments, specifying with detail the colours that were to be used. The recently restored painting by the fifteenth-century Barcelona workshop of Lluís Borrassà, *Saint Barbara and Saint John the Baptist* at Harvard Art Museums, is a clear example (Figure 1). Here three blue inorganic pigments have been found through technical examination: basic copper carbonate of different qualities (natural azurite), ultramarine of low and medium quality (manufactured from lapis lazuli mineral), artificial basic copper carbonate (artificial azurite) [40]. There is a hierarchy in the distribution of the analyzed pigments that certainly matches with specifications in contracts: both ultramarine and azurite have been detected in robes of Christ, the Virgin, and the figures of saints, while only low-quality azurite (probably artificial, from copper plates) was identified in structures of altarpieces. The backgrounds of the altarpieces are painted instead with a dull blue, a basic copper carbonate applied usually in a single layer. While still to be completely identified, lower quality pigments were used in those areas, probably artificial azurite with a different, lower visual quality than the pigments used in robes [40].

In the Scrovegni Chapel, Giotto used four different materials for the halos of Christ (which is a gold leaf), the Apostles (gilded silver leaf, now blackened because of the oxidization, except for Judas, who has a black halo) (Figure 2), the angels closer to God (gilded copper), and those who are more distant (yellow ochre) (Figure 3) [41].

Figure 2. *The Last Supper*, Giotto, Scrovegni Chapel, Padua.

Figure 3. *The Last Judgment* (detail), Giotto, Scrovegni Chapel, Padua.

The hierarchical use of pigments of the same colour can be found in many other paintings, for example, on the wall paintings in the Church of Sts. Cosmas and Damian at Basconcillos del Tozo, Castile and León, Spain, they found the selective use of the precious cinnabar for the most important biblical figures (Figure 4) [42]; and also in illuminated manuscripts. We can refer, for example, to the decoration of a fifteenth century parchment folio kept at the Archivio di Stato in Milan, originally commissioned by Francesco Sforza. The work is attributed to the Italian artist Michelino dei Molinari (Michelino da Besozzo). Here, following a traditional medieval practice, a hierarchy in the use of colours was found; regarding the blues, for example, to the Virgin's cloak and the Sforza's 'Biscione' were reserved the brushstrokes of the extremely valuable natural ultramarine blue; in contrast, for the initial capital letters in the text the less costly azurite was used [43].

Figure 4. *Christ Pantocrator*, Church of Sts. Cosmas and Damian, Basconcillos del Tozo, Castile and León.

In insular illuminated manuscripts of the early Middle Ages, namely in the Book of Kells, exceptional for the richness of the palette [44], for example, the precious *aurum pigmentum* (orpiment) was used only for the veil of the Virgin and the hair of Christ and the angels, to stress the relevance of the characters who deserve the most precious material (Figure 5); in contrast, for the evangelists the cheaper yellow ochre was used [45-46] (Figure 6). In the late medieval *Book of Hours* of Antoine de Lonhy (Figure 7), red lead (minium) was used throughout the manuscript for most of the images, except for the detail of Jesus' blood [47] trickling from his hands and chest in the *Crucifixion* scene (Figure 7h). Here, to emphasize the holiness of this detail, the illuminator employed the more precious vermillion (cinnabar), that back then vermillion was sold for about four times the price of red lead [46].

The hierarchical use of pigments of the same, or similar colour, can be found also in sculpture. In In the stucco figures of the ciborium's tympanum in St. Ambrose in Milano, for instance, the original polychromy beneath the actual one shows that the precious vermillion was employed only to paint the mantle of Christ; at the same time, red ochre was used for the decoration [48]. In the cloister of Sant Cugat del Vallès, cinnabar was used only for the figurative representations of characters, almost all taken from biblical scenes, and in capital 109 with the self-portrait of the sculptor and architect of the cloister, Arnau Cadell, where in his leg the same cinnabar red was analyzed; for the rest of the animals, monsters or mythological characters, lower-quality materials would be used [49]. The analyses of other medieval stone sculptures [50], revealed in the same artifact and the same (or supposedly so) painting campaign the use of both ultramarine and azurite, another mineral blue pigment, far less expensive and valuable than lapis lazuli; in fact, there was a vast difference in price between lapis lazuli and azurite [21, 46]. That is the case of the choir screen of the Cathedral of Modena (Figure 8). Here, the Apostles' background and their clothes are painted in azurite, while the mantle of Christ is painted in lapis lazuli [51]. Another interesting case is about the Cathedral of Genoa. Here, even though the polychromy of the lunette of the central portal of the church is now almost entirely lost, we know for sure that the background of the entire surface was covered by azurite; in contrast, the background of the Mandorla, with Christ in Majesty, was painted in lapis lazuli [52].

Figure 5. *Christ enthroned*, Book of Kells, ms. 58, f. 32v, Trinity College, Dublin.

Figure 6. *St. John the Evangelist*, Book of Kells, ms. 58, f. 291v, Trinity College, Dublin.

Figure 7. *Book of Hours*, Antoine de Lonhy Torino, Museo Civico di Arte Antica a Palazzo Madama: a) *Annunciation* (f. 1r); *b) Visitation* (f. 15r); *c) Nativity* (f. 24r); *d) Angel announcing the Nativity to the shepherds* (f. 28v); *e) Adoration of the Magi* (f. 31v); *f) Holy Family in the run to Egypt* (f. 36v); *g) God the Father and Jesus crowning the Virgin* (f. 42r); *h) Crucifixion, with the Virgin and St. John the Evangelist* (f. 46r); *i) Pentecost* (f. 49v); *j) Burial service* (f. 71v).

Figure 8. *The Last Supper*, Campionesi Masters, Choir screen, Cathedral of Modena.

Figure 9. *Majestas Domini*, Ratchis Altar, Museo Cristiano, Cividale del Friuli.

Some hierarchical schemes also operate in the pigment application technique. In the Langobard altar of Ratchis in Cividale del Friuli, for example, while the back side reveals the use of a very cheap blue pigment, the more elaborate front side shows three different hues of blue, all three made of indigo mixed with other components [53]. But only for the robe of Christ and the angels' wings the more precious azurite (more precious than indigo blue) [46] was used (Figure 9). Similarly, pure vermillion (since Antiquity, it was considered a very precious and valuable pigment connected with sacred meanings) was used only for the lips of Christ [28], while all the other red pigments are mixtures of vermillion and red lead, and gold leaf only for the halo of Christ while the rest of the yellow pigments are made of yellow ochre. The halo was likely encrusted and ennobled with precious stones, maybe blue stones.

Conclusions

The quality of the materials result from the stratification of multiple meanings attributed to them over time, depending on their occurrence and importance in various texts, their market value, and their colour, which in turn had its own cultural and spiritual meanings. It goes without saying that pigments made from certain materials borrowed their meanings from the materials they were made from, as it is easily demonstrated with lapis lazuli and ultramarine.

Consequently, the more valuable the material, the more valuable the pigment. This may explain why pigments of different origins and values but of the same colour, are sometimes used in the same work of art, as scientific studies of sculptures, paintings, and illuminated manuscripts have shown. What is of interest here is not when they are used in chromatic combinations, but as alternatives. The choice of two or more pigments of different origin and value but of the same colour (e.g., orpiment and yellow ochre, cinnabar and red lead, lapis lazuli and azurite, azurite and indigo, natural azurite and artificial azurite etc.) was never accidental but deliberate, as an analysis of the relationship between the pigments used and the

iconography can demonstrate. In the cases presented here, pigments of greater economic and spiritual value were used for the most important figures in the scene, and this cannot be random. It can therefore conclude that there was a kind of taxonomy of the materials of the same colour and, consequently, a hierarchical classification of the pigments. In other words, it seems that when artists had the possibility to make a choice, a hierarchical pattern lay the choice and use of specific pigments, responding to communicative and significant strategies. This does not mean, of course, that this was the rule, since many other reasons are behind the choice of specific pigments. Sometimes, however, this choice appears not merely bound to technical or aesthetic reasons; the idea is that, among the various criteria used by patrons/artists to choose a particular pigment, there was also a hierarchical classification of materials of the same colour.

This is the focus of the present research, which is still ongoing. Its goal is to trace, over a long period covering the whole of the Middle Ages, and considering different media and colours, the existence of a hierarchical scheme which determined the choice of pigments (and especially the choice of raw materials underlying the pigments) based on the value scale of figures and scenes. We do not know how much of all this the observer could perceive, but certainly patrons and artists were aware of the material and spiritual worth of the pigments used. Although interest in this type of analysis has grown recently, and there seems to be an increasing number of studies exploring the relationship between the nature of pigments, iconography, and the symbolism of colour, the field of investigation needs more case studies to be better defined and framed, to demonstrate the existence of colour-based value criteria and, in particular, material-based value criteria.

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Author contributions
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Crafting culture in the Adriatic: a case of woodcarvers and painters in Quattrocento Dubrovnik

A cultura artesanal no Adriático: um caso de entalhadores e pintores no Quattrocento, em Dubrovnik

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Abstract

The well-preserved archival documentation in Dubrovnik provides valuable insights into various subjects, including production of art. This study delves into the collaboration between woodcarvers and painters in late medieval Dubrovnik, focusing on the mid-15th century, when artistic production was greatly influenced by the exceptional stability of the commune. Contribution challenges conventional assumptions regarding artist specialization during this era. Contracts from this period often delineated the responsibilities of painters in supervising carpentry work during artwork fabrication, while some documents suggest woodcarvers executed basic painting tasks. Discoveries are consistent with the knowledge of Italian art production, affirmed through meticulous examination of exceptionally well-preserved archival sources.

KEYWORDS
Woodcarvers
Painters
Polychromed wooden sculpture
Polyptychs
Art production
Dubrovnik

Resumo

A documentação arquivística, bem conservada, de Dubrovnik fornece informações importantes sobre vários assuntos, incluindo a produção de arte. Este estudo investiga a colaboração entre entalhadores e pintores na Dubrovnik medieval tardia, centrando-se em meados do século XV, altura em que a produção artística foi grandemente influenciada pela estabilidade excecional da comuna. A contribuição desafia os pressupostos convencionais relativamente à especialização dos artistas durante esta época. Os contratos deste período definiam frequentemente as responsabilidades dos pintores na supervisão do trabalho de carpintaria durante a realização das obras de arte, enquanto alguns documentos sugerem que os entalhadores executavam tarefas básicas de pintura. As descobertas são consistentes com o conhecimento da produção artística italiana, corroborado através do exame meticuloso de fontes de arquivo excecionalmente bem preservadas.

PALAVRAS-CHAVE
Entalhadores
Pintores
Esculturas em madeira policromada
Polípticos
Produção de arte
Dubrovnik

Introduction

Pictor* vs. *sculptor

One of the numerous Dubrovnik contracts between a patron and an artist, concluded in the summer of 1449, presents a particular challenge for researchers of the production of wooden and polychrome artworks. Ivan Pripčinović commissioned a painting (*unum quardum*) from the painter Ivan Ugrinović. Since the desired painting was not received within the agreed-upon deadline of two months, he placed an exact same order with the woodcarver Radosav Vukčić. In fact, the notary only replaced one name with another, while all other provisions of the contract remained identical [1, doc. 360]. We may never learn the circumstances related to the described case, but the contract can certainly prompt reflection on the relationships between painters and sculptors in medieval Dubrovnik and the broader Adriatic *milieu*.

When examining polychromed wood artworks, it is commonly believed that medieval painters were also skilled woodcarvers, and vice versa. The subject of collaboration between wood sculptors and painters has captivated researchers in the field of Italian late medieval and early Renaissance art for decades. However, it is still challenging to determine whether terms such as *carpentarius, magister lignaminis, faber lignaminis, intarsiatore, intaiador, intagliatore, incisor lignaminis, sculptor lignaminum, statuario,* and others implied diverse woodworking skills and to what extent they encompassed execution of polychromy and painting [2, pp.40-41]. While John White's focus on prioritizing the technical aspects of altarpieces in sixties was innovative, it also poses the risk of uncritical acceptance, as seen in his assumption, without substantial evidence, that during Duccio's time, the woodwork was executed in the painter's workshop [3-4]. Analysis of a prominent historian of medieval and Renaissance art emphasizes a key difference between medieval and modern art practices: in contrast to the contemporary practice of adding frames to finished paintings, medieval artists worked on panels that were inherently framed [4]. Furthermore, the form and execution of the panels and frame (which was not simply a rectangular *quadra*) were extremely important for the medieval artist and patron, making the connection between collaborators more inseparable.

Contrary to the expected trend of specialization by the thirteenth or fourteenth centuries, in the middle of the fifteenth century, we still encounter various examples displaying the versatility of these artists. We come across a range of examples, when woodcarvers or their bottegas often gilded and painted their own artworks, while painters were also capable of carving wooden statues [2, p. 41]. According to research by Michelle O'Malley, the majority of Italian painters in the fifteenth century never modeled sculptures for their altarpieces. However, it is known that some sculptors, such as the Venetian sculptor Jacopo Moranzone, engaged in painting [5]. Some researchers believe that the painter Giovanni d'Alemagna was also a skilled woodcarver and should be credited with the wooden structures of polyptychs on which he collaborated with the painter Antonio Vivarini [6, p.13]. Anne Markham Schulz provides several examples from fifteenth century Venetian woodcarving illustrating that an individual could simultaneously be an *incisor* or *intagliator* while also being recognized as a *deaurator* – a gilder. Additionally, Schulz demonstrates that painters could also engage in woodcarving. Joško Belamarič highlighted the case of Juraj Petrović from Split, who, in the mid-fifteenth century, served as a *primicerius* of the cathedral chapter of St Doimus while also working as both a woodcarver and a painter [2, p. 41].

In his groundbreaking analysis of Venetian Renaissance altarpieces, Peter Humfrey thoroughly investigated the commercial interactions between painters and woodcarvers in Venice during the second half of the fifteenth century. Research has confirmed the structural interdependence between the making of wooden structures and the painted part, suggesting intensive collaboration between painters and woodcarvers at every stage of execution, up to the final placement of the finished work in its designated location [7, pp. 141-146]. This is supported by the repeated complaints of painters against woodcarvers painting practice in Venice [8, 9, pp.68-69]. Unfortunately, we do not have preserved documents for Dubrovnik that shed light

directly on this area of activity organization [6, p. 16]. However, given the known facts, it is apparent that the regulations were probably less stringent. Only a handful of Dubrovnik artists seemed to dominate the small art market for painted crosses, paintings of Madonnas and polyptychs, subject to stricter (written or unwritten) rules.

Even Lovro Dobričević, perhaps the most characteristic representative of the early Renaissance in Dubrovnik and the Montenegrin Bay of Kotor, who art history has exclusively treated as a painter (which undoubtedly was also his identity), for example, appears in two documents as *magister Laurentius de Cathato, intagliator et Pictor* [1, docs. 430, 445]. With great certainty, we can thus assert that he personally executed at least these two commissions, one for two paintings with carvings (*duas anchonas pulchras, firmas, bene intagliatas,* …) and another one of similar nature, all by himself. At the same time, Antun Pribisalević Car from Split (*Antonio lignicida*), who is mentioned as a painter in a single document (*lignicida et pictor Spaleti*) [10, p.25], is often also considered as a painter [6, p. 14, 11, p. 225].

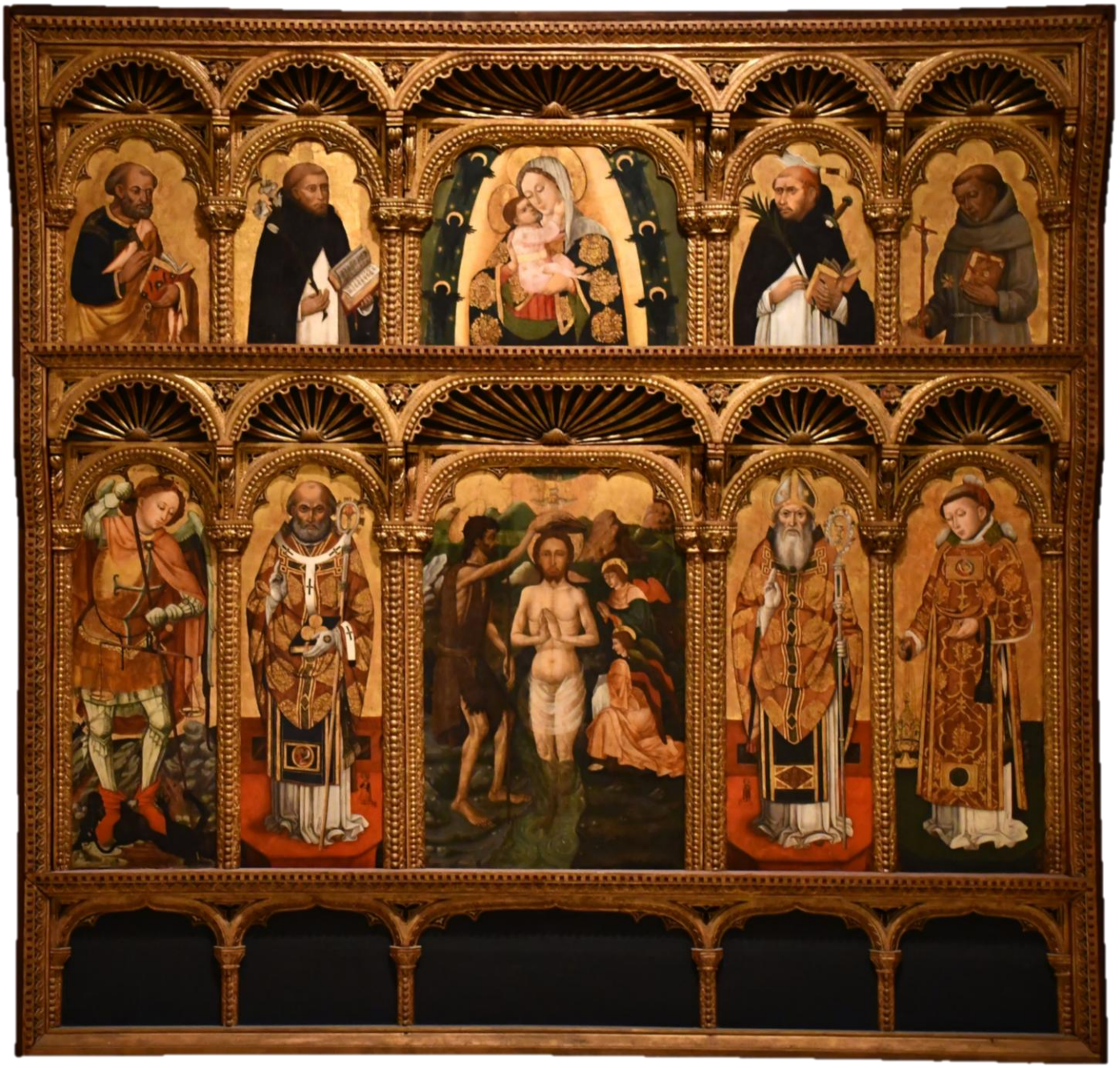

Figure 1. Lovro Dobričević, polyptych with the Baptism of Christ in the Jordan, 1448, tempera and gilding on wood, 240 × 249 cm, Dubrovnik, collection of the Dominican Monastery.

The article will attempt to outline the process of creating polychrome wooden artworks (Figure 1), using the example of a smaller late medieval community with a thriving economy and culture, as well as close connections to other cities in the Adriatic and the Apennine Peninsula. The small coastal town is of exceptional importance for (art) historiography, as it boasts a very well preserved archive that provides us with a high-quality insight into the political, economic, and cultural life of the people of Dubrovnik, and in our case, the production of wooden polychrome artworks.

Dubrovnik in Quattrocento

Medieval Ragusa was a prominent maritime republic known for its strategic location along trade routes connecting the Mediterranean with the Balkans. In the fifteenth century, the political map of the Adriatic revealed a varied landscape: the Venetian Republic dominated the north, followed by small court states along the western coast and the expansive Papal States encompassing modern-day Marche, Emilia-Romagna, and the Kingdom of Naples in the south of the Adriatic basin [12-13].

Dubrovnik enjoyed full statehood by the fifteenth century. With Venetian Dalmatian on the north and Venetian Albania on the south, renowned for its fortified walls, bustling port, and cosmopolitan culture, Dubrovnik thrived as a center of commerce and intellectual exchange during the Middle Ages, leaving a lasting impact on art, architecture, and governance in the Adriatic region [14]. Economic and political prosperity and close links with the Apennine peninsula, especially Ancona and Kingdom of Naples, enabled Dubrovnik to develop its urban center in the fourteenth and first half of the fifteenth century by all the modern standards of the wider region of the time, which also allowed a rich production of art works to flourish [13].

The rich painting scene – widely accepted by researchers as the Dubrovnik School of Painting – and broader artistic production were greatly influenced by the exceptional stability of the commune and significant changes that occurred during this period in politics, international relations, economy, social life, and culture. Sorman's visitation [15] in the years 1573-1574 in Dubrovnik lists more than 150 altars and 150 paintings in churches, monasteries, and hospitals, indicating relatively high demand for painting and carving products. Unfortunately, not even a tenth of them have been preserved, but well-preserved and mostly already published archival sources [1, 16] provide a sufficiently detailed insight into the organization of painting activity, especially after 1275, when even minor credit transactions needed to be recorded by official city notaries [17].

Sources and methods

The archival documentation in Dubrovnik is enabling a high-quality analytical approach to researching various issues. The Dubrovnik notary, that, unlike in the Venetian system, was part of the state structure, documented private transactions, including promissory notes, sales contracts, leases, slave sales, dowry receipts, and debt repayments. Meanwhile, the chancellor served the Rector and judges by drafting public-law documents. The *Diversa cancellariae* and *Diversa notariae* series are essential for studying Dubrovnik's art production, featuring similar contracts but differing recording methods [18]. The archival documentation makes it easier and more comprehensive to understand the orders for paintings and other objects in Dubrovnik's homes and churches compared to similar towns in the Adriatic. The analysis of archival records reveals that in the fifteenth century, the number of documents related to paintings exponentially increased. Many published documents originate from notarial series, offices, and council decrees. Within the documented archival material, painters and others who significantly contributed to the creation of paintings are identified. They appear as testators, witnesses, or masters commissioned for work. Contracts often also refer to education and work in painting workshops. Given the relatively poor preservation of the pictorial material itself on

one hand and, the relatively numerous archival sources on the other hand, the use of classical historiographical methods will be crucial, primarily involving meticulous reading and analysis of already published archival sources.

Previous scholarship on woodcarving and painting in Quattrocento Dubrovnik (and Dalmatia)

Today we can ascertain that artistic phenomena on both shores of the Adriatic are fairly well researched, but in the literature, we still notice a significant difference in their evaluation: while art on the western coast has always been treated as an integral part of the "great Italian Renaissance," most Italian art experts still perceive something distant and unknown on the eastern Adriatic coast. They briefly dismiss it as *hic sunt leones* [19, p. 57]. In 1938 study, in what is arguably the earliest (and only comprehensive) scholarly work addressing wooden sculpture in Dalmatia, Arnolfo Bacotich articulated "(Q)uest arte, per i pochi contatti delle popolazioni dell`interno con le popolazioni di altri paesi, é, del vero senso della parola, in Dalmazia, arte locale," [20, p. 302] thereby reflecting the perspective of the relatively scarce Italian investigations of Dalmatia.

The most significant contribution to the study of late Medieval and early Renaissance fine art comes from Ljubo Karaman in the first half of twentieth century. He also devoted discussions to Dubrovnik painters [21-23] and – together with another prominent scholar at the time Kruno Prijatelj – to local groups of the Dalmatian Painting School in the fifteenth century [24]. Numerous important details about the matter were also unveiled by Cvito Fisković in his synthetic works or his studies on churches or sculptural production from the Romanesque to the Renaissance along the Dalmatian coast. In studies on Gothic wooden sculpture in Split [25] and Trogir [26], he published valuable documents on the work and achievements of many unknown local masters. The archival data found in these works will have far-reaching importance.

For research on the relationships within workshops and the dynamics between patrons and creators, Jorjo Tadić's archival study on documents connected to painting is extremely important. His archival research in the mid-twentieeth century (1952) provided the basis for a synthetic review of the old "Dubrovnik painting school" [1]. Vojislav J. Đurić's overview of Dubrovnik painting in the fifteenth and sixteenth centuries also contribute to the field of wooden sculpture. It touches upon their collaborative efforts and explores the impact of their working relationship on their respective artistic practices [27]. However, woodcarving of the time in Dubrovnik has not yet been the subject of thorough scholarly attention, so we can only rely on basic reviews; besides already mentioned studies for Split and Trogir, also a more systematic and thorough study for Zadar [28] by Ivo Petricioli.

These contributions reveal and catalogue numerous carved products on the eastern coast of the Adriatic Sea, but very few delve into the operation of workshops – the creation of artworks like altarpieces and their polychromy. Wooden polychrome sculpture in Dubrovnik is generally treated very sporadically. In surveys of sculpture, such as in catalogs like "Zlatno doba Dubrovnika," there is little space dedicated to the poorly preserved segment of predominantly sacred wooden sculpture [29, catalogue numbers K/28-K/30]. Among the most recent works on what is generally understood as the Dubrovnik painting school, Ivana Prijatelj Pavičić's book "U potrazi za izgubljenim slikarstvom" [6] is significant as it raises intriguing questions about woodcarving and the collaboration between both profiles, painters and woodcarvers, at several points [6]. However, intriguing study unfortunately could provide answers to only a few of these questions.

"The art of craft" or the "craft of art"? A short *excursus* on artist's position

With the great artists of the Italian Renaissance, who mark the art historical canon, talent begins to rise above ordinary people, and the artist can compete with the educated aristocratic elite, often the patrons of elitist, fine art. Before this, during (late) Middle Ages, the production of artifacts that we now unequivocally label as artworks was mostly the domain of craftsmen, although the artistic historiography of painting often detached it from other stages of the final product's creation, focusing on style and iconography. Considering the socio-historical circumstances of late medieval Dubrovnik, it is important to note that painting during this period was closely associated with the development of local craftsmanship [30, p. 8]. We do not know the exact annual earnings of Dalmatian painters, as information available about artists' incomes during that time is not consistent. This information would probably most vividly and simply illustrate their social status. However, we do have some records.

During the fifteenth century in Dubrovnik, architects emerged as the top earners among artists. Despite not being the most proficient sculptor or architect, Pietro da Milano attained notable success thanks to the outstanding quality of his work, surpassing local standards. His collaborators always held subordinate roles, as partnering with other masters would have been impractical given his superior craftsmanship [31, p. 107]. If we sum up the payments for all known contracts he concluded from 1440 until his departure from Dubrovnik in 1452, we get over 6000 perpers, which amounts to more than 500 perpers annually. Of course, this figure needed to cover expenses, so it was not pure profit, but still a significant sum.

Onofrio di Giordano della Cava, was generously paid by the government for the construction of the aqueduct, both main fountains, the Rector's Palace, and parts of the walls. In 1455, Dubrovnik extended an annual salary of more than 300 ducats to the hydraulic engineer and architect, equating to almost a ducat per day. When the Council of the Entreaties paid Michelozzo a monthly salary of 20 ducats in June 1461, it was considered a particularly high income for that time [6, p. 22]. Obviously, Onofrio was highly esteemed, as his departure from Dubrovnik in 1443 caused panic in the city about where and how to find a new engineer as the Ottomans approached.

Painters, on the other hand, were not as fortunate in terms of social status. Some painters are also found among the state employees. Among them, two Tuscans are documented in this period. Lorenzo di Michele from Florence adorned the hall of the Small Council between 1433 and 1435 and remained in Dubrovnik at least until the mid-century. He received an annual salary together with rent from the state on July 18, 1436, amounting to 100 perpers. On September 18, 1449, his salary was reduced to 30 perpers. From 1421 to 1427, Blaž Jurjev (*Biaggio di Georgio da Traú*), one of the most prominent and well researched Dalmatian late gothic painters worked in Dubrovnik (Figure 2). He, too, was employed by the state with an initial salary of 30 perpers, which increased to 60 over the years. He also brought his permanent collaborators to Dubrovnik and established connections with wealthy merchants and craftsmen, such as Jacob de Goze and Pietro Pantello, whom he mentioned in his will [32, pp. 74-75]. In 1426, the painter requested an increase to 80 perpers, but on November 21, 1426, the Council decided to grant him sixty perpers. After this decision, he left the city [6, p. 22]. This might indicate the value placed on the origin of painters – while the native of Trogir, Blaž Jurjev, had to prove his skill, there was less doubt about Lorenzo's mastery, yet he was apparently less favored by the locals.

Figure 2. Blaž Jurjev, polyptych with St. James, 1436, tempera and gilding on wood, 92 × 144 cm, Trogir, Museum of Sacred Art.

Tadić observed that Dubrovnik painters belonged to the lower social classes, being ordinary craftsmen, sons of peasants, craftsmen, carriers, painters themselves and city poor [1]. Lučić also highlights that painters came from lower and middle urban peasant classes and did not have a special social status as they were, as he notes, "ordinary painters, colorists, decorators" [33, p. 257]. Certainly, only some of them can be included in the canon of artists who rose above ordinary craftsmen and undertook commissions for the most prestigious painting tasks of the time in the Adriatic region, altarpieces. Documented in the fifteenth century, these primarily included already mentioned painters Blaž Jurjev and Lovro Dobričević along with Ivan Ugrinović, Matko Junčič and woodcarver and sculpturer Radosav Vukčić. But majority of craftsmen involved with paint also identified with other occupations: Radoje Dragosalić was a cabinetmaker, woodworker, and painter (*cofanarius, marangonus vel pictor*), Ivan Ognjenović made shields, gunpowder, worked with wood, and painted, Radišin Junčić and Radić were shield makers and painters (*magistri a scutis et pictores*), Paskoje Radičević was a painter and was making chests, Frano Marinov identified himself as a painter and textile painter (*pictor, pictor a cultris*), Jacobum Roselli from Florence was a carver and painter (*inteleator et pictor*), and Luca de Fiori was a saddler and painter (*sedlaro et pentore*) [30, p. 9].

It's important to highlight that the total cost of a painting during the fifteenth century was impacted by several factors, including the materials utilized, the quality and variety of wood and paint, the type of gold employed, but maybe the biggest factor were expenses associated with labor (Figure 3). The cost of the woodcarving in Apenine peninsula varied from around 15 % to, according to O`Malley, 30 % at best [5, pp. 41-44]. Ivana Prijatelj Pavičić highlights a case of polyptych by Michele Giambono from 1447 (which cost a total of 130 lire), where cost of woocarving was 33 lire, 25 % of the total price. We know that in this specific example, the painter Giambono paid the woodcarver. The cost of woodcarving on a painting by Alvise Vivarini for Noale in 1502 (the total price of the painting was 134 lire) was 34 lire. However, the buyer paid

the woodcarver at that time [6, p. 23]. Fisković asserted that Dubrovnik saw the creation of monumental and highly representative altarpieces, where both the painterly and sculptural contributions were equally valued [34, p. 135]. A systematic review of all documented commissions for polyptychs in the second quarter of fifteenth century in Dubrovnik, compiled by Ivana Prijatelj Pavičić, shows that the carving component usually amounted to less than 30 % of the price. However, in one instance, it accounted for as much as 48 %, yet still insufficient to claim that both contributions were equally valued [6, pp. 23-25].

Figure 3. Lovro Dobričević, polyptych with the Baptism of Christ in the Jordan, 1448, Dubrovnik, collection of the Dominican Monastery: detail of the central scene, showing the significant contribution of the woodcarver.

A woodcarver and a painter: a *compagnia*?

Collaborative endeavors among numerous masters are evident from historical records, but on the contrary to what Igor Fisković claimed in 1990, we cannot state that it was common for painters and woodcarvers in Dubrovnik to share a workshop or production space [34, p. 135], at least not for most of the fifteenth century. It is far more likely that each master owned or rented their own bottega and hired an assistant or apprentice, that specialized an area that was less favored by the master. For example, Radosav Vukčić, by far the most sought-after and well-profiled sculptor in wood in the first half and mid-fifteenth century, acquired his education from a painter, Blaž Jurjev. They entered a typical apprenticeship contract, where Radosav's father, a trumpeter from Dubrovnik, is listed as the responsible party. Radosav undertook to live and work with master Blaž Jurjev, while the master, in return, promised to take care of the young apprentice in health and sickness (the entitlements of apprentices were also defined by guild rules) and to teach him the art of painting to the best of his abilities (*et ipsum Radoslauum docere artem suam pictorie juxta posse suum*) [1, doc. 164]. That means that Blaž`s bottega at that time consisted of at least two apprentices, Martin Petković from Jajce [1, doc. 152], that later turned out to be a painter, and Radosav Vukčić, that later went on to be woodcarver. Creighton Gilbert in 1977 – commenting on Martin Wackernagel's writing on quattrocento Florence – claimed that we shall never find a woodworker employed in the artist's studio [4]. But it looks like Blaž's bottega was self-sufficient and that may be the reason that we do not have any known commissions where Blaž would accept work with another master, as it was often the case with other artists.

Fisković also claimed that moreover, sons of painters and woodcarvers, raised in family workshops following typical medieval customs, often gravitated more towards the branch where the father, as the head of the activity, was less skilled, thus being groomed as assistants [34, p. 135]. Although do we find one such example in Dubrovnik, we cannot claim that it is the rule, rather an exception. Radosav`s son, Matko Alegretović, trained to be a painter and after his father's death, he collaborated for some time even with Ivan Ugrinović, one of the most successful painters in Dubrovnik around mid-fifteenth century (perhaps even as a woodcarver). Later, he closely collaborated with Božidar Vlatković and Stjepan Ugrinović, with whom they even accepted an order for the main altar of the church of St. Severin in San Severo, Apulia [1, doc. 606].

Collaboration between the most popular painter in Dubrovnik, already mentioned Ivan Ugrinović, whose rise began immediately after Blaž's departure, with Radosav Vukčić was a very usual practice. At times he collaborated with others as well, for example Ivan Ognjanović, Matko Junčić and Lorenzo from Florence. It seems that at a certain point, particularly after 1438, the collaboration between Ivan Ugrinović and Radosav Vukčić was almost exclusive; Ivan very rarely collaborated with other sculptors, Radosav with other painters, while they both functioned as individuals. Whether the collaboration between Ugrinović and Vukčić was temporary, limited to a specific project, or organized in a more formal manner is not known. They concluded numerous joint contracts, in none of which they were named as *compagni*, yet they very regularly worked together. It's important to note that compared to some urban centers on the western Adriatic, Dubrovnik is a very small community where exclusivity may ultimately arise because there are very few masters working in their respective fields at the same time.

Apart from informal collaboration among masters, we also know of the professional relationship between Ivan Ugrinović and his son Stjepan, that most likely was based on the principle of *paternae compagniae*.

Contract agreements for joint workshops (*feno pato e conpagnia*) are indeed found among the documents of Dubrovnik; first in 1456, when Petar Ognjanović and Stjepan Ugrinović (both were painters, but the latter was evidently more successful) entered into an agreement defining the workspace, tasks, and finances [1, doc. 451]. They worked in premises owned by Petar, who

provided materials (chalk and pigments), while Stjepan was responsible for painting and carving. Stjepan did not have to pay for materials or accommodation in the room above the workshop [6, p. 33]. The same year painters Franko Miljević and Franjo Marinović agreed to work together, diligently and share the earnings equally in a joint company (*pro facto presentis societatis et colligantie*) [1, doc. 411].

Unfortunately, we were not able to find this type of an agreement between painter and a sculptor, woodcarver. An interesting business agreement was made in 1442 between Ivan Ognjanović and Ivan Ugrinović (the latter, unlike the former, accepted many commissions for polyptychs). Ivan Ugrinović promised Ivan Ognjanović that as long as he lived in Dubrovnik, he would only paint chests for him and only with his consent. To fulfil this commitment, Ognjanović paid him four ducats (about 12 perpers), and for each chest he painted, he would receive two perpers [1, doc. 272].

Woodcarving, polychromy and gilding

During negotiations, the painter could bring with him drawings (*disegno*) that served as templates and assisted in aligning the concept. It has been established that "disegni" of the architectural structure of altarpiece paintings in Italy became an integral part of the contract-making procedure around 1450. A similar conclusion can be drawn by examining contemporary painting contracts in the Dubrovnik area [6, p. 12]. Unlike previous researchers claim [6, p. 12], the oldest known Dubrovnik contract mentioning a design is dated in 1431, when Ivan Ugrinović agreed to make a painting of St. Agatha by the design patron gave him (*figure sancta Agate ad designum et formam …*) [1, doc. 201]. In 1442, Ivan Ugrinović and Radoslav Vukčić agreed to create an altarpiece painting according to a design (*cum figuris nominantis in disegno depicto ipsius anchone, contento et depicto in folio papiri hic affixo*) [1, doc. 259]. For example, in the case of Ivan Ugrinović, during his forty active years of activity (between around 1420 and 1460), we could only find two documents where a sketch served as the basis for ordering an altarpiece, which was provided by the patrons. In the case of Lovro Dobričević, who belonged to a younger generation and was active in the second half of the fifteenth century, we find six examples where the form of the altarpiece was agreed upon based on a sketch [6, p. 12].

Martin Wackernagel, an expert on studio working conditions noted that it was not uncommon for clients in fifteenth century Florence to commission panels from woodcarvers before painters took possession of them, but the lack of substantial evidence for this specific practice suggests that it cannot be accepted as a widespread norm [35]. Creighton Gilbert in 1977 claimed that Wackernagel's assertion is well founded, but is perhaps too tentative [4]. Gilbert claimed that his hesitation is understandable, however this practice of the woodwork being commissioned beforehand does not fit in with previous theories and we shall see another custom, in which the painter subcontracts the panel to a woodworker [4].

Several commissions align with the thesis laid out by Wackernagel, from gilding smaller carved pictures [1, doc. 274] to coloring big altarpieces. In 1439, for example, Lorenzo from Florence undertook to paint in colors and with figures and to gild the carved altarpiece for Rijeka Dubrovačka made by Radosav Vukčić, for 40 ducats [1, doc. 239]. The same day patron Florio Radosav Turcini commissioned that carved wooden "base" like the one in the church of St. Dominic for 17 ducats [1, doc. 238]. Three years later, in 1442, Marino de Bizia ordered Radosav Vukčić to make a similar altarpiece as the one he had made for Florio de Turzina. This time, Radosav charged one more ducat for the execution, totalling 18 ducats [1, doc. 275]. The replication and reference to existing paintings when commissioning new ones was indeed a common provision in contracts of that time.

Elena Favaro in 1975 highlighted a discussion among members of the painters' and woodcarvers' guild in Venice in 1457 regarding the boundaries of their respective roles. Painters raised concerns about unauthorized woodcarvers producing painted elements of altarpieces,

while woodcarvers objected to painters creating reliefs [9, pp. 68-69]. Giustizia Vecchia at that time stated that neither party should be allowed to take over each other's work. However, just two years later, they realized that such practice could not be prevented. This is evidenced by a record in the register of the Venetian painters' guild on May 19, 1458 [9, pp. 68-69]. Igor Fisković even claimed that neither could survive without the other, as they earned the most from artistic works where their knowledge and skills complemented each other [34, p. 135]. Their work did in fact intertwined, and the most renowned artists were commissioned for projects encompassing both aspects.

Clauses in contracts where the painter takes responsibility for making the wooden base or carvings on the painting or negotiates for the payment of wooden materials and carpentry work, were common in the contracts of this time in Dubrovnik. Many documents mention painters who are required to *facere et construere unam tabulam ligneam;* or construct some wooden barrier and corresponding relief ornaments. With these provisions, the contract encompassed all aspects included in the price, detailing what the artist-executor must furnish to the patron of the altarpiece for the agreed-upon price. Additionally, it was customary for the painter to oversee carpentry tasks during the fabrication of the altarpiece [6, pp. 14-15].

Of course, we can also find different examples of commissions. In one case in 1442 Ugrinović promised to take care of everything needed to make an icon of Madonna, but the wood, for four and a half ducats. The client, Ivan Palmotić, explicitly committed to providing the wood (*excepto lignamine*) [1, doc. 274]. It seems that Ivan Ugrinović did not fulfill the commission for a long time. About four years later, he finally reaches an agreement with the patron, and Ugrinović completes the image of Madonna with the Child on a wooden base, which, as we can learn from this document, was made by Radosav Vukčić [1, doc. 332].

In fact, most of the orders accepted by Radosav Vukčić himself were for the execution of the carved part of the product, essentially for a semi-finished product that the client would take to the painter and order painting, which would actually cost him more than carving. But in some cases, we must even allow for the possibility that Radosav undertook the entire order himself. For example, in 1447, the prioress of the Monastery of Our Lady of the Angels commissioned a polyptych with 14 panels with painted figures (*cum quatordecim campis in quibus pinguntur figure*) from Radosav. Whether Radosav executed (or at least arranged for) the painting of these figures, we cannot know. However, it is a fact that Radosav had to take care of the silvering of the altarpiece, as the contract stipulated that he would do so at his own expense [1, doc. 333].

Conclusion

The basic characteristics polychromed wooden sculpture required collaboration of sculptors – woodcarvers and painters, or at least the integration of sculptural and painterly skills. In Dubrovnik, we have exceptionally well preserved archival sources that are also notable in a broader context. As there were very few masters capable of creating altarpieces, the relationship between the patron and the master (either a woodcarver or a painter) is transparent and can be well monitored. In some cases, we can predict the number and names of assistants and apprentices in the workshop as well. However, relationships within the workshop remain unclear in most cases. Therefore, it is often impossible to determine whether the painter personally executed the carving work or if they had an employed assistant carver for that task. The relationship between Ivan Ugrinović and Radosav Vukčić appears somewhat clearer, as they evidently operated as equal masters. Unfortunately, very few works have been preserved, making it difficult to assess the quality and extent of carving in these extant pieces. Consequently, attribution of the carved elements through stylistic analysis is not feasible. In future research, it would also be necessary to examine the activities of woodcarvers operating independently from their joint activities with painters.

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The (after)lives of the pseudo-sumptuous surfaces: the case of the Venetian Gothic and Renaissance wooden sculpture in the Adriatic

As (pós-)vidas das superfícies pseudo-sumptuosas: o caso da escultura em madeira veneziana gótica e renascentista no Adriático

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Abstract

This paper discusses the alterations to the surface of the 15th- and early-16th-century wooden sculpture, mostly executed by Venetian workshops for the clientele of the minor centres of the Adriatic region. It examines the cases of wooden statues that imitated metalwork via their glittering surfaces by considering both the place of such works in their time and their "afterlives", given that their original appearance was regularly altered in the following centuries. The sparkling effect of the pseudo-sumptuous surfaces was replaced by polychromy covering the draperies in mimetic colours imbued with religious symbolism. The instances of the reverse approach are also considered, given that in the eighteenth and nineteenth centuries, several late medieval artworks were repainted to mimic bronze or marble. These converging approaches to the surface of wooden sculpture tackle the issue of taste and the meaning of surface in the reception of sacred art in an extensive time frame.

KEYWORDS

Wooden sculpture
Venetian Renaissance sculpture
Polychromy
Pseudo-sumptuous surface
15th century
16th century

Resumo

Este artigo aborda as alterações da superfície da escultura em madeira do século XV e início do século XVI, executada maioritariamente por oficinas venezianas para a clientela dos centros menores da região do Adriático. Examina os casos de estátuas de madeira que imitam o trabalho em metal através das suas superfícies brilhantes, considerando tanto o lugar dessas obras no seu tempo como as suas "vidas posteriores", dado que o seu aspeto original foi regularmente alterado nos séculos seguintes. O efeito cintilante das superfícies pseudo-sumptuosas foi substituído pela policromia que cobria os panejamentos com cores miméticas imbuídas de simbolismo religioso. Os casos de abordagem inversa também são considerados, porque nos séculos XVIII e XIX, várias obras de arte medievais tardias foram repintadas para imitar o bronze ou o mármore. Reflete também a questão do gosto e do significado da superfície na receção da arte sacra num período de tempo extenso.

PALAVRAS-CHAVE

Escultura em madeira
Escultura renascentista veneziana
Policromia
Superfície pseudo-sumptuosa
Século XV
Século XVI

Introduction

Understanding the original appearance of Medieval and Renaissance polychrome wooden sculpture is a challenging task, to be grasped only with the help of thorough technical research. As a general rule, the periodic application of newly painted layers to the surface of older statues has significantly altered the intended presentation of the formal qualities and the plasticity of saintly figures. Occasionally, such an approach has entirely tainted their visual quality [1, p. 11]. Indeed, the surface of religious objects carved in wood is no more than a thin layer of paint set atop the preparation, yet it is regularly treated as an illusionistic area mimicking other materials, primarily the most precious ones such as gold, silver or marble, and is therefore held in great esteem.

In many regions, this memorable effect of the richly folded draperies enlivened in gold has been a constant in the production of sacral art in wood made in different epochs. Still, the reception of late medieval pseudo-sumptuous surfaces in an extensive time- and geographical frame merits further investigation. For instance, Mattia Vinco, in a recent discussion of the wooden sculpture produced in early Renaissance Verona, remarked that the original gilded surface of the holy figures has rarely been altered in subsequent centuries. According to Vinco, the gilding was the prime reason for the high esteem in which their Veronese beholders held the simulacra of Virgin and Child for centuries [2, p. 35]. Yet the attitudes towards the surface of sacred art significantly varied from region to region, with nearly a total lack of comparative studies [3].

For example, the flattering surfaces of the holy figures preserved in the Eastern Adriatic area (discussed later in this paper) could have been cherished only by its first generation of viewers. As if, almost by rule, it was entirely obfuscated by the subsequent layers of paint. This short paper explores several such cases by analysing the various approaches to the surface of wooden sculptures preserved on the mostly insular territories of the Eastern Adriatic coast. In doing so, the paper aims to gain a more comprehensive understanding of the meaning of the surfaces of sculpture made from wood while simultaneously addressing the issues of taste and the expectations of beholders regarding the older sacral art in the Early Modern period, up until the beginning of the nineteenth century.

The group of altarpieces and independent statues of saints that this paper investigates were mainly – if not exclusively – products of Venetian shops such as that of the Moronzone family, Andrea da Murano and his brother, Girolamo, and Paolo Campsa and Giovanni da Malines, to name just the most versatile and the best-studied master carvers. Most customers of their *prêt-à-vendre* products were church authorities, confraternities or individuals from the minor centres of Venetian Stato da Mar. The procurement of the sculptures directly in Venice (or dispatched via sea from Venetian shops) has rarely left traces in the archival sources, resulting in the procurement process of sculptures remains largely unknown. Nevertheless, we can assume that in the local communities for which the works were destined, these "made in Venice" products were perceived as lavish and high-quality works of foreign carvers operating in the foremost centre of the region and, of course, the Mediterranean [4].

This sentiment was likely supported by the memorable visual effect of the surface, given that such works drew on the medieval tradition of altarpieces entirely covered in silver and gold. Within these premises, the paper will examine the (for the most part) unpublished technical data from the conservation-restoration work on selected fifteenth- and sixteenth-century objects both from significant towns and minor villages, namely Pula, Cres, Poreč, Zadar, Tisno and Kotor. The wooden artworks will be examined from an art-historical perspective and from three aspects: their original state, their state centuries after they were made, and their present state, as their original effect has often been restored in recent restoration campaigns.

Silver altarpieces and their wooden counterparts

The development of the altarpiece as an independent genre of late medieval art has become much clearer thanks to art-historical and archival research [5]. However, the lines of evolution and chronology are far less specific in minor regions, where commissioners have preferred full-volume sculptures instead of paintings on panels until at least the mid-sixteenth century. In general terms, and judging by surviving artworks, the visual culture of late medieval Adriatic was varied. In the central and southern parts, the altars were graced equally by paintings on panels, carved altarpieces and independent full-volume sculpture, both in wood and stone, while the northern area primarily cherished sculptured works, regularly in wood.

A parallel line of the altarpiece typology can also be traced to an earlier period (the fourteenth and fifteenth centuries): the altar retables made of silver. Only a few examples survive, such as those from cathedrals of Split (late fourteenth century, preserved in fragments), Poreč (early 1450s), Kotor (mid-fifteenth-century) and Krk (1480s) [6-7]. That such a genre of sacral art was accessible to financially most adapt commissioners and communities is corroborated by the archival sources for the churches in Dubrovnik, where such pieces adorned only the most important churches of the city such as the Cathedral, St. Blaise church and the Mendicant churches [8-9].

These silver altarpieces regularly displayed saintly figures in two registers, with the Virgin and Child as the central representation. Placed atop the altars under suffused natural light and within the proximity of flickering candlelight, these works would have likely had an extraordinary effect on their viewers. The sensation was most certainly supported by the awe the altarpieces inspired after their protective shutters were lifted, which occurred exclusively on the most solemn days of the church calendar. Most of the time, however, they remained covered.

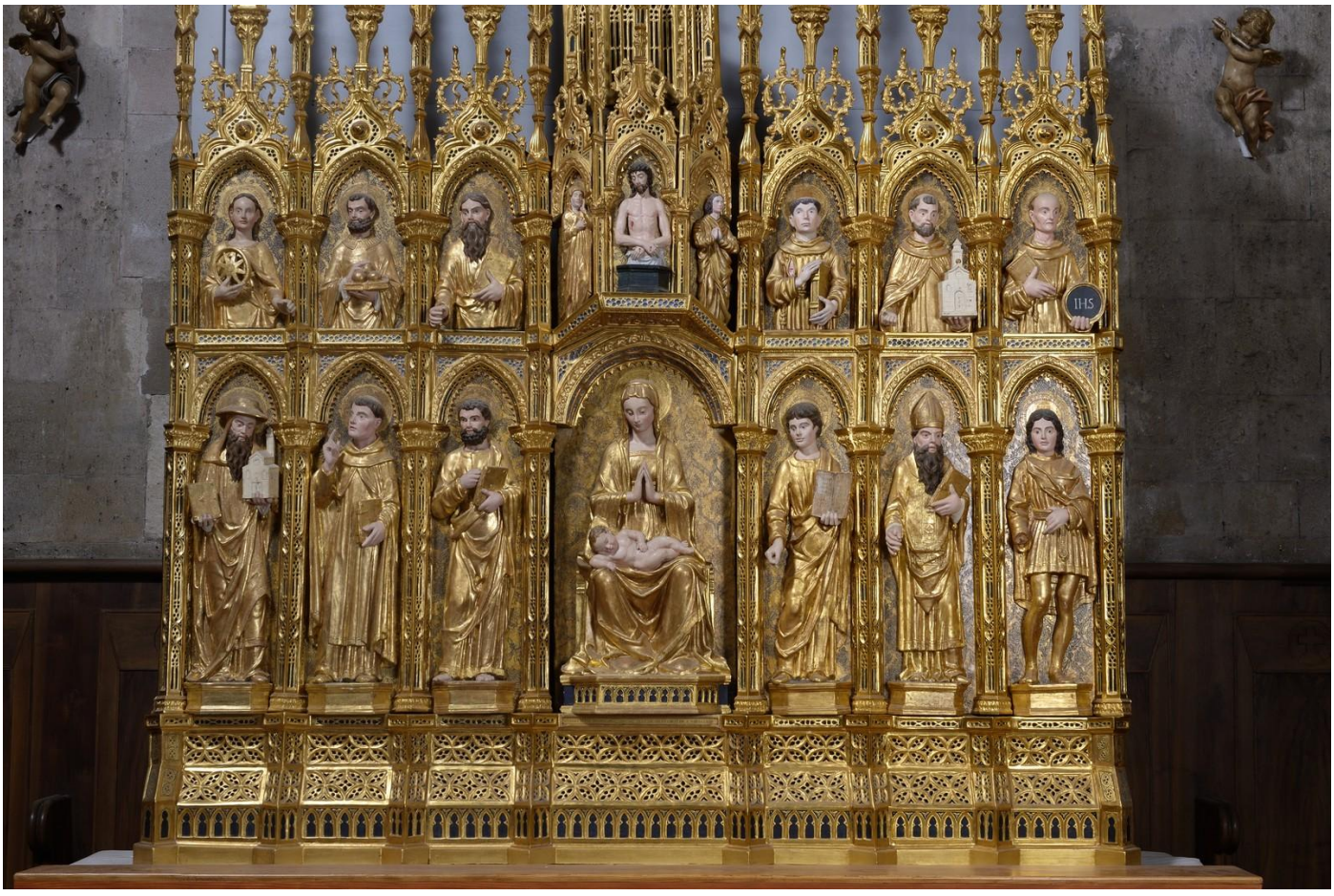

Figure 1. Venetian workshop, Pula polyptych, the second half of the 15th century (Pula, St. Francis' Church).

For this paper, it is essential to note that the fifteenth-century woodcarving shops emulated the typology of silver altarpieces. The most completely preserved example of this is the so-called Pula polyptych (Figure 1), executed for the high altar of the Franciscan church in the second half of the fifteenth century, probably by a Venetian workshop or, as recently proposed by Ivan Matejčić, by Andrea da Murano and his shop [10, pp. 112, 115]. The gilding covers most of the object's surface and all the draperies of the holy figures except for Christ's perizoma in the upper central panel showing the *Imago pietatis*, which is painted in white. The present state of the Pula polyptych has been compromised by several restorations in its modern and recent history, which gave the porcelain-like appearance to the faces and the rather cold tone of the gilding. Moreover, the removal of the varnish resulted in pale skin colours, and the gilding was reconstructed. Nevertheless, the overall intended glittering appearance of the piece remains.

Figure 2. Paolo Campsa and Giovanni da Malines, Virgin and Child, late 15th century (Tisno, Church of the Holy Spirit).

The nexus between the production practices of goldsmiths and woodcarvers and the fluidity between these media is critical to the concerns of this paper. One of the key pieces of evidence of the collaboration in the years around 1500 (that is, several decades after the Pula polyptych) is the Virgin with Child from the main altar of the Parish church in Tisno, tentatively attributed to the woodcarving circle of Paolo Campsa, and dated to the very beginning of the sixteenth century (Figure 2) [11, pp. 112, 115]. The surface of this essentially wooden sculpture is encased in a thin silver revetment, and only the yellowish skin of the two holy figures is left visible. It has been presumed that the silver cover was not original, i.e., that it was added to the wooden core of the piece later, at an undetermined moment. Such a practice, characteristic of older and venerable icons painted on panels, was also widespread in Dalmatia, with numerous icons still retaining the silver revetment. Such so-called "additions", which were regularly ex-voto offerings of pious individuals or groups, left only the skin on the faces of the Virgin and Child visible, as no alterations to the faces of holy figures were allowed [12, pp. 52-54].

The Tisno Madonna still awaits thorough investigation, yet scholars speculate that it was initially conceived with this silver cover on its surface [13]. Future technical research must corroborate or refute such a hypothesis, for the floral ornaments on the surface are impossible to date with certainty. If this were indeed the case, the object would be a rare transmedia accomplishment, which would not only mimic the precious material through the illusionistic drapery. In terms of chronology, moreover, this later example corroborates that the appeal for precious materials persisted well into the sixteenth century. However, while the glittering effect was retained on the Pula polyptych and the Tisno Madonna, most of the gilded wooden sculptures preserved on the Eastern Adriatic – to which this paper now turns – relatively soon changed their "skin", even after several decades, that is, in the very first campaign of their "renewal".

The changing skin of wooden sculpture

The Early Modern alterations to the polychromy of Adriatic woodcarving have rarely been discussed as a topic in its own right. The results of the restoration work conducted through the twentieth century on wooden sculptures from the area have remained largely unpublished or even entirely unrecorded. Subsequent layers of paint have generally been eliminated, and no records of their dating and visual properties have survived. It is, therefore, hazardous to investigate the approaches to their surface if not through a combined conservation and archival investigation. A more recent approach pays considerable attention to the "long lives" of wooden sculpture, but – almost as a rule – the results remain unpublished.

Regarding the varied approaches to the surface of sacral art in wood, take, for example, the surviving relief figures from the early- to mid-fifteenth-century triptych from the town of Cres. The middle-sized altarpiece, whose frame is lost, is considered to be stylistically proximate to the woodcarving circles of the Moronzone family of carvers, one of the most prosperous shops on the Eastern shore of the Adriatic (Figure 3) [14, 15, pp. 180-181]. Up to six layers of paint applied after the original one were determined in two conservation-restoration campaigns conducted through several decades: the first (in the late 1980s) involved only the central figure of Virgin and Child, while the second one (from 2006) concerned the side figures, Sts. Fabian and Sebastian [16].

The draperies were initially gilded, but the gilding has survived only in traces except on the surface of the draperies of Virgin and Child. Therefore, the restorers presented the third consecutive layer of overpainting on the side figures. Probes of two earlier (and the subsequent) layers were left visible both on the draperies and the incarnate. The viewer can, therefore, surmise that, over time, the tone of the incarnate was also changed, albeit with no compelling impact on the visual qualities of the figures (Figure 4). On the contrary, the subsequent layers on the draperies – brown, green, blue, and white – significantly altered the intended visual

effect of the carver of the Cres triptych. The corresponding procedure of the alterations to the surface can be traced on several other relief sculptures, such as the Madonna and Child from Cres, signed by Andrea da Murano and dated by inscription to the 1470s (the last digit of the number is effaced). In that case, however, only the original gilding was presented in the 2009 conservation-restoration work [17].

Figure 3. Unknown Adriatic carver, Virgin and Child and Sts. Fabian and Sebastian, ca. 1425 (Cres, Church of Saint Mary the Great).

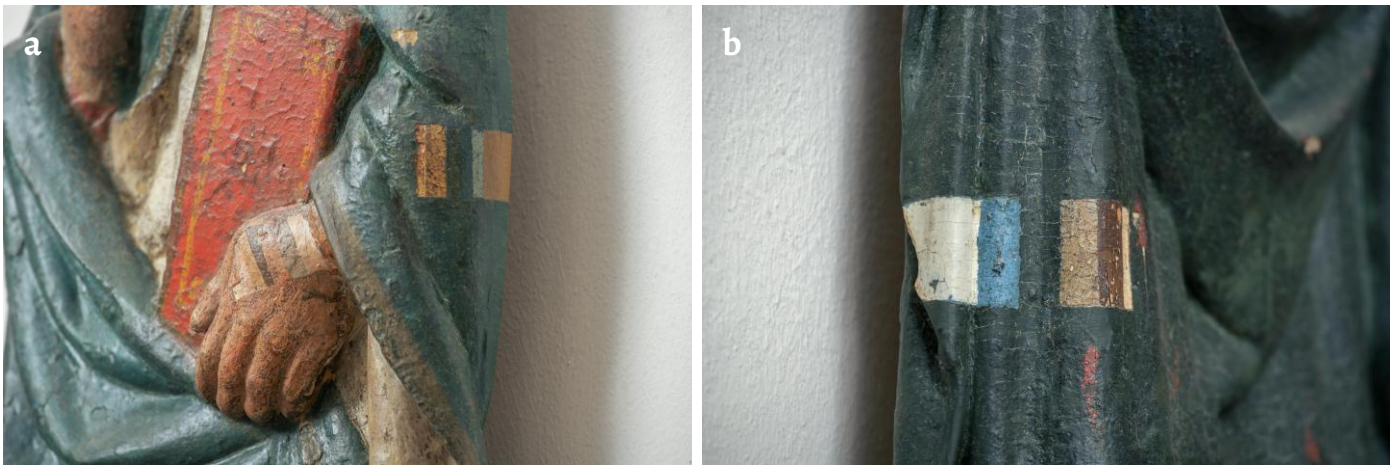

Figure 4. Stratigraphy of polychromy on the side figures of the Cres triptych: *a)* drapery and incarnate of St. Fabian; *b)* perizoma of St. Sebastian.

Gilded draperies were also characteristic of full-volume sculpture of the same period. Again, there is no need to look further than the sculptures of the same town. The recent technical investigation of the monumental simulacrum of St. Isidore, the patron saint of Cres represented seated on the throne, revealed that its original surface was similarly gilded, rendered decisively more lavishly than the present reddish paint, applied probably during the first half of the twentieth century. The rich ornamental decoration on the mitre and the sleeves has been determined on the smaller portions of removed polychromy (Figure 5); the research was conducted by Nives Maksimović Vasev (Gilda d.o.o.).

Figure 5. Unknown Adriatic carver, St. Isidore, last quarter of the 15th century (Cres, Church of St. Isidore).

The illusion of richer material was highly pertinent to the media of sculpture, as illustrated by the middle-sized Virgin and Child from Viganj (from the church of Our Lady of Rosary), probably dating from the last quarter of the fifteenth century. Scholars have argued that the pose of the Child, erected on the Virgin's lap holding a thin and transparent perizoma, whose end also serves as Mary's *peplum* with which she wipes the tears, is of Mantegnesque inspiration. The similarity to some of the most notable altarpieces painted by Andrea Mantegna, such as the San Zeno altarpiece for the homonymous church in Verona (finished in 1459), is telling in this respect (Figure 6) [18]. Numerous extant artworks attest to the circulation of compositions between the masters of different specialisations, and scholars largely agree that painted compositions were frequently translated into sculpture [19, 20, pp. 63-64]. Still, for the purposes of this paper, it is essential to underscore that in the said case, when the model was converted from two to three dimensions, the naturalistic treatment of drapery was replaced with gilding. In such a setting, the Viganj Madonna lost some of the main qualities of its "Renaissance" model.

The question of "style" is crucial in this regard, considering that by the middle of the sixteenth century, gilded surfaces of Venetian sculpture became much rarer than before. At least part of the reason why this effect of sculptures was changed in their first "renewal" lies in – generally speaking – a change of taste and different expectations of the appearance of sacral art. This can be further corroborated by sculptures not originally gilded, such as the Beautiful Madonna (*Schöne Madonna*) from Cres, produced in some central European workshop in the first decades of the fifteenth century. The circumstances of the sculpture's arrival to Cres are unknown, but it was the focus of an enduring cult until the late nineteenth century. Accordingly, it has been repainted no less than five times [21]. The Virgin's robe, as is characteristic to central European Beautiful Madonnas, was originally white on the outside, with a thin golden border running along the rich cascade folds dotted with lilies, and golden from the inside. The effect was not changed drastically in the first two repainting campaigns but was gradually annulled by the nineteenth century in favour of a decisively cooler pallet (Figure 7) [22].

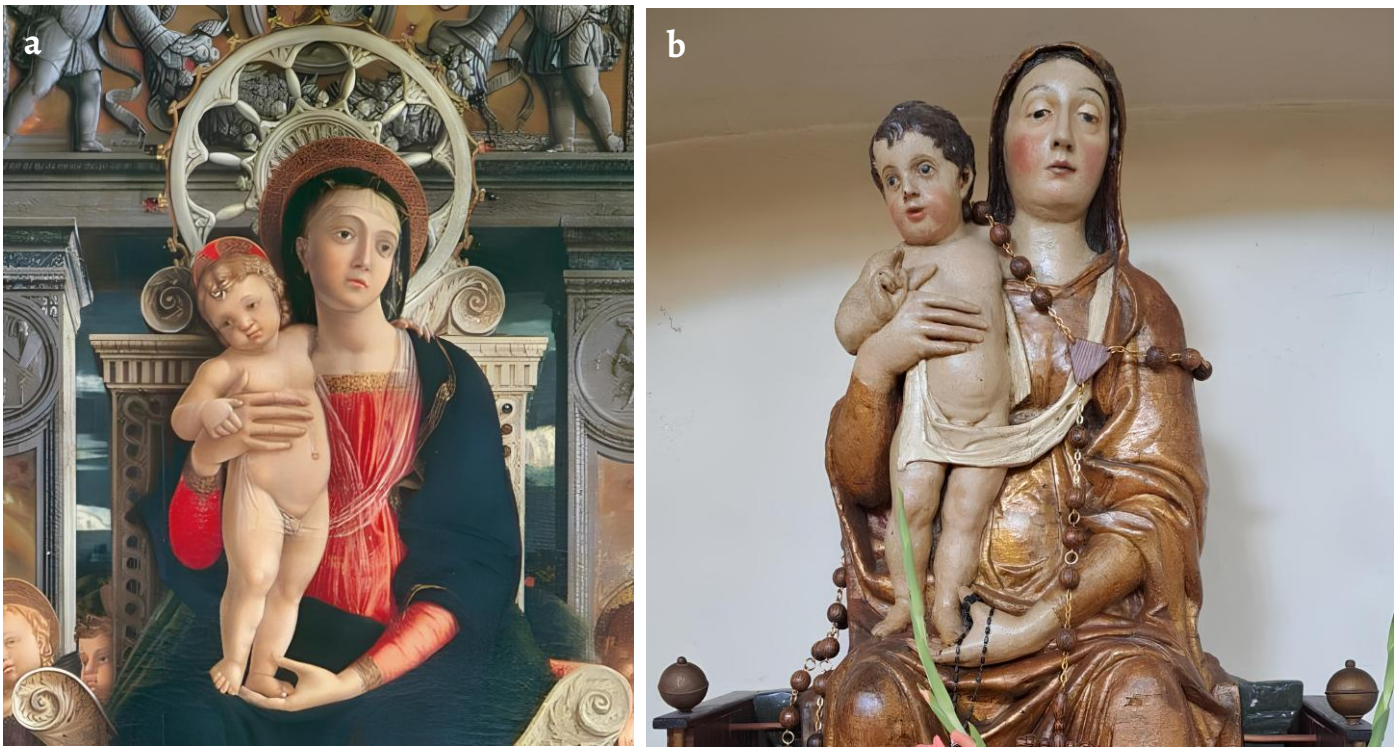

Figure 6. Comparison of the composition of: *a)* Andrea Mantegna, San Zeno Altarpiece, 1456–1459 at Verona, San Zeno Church (detail of the central panel depicting Virgin and Child); and *b)* anonymous Venetian carver (?), Virgin and Child, late 15th century, at Viganj, Church of Our Lady of Rosary.

Figure 7. The chromatic pallet of the Beautiful Madonna from the Parish Office in Cres, early 15th century (the present state of the sculpture dates from 2008; it included the original white drapery dotted with lilies and post-medieval colouring of the cascade-like folds of the mantle in blue).

Diverging approaches to polychromy: from wood to bronze

However, the afterlife of late medieval polychrome wooden sculpture in the Adriatic was not straightforward, as may be inferred from the cases analysed thus far. It had a peculiar twist, considering that the surface of several sculptures was altered in a reverse fashion. Some artworks of originally mimetic surfaces were repainted in such a way as to mimic precious materials. In such instances, the desired effect was rarely that of gold but rather bronze or marble: materials that were rarely mimicked at the time of the fabrication of sculptures. Among such instances, the older and venerable crucifixes can be singled out: the sizeable late-fourteenth-century crucifix from the Collegiate Church of Saint Mary in Kotor (Montenegro) and the adjacent figures of the mourners, Virgin Mary and John the Evangelist, which were added in the eighteenth century [23]. Although the sculptures were not initially gilded, they were transformed into objects made of bronze by new polychromy.

In the region under discussion, the practice in question was exclusive to monumental wooden crucifixes. There are also dozens of analogous cases in the Veneto region [24, p. 33]. There, it is presumed that the desire to possess "bronze" crucifixes was fuelled by the revered status of a specific devotional object: Donatello's bronze crucifix for the Basilica of Sant'Antonio, executed in the 1440s. The crucifix changed several locations within the interior of the Basilica, and the loincloth was remodelled in the seventeenth century [25-26]. The more nuanced understanding of how the material of the fifteenth-century Paduan crucifix was emulated by dozens of crucifixes across Veneto, but also (possibly) in Istria and the Adriatic, mainly in the eighteenth and nineteenth centuries, remains to be studied more thoroughly. Of course, the described change in taste, the shift from polychrome to monochrome, corresponds to the general trend of approach to the sculpture in the seventeenth and eighteenth centuries [27]. Admittedly, there was a practical side to this custom: new polychromy needed not to pay attention to the slightest detail to the rendering of the skin of Christ, wounds on the skin or the overall passion on the face.

The same was true for late medieval wooden sculptures covered in white to imitate marble or stone. The practice seems exclusive to the sculptures divorced from their original altar setting and employed as architectural sculptures. For example, the figures of the apostles executed in the 1420s for the choir screen of the Zadar Cathedral by Matteo Moronzone and gilded by Giovanni da Milano in 1431, were set atop the pilasters of its central nave of the Cathedral, probably in the eighteenth century [28]. Conservation research on sculptures is currently being conducted at the Croatian Conservation Institute. It has been determined that the sculptures were first repainted with a dark glaze, similar to the crucifixes already discussed, while several were repainted white: the new display of older sculptures required their appearance as statues made of stone and not polychromed figures [29, p. 63]. The same procedure was applied to other fifteenth-century sculptures, such as the sculptures of St. Jerome and St. Simeon, which originally adorned the high altar of the Franciscan church in Zadar. The pieces in question are exhibited in the Collection of the Friary; the statues were returned to their pristine appearance after the restoration campaign in 2006, so their alteration to a marble-like surface can only be captured through archival photographs [30, pp. 240-244].

Conclusion

The interventions to the surface of sacral art in wood through the centuries can generally be understood as purely practical. Indeed, the renewal of the gilded surfaces was a complex and decidedly more expensive task, which has, in many cases, been the main reason why the gilding was covered. However, even when subsequent layers of paint were rendered in much lower quality than the original, there was persistent motivation to introduce alterations and novelties to the chromatic pallets of sculptures. These alterations effaced the original glittering effect of

saints carved in wood, whose draperies were repainted into a more naturalistic pallet, mostly plain and free of any ornamentation. Yet, new polychromy – which is customarily considered of lower quality and side-lined in art-historical literature – could have been the critical step in prolonging the life of late medieval and Renaissance sculptures. Indeed, while it is often remarked that the changes in the composition of wooden sculptures through time were moderate to minor, the same cannot be argued for their frequently changed skin.

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Light, surfaces and materials: sculpting the imperceptible

Iluminação, superfícies e materiais: esculpir o imperceptível

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Abstract

Polychromy of Medieval and Early Renaissance sculpture can be painted, but also obtained with inlaid and using different materials. This paper focus on polymaterial sculpture and glazed terracotta sculpture in Tuscany, and the interplay between materials and lights – natural or artificial. Sculptors, indeed, used different materials and their surfaces – matte, glossy or shiny – in order to reinforce and convey the political or theological message to the beholder. They also adapted the device for the domestic setting, the interior of the ecclesiastical buildings or the façades of churches and civic buildings. Luca della Robbia's implementation of glazed terracotta technique, in the 1430s, considerably changed the relationship between sculpture, material, and light.

KEYWORDS
Sculpture polymaterial
Colours
Painted glass
Glazed terracotta

Resumo

A policromia da escultura medieval e renascentista pode ser pintada, mas também obtida com incrustações e utilizando diferentes materiais. Este artigo centra-se na escultura polimaterial e na escultura em terracota vidrada na Toscânia, e na interação entre materiais e iluminação – naturais ou artificiais. Os escultores utilizaram diferentes materiais e superfícies – opacas, brilhantes ou lustrosas – para reforçar e transmitir a mensagem política ou teológica ao observador. Também adaptaram as esculturas ao ambiente doméstico, ao interior dos edifícios eclesiásticos ou às fachadas das igrejas e edifícios cívicos. A implementação da técnica da terracota vidrada por Luca della Robbia, na década de 1430, alterou consideravelmente a relação entre a escultura, o material e a iluminação.

PALAVRAS-CHAVE
Escultura polimaterial
Cores
Vidro pintado
Terracota vidrada

Introduction

Looking closer to Late Medieval and Renaissance polymaterial sculptures in Tuscany allows new and capital insights for the understanding of the transfers between techniques. Building on the elements emerged from comparative analyses, we will focus on the links between Tuscan workshops and, in particular, the ties between inlaid stone sculpture and glass production.

To better define our topic, polymaterial sculpture corresponds to ornamentation resulting from the free use of materials of different natures or colours in various combinations, and it is characterised by the simultaneous visibility of materials [1]. Understanding the relationships between the materials and techniques used is essential to a deeper understanding of the sculpture itself. The materials, their treatment, their assembly and their colour are a fundamental dimension of the plastic and figurative language. The polychromy, both painted and provided by the materials, which originally enhanced medieval sculptures, played a full part in the visual strategies designed to immerse the faithful and encourage total devotion [2]. The material value of the sculptures was as decisive as the semantic content of the materials and colours, which were very often luxuriant [3-4]. The pictorial aspect that results from the use of different materials gives a naturalistic aspect to the stone sculptures and sublimated representations from both an aesthetic and spiritual point of view. Exploiting the multiformity of materials, the figures reinforced their anchorage in the earthly world, but also their capacity of evoking the heavenly world. The variety of surface and light effects, the diversity of materials and their colours, functioned as a stimulus for the faithful, activating the meditation through a sensory experience. Moreover, particularly in the late Middle Ages and early Renaissance, polymateriality and polychromy confronted the faithful with the spiritual dimension of sculpture. *Varietas*, the multiplicity of elements assembled with skill and virtuosity in relation to one another [4], together with polychromy and ornamentation, participated in the quest for the apprehension of the divine word [5]. The variety of materials and the plural nature of the elements of the objects are intended to help the mystical experience. Like the Holy Scriptures, which reveal divine law to mankind, polymaterial creations were themselves charged with various narratives and mental images revealing the abundance and diversity of Creation [6].

The relationship with sight, and more particularly with light, is an important issue in this type of polymaterial work [7, pp. 132-134]. The use of glass or majolica inserts is ubiquitous in Tuscan artistic production: thanks to the diversity of their surface effects (smooth, shiny, matt), they reflect the different sources of light offering shimmering colours that vary according to the time of day and the light source. Like the glassy surfaces of stained-glass or mosaics, those inserts enhanced the representations from both an aesthetic and spiritual point of view, making it easier to read the episodes they highlighted.

The relationship between materials and light has undergone a remarkable change in Tuscan art between fourteenth and fifteenth centuries [8, pp. 29-33]. Looking at sculptures for religious building – in and outside – or to private devotion, this paper aims to study the different techniques employed to enhance space, depth and figures and to make the spiritual message perceptible in the interplay with different sources of light, both inside the private residences and the churches or on the exterior of religious and civic buildings. Luca della Robbia's invention of glazed terracotta inserted in this quest but aimed to answer those formal and spiritual needs with a unique material. This deep technical renewal played a major role in the neglecting of polymateriality.

Artificial lighting in enclosed spaces: devotional reliefs and glassmakers' influence on sculptors

The use of images in devotion has been an established area of research for a century [9-12]. The devotional image – as it emerged at the end of the Middle Ages and as defined by Erwin

Panofsky – is characterised by a combination of format and specific function [13]. In private devotion, it "allows the viewer's individual consciousness to immerse itself contemplatively in the content being meditated upon, and allows the subject's soul to merge, as it were, with the object" [14, p. 14]. Building on cognitive studies, Mary Carruther reinforces this point by explaining the function of senses in a devotional space: the objects allow the reactivation of the art of memory through emotions to get the attention of the devotee [15, pp. 116-118]. Hans Belting, on his side, showed that the *imago pietatis* could serve sacramental as well as devotional purposes, and that the traditional distinction between ecclesiastical public worship and private domestic devotion was not strict in practice [16]. Against the assumption that images have a unique established function, these studies show that the meaning of images is constructed through practices and uses [8, pp. 29-33]. To understand how an "image-object" [17] – i.e. the artwork considered as an object inscribed in a place invested with a specific value – works, it is necessary to take into account the nature of the images, their social or symbolic significance and their liturgical functions in their setting. This is even more important for polymaterial sculptures, especially for those presenting vitrified inclusions.

Like the many small-scale bas-relief Madonnas, the Madonna and Child, known as the *Madonna Goretti Miniati* (Figure 1), was intended for private devotion. The tradition of owning devotional images dates back to the beginnings of Christianity [18, p. 111; 19, p. 51; 20, p. 101]. However, in the Latin world, this tradition of religious image acquired a profound theological justification only with the Scholasticism [21, p. 72]. The images we focus on here are mainly the icon-inspired half-body representations referred to by Guillaume Durand as *picturae dimidiatae* and discussed by André Chastel [22] and Jean Wirth [23, p. 23]. In this context, these images play an important role in the development of religious affectivity, reflected in the attitudes and behaviour of Christians to the end of the Middle Ages to the end of the Middle Ages [24].

Figure 1. School of Donatello, *Madonna and Child*, known as *Madonna Goretti Miniati*, c. 1430, marble, blue glass inlay, Florence, Bargello.

This bas-relief shows a nimbed Virgin Mary carrying the Infant Jesus in her arms. Originally, the Virgin's halo, cloak and arm showed traces of gilding [25], now invisible to the naked eye. Both placed in line with a window, they are viewed from a slight three-quarter angle, marking out the lines of the rectangular room.

The main purpose of the window, which is materialised here by the blue glass inserts, is to mark the space visually [26]. Immersed in a deep blue, the two figures stand out thanks to the luminous effects of this blue-light, allowing the faithful to meditate on the absolute model of filial and maternal love. The setting in this image, combined with the traditional position of the Virgin and Child, gives it a timeless reality, while retaining the characteristics of the antique style that distinguish spirituality from physical existence [16].

The deep blue used to materialise the scene is associated with sapphire. In the Old Testament, this precious stone had a direct link with God and the celestial spheres, and was at the frontier between light and matter. Its vivid colour evoked the heavens, and more specifically the promise of celestial life announced by God [27, pp. 329-332]. In this context, the richness of the hue and the effects of brilliance and shimmer reinforced the effectiveness of the devotional content of the image and accentuated its sensitive dimension. Thanks to the meditative and performative power of the scene, which came to life as the devotee's lights and movements changed, the image functioned as a stimulus that produced mental images in the devotee.

The attribution of this bas-relief is not completely established. The inserts indicate a source close to Donatello or Michelozzo, both of whom enjoyed experimenting with materials. The blue glass of the background, in particular, creates an architectural setting reminiscent of the *Madonna del Perdono* (Figure 2), now in the Museo dell'Opera di Siena. Although not entirely by Donatello, the *Madonna del Perdono* is an important work in his catalogue. Among all Donatello's surviving Marian reliefs, this *tondo* is the only one to have been commissioned and designed not for private, domestic use, but for a monumental public display [28]. It is precisely for this reason that Donatello has elevated this Marian image in a project that presents a real optical challenge to the viewer, which is a peculiarity of this sculptor [29-30].

Figure 2. Donatello, *Madonna and Child with Four Cherubs*, known as Madonna del Perdono, c. 1457-1459, marble, blue glass inlay, Siena, Museo dell'Opera.

Comfortably seated, the Virgin Mary is depicted in a three-quarter view, with the Child seated on her mother's legs. Presented in the Celestial kingdom, several cherubs, signified simply by their heads, are crowding around them.

The *tondo*, similar to an *oculus*, acts as a window open onto Mary's kingdom, only half revealing the scene. The Virgin and Child's Glory could only be partially seen by the faithful, who were looking up on the scene constrained by its round frame. For this reason, the Virgin was sculpted in a progressive overhang, from the bottom upwards, and that her nimbus is so pronounced. As Enzo Carli reminds us, the expressive power and plasticity of the scene are undeniably more pronounced when viewed from below than if the bas-relief had been presented head-on [31, pp. 35-36]. While the Virgin's face appears elongated and sullen in a frontal view, it can be fully appreciated for its suppleness and roundness when viewed from below, and it gains in tenderness and melancholy. To reinforce the window-like appearance of this *oculus*, Donatello and his workshop decorated the thickness and depth of the marble with inserts of blue glass forming a coffered ceiling.

For a long time, the sculptor's original intention was incomprehensible because the relief was moved due to Bernini's rebuilding of the chapel of the *Madonna del Voto* in 1660. Placed in the lunette above the south portal of the transept, known as the Porta del Perdono, this bas-relief was exposed to the elements. Seriously damaged, the sculpture had lost many of its inserts, and the two remaining ones were tarnished before restoration work was carried out between March 1988 and July 1990 by Annamaria Giusti (restoration director) and Ernesto Tucciarelli (restorer) [32].

These glass inclusions were not only ornamental, but also create an illusory three-dimensional and perspective effect that could be appreciated from the point of view of the faithful crossing the doorway to the *Cappella delle Grazie*. In the apparitions, the Virgin is described as surrounded by a beautiful celestial radiance [33]. Ornamentation was therefore used as a means of honouring the Virgin in the image. The Virgin's role in the history of salvation and her role as mediator between earthly reality and the afterlife means that we need to understand her central position in Christianity. When the faithful entered the chapel, the Virgin and the panels of tinted glass sparkled and were illuminated by natural light and the oil lamps placed around them in the chapel. The special nature of this lighting system evoked the presence of God and became an indicator of holiness. This decorative system and the resulting reflections arise from a long tradition that was already well established in the Middle Ages. Glass, like many other materials, could be used to create effects of colour, surface and light that fascinated and captivated the beholder. Indeed, more than the glass itself, it was the search for light that was paramount in many works, whether painted or sculpted, polymaterial or otherwise. Light is part of the sacred, because God himself is light. As a result, anything that helps to produce, transmit, disperse or multiply the light is associated with devotion [34]. Because of its position, high up in the lunette overlooking the altar and the painted panel of the *Madonna delle Grazie* in the chapel [35], the *tondo* functioned like a stained-glass window. Thanks to its location, it offered the faithful a spectacle of light, where the blue, symbol of purity and the celestial kingdom, was in perpetual movement, animated by the undulating flames of the nearby candles and lamps. In this way, the surface of the stone was dematerialised and functioned like an open window to the heavens.

The special nature of this light system evoked the presence of God and became an indicator of holiness. The presence of the Marian image thus served to make sacredness visible; by representing the "heavenly sovereign" in the human appearance he adopted through the "Incarnation".

Shimmering in the sunlight: polymaterial sculpture for the façades

In the last decades of the twentieth century in Italy, the restoration of stone objects evolved beyond the simple cleaning of surfaces, revealing the elements of colour still present on the works. This marked the beginning of research into the preparation, finishing and colouring of stone surfaces, which were becoming increasingly evident [36]. Restoration files and analysis reports, rich in the results of diagnostic investigations, are a fundamental element in establishing a dialogue between the sciences and the arts, and provide a better understanding of polychromy and polymateriality.

The bell tower of Santa Maria del Fiore (Figure 3), built between 1334 and 1359, has a very complete iconographic cycle with a strong theological message, making it the second largest theological programme in medieval Florence, the first being the patristic and biblical mosaics in the Florence Baptistery [37]. The Campanile cycle is conceived as a scholastic and humanist cycle, based on an Aristotelian scheme derived from the doctrine of Saint Thomas Aquinas, which reconciles the demands of the Christian faith and the affirmation of Being as a universal reality [38].

Figure 3. Campanile di Giotto, 1337-1342, Florence.

In this cycle, each relief, whether hexagonal or lozenge-shaped, is linked to a human activity or an art that is revealed as an essential element in the vocation to know God. All human knowledge, whether manual, related to the arts or theology, is brought back to its primary source, God. In this way, the earthly skills have been arranged in hexagonal reliefs, with backgrounds painted blue [39]. Apart from the architecture, which features small black marble inserts, there are no inlays on this level.

Polymateriality, instead, has been reserved for the lozenge reliefs relating to celestial spheres (Figure 4). They represent the *Planets* (west side), the *Virtues* (south side), the *Liberal Arts* (east side) and the *Sacraments* (north side). Here, the painted backgrounds were replaced with inserts of glazed blue majolica. Exposed to the elements, in the centre of the city, the inserts were covered in micro-organisms and tarnished by pollution. As a result, until the 1980s, the majolica did not appear in its original state, but looked like painted backgrounds. The cleaning process has enabled us to gain a better understanding of how the sculptures interact with day light. While the deep blue paint of the hexagons remained matt and did not react to the sun, the lozenge-shaped reliefs, inlaid with blue majolica, detached the figures and brought out their modelling against a shimmering blue background that modulated according to the hours of the day and the intensity of the sun. This way, their different appearance clearly indicated to the beholder the distinction and emplacement of the terrestrial and celestial spheres.

The choice of majolica instead of glass, is probably due to the solidity of this material, that offers comparable mutability properties and very similar effects. Glass is more fragile and would become detached, tarnished or broken.

Figure 4. *Venus as planetary divinity*, 1337-1342, marble and majolica, Florence, Museo dell'Opera della Cattedrale di Firenze.

The allusion to the celestial spheres was usually made through the colour and position of the blue background with inserts, whether in majolica or glass. The use of inserts in coloured materials with a high degree of reflectivity, as we have just seen, was widespread in Tuscany, and particularly in Florence, from the fourteenth century onwards [40, 41, pp. 91-102]. The Loggia dei Lanzi, built in the 1380s, and in particular the compartments of the *Virtues*, are a continuation of the research into the plastic materialisation of the Kingdom of Heaven through the use of reflective and shiny materials. The upper sections of the Loggia, formerly known as the Loggia della Signoria, feature the four *Cardinal Virtues* and the three *Theological Virtues* in four-lobed forms, sculpted in marble between 1383 and 1391 to designs by Agnolo Gaddi [42]. For some polymaterials – we are thinking, for example, of the bronze crown placed on the head of the *Faith* – these marble representations were enhanced with paint and gold to highlight details of the figures' hair and dresses, as can still be seen on the *Temperance* (Figure 5). These touches of colour complemented the polychromy produced by the blue inlays on the backgrounds, which were originally made of ceramic [43, pp. 13-36]. During the twentieth century restauration, those backgrounds have been entirely replaced with glass, with the exception of the *Prudence*, whose background has been reconstructed with ceramic tassels [44]. The construction of this loggia began at a decisive moment for the affirmation of Florentine republican identity, which was seeking to assert itself against the great powers of the Italian peninsula [44].

The conflict between the Holy See and Florence in 1375 prompted the Florentine humanists to establish Florence as the leader of the free communes. The Loggia was part of this project. Its strong symbolic dimension played a very important role in the city's political and religious events [44]. This loggia was intended to give the gonfaloniers and priors their office, but also to house government representatives during public ceremonies in the presence of the people [45]. Placed in the upper parts, they personified the image of good government and its virtues, as represented in Anjou imagery [44]. The decorative system of polymateriality and their position in the spandrels of the arches allowed them to dominate the building as a whole, making them visible from the Piazza della Signoria. The *Virtues* were reflected in their own background, depending on their exposure to the sun, and thus came to life as the hours passed in the quatrefoils. The blue glass or ceramic backdrops were dotted with gold stars, helping the marble figures to stand out against the *pietraforte* of the building, creating a strong contrast. Both the iconography and the staging of these images served to affirm the importance and decision-making power of Piazza della Signoria in the Trecento.

Figure 5. Agnolo Gaddi, *Temperance*, c. 1380, marble and blue glass inlay (eglomised glass), Florence, Loggia dei Lanzi.

The everlasting solidity of the material was highly praised also for Luca della Robbia's new technique, the glazed terracotta sculpture. As Giancarlo Gentilini and Marco Collareta, among others, demonstrated, the luminous quality of the surface was much more important in Luca's first attempts intended for church interiors, but the resistance to elements was also a key factor of his success [46-47]. The heraldic program of Orsanmichele in the around 1450s offers a precious perspective on the dialogue between techniques.

The ancient *loggia* of the grain market, transformed into a church, received not only the niches and the statues of the Saints of the Florentine guilds, but also the heraldic medallions of those guilds, placed on the second level of the building. Some of them were fresco painted – and are, thus, very badly preserved – while others took advantage of Luca della Robbia's new medium.

According to Giancarlo Gentilini, the first glazed medallion was, around 1450, the one of the *Maestri di Pietra e Legname* – the guild of stone and woodcarvers, to whom Luca himself belonged [48, pp.153-161]. This medallion is neither a polymaterial nor a three-dimensional sculpture and, nevertheless, it is of the greatest interest to understand Luca della Robbia's meditation on the use of glass and ceramic inserts or marble inlaid in his predecessors' works (Figure 6).

An interesting point to understand Luca's formal choices was made by Suzanne Butters: she noted, for the first time, the importance of the hagiography of the patron saints of the guild, the *Four Crowned Martyrs*, portraited by Nanni di Banco in the Tabernacle underneath the medallion [49, pp. 176-180]. According to their *Passio*, the four saints were sculptors working in porphyry caves in Pannonia under Diocletian, unparalleled skilled in carving ornament from that hard stone: the central roundel, purple and decorated with acanthus, would then directly refer to their work, rather than to a textile. The presence of Cosmatesques motives, as the quincunx – already noted, for instance, by John Pope Hennessy – would also refer directly to the Roman eponym basilica [49-50]. The motifs, shape and colours, thus, would not only present the heraldry of the stone and woodcarvers, but also enrich and comment the marble niche with the patrons' statues.

Considering this meta-reflection upon sculptors' work, however, the choice of a flat painted support – and one of Luca's finest works in this field – appears even more intriguing. According to John Pope-Hennessy, the reason is to find in the pre-existent fresco painted heraldic medallion, and the flat-painted glazed terracotta would have been, thus, a simple replacement [50]. The perception and the interaction with the light, however, is profoundly different: the motif painted and glazed appears much closer to an opaque stained glass rather than a fresco painting.

Figure 6. Luca della Robbia, Heraldic Medallion, stone and wood carvers (Maestri di Pietra e Legname), c. 1450, Glazed Teracotta, Florence, Orsanmichele.

The *stemma*, however, is not "simply" painted: as pointed out by Giancarlo Gentilini, the technique also recalls the mosaic or the *tarsia* [48, pp. 153-161]. Indeed, due to an experimental technique of glazing a gilded surface, the heraldic motives and the background could not be fired together and are thus assembled afterward as a mosaic. Due to its location, the Orsanmichele medallion is difficult to study closely, but the technique is strictly comparable to the gold-glazing attempt in the frame of the *Monument of Bishop Benozzo Federighi*, nowadays in Santa Trinita (Florence), also not very successful [51-52]. The recent conservation treatment has shown that the glazed mosaic is strictly comparable to the inlaid of marbles. Luca, trained as a marble sculptor, probably in Nanni di Banco's workshop, certainly was familiar with this technique, largely employed, for instance, in the *Four Crowned Martyrs* niche. In other tabernacles in Orsanmichele, moreover, the marble niche also shows a glass mosaic inlaid. For instance, in Niccolò di Pietro Lamberti's *Madonna of the Rose* (1399), the background is covered with a mosaic of blue and gold-foil glass mosaics [53]. The same technique, with a different pattern, is also to find in the niche of *Saint James Major*, also by Niccolò di Pietro Lamberti, probably made around 1420 [53].

The glazed terracotta mosaic, thus, recalls some of the techniques largely employed by the Florentine sculptors and, in that sense, is complementary to the marble sculpture of the niche.

The perception of the medallions by their beholders on the Florentine street, however, is much more related to the flat, reflective surface and put Luca's work in a direct dialogue with the art of stained glasses.

Natural and artificial light: glazed terracotta and stained glasses

The reference to stained glasses in Luca della Robbia's glazed terracotta *œuvre* becomes more evident if we come back to the figurative production intended to the church interiors. The cycle of the *Apostles* in the Pazzi Chapel – in the first cloister of the Florentine convent of Santa Croce – seems a good example in this sense and will also contribute to a better understanding of the complex role of Filippo Brunelleschi in the ornamental project of this chapel.

Before looking to the glazed medallions, a brief point on the building is needed: we must consider, indeed, that this analysis is complexified by the lack of documents for the dating of the building and its decoration. However, it is currently admitted that the construction began about 1429-1430; the building was still in progress in the 1450s, and the inner dome was covered in 1459, while the mall dome of the portico in 1461 [54]. As Brunelleschi died in 1446, more than a decade before the achievement, many concerns have arisen about the respect of the original project, but it commonly accepted that the interior of the building follows his project, while the exterior porch, with its small dome, is a later addition [55].

The interior of the chapel shows the typical, sober contrast between the dark-grey structural elements in *pietra serena* and the white walls, only enhanced by the twelve grazed terracotta medallions in white and blue, showing the *Apostles* and, in the entablement, by a painted terracotta frieze with cherubs and *Agnus Dei*. The square apse has no altarpiece, but the window shows a stained glass with a standing *Saint Andrew*, surmounted by a roundel with the *Holy Spirit*. The central space is covered by a small dome, with twelve oculi, and its pendentives are filled with polychrome glazed terracotta medallions showing the *Four Evangelists* (Figure 7).

The attribution of the *Apostles* to Luca della Robbia, with some assistance from Andrea della Robbia on the last phase, is widely accepted, while the dating is not firmly established: Gentilini proposes a large span of time, going from the *Saint Peter*, about 1445, to the *Saint Thomas*, about 1465-70 [48-50]. The polychrome *Evangelists* are more problematic both on their date and their attribution. The style of the figures tends to exclude Luca della Robbia's paternity: among the last hypothesis, Pope-Hennessy suggested the name of Donatello, with Andrea della Robbia's glazing, while Gentilini proposed Filippo Brunelleschi, collaborating with Luca della Robbia [48, 50, 56].

Figure 7. Filippo Brunelleschi (architectural project), Pazzi Chapel, c. 1430-1459, Florence, Santa Croce.

Figure 8. Luca della Robbia, *Saint Peter*, 1445-1450 c., Glazed Terracotta, Florence, Santa Croce, Pazzi Chapel.

The figures of the *Apostles* are entirely white, seated on clouds against a blue background. In the four oldest medallions, on the east wall, probably made in the 1440s, this background is made with concentric circles of different shades of blue, going from the lightest in the middle toward the darkest on the exterior, while the remaining eight medallions, probably made some years later – around 1460-70 – have uniform blue backgrounds (Figure 8).

The concentric shades of blue clearly respond to the light: not the natural light, coming from the windows in the west façade, as thought by Carlo del Bravo, but to the light emitted from the figures themselves, as pointed out by Catherine Kupiec [57-58]. The *Apostles* are, thus, the symbolic sources of light of the chapel: Millard Meiss, followed by Paul Barolsky, already noted the connection between the twelve *oculi* of the dome and the glazed relief, indicating the medallions as an "extension" on the walls of the spiritual light coming from the dome [59-60].

The symbolic function of the medallion as "sources of lights" reinforces link to the stained glasses, and several material and formal elements also go in this direction. The first one concerns the concentric circles of the background: this device has been read as a condensed representation of the Heaven, as in various fourteenth and fifteenth century paintings [61]. However, a much closer model could be recognised in the stained glasses of the *oculi* in the Florentine cathedral: both in Lorenzo Ghiberti's *Assumption* in the façade and in almost all the episodes of the *Passion* in the drum of the dome, the blue background is formed by concentric circles. A further element that could have reinforced the perception of the *Apostles* medallions as self-luminous *oculi*: on the walls of the Pazzi Chapel, just beneath of the *pietra serena* frames, are still visible some metal hooks. Those hooks are still visible on the Northern side of the chapel, but on early twentieth century photos they also appear on the other side, one under each medallion. Nowadays, those hooks have no function, but it seems highly probable that they held some kind of artificial lighting, such as oil lamps (Figure 9). Joined to the light coming from the dome, the flickering artificial lighting from the bottom should have reinforced the heavenly, luminous presence of the *Apostles*.

The most decisive connection between the glazed terracotta and the stained glasses, however, resides in the choice of the materials themselves and further reinforces the hypothesis of a Brunelleschian paternity for the *Evangelists*. Indeed, as mentioned in the rapid overview of the chapel, all the figurative elements present in the chapel are either in glazed terracotta – *Apostles*, *Evangelists* – or in stained glasses. This choice seems to follow Filippo Brunelleschi's concerns to the respect of spatial unity of his architectures: Alison Luchs demonstrated the architect's aversion to painted altarpieces, perceived as an unfortunate insertion breaking this unity, while the stained glasses could absolve the same function without this problem [62] (Figure 10). The polemic reception of Donatello's stucco medallions in the Old Sacristy can also be read at the light of the loss of spatial unity of the architecture. The very simple spatial layout of Luca's *Apostles*, on the reverse, was interpreted by Catherine Kupiec as a way to preserve and reinforce the unity of space of the chapel [57].

Figure 9. Filippo Brunelleschi, Pazzi Chapel, archival photo (Florence, Kunsthistorisches Institut).

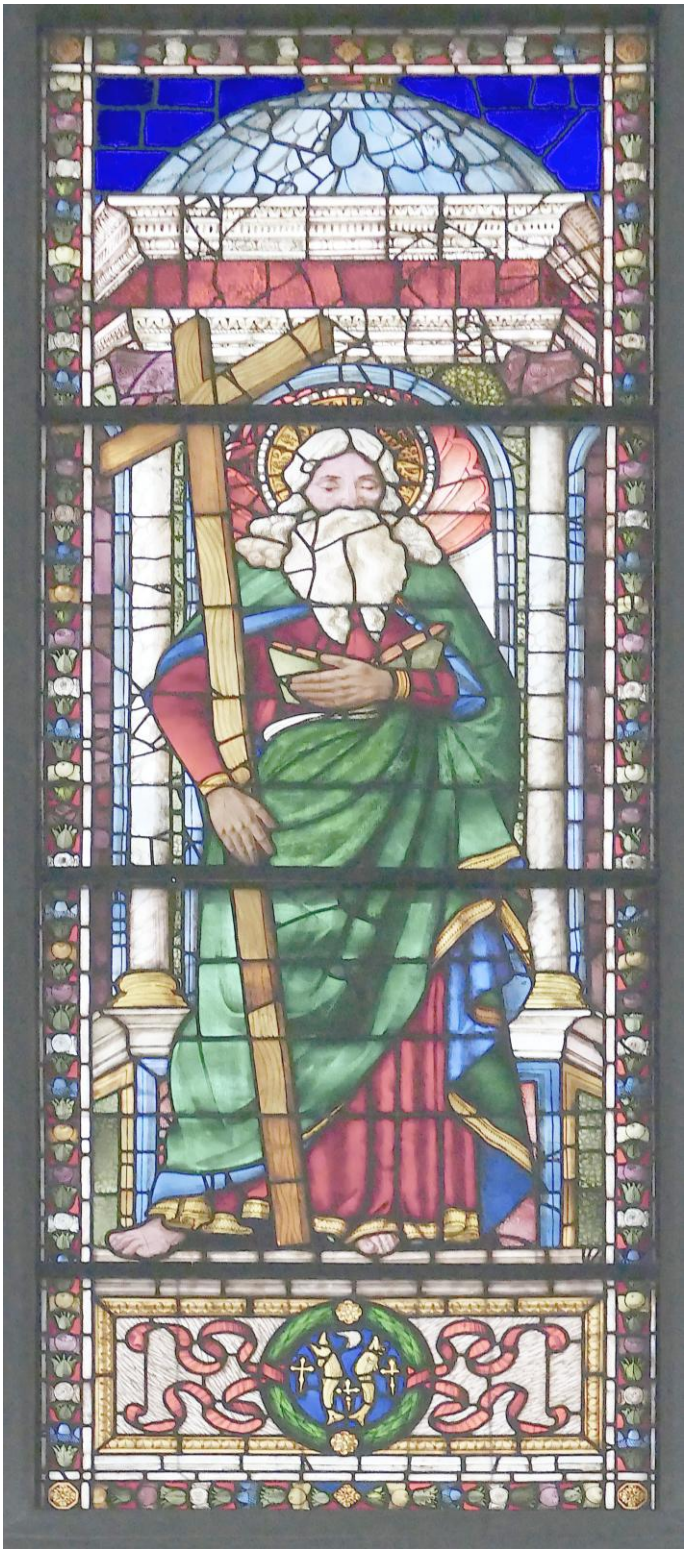

Figure 10. Alesso Baldovinetti, *Saint Andrew*, Stained glass, Florence, Santa Croce, Pazzi Chapel.

In fact, we think that the material proximity between the figures in stained glasses and the glazed images, and the similar way in which they react to the natural and artificial light is even more important in this sense.

If this hypothesis is correct, the whole decorative program of the chapel – including the *Evangelists* – looks much more unified and dependent from Filippo Brunelleschi's project.

The comparison between Donatello's medallions in San Lorenzo and the *Evangelists* can also be read in this sense: while the stucco medallions perspective breaks the space of the architecture, the *Evangelists* respect the "members and bones of the architecture", as Carlo

Ludovico Ragghianti demonstrated [63]. The attribution of those medallions to Brunelleschi, already proposed by Adolfo Venturi, Paolo Sanpaolesi and Giulio Carlo Argan among others, had been refused by John Pope-Hennessy – who advanced Donatello's name instead – but more recently reaffirmed by Giancarlo Gentilini, as a bright, luminous answer to Donatello's stucco [46, 64-65]. The choice of a natural polychromy, often perceived as antithetical to Brunelleschi's idea, would, on the contrary reinforce the link to the stained glasses and, thus, the unity of the program.

The diversity of materials used in Tuscan sculptures of the fourteenth and fifteenth centuries shows the range of artists' research about the interplay of reliefs and light and perception. Glass and majolica, as well as inlaid, were widely used in Late Medieval sculpture to enhance the visibility, the symbolic significance and, ultimately, the agency of the sacred images. The first generation of Renaissance sculptors – and especially Donatello and Luca della Robbia – built on this tradition. Donatello's *Madonna del Perdono* and Luca's glazed medallions perfectly show the sculptors' reflection on this tradition, but also the span of their technical innovation, in the mastery play with natural and artificial light and with the beholder's point of view.

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Pastiglia relief and sgraffito: a study of the polychromy on a late Medieval English alabaster altarpiece

Pastiglia e esgrafitado: estudo da policromia de um retábulo medieval tardio inglês em alabastro

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Abstract

English late medieval alabaster altarpieces and fragments of such, are preserved in many countries in Europe. Scientific examination of the polychromy on alabaster carvings has provided new information about materials and painting techniques employed. The elaborately polychromed wooden frameworks of this type of altarpieces remain unstudied so far. Only a few original frameworks are preserved intact, amongst these one belonging to the Passion altarpiece from the convent of Reynistaður, now kept at the National Museum of Iceland. The article presents the results of the examination and analysis executed on selected features of the polychromy on this altarpiece. A sgraffito décor mimicking chain mail on the alabasters is shed light on, as well as sgraffito and pastiglia décor on the framework. Light microscopy, XRF and analysis of cross sections with SEM-EDS, Micro Raman and ATR-FTIR provide insight into the production of this group of works and the employed pigments and binders.

KEYWORDS
Late medieval
England
Altarpieces
Alabaster
Polychromy
Material analysis

Resumo

Os retábulos e fragmentos de retábulos medievais tardios ingleses em alabastro estão preservados em vários países europeus. A caracterização analítica da policromia destes alabastros tem contribuído com novas informações sobre os materiais e as técnicas de pintura utilizadas. No entanto, a policromia complexa das molduras em madeira destes retábulos continua por estudar. Apenas algumas molduras originais se mantêm intactas, entre as quais uma pertence ao retábulo da Paixão do convento de Reynistaður, atualmente no Museu Nacional da Islândia. Este artigo apresenta os resultados de exame e análise realizados sobre características particulares da policromia deste retábulo. Destacam-se a decoração em esgrafitado que imita a cota de malha nos alabastros, bem como a decoração em esgrafitado e pastiglia na moldura. A microscopia, o XRF e a análise de seções transversais com SEM-EDS, Micro Raman e ATR-FTIR contribuem para a compreensão da produção deste grupo de obras, assim como dos pigmentos e aglutinantes utilizados.

PALAVRAS-CHAVE
Medieval tardio
Inglaterra
Retábulos
Alabastro
Policromia
Análise material

Introduction

Altarpieces with carved and polychromed alabaster panels inserted into wooden polychromed frameworks from late medieval England were sought-after in the fifteenth and early sixteenth century. These were usually rectangular triptychs which could be closed by folding their lateral sections over the centre. The most common types of such altarpieces were *Passion* cycles or cycles of the *Life of the Virgin*, however, there were also cycles dedicated to other Christian saints. English late medieval altarpieces are distinctive in appearance, not only due to the late Gothic style in which they were carved, the composition of the narrative scenes, their iconography, but also in the way the framework and alabaster carvings were polychromed.

Examples of English late medieval alabaster altarpieces, series of alabaster panels, or fragments of such, are preserved in many countries in Europe [1-2]. Recent research seeks to reassess their significance within the corpus of preserved late medieval cultural heritage [3-6]. Furthermore, the study of their polychromy using scientific examination methods has provided valuable new information about materials and painting techniques employed [7-9]. The elaborately polychromed wooden frameworks, however, have remained unstudied so far. The frameworks enclosing the carved alabaster panels are often lost or heavily affected by damage, alterations, overpaint, or deterioration of painting materials. Only a few original frameworks remain intact. These exhibit pastiglia and sgraffito décor including gilded and coloured bands with patterns and floral motifs, which appears to be typical of frameworks in English late-medieval alabaster altarpieces.

A substantial number of English late medieval alabaster altarpieces or fragments of such are preserved in Iceland. Among the Icelandic corpus, the seven-panelled *Passion* altarpiece from the convent of Reynistaður stands out. It is dated to the second half of the fifteenth century and is now kept at the National Museum of Iceland, Reykjavik (Figure 1a). It has a well-preserved polychromy which appears to be without secondary additions. What is more, almost the entire framework is in place.

The study seeks to contribute to research on English alabaster altarpieces by focusing on the polychromy on the framework. In addition, a sgraffito décor mimicking chain mail is examined on the alabaster reliefs. The latter has been documented by the authors in earlier research and will be put into a broader context by comparing it with other (late medieval) polychrome sculpture [7-9]. The study of the polychromy of the altarpiece of Reynistaður may add insight about English alabaster altarpieces especially but seeks also to contribute to the discussion of late medieval polychromy more generally.

In the following section the altarpiece of Reynistaður will be viewed within the corpus of preserved altarpieces in Iceland and introduced with respect to its motifs, stylistic features and condition. The next part features a short description of the analytical instruments used for examination and analysis of the altarpiece's polychromy. The representation of chain mail on the alabaster carvings is the topic of the subsequent section. In the concluding remarks, the authors relate their findings to other English late medieval sculptures. In addition, connections are drawn between the polychromy on the framework and that on the alabasters, providing insight into the production of this group of works.

Figure 1. Reynistaður altarpiece, National Museum of Iceland inv. no. 1064, dated second-half 15th century: *a)* alabaster reliefs mounted in a wooden polychrome framework, 195 × 59 × 6 cm; *b)* detail (yellow square) of the alabaster panels depicting *The Entombment*, *The Resurrection and St Paul*.

The Reynistaður altarpiece

Cheetham's survey of preserved English alabaster altarpieces, conducted in 1984 and 2003 respectively and Nordal's study on the Icelandic corpus from 1985, catalogued a total of seven multi-panelled altarpieces. The altarpieces from Munkaþera and Reynistaður and the Trinity triptych from Selardalskirkju have their original wooden frameworks in place, while Holar, Þingeyrar, Möðruvellir and Kirkjubær have undergone varying degrees of alteration. From Hítardalur, alabaster carvings of a five-panelled altarpiece are preserved without a framework. Most alabaster altarpieces preserved in Iceland are now kept at museums such as the National Museum of Iceland in Reykjavik (Reynistaður, Hitardalur, Kirkjubær, Hvanneyri), the Museum of Akureyri (Möðruvellir), the National Museum of Danmark (Munkaþvera). The only exceptions are the altarpieces of Holar and Þingeyrar, which are still in their respective churches. In addition to these altarpieces, there are single panels or sequences of a few panels surviving which derive from English late medieval alabaster altarpieces (e.g. three panels from

Staðarfell and fragments of four panels from Hvanneyri), all now kept at the National Museum of Iceland.

The Reynistaður altarpiece was, like several of the altarpieces preserved today, originally located in the convent at Reynistað, which was founded in 1295. According to the Icelandic art historian Bera Nordal, the Reynistaður altarpiece it is not mentioned in the church's liturgy from 1525 [10]. She concludes that it was most likely first imported to Iceland after that year or after the Reformation, when against the backdrop of violent iconoclasm in England, many Catholic altarpieces were either destroyed, hidden, or exported to other countries [10-11]. The altarpiece depicts seven narrative scenes from the Passion of Christ, flanked by figures of the apostles Saint Peter and Saint Paul. The altarpiece is 195 cm wide, 58 cm high and 5 cm deep (interior). It is however missing its original top horizontal frame member and is believed to have been approximately 1 cm higher. While the carvings may not represent the finest examples of preserved English alabaster, the altarpiece is noteworthy because it seems to have preserved all its original elements without later additions. The only modification is that the original framework has been mounted in a new wooden supporting framework tightly fitted to the original. There are substantial damages to both the alabasters and the original framework. The framework is missing the cresting; only small parts are preserved on the left part of the triptych. The middle part of the triptych is also missing the boards above the canopies. The alabaster panel depicting *The Bearing of the Cross* and *The Deposition* both have a damaged corner, while from *The Crucifixion* only fragments are preserved. Saint Paul to the right is missing both his head and the alabaster canopy above. Most of the canopies are heavily damaged or only small fragments remain. The canopy above Saint Peter seems to be intact, while the canopy above *The Bearing of the Cross* shows only minor damage.

The alabaster canopies are partially polychromed, which is typical for English alabaster altarpieces from 1460-1500 [3] (Figure 1a-b). The underside of the canopies is painted in red or blue and decorated with painted ornamentation, while the carved Gothic tracery above is mostly left unpainted apart from minor elements which are painted blue, red or are gilded. On the narrative panels the figures' garments and flesh colour are left unpainted, apart from some detailing like gilded buttons, gilded hemlines and blue or red lining on garments. The backgrounds, however, are densely polychromed from top to bottom and create a contrast to the unpainted white alabaster figures. As it is typical for English alabasters, the gilded background with round dots and the so-called daisy pattern on the green ground fill the entire space, enhancing the whiteness and lustre of the carved stone figures and providing rich embellishment. The hair of holy figures is gilded, and the faces of bad characters are painted with flesh colour and dark facial features. Objects which are important for the identification of the biblical scene or figures' attributes are polychromed, not with one single colour, but with different types of patterns or ornamentation. The column Christ is tied to in *The Flagellation* is marbled in a simple but effective way in dark purple on pink ground; Christ's cross is boldly veined using bright red colour on a light-yellow ground. Christ's tomb is painted pink and adorned with dark blue leaf-ornaments, while its profiles are contrastingly gilded or painted dark red. This effect also applies to minor objects and characteristic features of the figures. The angels' wings, halos and swords are painted red or blue and decorated with patterns in white and gilded details. Another rather laborious polychroming technique is the sgraffito technique employed to represent the armour of soldiers depicted in *The Betrayal* and *The Resurrection*. The soldiers wear suits of armour with tippets made of mail in either green or dark red colour. The latter appears darkened and discoloured today. In a later section we will take a closer look at the chain mail décor.

Methods

Portable micro X-Ray Fluorescence (μ-XRF)

For the preliminary examination of the Reynistaður altarpiece, non-destructive analyses with handheld μ-X-Ray Fluorescence Analysis (μ-XRF) were employed. Such analyses provided information on the paint stratigraphy, preliminary evaluation of paint materials and applied painting techniques, suggesting what could be important insights about the sampling areas. The XRF analyser used was a Thermo NITON XL5 plus handheld XRF (Thermo Fisher Scientific, Oslo, Norway) equipped with an extra large area silicon drift detector (1μm graphene window). Since the nature of the substance was unknown before the measurements, the proprietary "Mining Cu/Zn Testing Mode" was used. This mode one allows to detect the largest range of elements. Total measurement time was approx. 120 s for each zone and the instrument switched automatically from main (Al/Fe filter, potential: 50 kV, maximum current: 40 μA), low (Cu filter, potential: 20 kV, maximum current: 100 μA) to high (Mo filter, potential: 50 kV, maximum current: 40 μA) and light range filters. The data were collected and organised using the Niton Connect 7.1 computer software by Thermo.

Cross-sections

Altogether seven material samples were taken from the Reynistaður altarpiece. Three of these were taken from decorated stiles on the framework, the bands of gilded pastiglia décor, and the bands with red and green sgraffito décor, respectively. Another four samples were obtained from the green and red sgraffito décor mimicking chain mail on the alabaster panels *The Betrayal* and *The Resurrection*. The material samples were mounted in a mounting medium of synthetic resin (Technovit 2000 LC) and sanded with increasing grain size (220-8000).

Light microscopy

Dark field reflected light photomicrographs of the cross-sections were acquired on a Nikon Eclipse Ci POL microscope (Nikon Corporation, Tokyo, Japan) equipped with different lenses (4×, 10×, 20×, 40×, 60×). Visible and UV light were respectively provided by a 50 W (12 V) halogen lamp provided by built-in ND4 filters. Photomicrographs of the cross-sections were taken with a Nikon DS-Fi3 (Nikon Corporation, Tokyo, Japan) microscope digital camera (equipped with a 5.9 megapixels CMOS image sensor for high-resolution imaging, up to 2880 × 2048 pixels) and processed with the NIS-Elements Advanced Research software by Nikon.

Scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM-EDS)

SEM-EDX analyses were performed on all the cross-sections using a FEI Quanta 450 Scanning Electron Microscope (Thermo Fisher Scientific, Waltham, MA, USA) coupled with an Oxford X-MaxN 50 mm^2 detector, using low vacuum mode to avoid charging. Measurements were carried out at 20 kV accelerated voltage, a pressure of 40 Pa and a working distance of 10 mm.

Micro Raman

Raman spectra were collected using a confocal Raman micro-spectrometer system (InVia Renishaw, Renishaw, Wotton-under-Edge, UK). A grating of 1800 lines was used with a spectral resolution of 2 cm^{-1}. The excitation wavelength adopted for analyses was a diode laser at 785 nm. Spectral collection was achieved with a 50× objective (Leica) with a spatial resolution of the order of 3 μm. The acquisition time was 30 s with 10 accumulations. Laser power on the sample was around 1 mW. Spectra were collected using the Wire 4.2 software provided by Renishaw. Raman spectra were plotted and baseline corrected adopting the Origin Lab 2017 software. Raman spectra were gained for all layers on the cross-section of the green chain mail décor on the alabaster carvings and the pastiglia décor on the framework. In addition, ground layer and mordant were analysed with Micro Raman on cross-sections on the sgraffito décor

on the framework. Also, for the mordant in the cross-section of the red chain mail a Raman spectrum was collected.

Micro Fourier-transform infrared spectroscopy (μ-FTIR)

Micro Fourier-transform infrared spectroscopy (μ-FTIR) was undertaken using a Thermo Fisher iS50 Nicolet Continuum FTIR microscope equipped with a liquid N_2 cooled MCT-A detector. Loose paint samples (of the order of μm) were analyzed by μ-transmission FTIR using a diamond compression cell. This method was employed for the analysis of mordant (layer 1) and top layers (layer 3) on samples of red and green chain mail on the alabaster carvings. 100-250 scans were collected at 4 cm^{-1} resolution across 4000 to 650 cm^{-1}. Data were processed with Spectrum 5.1 software.

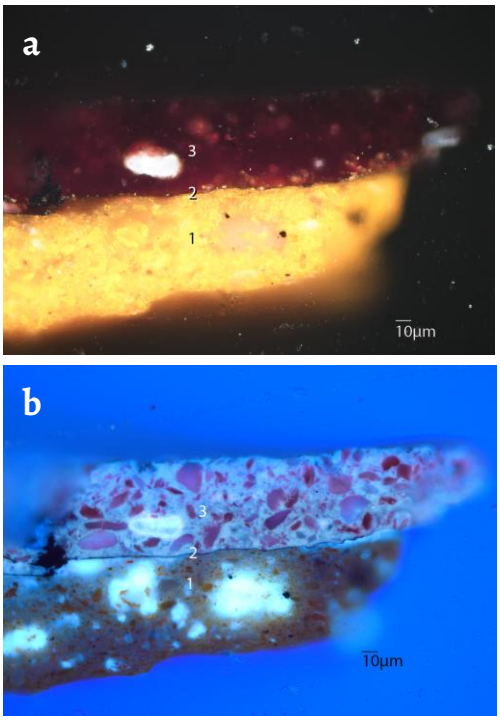
A representation of chain mail

On the alabaster panels from the Reynistaður altarpiece, the impression of chain mail is generated by a pattern of interlocking semicircles which cover the surface of the soldiers' tippets (Figure 2). Studying the pattern up close reveals that this décor is made using a sgraffito technique as specified by Rolf E. Straub, as a decoration technique applied not only on murals, but also on panel paintings, for example in the imitation of precious textiles [12, pp 229-230]. For sgraffito on panel painting "fine hatchings, as well as ornamental and fine figurative drawings or letters are scraped out of a layer of paint over burnished metal leaf using a sharpened wooden stick." [12, p. 229] Cennino Cennini describes such a technique in his *Libro dell'arte o trattato della pittura* of 1417 (Chap. CXL, p. 87) as does the Montpellier *Liber diversarum arcium*, dated around 1400 (Chap. xiii, §2.13.1A, p. 142) [13-14].

In our late fifteenth century example from England, the uppermost paint layer has been removed in the shape of semicircles and the metal leaf underneath exposed. Analysis of cross-sections gave information about the stratigraphy in this type of décor (Figure 3 and Figure 4). For both the red and the green chain mail, an orange-coloured first layer was applied directly to the surface of the alabaster stone. Raman spectra of this layer show typical bands for red lead (Figure 3c), while μ-FTIR analyses made it possible to determine that the pigment is bound in a natural drying oil. Such results identify the gilding in this décor as a mordant gilding. Alabaster presents an excellent ground for painting, and paint-layers or mordants are usually applied directly to the smoothed stone surface without a preceding application of a ground layer. A second layer follows, made of metal leaf, while the third and last layer is a paint layer, which is then locally removed to expose the metal leaf underneath. EDS maps showed that silver leaf was applied as second layer in the red chain mail, while for its green counterpart, EDS maps showed the presence of both gold and silver, indicating the presence of so-called part-gold (Figure 4d). According to Nadolny "part-gold was formed by beating a layer of gold and a thicker layer of silver together until a leaf of much the same thickness as gold leaf (between 0.25-5 μm) was obtained." [15, pp. 159-160] Micro-FTIR analyses of the red top-layer characterising the red mail, would indicate the presence of the organic lake pigment cochineal carmine bound in a drying oil (Figure 5a). The μ-FTIR spectra of the green mail, evidences instead presence of the pigment verdigris also bound in a natural drying oil (Figure 5b). Micro-FTIR spectra of the cochineal lake show the typical bands of carminic acid [16]. In addition, the band located at 1707 cm^{-1} might indicate the presence of kermesic acid [16]. However, it is very difficult to confirm the presence of kermesic acid based only on FTIR bands, since the same band may also relate to the carboxylic acids of the drying oil in which the organic lake is bound [17]. The early dating of the cochineal and the possible presence of both carminic and kermesic acids could indicate cochineal from Eastern Europe, the so-called "Polish cochineal" or "Old World cochineal" as Bucklow calls it [18-20]. Cochineal carmine from America was only introduced to Europe after the discovery of Mexico in the 1520s. To date, only one instance of kermes carmine has been

identified on English alabaster carvings, namely the late fourteenth century Kettlebaston panels at the Victoria and Albert Museum. On these panels the organic lake pigment, kermes carmine was detected in a mixture with lead white in a pink paint layer [8]. Polish cochineal was more expensive than kermes and the later American cochineal [21].

Figure 2. Reynistaður altarpiece. Detail of soldiers with tippets of green and dark red chain mail on panel depicting *The Resurrection* (Figure 1b).



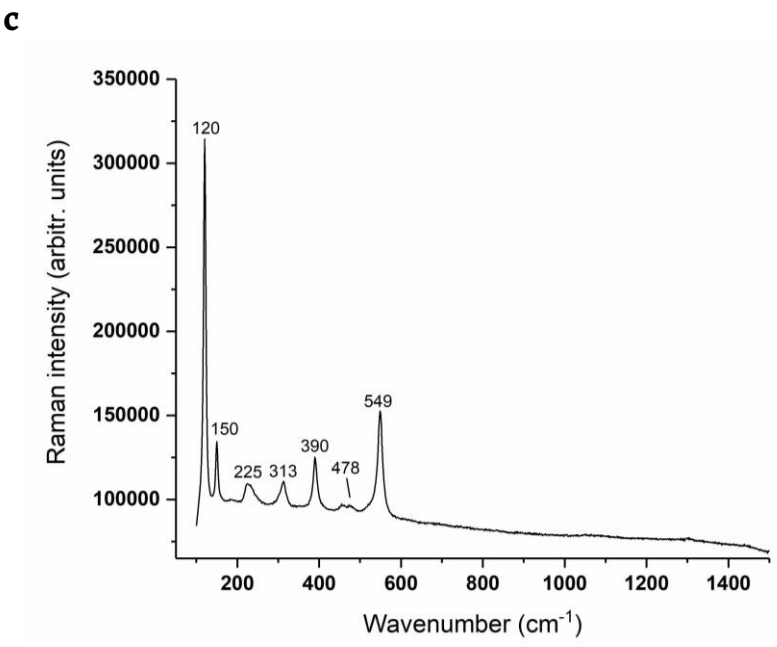


Figure 3. Cross-section of red chain mail 40× objective: *a)* Vis-light and *b)* UV light: layer 1: mordant pigmented with red lead and possibly a red bole in oil, layer 2: silver leaf, layer 3: paint layer pigmented with organic lake pigment cochineal in oil; *c)* Raman spectrum of red lead in layer 1.

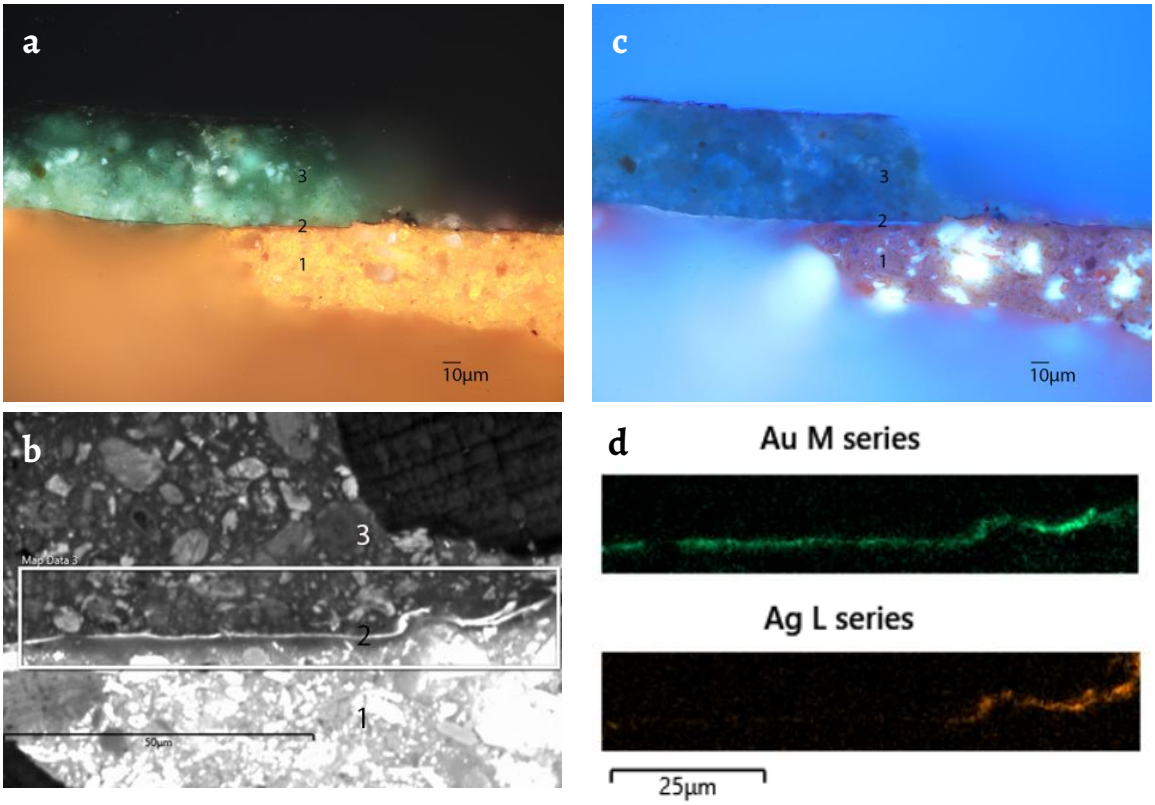


Figure 4. Cross-section of green chain mail, 40× objective: *a)* Vis-light: layer 1- mordant pigmented with red lead and possibly a red bole in oil, layer 2- part-gold leaf, layer 3- paint layer pigmented with verdigris in oil; *b)* UV light; *c)* BSE image; *d)* EDS maps of the elements Au and Ag in layer 2.

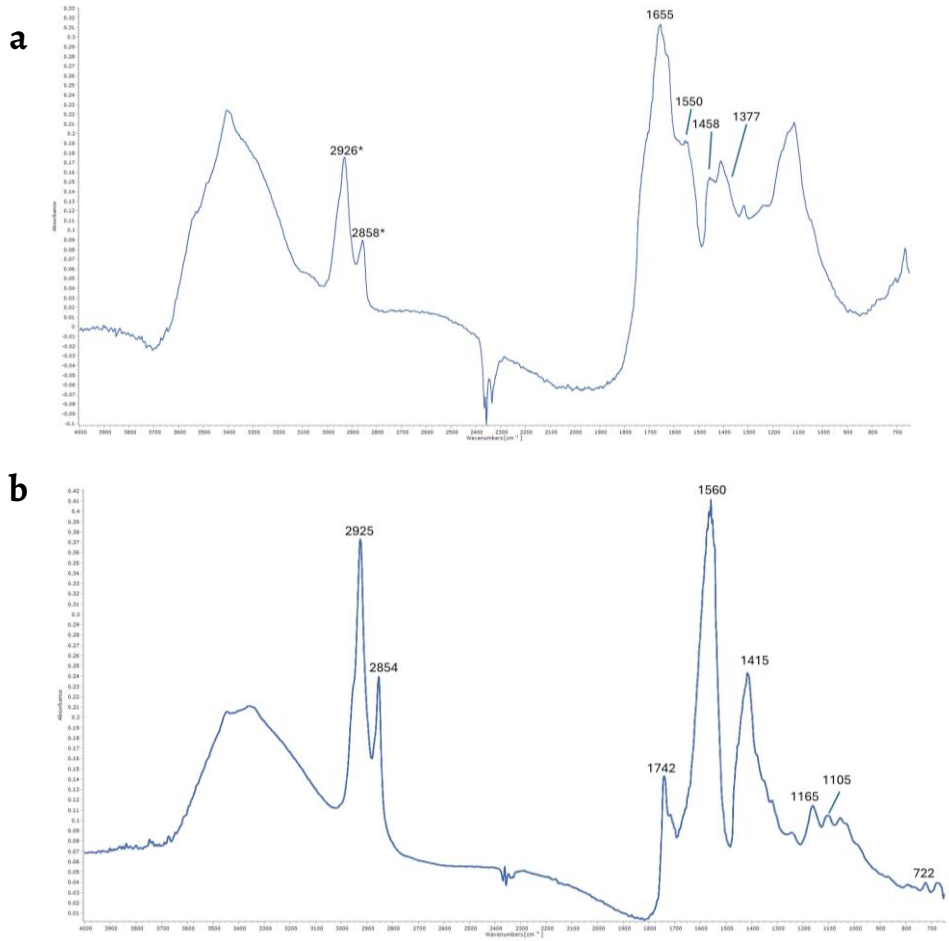


Figure 5. Micro-FTIR spectra: *a)* layer 3 on red chain mail showing typical bands for carminic acid (cochineal); *b)* top layer on green chain mail showing characteristic bands for verdigris in oil.

Figure 6. Details of chain mails: *a)* in sgraffito technique, *The Betrayal* panel (Trondheim, Norway, church of Lade); *b)* Rabastens altarpiece, *Christ before Pilate* (Toulouse, France, Musée des Augustins), *c) The Resurrection*, late 15th century, (Nantes, France, Musée Dobrée) (photography b and c: Markus Schlicht); *d)* tippet painted on gold leaf, *St George and the Dragon*, 1370-1420, alabaster, English provenance (Washington D.C., USA, National Gallery of Art, Samuel H. Kress Collection) (photography: National Gallery of Art); *e)* generated by using tin-relief technique, Tomb of Sir Edmund Crouchback Earl of Lancaster, knight in trefoil north side, 1296-1301 (Westminster Abbey) (photography: Helen Howard, Dean and Chapter of Westminster Abbey); *f)* carved, Tomb of Sir John Swinford, d. 1370-71, alabaster (Spratton Northhamptonshire, Church of St Andrew) (photograpy: Spratton Local History Society).

A similar sgraffito technique in green colour is used on the English alabaster carvings from the same period preserved in the church of Lade, Trondheim (Figure 6a). On the Lade alabasters the incised semicircles are accompanied by dots, but paint cross-sections show a similar stratigraphy as the Reynistaður alabasters including an orange layer containing yellow ochre mixed with red lead applied to the alabaster surface, followed by a metal leaf and a verdigris-pigmented oil bound paint layer in which the pattern was drawn by uncovering the metal leaf underneath with a pointed object [22]. However, for the green chain mail décor on the Lade alabasters, silver leaf was used instead of the part-gold detected at Reynistaður.

On the Reynistaður panel depicting *The Betrayal* two soldiers wear tippets of green mail, while the one grasping Christ's cloak has a tippet of red mail. This corresponds to the finds on the alabaster carvings from the church of Lade. It has previously been discussed whether the alternative colour could be a means to enhance this soldier's importance to the biblical narrative [22]. However, the *Resurrection* scene in the altarpiece of Reynistaður altarpiece depicts a total of four soldiers, where two have green tippets and the other two red ones. In this case the red mail does not seem to be used to make the soldiers stand out, rather the alternating colour may be seen as another element which contributes to creating a strikingly playful polychromy. This is mirrored in the variation between red and green sgraffito décor on the stiles of the middle

section of the framework. Alternating between areas or decorations in red and green is a frequent feature of English medieval polychromy. The background of the painted Saints on the Westminster retable may serve as an example, as well as the two-coloured columns dividing the Thornham Parva retable into sections, as well as the backgrounds to the Saints on some of the church screens in East Anglia [23].

Other examples of comparable patterns and techniques may be seen on the soldiers' tippets in the altarpiece from Rabastens kept at the Musée des Augustins, Toulouse, and an alabaster panel at the Musée Dobrée, Nantes (Figure 6b-c). These English late medieval alabaster reliefs show evidence of a similar repeating interlocking pattern but have so far not been analysed. It remains uncertain whether a sgraffito technique was used.

Similar patterns may be observed on fourteenth century English alabasters by De Beer; a sculpture depicting St George and the Dragon, now kept at the National Gallery in Washington, D. C. (Figure 6d), and two alabaster panels deriving from altarpieces: *The Betrayal*, from St Peter and Paul Church, Hawkley, Hampshire and *The Resurrection* now kept at the British Museum, London [4, p. 167]. On the sculpture of St George, the mail is golden, with semicircles which seem to be painted in a light, perhaps white colour on top of the gilded surface. Comparing these examples with our late fifteenth century sgraffito chain mail, there is not only a difference in technique, but also in style: The chain links of St George's mail are painted rather flat and not arranged in an interlocking manner. Nevertheless, as with Reynistadur and Lade, the impression of mail is created by a repeating pattern of curved lines.

Other representations of chain mail include the effigy of Edmund Crouchback (1245-1296), Earl of Lancaster and his wife Aveline de Forz at Westminster Abbey (Figure 6e). The tomb was erected between 1296 and 1301. On Sir Edmund's tippet a pattern of interlocking semi-circles has been generated using the tin-relief technique [24]. In addition, on the tomb's frieze of knights, chain mail is painted on silver leaf [24]. On the Tomb of Sir John Swinford of Spratton (ca. 1340-1371) in the Church of St Andrew in Spratton, a similar pattern of many small interlocking semicircles has been carved directly into the alabaster stone (Figure 6f) [3].

From these rather labour-intensive representations of chain mail, we can reason that portraying the armour of knights and soldiers was considered worth some effort. This is not surprising since armour may imply high status, as in the case of Sir Edmund Crouchback's and Sir John Swinford's tombs, or act as visual aid in the identification of military characters in narrative scenes, such as the Passion cycles. The different techniques that were employed in these few examples from the fourteenth and fifteenth century is evidence of the creativity employed in the representation of this feature.

Décor on the framework

The stiles dividing the Reynistaður altarpiece into sections housing one narrative panel each, had oak chamfers attached. These are richly ornamented in different decorative techniques (Figure 7). First, a red ground was applied across the chamfers, which provides a surface suitable for gilding by covering the porous wood and producing an evenly absorbing surface. At the bottom and on the top, the chamfers were highlighted by a narrow band painted in bright red. Based on μ-XRF analyses the paints in these areas might contain vermilion and realgar (or orpiment). In between the red bands the chamfers were adorned with alternate bands of gilded relief décor and sgraffito décor. None of the decorated bands look exactly the same, which indicates that the motifs were created free-hand. The chamfers flanking the raised central scene depicting *The Crucifixion* display bands of gilded, dark red or green décor, while the lateral chamfers are confined to gilded and dark red décor. The dark red colour has become matted and appears discoloured, however in areas where the red has spilled over on the adjacent gilded area, it has a red appearance. The upper part of the vertically dividing stiles are rendered contrastingly with a "Barber's Pole" décor. Here diagonally painted stripes of green and red

alternate with areas where silver leaf underneath was left exposed. The silver leaf has tarnished and now has a dark grey appearance. The chamfers flanking the saints were adorned with a simpler painted décor (Figure 1b). Bunches of three-lobed stylised leaves in white and yellow were painted freehand on a blue ground. On this décor μ-XRF measurements were carried out. The results point to the presence of an organic dye for the blue ground, perhaps indigo, but they also suggest the possible presence of lead white, orpiment and possibly vermilion for the painted leaves.

Figure 7. Detail of Reynistaður altarpiece, décor on framework flanking *The Crucifixion*. In the middle section alternate red and green sgraffito décor with gilded pastiglia décor. On the sides red sgraffito décor alternates with gilded pastiglia décor.

Bands of pastiglia relief

Details and cross-section of the bands with gilded relief décor are given in Figure 8e-f. First a red layer has been applied to the framework, then drops and lines of fluid white ground followed to create decorative patterns and motifs. During sampling the first red layer proved strongly bonded to the framework and is therefore, unfortunately, not present in the cross-section. Due to the missing first layer, the numbering of layers in the cross-section starts at 2. Layer 1 is visible in photographs of the décor in areas where the white droplets have come off the ground (Figure 7). Subsequent layers must have been applied after the fluid ground had hardened. Another layer of red paint followed covering the entire band (layer 3), before the orange layer was applied (layer 4) and finally the metal leaf (layer 5). Although the motifs in the relief décor are repeating, none of them look exactly the same, meaning the white droplets were likely applied free-hand, probably with a brush. According to publications by Peter Tångeberg, Manfred Koller and Jilleen Nadolny this technique can be described as a freehand pastiglia technique, where traditionally fluid ground was applied to a ground layer for the creation of decorative patterns and motifs [15, 25-26]. Like Sgraffito décor, pastiglia relief was often used to mimic valuable goldsmith works or textiles. While Tångeberg and Nadolny concentrate on medieval examples of the use of this technique, Koller uses the term in a broader sense and includes examples from later centuries, including when the ground is oil-bound. Freehand pastiglia must be differentiated from pre-produced cast relief.

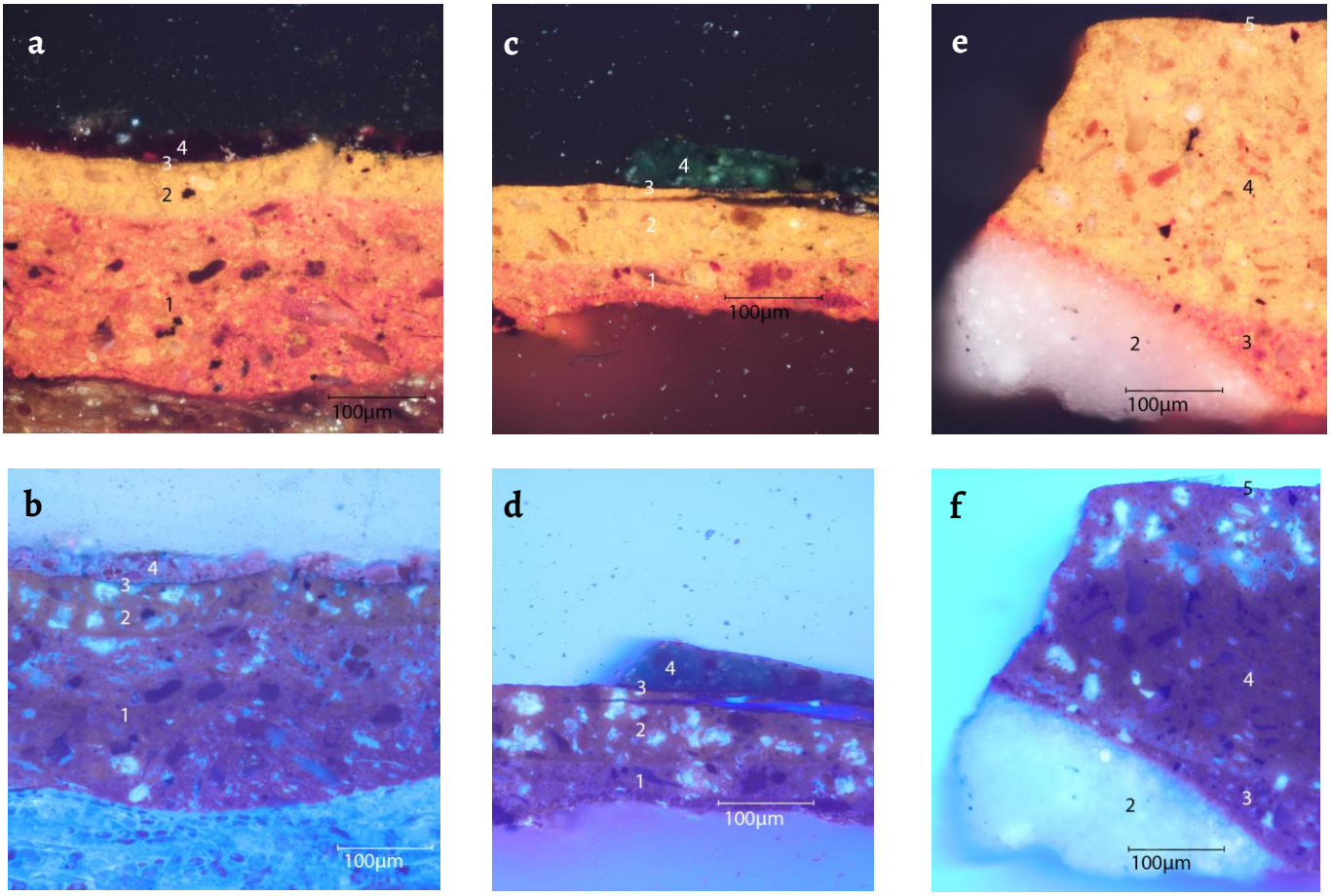


Figure 8. Cross-sections of the polychromy on the stiles dividing the framework into sections (all 20× objective): *a)* dark red sgraffito décor in VIS light: layer 1 - red ground layer of red lead and likely a red bole in oil, layer 2 - orange mordant pigmented with red lead and possibly a red bole in oil, layer 3 - silver leaf, layer 4 - dark red top layer of cochineal in oil; *b)* dark red sgraffito décor in UV light; *c)* green sgraffito décor in VIS light: layer 1 - red ground layer of red lead and likely a red bole in oil, layer 2 - orange mordant pigmented with red lead and possibly a red bole in oil, layer 3 - part-gold leaf, layer 4 - green top layer of verdigris in oil; *d)* green sgraffito décor in UV light; *e)* gilded pastiglia décor in VIS light, layer 2 - white chalk drop, layer 3 - red ground layer of red lead and likely a red bole in oil, layer 4 - orange mordant pigmented with red lead and possibly a red bole in oil, layer 5 - gold leaf; *f)* gilded pastiglia décor in UV light.

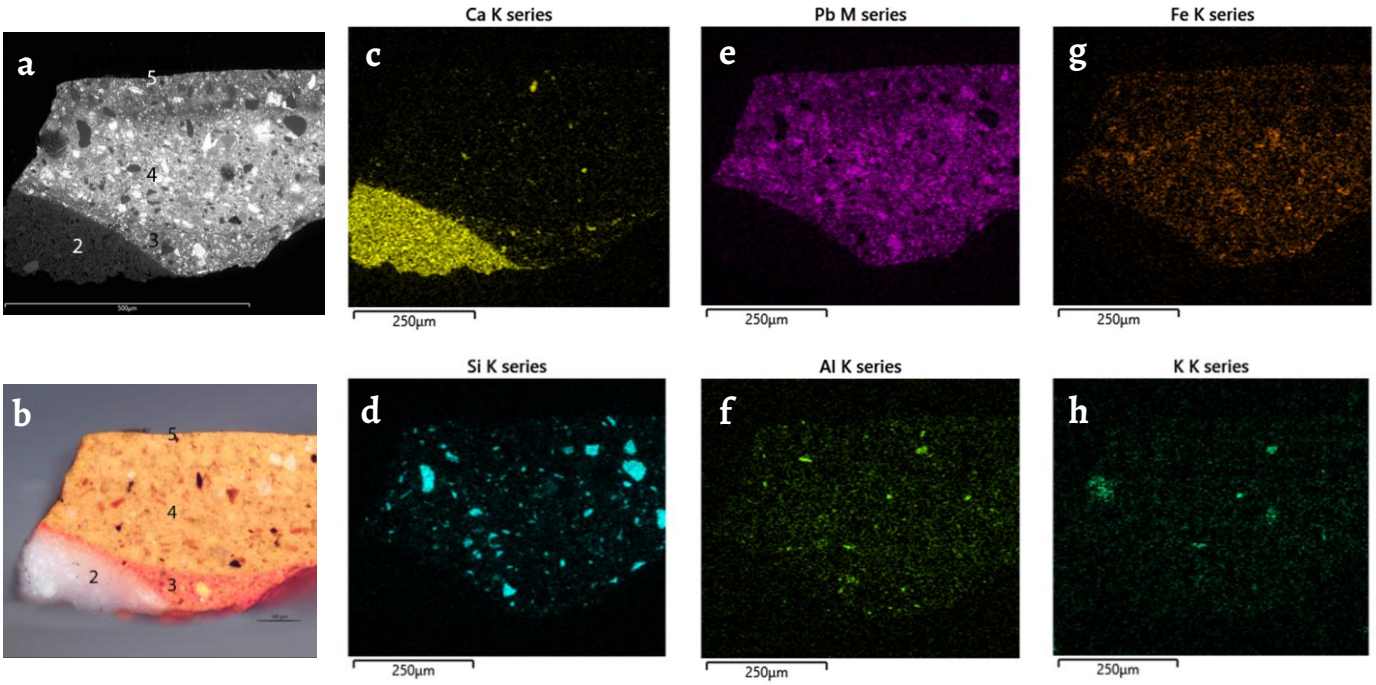


Figure 9. Cross-section of pastiglia décor on framework (10× objective): *a)* SEM BSE image; *b)* VIS light; *c)* EDS map of Ca in layer 2; *d)* EDS map of Si in layer 3-4; *e)* EDS map of Pb in layer 3-4; *f)* EDS map of Al in layer 3-4; *g)* EDS map of Fe in layer 3-4; *h)* EDS map of K in layer 3-4.

Analysis of the paint layers show that layer 2 in the cross-section, the fluid, white ground used to create a decorative pattern, consists of chalk (Figure 9c). The EDS map shows proof of a homogenous distribution of calcium and μ-Raman spectra show the characteristic bands for chalk. Due to insufficient contact between the μ-ATR-FTIR tip and the paint cross-section, it was not possible to analyse the binding medium in this layer. Raman spectra of first and second layer showed the characteristic bands for red lead. EDS maps showed a homogenous distribution of Pb in both layers (Figure 9e). In addition, EDS analyses detected the elements Si, Fe, Al and K in both layers (Figure 9). Due to the similarities in the distribution of the elements, it was not possible to distinguish between these two layers in the EDS maps, although they are clearly distinguishable under the microscope. Together the detected elements might indicate the presence of a clay-based red bole where the colouring agent is the iron oxide hematite, like in Armenian bole. It seems likely that in the first two layers red lead is mixed with a red bole. A natural drying oil could be detected as the main component of the binding medium in both layers by FTIR and μ-Raman. EDS mapping showed an even distribution of gold in the top layer of the cross-section, layer 5.

Bands of sgraffito décor

Figure 8a-d show cross-sections of the dark red and green bands of sgraffito décor on the framework. Studying this décor up close reveals that the respective top layer has been locally removed to expose the layer underneath creating a leaf- or twig-like motif in the middle and a frame of straight lines along the band's edges. Analysis of the cross-sections showed that this type of décor is built up in four layers. The first layer applied to the wooden surface of the chamfers is interpreted as a ground layer. It is red in colour and is followed by a lighter orange layer, which again is succeeded by a metal foil. The top layer of the bands constitutes the above mentioned dark red or green paint layer.

Layer 1 and 2 gave the same results as for the pastiglia decorated bands and sgraffito décor on alabaster. The binding medium is a natural drying oil and the main pigment is red lead. In addition, a red bole could be present. Analysis of the metal leaves in green and dark red sgraffito décor showed some differences. EDS maps would indicate the use of part-gold in the green sgraffito, due to the detection of both Ag and Au, while silver leaf was registered for the dark red version. The coloured top layers of the sgraffito décor on the framework were similarly pigmented as their counterparts on the chain mail in alabaster carvings: The red top layer was, identified as cochineal (likely Polish cochineal) and the green as verdigris, both bound in a natural drying oil.

Paints on the framework's interior behind the alabasters

On the inside of the framework beneath the pierced Gothic miniature architecture of the canopies, a dark red and a bright red paint were found to have been applied. None of these layers seem to serve as a ground layer, since no paint layer has been applied on top. The dark red paint covers the lower part of the area behind the canopies and is superseded by the bright red paint further up. It seems likely that these paints were intended to be visible through the pierced carved architecture and that the transition from dark red to bright red was meant to provide a glow from behind the canopies. Comparable coloration below traceries is typical of late-medieval altarpieces, at least the ones deriving from Germany [27, p. 97]. XRF measurements were taken on both red paint layers behind one of the canopies. The brighter red paint in the upper part contains Hg, As and S which points to the presence of cinnabar and realgar or orpiment. Furthermore, Al, Si, Fe and K were also detected in this layer, which may indicate a red bole, as observed in all the cross-sections. In the dark red paint neither lead nor mercury were detected. Instead, the presence of As and S suggest an arsenic-based pigment

such as realgar or orpiment. Here again the elements Al, Si, Fe and K were detected, which may point to a red bole.

A similar case of red colour beneath the canopies has been noted on one of the three fifteenth century wooden polychromed cases housing alabaster carvings depicting the head of St. John the Baptist, which are now kept at the Burrell Collection, Glasgow Museums. The woodwork of the relevant St. John the Baptist alabaster (Inv. 1.34) "displays remnants of red colouration, discernible through the cut-out alabaster structure [of the canopy]. Beneath the lower piece, sparse and random patches of green and red coloration have been noted." [28] These finds seem to indicate that the design of the area behind the canopies is of similar kind as that on the Reynistaður altarpiece. It remains unclear if these two independent observations suggest that (red) paint beneath the canopies may have been a frequent or regular feature in the polychroming of English alabaster altarpiece frameworks, at least in some workshops. In any case, the paints behind the canopies on the Reynistaður altarpiece seem to be deliberately applied features, rather than accidental occurrences.

The finds on the St. John the Baptist at the Burrell Collection are not limited to paints behind the canopy but include random patches of red and green behind the narrative panel. A dark red paint layer is also observed on the inside of the framework of an English alabaster altarpiece which may hail from Cluny, but which is now kept at the Bode Museum in Berlin (Inv. SI-1). Though it has undergone some changes and treatments, most of the framework of this altarpiece is understood to be original [29, pp. 518-526]. In addition, Castro et al. found remnants of dark red colour on the rear side of the panels of an English Passion alabaster from the church of Santa María Magdalena, Plentzia, Basque Country, Spain, which is dated 1440-1460 [7, p. 759]. Castro et al. assume that the reliefs "were set in a red painted wall. After the alabaster panels were pulled away, some parts of the colour have remained in the carvings." Their analysis on the remnants of dark red colour identified the elements Fe and Pb employing μ-XRF, while Raman spectra showed typical bands for red iron oxide. Considering the other examples gathered here, it is possible that the framework lost today was originally painted red, and when the alabaster panels were removed from the frame, some paint remained on the rear side.

Similarities of the polychromy between alabasters and framework

The examination of the Reynistaður altarpiece and analyses of paint layers have revealed similarities between the polychromy on the alabaster carvings and that on the wooden framework.

Analysis of the composition of the mordant has shown that the same pigments and binder are present in the mordant on the alabaster reliefs and on the wooden polychromed framework. On the reliefs the mordant was applied directly to the alabaster, while on the wooden framework it was applied on top of an oil-bound ground layer. Also, the sgraffito technique used on both the alabaster and the wooden framework is similar in its stratigraphy and its composition of layers. The same type of metal leaf was used on the alabaster carvings and framework for red and green sgraffito respectively. Moreover, the top layers of these same decorations were analogously composed of cochineal in oil and verdigris in oil respectively. Based on these findings, it seems reasonable to suggest that the polychromy on the alabasters and framework were made within the same production environment, e.g. a workshop or a group of loosely associated craftsmen.

Another characteristic feature of the polychromy that should be taken into account when discussing similarities between alabasters and framework is the painted freehand décor. A simple motif of three-lobed stylised leaves decorates Christ's tomb on the alabasters, as well as the blue painted chamfers on the framework flanking St Peter and St Paul (Figure 1b). In addition, the same motif is chosen to represent and adorn the green meadow-like ground on

the narrative alabaster panels. On the lower part of the carved alabaster canopies is a related motif, reminiscent of fleur-de-lis. The similarity of décor on the framework and alabaster, is not restricted to the choice of motif, but includes the way the leaves are painted; the "handwriting" of the craftsman as it were.

Considering to the above noted similarities in composition, motifs and style of the décor on framework and alabasters, it seems reasonable to infer that both were polychromed within the same production environment, such as a workshop. The similarities in "handwriting" of the painted décor even suggest it was the same craftsman working on the polychromy on both alabaster and woodwork.

The distinctive, colourful and labour-intensive polychromy of English alabasters

Late medieval English alabaster altarpieces were highly sought-after commissions, produced on a large scale and widely distributed across many European countries for a diverse clientele [3-4, 6]. Although the English medieval quarries for alabaster stone were located in the Midlands, near Chellaston and Tutbury [30], there is a notable lack of written sources that clearly identify the production centres of alabaster altarpieces or provide detailed information about their makers, production environments, and workshop practices [3, 30].

These alabaster altarpieces are easily recognisable due to their distinct features and painting techniques. For instance, the Reynistaður alabasters exhibit labour-intensive characteristics, such as sgraffito décor, gilded dots in the background, and meticulously painted daisy patterns on the grounds. These elements contributed to the creation of a colourful and elaborate polychromy. Furthermore, this study shows that not only the alabasters but also their wooden frameworks incorporated brightly coloured paints, gilding, freehand décor, and a variety of painting techniques, including raised pastiglia, sgraffito, and glazed metal leaf. This contradicts previous assumptions regarding the simplicity of such works.

The same sgraffito technique was employed for the polychromy of both alabasters and frameworks, showing similarities in layer composition and stratigraphy, although on alabaster lacks a ground layer. The mordants used contain the same pigments and binder, and the same types of metal leaf are employed for the green and dark red sgraffito. Additionally, the top paint layer (comprised of verdigris and cochineal) also employs the same pigments and binder. Such similarities in polychromy suggest that both the frames and reliefs were produced in the same working environment. Furthermore, similarities in style and "handwriting" indicate that the same craftsman may have worked on the polychromy for both alabaster and woodwork.

While the majority of preserved late-medieval grounds examined in Northern Europe are composed of white chalk and glue, instances of coloured grounds are documented [31], particularly in the English county of Devon, where many church screens feature a ground layer containing red ochre and red lead [32]. This phenomenon is understood to be regional, as the red ochre is sourced locally. Although the binding medium on the Devon screens has not yet been analysed due to limited study, conservators working on these screens have noted that the grounds appear to be water-soluble [33].

The red, oil-bound ground layer discussed in this article further testifies to the existence of variations within English late-medieval polychromy, as well as in late-medieval polychromy more broadly. Despite the significance of this large corpus of preserved English alabasters, few studies have been conducted on their polychromy, leaving many traditions still waiting to be discovered.

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(In)tangible archaeology of colours: permanent marks on anthropomorphic *haniwa* and tattooing in Kofun-period Japan

Arqueologia (in)tangível das cores: marcas permanentes em *haniwa* antropomórficos e tatuagens no Japão do período Kofun

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Abstract

The aim of this paper is to understand the meaning and function of reddish pigments present on the surface of anthropomorphic *haniwa* of the Kofun period. In Japan, the practice of tattooing (*irezumi*), whose symbolic meaning has changed over time, can be traced back to the Jōmon period. Tattooing is generally considered an intangible cultural heritage (ICH): the transience of human bodies significantly contributes to the archaeological impermanence of this practice except in the case of artificial intervention or natural accidental preservation. The presence of reddish decorative motives on both the face and the body of *haniwa* raises many questions triggering diverse interpretative scenarios. *Haniwa* are terracotta figures, placed outside the mounded tombs as an integral part of the funerary rituals and religious practices of protohistoric Japan, and in this sense, they are considered valuable objects not only for reconstructing the burial rituals, but also for Kofun society.

KEYWORDS
Kofun Period
Haniwa
Irezumi
Archaeology of colours

Resumo

O objetivo deste ensaio é compreender o significado e a função dos pigmentos avermelhados presentes na superfície dos *haniwa* antropomórficos do período Kofun. No Japão, a prática da tatuagem (*irezumi*), cujo significado simbólico tem mudado ao longo do tempo, remonta ao período Jōmon. A tatuagem é geralmente considerada um património cultural imaterial: a transitoriedade dos corpos humanos contribui significativamente para a impermanência arqueológica desta prática, exceto em caso de intervenção artificial ou de preservação natural acidental. A presença de motivos decorativos avermelhados, tanto no rosto como no corpo dos *haniwa*, suscita muitas questões que permitem clarificar diversos cenários interpretativos. Os *haniwa* são figuras de terracota, colocadas no exterior dos túmulos, como parte integrante dos rituais funerários e das práticas religiosas do Japão proto-histórico e são considerados objectos valiosos para reconstruir, não só a arqueologia funerária, mas também a sociedade do período Kofun.

PALAVRAS-CHAVE
Período Kofun
Haniwa
Irezumi
Arqueologia das cores

Preliminary note

The aim of this paper is trying to understand the meaning and the function of the reddish pigments which are present on the surface, mainly the face, of anthropomorphic *haniwa* of Kofun-period Japan. *Haniwa* (埴輪), which literally means "clay cylinder" or "circle of clay", is a term used to identify a variety of earthenware funerary objects placed for ritual use on top of ancient [mounded] tombs (*kofun* 古墳). As Matsumoto Naoko [1] points out, the production of red and black pigments by grinding rocks (i.e. hematite and manganese dioxide) is known at least since the Upper Palaeolithic, while shells, animal teeth and ivory were used for manufacturing white colour. These colours were intentionally applied on a diversity of surfaces, which means that they should have acquired a decorative function and possibly a symbolic meaning. In the specific case of *haniwa* it was observed that some clay figurines bore red, white and/or black pigments. Although it is not clear what the meaning attributed to these pigments is, one can suggest that they were used for decorative, spiritual and/or protective purposes. The idea of red being protective could be in line with Kondo's theory, according to which the placement of *haniwa* in a circle on the tumulus could represent a way to prevent the spirit of the dead from wandering around [2, p. 173; 3, p.65]. Whether these pigments "can be interpreted as part of the tattooing practice, which is common in Japan since, at least, the Jōmon period", is a question that remains open.

This contribution is part of a larger project on *Haniwa: The religious practices and political landscape in Kofun period Japan* (in progress), which is investigating the relationships between religious practices and political landscape by analysing anthropomorphic *haniwa*. Taking as starting point Tanaka Masaki's theory according to which governance grew out of ritual [4, p. 149], one of the goals of this research is to better understand the characteristics and the function of the *haniwa* located on the *kofun* of the *Mounded Tomb Culture* (MTC) period, through an analysis of the relationship between archaeological heritage, landscape and written sources.

The Kofun period was not homogeneous in terms either of time or space. According to Koji Mizoguchi the chronology of the Kofun period is based on the combined typo-chronology of its pottery (i.e. *haji* (土師) and *sue* (須恵) wares and *haniwa*), the typo-chronology of the mounded tomb shapes and the grave good assemblages [4, p. 149].

The structure of the mounded tombs, of the prestige goods and of the *haniwa* did not only represent the power and position of the deceased, but was also representative of regional differences. Traditionally grouped in clusters (i.e. Kyushu, Izumo, Kibi, Kinki, Kanto and Gunma, *inter alia*), the Japanese archipelago cannot be culturally treated as an homogeneous reality, but rather as a complex network of individual policies that in time were engaged in strategic alliances or conflicts.

Figure 1 shows a map of Japan and Table 1 shows the"relative" chronology of the Kofun period. It is important to pinpoint that the Kofun period is marked not by the emergence of the mounded tumulus, but by the spread of this practice, which in fact had begun in the Yayoi period, during which burial mounds had sometimes been relatively large in size [3, p. 23].

Table 1. "Relative" chronology – Kofun-period [3, p. 34].

Phase description		Absolute dates
Yayoi VI/Shonai	Yayoi Kofun transition	c. CE 200-250
Kofun I, II, III, IV	Early Kofun	up to 400 CE
Kofun V, VI, VII, VIII	Middle Kofun	up to 500 CE
Kofun IX, X	Late	up to 600 CE
Kofun XI	Final	up to 645 CE
Asuka	(*Buddhism from 525 CE)	from 538 to 710

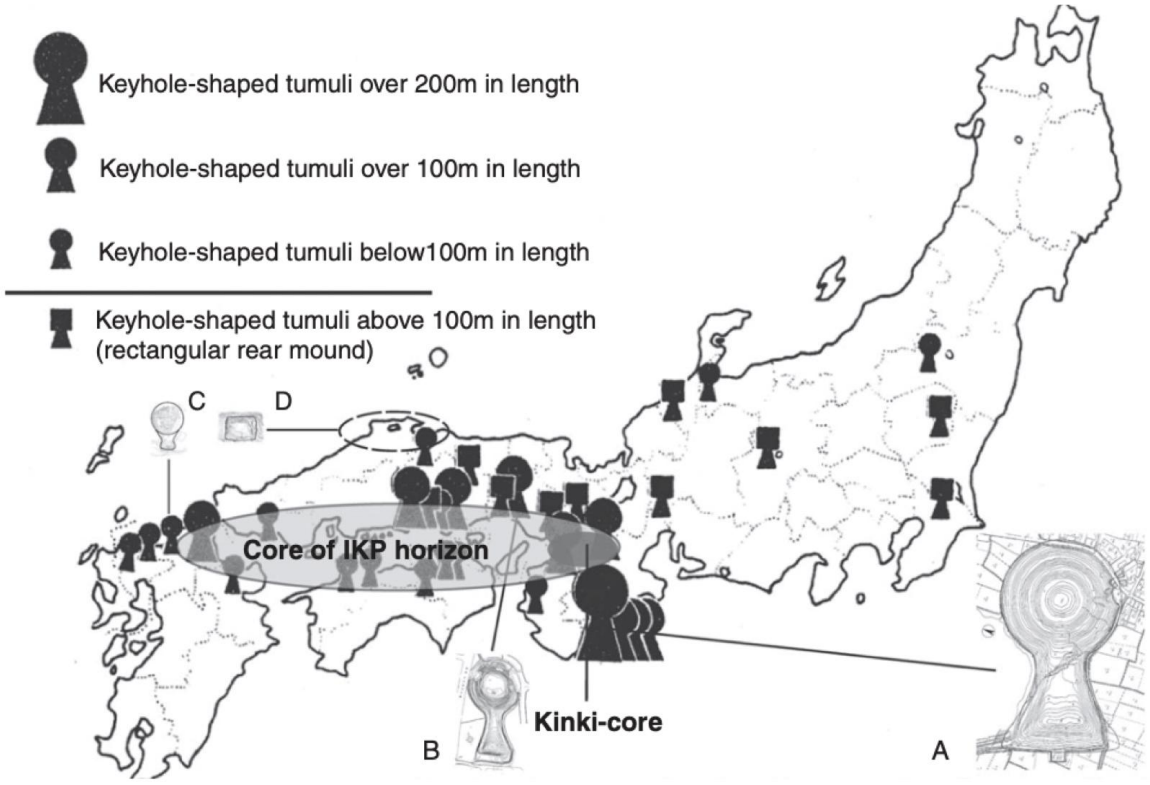

Figure 1. Map of Japan [5, p. 17].

The tattoo in Japan

Experimental archaeology, based on the more recent analysis conducted outside Japan, on the Neolithic Huslabjoch herder from the Alps of Northern Italy (also known as the Ötzi ice mummy) has shed light not only on the tattooing techniques in Prehistoric Europe. Based on recent analysis [6], researchers have concluded that the tattoos on the Ötzi ice mummy were made by incision, using a different technique from the modern one, by producing small incisions in the skin, which were then covered with charcoal (a rudimentary form of carbon black). These finding provide potential answers to how tattoos were eventually done in other parts of the world.

Although it is impossible to date exactly when tattooing had started in Japan, the earliest evidence of tattooing in Japan became more evident during the Jōmon period. This practice was attested by the presence of engraved and painted decoration on masks and on clay figurines known as *dogū* (土偶). Especially during the late Jōmon phase, when anthropomorphic figurines became much larger and more adorned than previous ones, one can observe the incorporation of decorative elements commonly interpreted as being tattoos [7]. Harunari Hideji suggests that in the Final Jōmon social groups were distinguished by the way they tattooed and painted their face [8, p. 133]. Another important aspect to note is that the *dogū* were decorated with engraved motives on the face and around the mouth, where red pigments were also found [8, p. 149]. This practice of tattooing the mouth (*sinuye* シヌイ エ) was quite common among the Ainu people, but was prohibited in the Meiji period and currently Ainu women paints only in special occasions their faces. Woman in the past were in charge of *sinuye* tattoos using obsidian utensils [9, p. 188]. Although we cannot assume that the *dogū* were depictions of Jōmon people themselves, these clay figures, which flourished in the Middle, Late and Final Jōmon periods, project the aesthetic values of their makers, they reveal something on Jōmon appearance and their connection to Ainu people traditions. Even more difficult is to

determine whether red pigments on the faces and bodies of these clay figurines represent tattoos [9, p. 151].

Chinese sources attest that people from the Japanese archipelago tattooed their body. The information provided by these sources can be interpreted in different ways and still drives debates among researchers nowadays. In the *Book of Wei* (ca. third century CE), for instance, the Wajin 倭人 (C. Woren) were described as people who practiced tattooing *geimen bunshin* 鯨面文身, (C. *qingmian wenshen*), which literally meant that they tattooed their faces and bodies [10, p. 14]. The same source quotes that in the Kona/Kunu/Kuna 狗奴 (C. *gounu*) chiefdom, ruled by a male king, people were also used to tattooing their bodies with motives depicting wild beasts and three marks on their foreheads [10, p. 14]. The text also informs that the marks were straight for noble people and small for inferior people [10, p. 14].

These two examples demonstrate that tattooing existed in Japan and that it was a functional emblem in social hierarchies as it happened with other practices (i.e. tooth ablation). Similar information could be found in earlier Chinese sources, although with less detail, such as the *Book of Han* (in the *Treatise on Geography*) compiled around the first century CE and the *Classic of Mountains and Seas* of the third or fourth century BCE. The list of Chinese sources on this topic could follow on.

Edward Kidder [10, p. 14] in his monograph about Himiko, the woman who ruled during the transitional stage at the end of Yayoi and the beginning of the Kofun period, shows four heads of clay figurines identifying the marks on their faces as being tattoos. These artefacts, spanning from the Middle Yayoi to the Late Kofun periods, demonstrate that some practices endured from one phase to another. The artefacts were: one from Osagata, Ibaragi, dated of the Middle Yayoi, another from the Òtsuka tomb cluster in Tochigi city, dated from the Middle–Late Yayoi, and two heads of full *haniwa* figures (one from Shijo Tomb, Kashihara city, Nara, dated from the Middle Kofun and another from the Horiki Tomb 7, Tanabe-machi, Kyoto of the Late Kofun period). Other examples, show a kind of decorative pattern on face (Figure 2a) identified as tattoo and red pigments, while in the case of Figure 2b these decorative patterns are not necessarily identified as tattoos. From a later period are examples of anthropomorphic *haniwa* with red pigments (Figure 3a) and incised pattern identified as tattoos (Figure 3b).

These kinds of decorative patterns can also be found on earlier masks, which appeared during the Late Jōmon phase. Junko Habu [11, p. 156] divides them into the following categories: realistic masks, curved-nose masks, mask-shaped clay artefact, composite mask, “clown” mask, “tattooed” and painted masks. The “tattooed” masks were found in Sanganji; Fukushima Prefecture. It is interesting to note that she also describes the *dogū*, however, she does not identify the decoration on these clay figurines as a kind of tattoo. To sum up, the red pigments on masks and clay figurines (both *dogū* and *haniwa*) can be interpreted in a different way. I suggest that, if they did not represent tattoos, as one can observe in the Figure 2b, they were possibly used as a sort of protection against evil.

In thinking about Kofun-period Japan and in dealing with a “history without writing”, where social memory is reconstructed through non-textual material or by using sources from a later period or written outside Japan (for instance, in China), it is not easy to produce a coherent narrative around of this topic. Sometime looking toward the continent can provide some answers. China has a long historiographical tradition, set up by individuals who meticulously collected information not only about the territorial domain they originated from, but also about their neighbours. Although Chinese scribes did not always distinguish the inhabitants of South Korea from the Japanese, their histories constitute a valuable source to all those who are studying the Kofun period.

In East Asian cultures tattoo could represent a stigma, a branding mark (i.e. slave), an adornment (especially facial) and as a form of group identification (i.e. tribal, military, among others). In most cases, terms used to identify tattoo can also vary accordingly. In ancient China red body painting and tattoo drawings were discovered on pottery, bone and jade objects, suggesting that tattooing was not only meant to mark criminals, but had been somehow

connected to specific religious practices since ancient times [12]. Going back to the specific meaning attributed to red pigments found on the surface of figurines in China, both Mu Zhongjian and Zhan Jian assume that they represent tattoos.

Figure 2. Clay figurines with red pigments and face ornaments: *a)* jar with Human Face Ornament Yayoi period, 2nd–1st century BCE, found at Ozakata Site, Ibaraki TNM J-34947 [13]; *b) dogū* (Clay Figurine) Jōmon period, 2000-1000 BCE From Yoyama Shell Mound, Cho-shi, Chiba TNM J-7736.

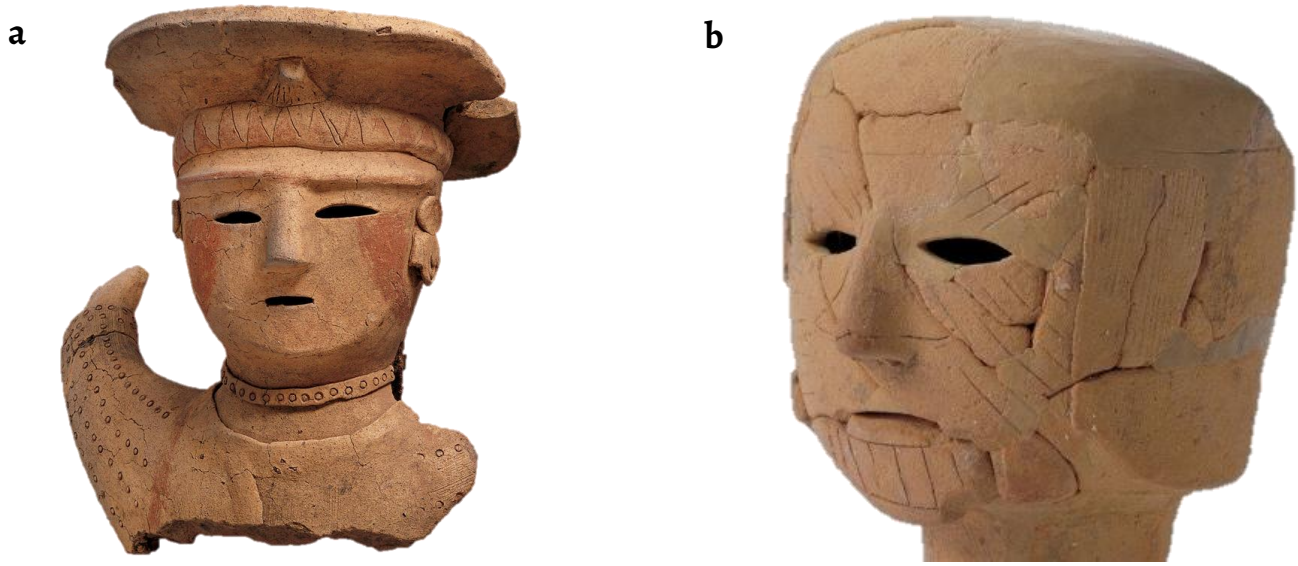

Figure 3. Clay figurines with red pigments and face ornaments: *a)* part of an anthropomorphic *haniwa* - female shrine attendant MET 2015.300.255; *b)* head of an anthropomorphic *haniwa* excavated from the Sumiyoshimiyamachi kofun cluster (Kobe) "tattooed" on the face - Kobe City Archeological Resource Center.

According to Mu Zhongjian [12, p. 55], tattooing was particularly widespread among people practicing totemism, as they believed that, if their bodies were marked with totemic patterns, they would be possessed by ancestral spirits and given magic powers and protection [12, p. 55] as had happened in Early China. It seem possible to conclude by analyzing diverse Chinese sources that tattooing was also a way to decorate and a method to empower the human body [12, p. 55] and, according to Yao Xinzhong, tattoos were eventually related to natural or ancestor worship [14, p. 78], but this should had happened long before the canonization of Confucius. In fact, according to Confucian thinkers, the body should be preserved intact as symbol of virtue and primary duty of respect, obedience, and care for one's parents, *kō* 孝 (C. *xiao*), *lit.* "filial piety" [14, p. 78]. Tattoo in China, especially after the influence of Confucian thought on society, does not seem to have ever been any used in a rite of passage into adulthood, as a mark of sexual maturity or marital status or as a mark of identification in a special occupation, among others [15].

Although it is not clear whether the practice of tattooing entered the Japanese archipelago directly from the continent or not, it is certain that the Chinese script exerted a great influence on the Japanese language, bringing – among others – a wide vocabulary to identify the tattoo practice implying different meanings and symbology. In an extensive study on *Irezumi* 入れ墨, its author, Rovert Van Gulik has explained how various *kanji* (漢字) have been used throughout history to identify the polysemy of the term tattoo: it was meant to beautify practice, to be used as an apotropaic device or to serve as punishment, a practice that seems to have begun around the late Kofun period and was abolished around 1870 [9]. Going back to the case of red pigments found on *haniwa*, if we agree that during the Kofun period tattoos, instead of being used for ritual or status purposes, began to be placed on criminals as a punishment, of course it is not plausible that those red pigments found on *haniwa* represented tattoos. On the contrary, if one assumes that red pigments symbolized a tattoo practice, in the specific case of the *haniwa*, they did not represent a kind of punishment. Anyhow, this remains a tricky question.

Red pigments (*sekishoku* 赤色): cinnabar-vermillion and bengara

The subject of colours in archaeology has been gradually drawing the attention of researchers from diverse disciplines [16]. Although various minerals have been ground for use as pigments for many centuries, various iron oxides ranging in colour from red to orange to black have been the most prevalent natural pigments.

The use of red colour established itself as a habitual cultural practice in Africa starting about 160,000 years ago [17]. This pigment was used to decorate living space, funerary environments, objects, body and clothes, among others. The use of red organic pigments (of plant or animal origins), which are brighter, only appeared much later, ca. 15,000 years ago, as a recent archaeological finding in the Kebara Cave (Mount Carmel in Israel) reveals [18]. Finally, the invention of synthetic pigments occurred in the mid-nineteenth century and around the twentieth century red cadmium sulfoselenides were also discovered.

Since Palaeolithic times, red pigment, often referred to as "ochre" (an umbrella term for minerals that are rich in iron and consequently have vivid colours) with a typically ruddy hue, due to its symbolic and sacred value, has been extensively used in a variety of rituals and social practices. The use of the bright red mercury sulphide [19] that has been documented in different parts of the world occurring in the last 10,000 years [20], was quite common in burial contexts. In East Asia, a wide use of this substance has been observed in funerary practices.

Yajima Kunio's contribution on colours [21] represents an important starting point to reflect on this topic. He states that cinnabar, the mineral, is the most common ore of oxidized mercury found in nature and that, although abundant in volcanic areas, it is not as easy to obtain. Pigments produced from cinnabar, were generally used for antiseptic and decorative purposes during the Kofun period, this being a practice that continued an earlier mid-Yayoi one [21], and

which became, eventually, a symbol of protection and power [22]. In a more recent study, Matsumoto Naoko, in her study on the Jōmon evidence of complex technology for creating durable coloured goods, pinpoints that in Japan there were two substances that were connected to the red colour: red iron oxide – *bengara* – and cinnabar – *shu*. Cinnabar (mercury sulfide), she adds, is associated to volcanic activities and hot springs and could only be excavated around the Median Tectonic Line [23]. Another important contribution to this field of research is the collective paper by Kawano Maya, Takeuchi Akinori, Takahashi Kazuya, Imazu Setsuo and Minami Takeshi [22]. The authors stress that throughout Japanese prehistory there were three main pigments that were used to produce red colour: red ocher, vermillion and lead oxide [22]. Most relevant though is that they highlight the importance of analysing the sulphur isotope ratio collected from remains as a key element to determine the provenance of red pigments found both in burial mounds and on grave goods. Research on sulfur isotope ratios has demonstrated differences between the cinnabar collected from Chinese ores and that from its Japanese counterparts [22], Minami also stresses that the cinnabar collected from mounded tombs could be divided into two groups [24] and concludes that, while in Western regions of Northern Kyushu and San'in, cinnabar was normally imported from China, in the case of Yamato there was a tendency to exploit local ores, which was observed back to the end of the second century CE [24].

In Japan, the funerary use of cinnabar has, most probably, a continental origin. In China, the Daoist soteriological dimension, which aimed at regulating the relation between the world of the living and of that of the dead, *dan* (丹, J. *tan*], red cinnabar, was used in alchemical methods for the preparation of elixirs. According to Daoist alchemy, the body was interpreted as a microcosm whose various parts corresponded to (macro) cosmic elements. It was believed that the ingestion of cinnabar turned the body imperishable [25-26].

Zhang Guoshuo and He Jun [27] have stated that bottoming burials with cinnabar was a common practice in ancient China, it decreased by the Shang period, but was not abandoned. In fact, this funerary custom became common also in other regions in East Asia.

The terminology used to identify the red colour sometime is misleading, especially when translated from one language to another [16]. Yajima Kunio has stated that red colour in general became important in diverse contexts. It was used to decorate earthenware and the author alerts that red pigments both from the Jōmon and Yayoi earthenware were sometimes referred to as *tansai* (丹彩). This word, according to Yajima Kunio, is an inaccuracy because *tan* should be understood as *entan* (鉛丹) or read-lead (minium), a mineral that was not used as a pigment until the Nara period (710-794) [21]. Red colour (J. *aka* 赤) is also found on clay in large numbers, but, while Jōmon pottery was painted after firing, Yayoi pottery was generally fired afterwards [21]. Yajima Kunio has affirmed that the red pigment found on *haniwa* is *bengara* (弁柄, also ベンガラ) [21]. As reported by Honda Mitsuko [28], *bengara* is a general term for pigments whose main constituent element is iron (ferric oxide) from which the red colour is derived. She has stressed that *begara* was just one out of three colours used during the Kofun Period to produce red pigments, the other two being vermilion (J. *shu* 朱) and cinnabar (J. *tan* 丹). She has also added that in ancient times the name used for red pigment was "Taisha" (代赭色), lit. red ochre colour. The list of terms used to identify the traditional red colours of Japan would become even more complex when studied in specific contexts (i.e. literature, art and crafts). The detailed analysis provided by Honda Mitsuko on red pigments found at sites of the Kofun Period demonstrate that the great majority is *bengara* (Gunma prefecture, Kyoto prefecture, Nara Prefecture, Okayama prefecture, Shimane Prefecture, Fukuoka Prefecture, Saga Prefecture, Kumamoto Prefecture and Ōita), the rest is *shu* (Shizuoka prefecture, Nagano prefecture, Kyoto prefecture, Osaka prefecture, Nara Prefecture, Okayama Prefecture, Shimane Prefecture, Fukuoka Prefecture, Saga Prefecture, Kumamoto Prefecture). In some sites, however, vestiges of both have been found [28].

From the late nineteenth century to the early part of the twentieth century various studies emerged that tried to quantify colors based on color matching and discrimination by eyes. Many methods have been refined in the time since [29]. Nowadays hue, lightness and saturation are the three dimensions typically chosen to describe colours. Colours is probably the most obvious way to categorise pigments, which are colorant and are grouped in families.

It is of general knowledge that the colour of a pigment is determined above all by its composition but also by the size and shape of the pigment particles. Vermilion is a typical pigment whose colour varies with particle size in particular when is naturally obtained from mineral cinnabar [29].

Observing Figure 4, one can speculate that, in the case of the anthropomorphic mask of the Jōmon period (Figure 4a), the red pigments could be interpreted as tattoos. One aspect that may lend support to this argument is the fact that Ainu women have kept the tradition of facial tattooing, especially around the mouth. According to Robert Van Gulik the Ainu women's tradition of keeping the tattooing practice is somehow linked to the fact that Ainu regarded this practice not merely as beautiful, but also as a way to emphasizing their communion with their great spirit ancestress, Kamui Fuchi, whose soot protects them against the evil [30].

In the case of *haniwa* (Figure 3a and Figure 4b) the red pigments on the cheeks are generally identified as tattoos too. If one relies on eighth-century Japanese sources, as mentioned before, tattoo was considered a kind of dermography symbolizing a status, a decoration and a punishment. In the *Nihon Shoki* there are at least two references to tattoos as a kind of body decoration, as in the description of the Yemishi from Hitakami [31, p. 300], and also as a kind of criminal's branding, this aspect having most probably been imported from the continent [31, p. 305]. In the *Kojiki* there are incidental mentions of tattooing as a punishment, but there is also allusion to woman "tattooing" their eyebrows and reference to the warrior Kume, whose tattoo on the corners of the eyes turned his gaze particularly sharp [32]. Still, although the sources clearly induce one to interpret the red pigments on *haniwa* as being tattoos, I would like to give one more suggestion: could the red pigments possibly represent a ritual that implied a sort of make-up of the face as a performative part of a particular war dance or funerary ceremony? This interpretation, however, comes from mere personal speculation and needs further investigation.

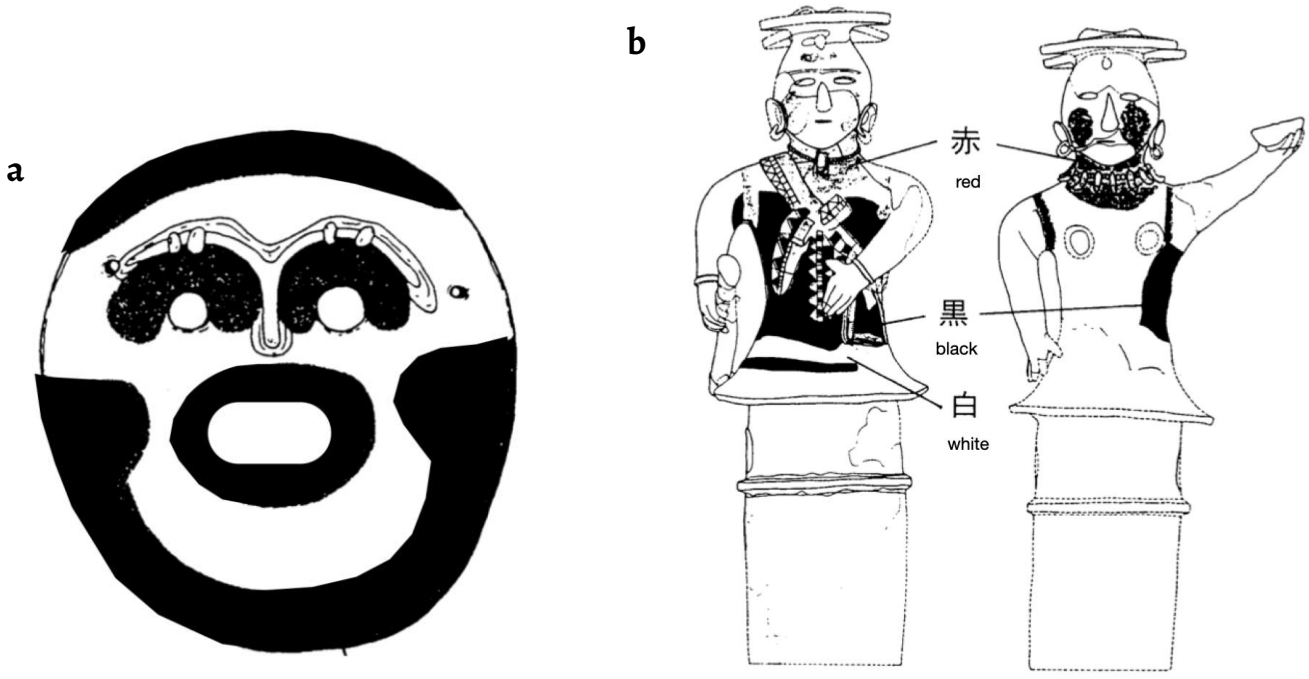

Figure 4. Clay artefacts with red pigments: *a)* anthropomorphic mask [21, p. 32]; *b)* anthropomorphic *haniwa* excavated from the nº4 tomb of the Tsukamawari Kofun cluster (Ōta-Gunma prefecture) "tattooed" on the face (red pigments) and with white and black pigments on the garment [21, p. 34].

Concluding remarks

Delving into the significance of the reddish pigments found on the surface of anthropomorphic *haniwa* it is not an easy task. These permanent marks may be seen as a reflection of the body adornment of those participating in the funeral rites and, possibly, the deceased. In Japan, the practice of tattooing, whose symbolic meaning has evolved over time, can be traced back to the Jomon period, nevertheless, the presence of reddish decorative motifs on both the face and body of the Kofun period *haniwa* leaves many interpretive possibilities open. There is no doubt that these marks hold a significant value, not only in the funerary context but also in shedding light on the broader social dynamics of Kofun *ethnoscape*.

A topic that was not developed in this paper and, could have further enriched our understanding of these permanent markings on *haniwa,* would have been the inclusion of crucial archaeometric data regarding the production and origin of the pigmentation used on *haniwa* during the Kofun Period. Cinnabar and bengara samples have been analysed using a range of techniques, including polarized light microscopy (PLM), X-ray fluorescence spectroscopy (XRF), X-ray diffraction (XRD), and energy dispersive X-ray spectrometry (EDS). As pinpointed by Minami Takeshi, Imai Akira, Bunno Michiaki, Kawakami Kawakami and Imazu Setsuo, of particular significance is the application of isotopic determination techniques (Carbon-Oxygen-Sulfur), which have proven indispensable in tracing the provenance of minerals like cinnabar used as pigment, offering invaluable insights into the sources and trade routes of ancient pigments [24].

These techniques are instrumental in mapping the provenance of artifacts, providing a deeper understanding of their origins and historical context. While there are no doubts as to the fact that *haniwa* were produced locally, there has, however, been some discussion as to the extent to which the pigments used to mark the anthropomorphic *haniwa* and decorate the mounded tombs might have been a commodity for long-distance exchange. So far, two different patterns of raw material provenance were evidenced through the archaeometric analyses of the red pigments determining that they were both imported and produced locally in the Japanese Archipelago. By examining the material culture, such as the pigments used in haniwa, researchers can trace patterns of migration and the spread of cultural practices, helping to build a more comprehensive understanding of how these populations interacted and influenced one another in the Kofun period.

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Different stones: the weight of colour in ancient near Eastern glyptic

Pedras diferentes: o valor da cor na glíptica do Oriente Próximo antigo

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Abstract

The cylinder seals of ancient Western Asia are a category of artefacts with a wide range of characteristics and implications. Their use was both administrative and bureaucratic, but they were ornamental and apotropaic objects too, thus acquiring diverse symbolic and cultural values. Moreover, they were mostly experienced by their owners and users by being kept in close contact with their bodies. This means that the physical characteristics of the seals (colour, conductivity, weight, etc.) probably had some importance for the ancient societies using them. Thanks to widespread and precise digital technologies, the recording of the data of seals has grown significantly in recent years. In this preliminary work, primary and secondary visual data and the metadata thus obtained have been collected, and statistical analyses have been carried out with the objective of testing the possibility of mapping the general colour trends of ancient Near Eastern glyptics.

KEYWORDS
Cylinder seals
Colours of artefacts
Ancient Western Asia
Principal component analysis
Quantitative methods

Resumo

Os selos cilíndricos da antiga Ásia Ocidental são uma categoria de artefactos com uma ampla gama de características e implicações. O seu uso era administrativo e burocrático, embora também fossem objetos ornamentais e apotropaicos, adquirindo assim diversos valores simbólicos e culturais. Além disso, eles foram experienciados principalmente pelos seus proprietários e usuários, mantendo-os em contato próximo com seus corpos. Isto significa que as características físicas dos selos (cor, condutividade, peso, etc.) provavelmente tiveram alguma importância para as sociedades antigas que os usaram. Graças à difusão e precisão das tecnologias digitais, o registo de dados de selos cresceu significativamente nos últimos anos. Neste trabalho preliminar, foram recolhidos dados visuais primários e secundários e os metadados obtidos, tendo sido realizadas análises estatísticas com o objetivo de testar a possibilidade de mapear as tendências gerais de cores dos glípticos do Oriente Próximo antigo.

PALAVRAS-CHAVE
Selos cilíndricos
Cores de artefactos
Ásia Ocidental antiga
Análise de componentes principais
Métodos quantitativos

Introduction: studying ancient cylinder seals

The use of cylinder seals is documented in ancient Western Asia, and especially in Mesopotamia, from the Chalcolithic period (around 3500 BCE). The first appearance of this type of artefact seems largely linked to the technology of writing and the emergence of the first forms of state administrations and complex societies [1-6] (Figure 1 and Figure 2). It was then rapidly adopted, albeit unevenly and in different periods and with different modes, in other areas and by other cultures of the Eastern Mediterranean and Western and Central-Western Asia. Among these were also less or differently literate cultures, such as those of Egypt, the Aegean, Anatolia, the Indus Valley, etc. The spread of the cylinder seal led in most cases (but not always and not everywhere) to the disappearance of the stamp seal [7; 8, pp. 5-7; 9, pp. 14-19].

It has often been emphasised that the cylinder seals had other functions in addition to their administrative use, that could have been acquired even before the first large-scale production and use: the seal became an amulet and an ornament, sometimes as part of its owner's clothing. Although it is possible that in its earliest use, and in some later cases, it had been linked to an office rather than to a person, it is likely that it was soon linked mostly to individuals. As such, it could be worn on clothing, as a pendant or as part of a bracelet or other pieces of jewellery. It is possible that, at least in some historical periods, the cylinder seal was also an explicit mark of high social status [4; 10-13; 14, pp. 16, 22-24, 229-230; 15; 16, pp. 57-60].

As far as we may now understand the daily life of the peoples who used them in antiquity, cylinder seals were perceived and experienced primarily through their peculiar corporeality, both when being used as administrative tools and when being manufactured or worn. Nevertheless, when publishing cylinder seals in scholarly works or catalogues, it has been common practice for many years to show their complete (and carefully produced) aseptic modern impression, so that their entire iconographic apparatus is shown in an easily understandable representation. However, such a display has no real equivalent in the actual ancient use of seals. Similarly, when seals are exhibited in museums, they are usually shown alongside their modern impression: in fact, a very poor representation of meaning and impact in ancient societies. As a rule, in both cases – i.e. museum exhibitions and printed publications – little information is provided about the physical characteristics of the seal, usually limited to height and diameter, while other interesting features are neglected (see, for example, the observations of Asher-Greve and Stern [17-18]). This means that very little information regarding cylinder seals has been recorded which could be truly useful for an investigation focusing on their nature as a cultural product. The perceptual characteristics associated with their intense physical relations with the bodies of their ancient makers and active or passive users also remain unexplored. Only in recent years have some research groups taken advantage of the recording and reproductive potential of digital technologies to expand the range of available information regarding ancient glyptic specimens [19-29].

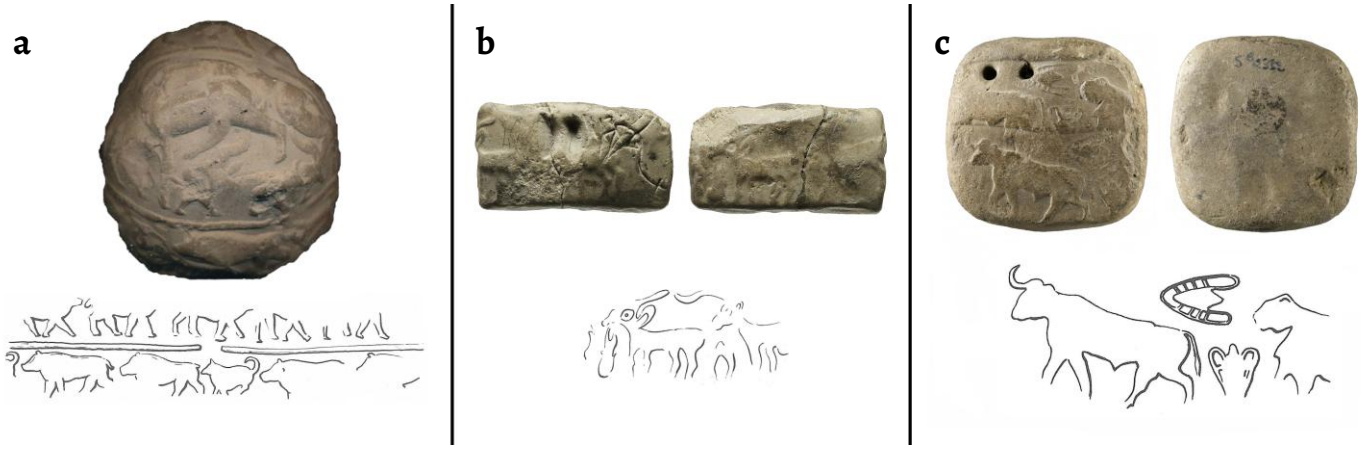

Figure 1. Fourth millennium sealed artefacts: *a)* Bulla from Susa (Louvre: SB 6295); *b)* Protohistoric administrative tablet (obverse and reverse) with numeric and pictographic signs (Louvre: SB 6349, from Susa); *c)* Protohistoric administrative tablet (obverse and reverse) with numeric signs (SB 2312, from Susa) [30].

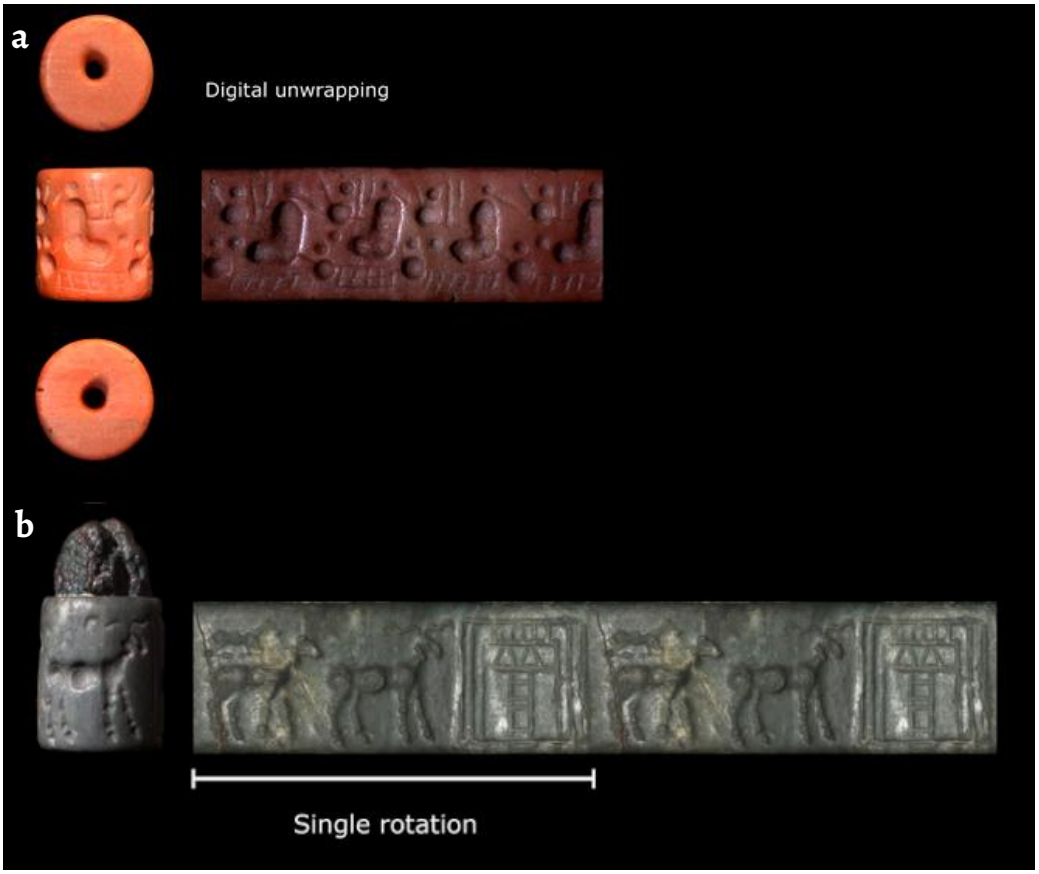

Figure 2. Two cylinder seals of the Late Uruk period: *a)* CDLI P502513; *b)* P476472, BnF Paris et Université de Nanterre (photography: N. Ouraghi for the SESPOA Project [31]).

This contribution illustrates research into the colours of cylinder seals, one of their physical features which has thus far been largely neglected in literature and research. It is worth recalling that most – though not all – known cylinder seals are made of stone, as are most of the seals used in this study, except for a few made of faïence.

This work and its development are based on – and have been made possible thanks to – four main components: the availability of a pre-existing independent open archive of digitised seals; a dataset based on this archive specifically developed for this research; open algorithms for the examination and analyses of colour in digital images; exploratory data analysis methods, such as principal component analysis (PCA). Our objective was to provide a preliminary step in a broader study on both colours of cylinder seals and on possible clues to the phenomena underlying their perception and choice. We have focused on two topics: the changes of the colours of cylinders during the historical periods when these artefacts were in widespread use (ca. 3500-300 BCE), and the possible relations between the colours of the seals and the iconographic subjects carved on them.

The structure and building of the data set

In order to build a dataset that would fit the aims of this investigation, specific information consistently recorded for a large number of artefacts is necessary. Such information must relate to three main features at least, namely: the colours of the seals, the subjects carved on their surface, and the historical period of manufacture.

The historical period of each seal's manufacture has been identified considering both iconography and carving style, while the subjects represented on the surfaces of the cylinders were recognised and named according to the traditional terminology used in literature (such as

"contest", "presentation", et sim.) or through a simple description ("geometric motifs", "animals", etc.). As sometimes more than one theme is shown on a seal, both primary and secondary themes have been recorded for each specimen, with possible inscriptions recorded as secondary themes too.

Identifying the colour of seals is not a trivial matter, as surfaces often show complex mixtures of shades or a dense juxtaposition of very different hues. Furthermore, as colour is the result of a subjective visual perception of the type of diffusion of light by a particular surface, a consistent perceptual response is needed to record and compare colours. The solution to this problem has been found in recently developed research projects. Indeed, various experiments have been carried out over the last twenty years which seek to optimise the documentation and representation of cylinder seals in scientific publications with the help of digital technologies [19-29, 32-36]. One of the most recent projects of this kind has been developed as an international initiative involving several research institutions, SESPOA-SIANE [31, 37]: using a structured light scan, a large number of digital representations of cylinder seals with consistent colour reproduction could be produced. Structured light is a system that projects a pattern of light onto an object: this pattern of light is distorted by the profile of the object's surface [28], such that it can be further analysed in its constituent parts. The team of SESPOA-SIANE used the same setup for capturing the images necessary to obtain the digital rollout – and possibly the 3D model – and consistently carried out post-processing of the images obtained, at least for the digital rollouts, made possible by calibration measurements made on the scanner. On the other side, the two bases and the single pictures of the sides of the cylinders shown in the archive sometimes – especially in the earliest phases of the project – had been taken separately with a digital camera: as a result, they may look a bit different in colour in the final display. For this reason in this work we took into account the colour data resulting from the digital rollouts. As numerous images of seals obtained through structured light scan are published on the freely accessible SESPOA website as images together with the "digital unwrapping" of their surface, we could take advantage to use these for our experiments (Figure 3).

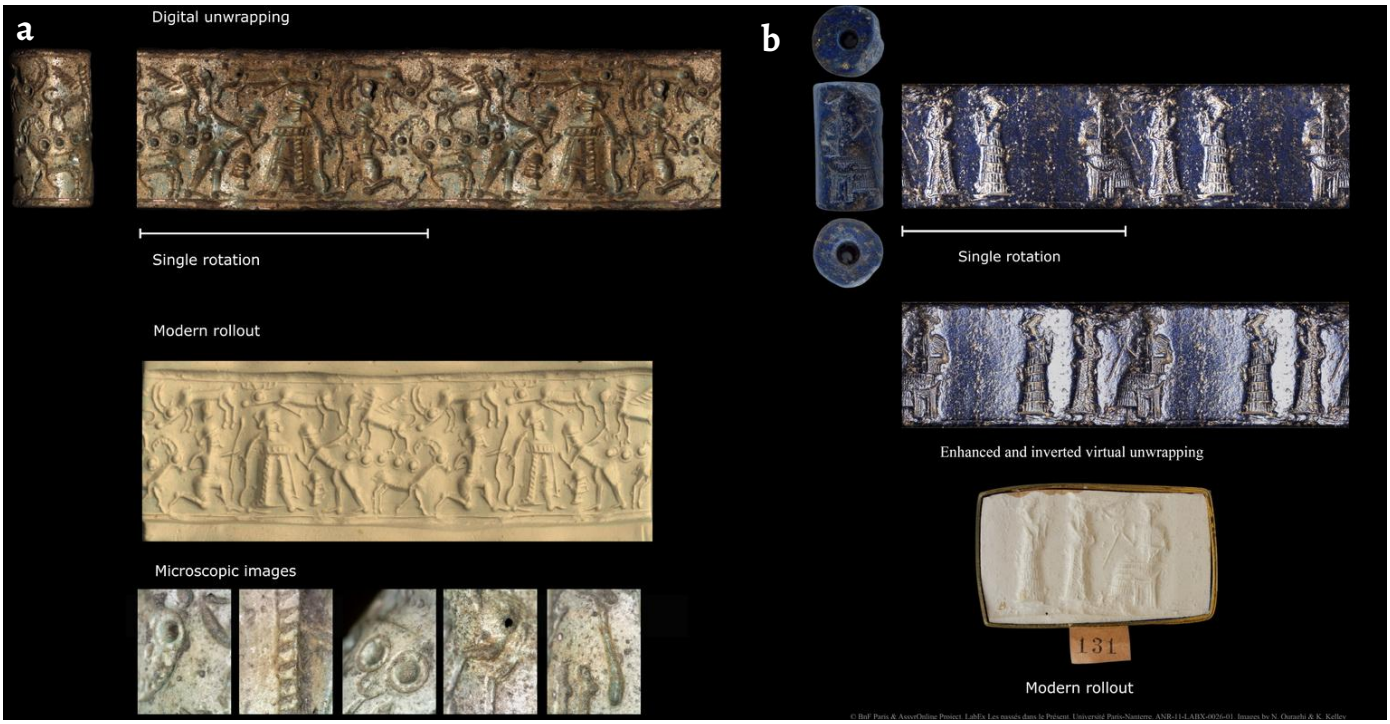

Figure 3. Two examples of scans published on the websites of SESPOA and CDLI: *a)* P502856; *b)* P502611, BnF Paris et Université de Nanterre (photography: N. Ouraghi for the SESPOA Project [31]).

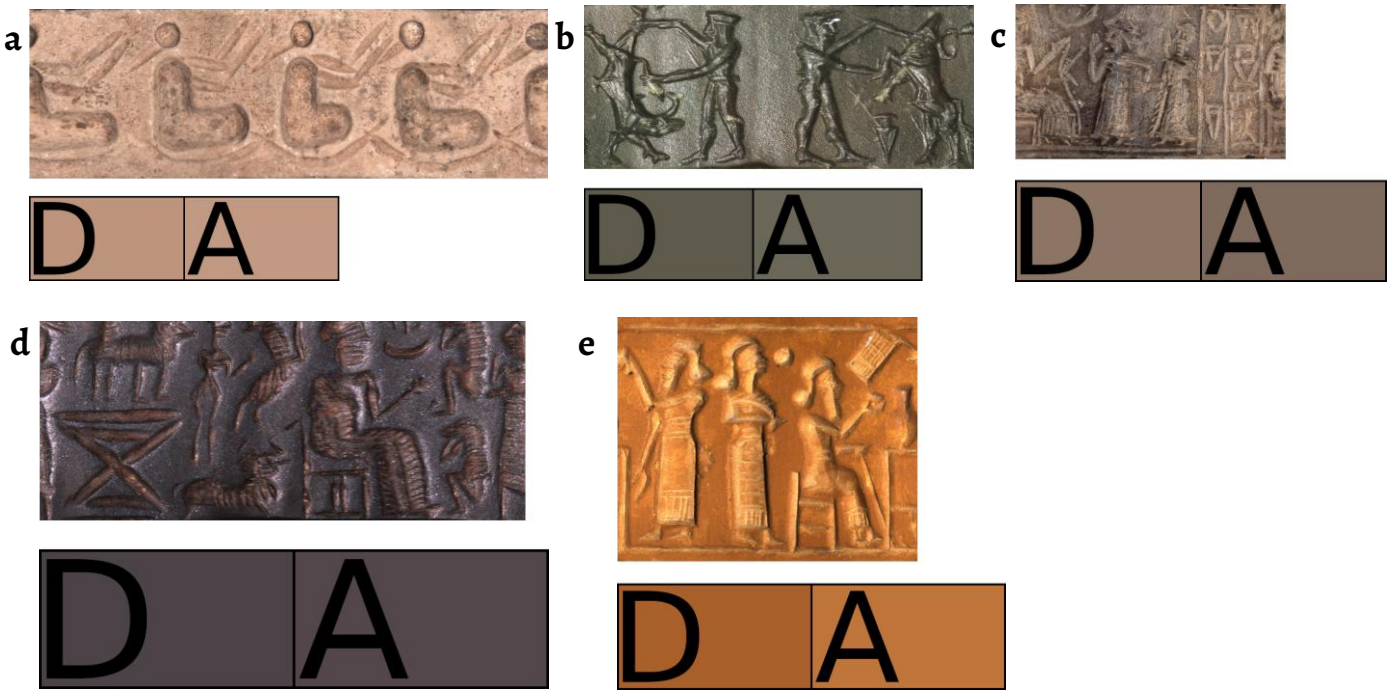

Figure 4. Examples of *Dominant* (D) and *Average* (A) colours recorded on some cylinder seals. The triples of values refer to the RGB coding of each colour (dominant; average): *a)* Jemdet-Nasr period working women (daily life): 189, 148, 124; 194, 154, 131; *b)* Akkadian contest: 95, 91, 76; 107, 104, 90; *c)* Ur III presentation: 140, 117, 100; 127, 107, 93; *d)* Old-Assyrian presentation: 75, 67, 72; 84, 71, 75; *e)* Neo-Assyrian banquet (daily life): 170, 96, 42; 192, 118, 58.

Nowadays, various strategies exist for measuring the colours present in a digital image, from client free or proprietary software to various web applications. Of course, the selection and consistent use of a single tool or set of algorithms is essential for a study comparing the colour values of images. In our case, the calculation and description of the RGB colour values of the images of the artefacts was performed using the image analysis web tool *Image Average Color Finder*, available on the DevPicker website [38]. This particular tool was chosen because it is easy and quick to use and has the advantage that the image analysis can be visually interacted with and controlled, making it well suited to the production of a large dataset. The *Square Root* and *Dominant* analyses were used to obtain the RGB values of the average and dominant colour for each specimen, respectively. Note that to measure the average colour *Square Root* proved to be more accurate and reliable than the *Simple* analysis.

Based on the values obtained from DevPicker, we created a dataset of the recordings of 639 seals, each consisting of 10 entries: 1) the unique identification number of the seal, linked to both the corresponding accession number of the collection and the identification number of CDLI [39]; 2) the historical period, made up of twenty possible values representing a range of periods from Late Uruk to Hellenistic; 3-4) the primary and secondary themes, entered as nine and seven formalised codings respectively; 5-7) the average and 8-10) the dominant colours, each recorded as the values of the three Red-Green-Blue (RGB) components, ranging from 0 to 255 respectively (Figure 4 and Table 1-3).

All the codings included in this first step refer to seals belonging to the collection of the Bibliothèque Nationale de France (Paris). They are based on the image archive published on SESPOA website [31], also present in the CDLI archive.

We were aware of the possible drawbacks of using a dataset largely based on artefacts from the antiquarian market and so ruled out any risk by careful visual inspection. In the corpus recorded in the dataset, forgeries or overly eccentrically coloured artefacts are absent. The latter were not excluded on purpose: this could be verified after completing the dataset, and thanks to the useful observations by Margaret C. Root (on the international congress *Archaeology of Colour*, 2024). However, not all seal images published by SESPOA were considered. About 35 % of them (hundreds) were excluded as a precaution, either because they

appeared to have been recorded according to different parameters than the others, or because the artefacts were too badly preserved to recognise their theme and period. As with a few other seals which were heavily damaged, but still clearly showing the carved theme, their profile was adjusted to avoid the possible influence of "empty" spaces on the analysis. A similar treatment was applied to the very few specimens in which light was reflected in an exaggerated manner.

Table 1. Composition of the dataset, according to historical periods.

Coding	Period	Number of specimens
Lt-Uruk	Late Uruk	18
JN	Jemdet Nasr	14
EDII	Early Dynastic II	16
EDIII	Early Dynastic III	26
Early Syr	Early Syrian	14
Akk	Akkadian	54
UrIII	Third Dynasty of Ur	44
Isin-Larsa	Isin-Larsa	36
Old Bab	Old Babylonian	123
Old Assy	Old Assyrian	32
Old Syr	Old Syrian	58
Cyprus	Cypriote Late Bronze	15
Kassite	Kassite	13
Middle Assy	Middle Assyrian	18
Mitanni	Mitanni	20
Egypt	Egyptian Late Bronze	16
Neo Bab	Neo Babylonian	23
Neo Assy-Sy	Neo Assyrian	57
Persian	Persian	30
Hellen	Hellenistic	12

Table 2. Composition of the dataset, according to themes.

Coding	Theme	Number of specimens
Inscription	Inscription (or legend)	12
Pres deity	Presentation before a deity	228
Daily life	Scenes of daily activities	56
Pres	Presentation	117
Deities	Deities	27
F-f-g	Floral, faunal or geometric motifs	22
Contest	Contest scene	122
Hunt	Hunting scene	37
Animal	Animal(s)	18

Table 3. Composition of the dataset, according to secondary themes.

Coding	Secondary theme	Number of specimens
Absent	Secondary theme is absent	426
Daily life	Scenes of daily activities	4
Animal	Animal(s)	40
Pres	Presentation	13
Inscription	Inscription (or legend)	126
Deities	Deities	7
Contest	Contest scene	23

The methods

The data analysis was essentially based on principal component analysis (PCA [40-41]), a very well-known tool for exploratory identification of the main features of a data set. PCA seeks the most informative graphical representation of the numerical data at hand through a transformation (singular value decomposition [42]) in which the units are represented on new uncorrelated variables – the principal components – along which most variation occurs. Since principal components are those most correlated with the original variables, their direction can be interpreted through them, leading to an optimal representation in reduced dimensional spaces of both the units and the numerical variables, in which the most relevant features of the data can be observed. On the same graphics, each value of the nominal characters – in the following, addressed as "level" – may be represented as a supplementary unit, situated in a central position with respect to the units showing such value. More precisely, these levels are set as "centroids", i.e. points whose coordinates are the average of the considered units. As such, both their absolute position and that with respect to the other levels may show to what extent the corresponding groups of units may be characterised by the average values of the original variables. All calculations were performed with the R package [43].

The results

The PCA was performed on the values of the two groups of three components of the digital RGB colour model recorded for each specimen, representing its average and its dominant colour, respectively.

On the three extracted components, accounting for 98 % of total variation – an outstanding amount –, all levels of period and themes have been projected as average of the seals grouped by each level. As expected, dealing with all positive values, the first component explains about 85 % of total variability, the second about 9 %, and the third more than 4 %.

A very important aspect of the results, particularly clear in the graphics, is the actual degree of distance or proximity between plotted items, which are generally expressed with the association or opposition along an axis, i.e. a straight line where the items' coordinates correspond to a principal component. For instance, two items are opposed on an axis if either lies on the positive and the other on the negative side of the axis. Moreover, the further they are from the axes' origin – the point where the axes cross, the center of gravity of the cloud of points – the larger is their opposition as well as, in general, their distinction from a very common item. For the interpretation of the axes, their correlation with the original variables – in this case, the six colour components – is considered and represented in the circle of correlations, where the angle between variables and axes approximates their correlation.

According to this representation (Figure 5), the resulting oppositions along the axes are the following: Axis 1, light (on the positive side) and dark colours (on the negative side); Axis 2, lighter average colours (on the positive side) – corresponding to higher values of the RGB components – opposed to dominant colour (on the negative side); Axis 3, higher values of Blue (on the positive side) as opposed to Red components (on the negative side), Green which comes out as average.

Note that, in addition to the colour hue, the first two axes also show the ability of the stone to reflect light. Therefore, however controlled and accurate they may be, image acquisition operations through structured light scanning and further processing could not avoid light reflections produced on the stones of which some of the seals are made [31]. In our case this happened with very few seals, but proper pre-processing of data, and counterchecking with the recording of both the average and dominant colours in the dataset helped us to minimise the effects of this introduced bias.

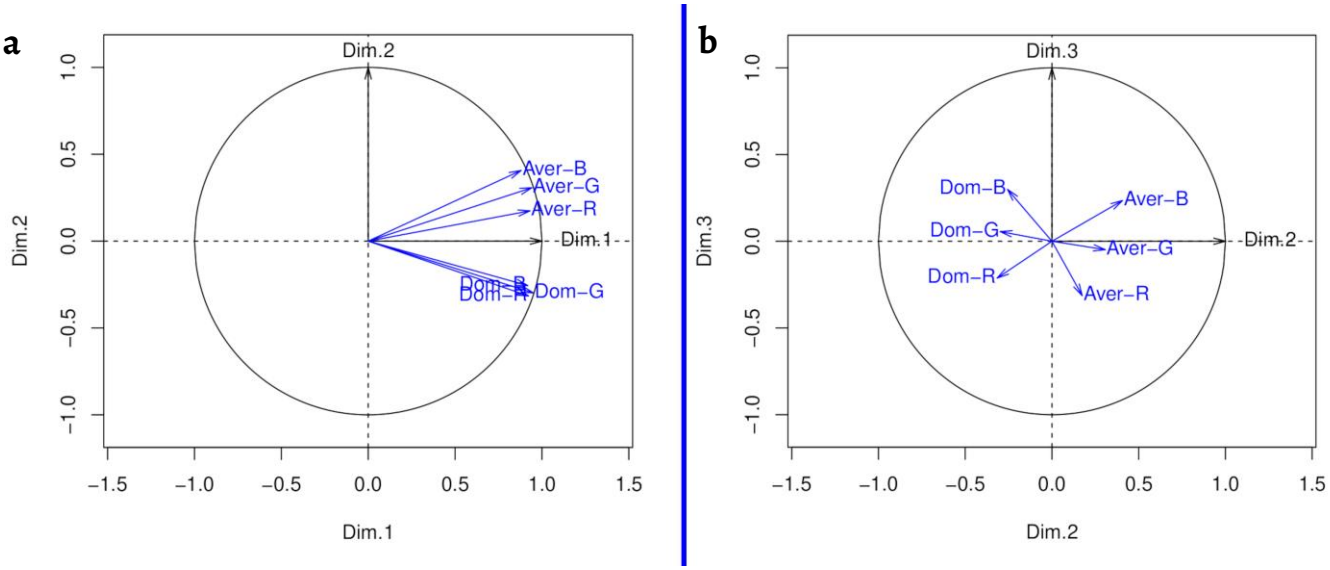

Figure 5. PCA results: the circles of correlations with respect to the axes 1-2 (a) and 2-3 (b). Note the positive correlation of all colour's components with axis 1 (hence interpreted as intensity), the opposition between average and dominant colours on axis 2, and the clear distinction between Blue, Green, and Red on axis 3.

Seal colours and historical periods

The representation of supplemental items on the graphics as a three-dimensional cloud of points, allows them to be interpreted according to the agreements-oppositions along the three axes of the space of representation.

On the plane spanned by axes 1-2 (Figure 6a), the cloud of historical periods suggests that the earliest Mesopotamian seals were made of stones of relatively homogeneous and intense colours and a shade of colour which gradually changed from moderately light to very light: this is suggested by the position of the levels of chronology Late Uruk (Lt-Uruk) and Jemdet Nasr (JN). These features seem to have been maintained in Mesopotamian glyptic until the middle of the third millennium BCE, apart from the fact that colours tend to become slightly brighter from Early Dynastic II (EDII) and darker in Early Dynastic III (EDIII). In the following centuries, i.e. in the Akkadian (Akk) and Third Dynasty of Ur (UrIII) periods, Mesopotamian cylinder seals tended to be darker and more homogeneous in colour, but apparently also shinier. This picture is confirmed and further explained by looking at the distribution of periods along Axis 3 (see the plane spanned by axes 2-3 in Figure 6b). From the early historical era (Late Uruk) to Early Dynastic III, the general development of colour is from greenish-reddish to yellowish with a general prevalence of the dominant colour, while in the second half of the third millennium, first in the Akkadian period and then under the Third Dynasty of Ur, the colours seem to become more balanced, with a prevalence of the blue component in quite dark and slightly shiny stones. The Early Syrian production (Early Syr) – which in this case can be chronologically paired with the late Early Dynastic III and Akkadian periods in the Land of the Two Rivers – differs markedly that of Mesopotamia, as it has lighter colours and a clear predominance of the red component.

Lower Mesopotamian glyptic production of the Middle Bronze age (represented in the graphics by "Isin-Larsa" and "Old Bab") shows a strong chromatic homogeneity, with a moderate balance of the three components (RGB) and significantly darker stones when compared to the earlier periods. Old Assyrian figures (Old Assy) are very similar, and the same is true for Old Syrian seals (Old Syr), if it was not for the significantly lighter colours of the latter.

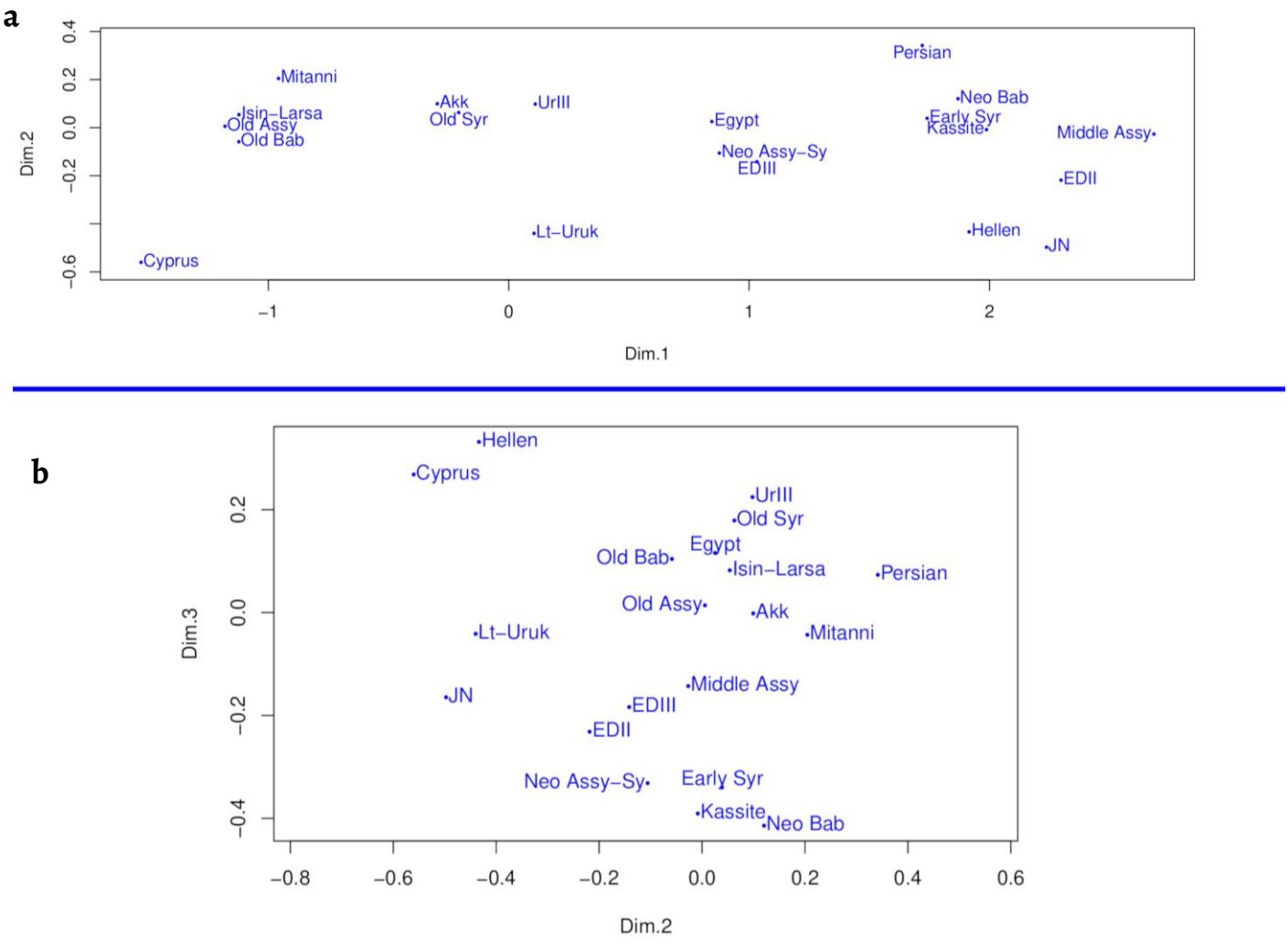

Figure 6. PCA results: representation of the historical periods on to the planes spanned by the axes: *a)* 1-2; *b)* 2-3.

In the Late Bronze Age regional and cultural-chronological distinctions emerge clearly, and with sharp oppositions. Kassite and Middle Assyrian (Middle Assy) specimens tend to be quite light in colour, relatively dull and with a marked prevalence of the red component – especially the Kassite seals. Mitannian production (Mitanni) seems brighter, much darker and with a good balance of the three components, while the specimens of Late Bronze Cyprus show extreme values on all axes, with a clear prevalence of the blue component on Axis 3 and a tendency towards dull (Axis 2) and dark colours (Axis 1). The Egyptian cylinders included in the dataset are not very numerous and can be dated to a period across Late Bronze and Early Iron Ages. They are essentially quite light in colour, with the blue component clearly predominant and the green component present to a small extent only.

In the first millennium the seals from Mesopotamia show a clear tendency towards lighter colours. The Neo-Assyrian (Neo-Assy-Sy) and Neo-Babylonian (Neo Bab) specimens share a predominance of the red component, but the former are somewhat darker and less bright. Later periods, i.e. Persian and Hellenistic (Hellen), are opposed on Axis 2, with the Persian production being brighter, but both showing a tendency towards light colours and a predominant blue component, especially the latter.

The general framework that can be established on the basis of these results has been summarised in Figure 7. This synthetic overview allows a quick diachronic comparison since it shows, and juxtaposes graphically, average RGB values recorded for the dominant (Dom) and average (Avg) colours of the seals of each period (Figure 4).

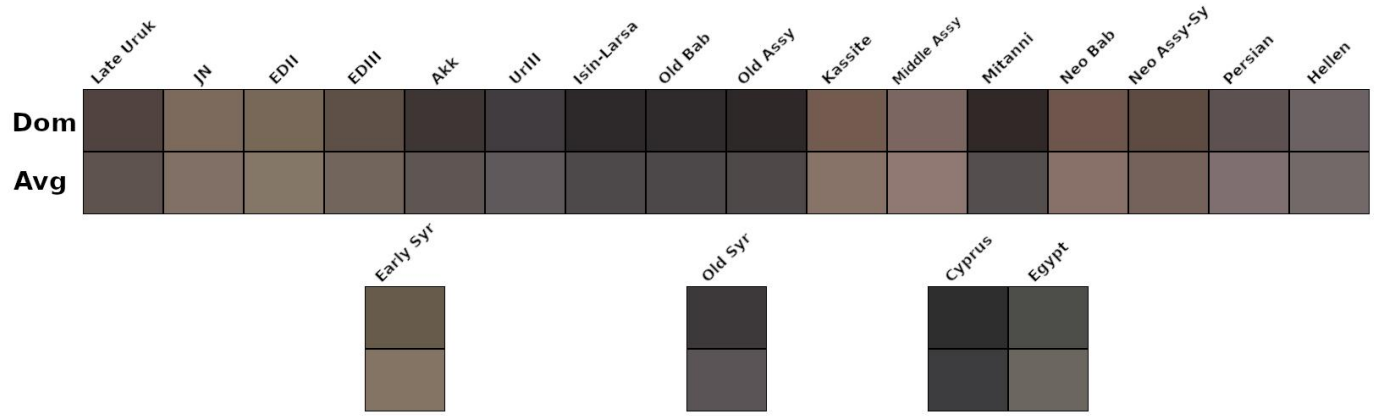

Figure 7. Synthesis of the average values of dominant (Dom) and average (Avg) colours of cylinder seals in different historical periods. The continuous series shown above represents Mesopotamian periods, or periods partly related to Mesopotamia. The discontinuous series below similarly represents the contemporary periods related to other regions of Western Asia. The upper half of each series shows the RGB rendering of the average of seals' dominant colours (Dom) for each period, while its lower half shows the RGB rendering of the relevant average of average colours (Avg).

Such a global view of the results shows remarkable diachronic changes in the colours of Mesopotamian cylinder seals from late fourth millennium to the early second half of the third. This seems an accurate reflection of the nature of changes that took place in the Early Bronze Alluvium in the realms of visual culture and regional political balances. The transition from the late Early Dynastic "proto-imperial" phase to the Akkadian empire is represented by changes in the colour of the seals that would characterise glyptic production until the end of the third millennium. The many cultural, political and organisational affinities that existed between Akkadian rule and Ur III are well reflected in the figures that emerge from this analysis, despite the differences in glyptic themes and iconographies. Geographical differences appear to emerge as early as the second half of third millennium when looking at the values for Early Syrian production.

The Middle Bronze Age is very homogeneous across different regions, with Lower Mesopotamian, Syrian and Old Assyrian productions showing great similarities. This can perhaps be interpreted in cultural and commercial terms (i.e., trade in raw materials) rather than in a political manner considering the diffusion of the Amorite peoples throughout these regions, often in leading socio-political positions, and the growing number of (mainly territorial) entities that played independent roles in international trade and politics. Such homogeneity could be due to trade networks that seem to have facilitated the fulfilment of demands for certain raw materials, though the general political situation, characterised by discontinuous international balances, may have rather favoured a differentiation between the political entities involved in terms of their internal structure and organisation. Indeed, this is much more evident when considering the iconographies of the seals rather than their colours. Looking at the figures of the analysis, it seems that the colours of Late Bronze Age seals reflect not only the changes in the local politics of most regions, but also a clear-cut cultural differentiation among these regions and a profoundly altered international political framework. It is only between the productions of Lower and Northern Mesopotamia that some traces of affinity can be identified, despite major differences in the iconographic tradition.

The general picture of the first millennium fits well with the historical-political situation, with appreciable – while not huge – differences between Neo-Babylonian and Neo-Assyrian productions and, later, the Persian and Hellenistic seals: these differ clearly only in that they are opposed on Axis 2, but not on axes 1 and 3. The colours of Persian seals seem to be in continuity with the developments of the Neo-Babylonian seals, and during the Hellenistic period many of their features are retained, while a tendency emerges to use duller stones.

Seal colours and iconographic themes

One of the aims of this research is the investigation of the possible relations between the colours of seals and represented subjects. This study was only partially carried out because, in addition to the interpretation of the carvings, it also involves their categorisation into thematic groups which is a complex and delicate question which could increase the degree of arbitrariness of the investigation.

The ideal association of the themes represented on different seals may be fairly solid and well-grounded in some cases, and also within the same historical period. However, it can become difficult and lead to the misleading coding and interpretation of data when formal similarities between different cultural or historical productions are very tempting. We have decided to limit the study to a few themes for which an ideal definition – based not only on compositional and formal features, but also on past research and literature – may reasonably be adopted.

One of these is the category of the so-called "presentation scenes", where the focus of the presentation or act of homage is a deity or a human being [16, 44]. This category of subjects ("Theme_pres deity" and "Theme_pres"), which is mainly attested in the late Early Bronze and Middle Bronze age, is associated with dark colours and a predominant blue component. In general, seals with "presentation scenes" seem to tend slightly towards being associated with shiny stones (Figure 8).

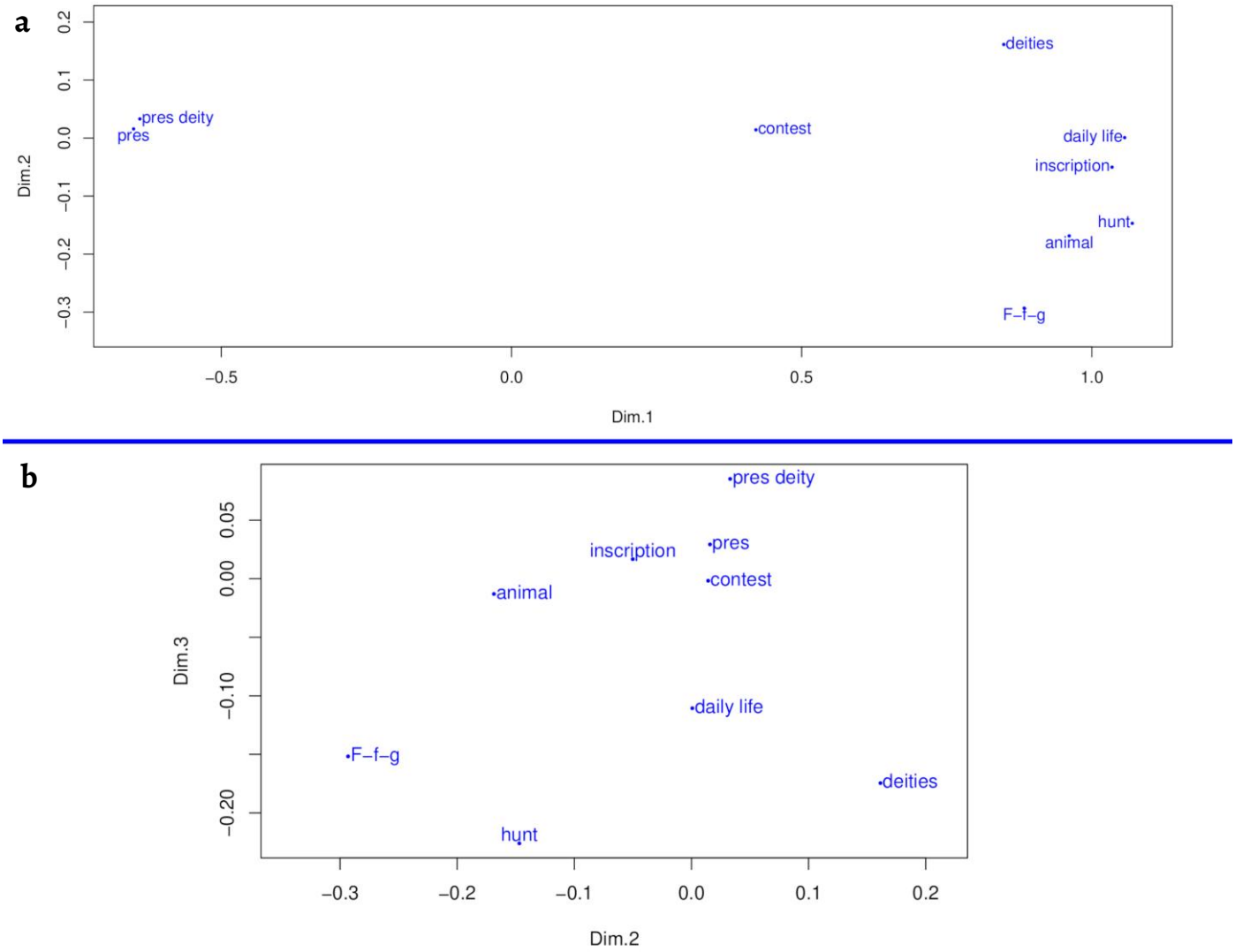

Figure 8. PCA results of the representation of the iconographic themes on to the planes spanned by axes: *a)* 1-2; *b)* 2-3.

Another group of subjects that can be considered fairly homogeneous is largely linked to the earliest historical periods: the combination of elements or patterns rhythmically distributed on the surface ("Theme_F-f-g"). These may include geometric motifs and floral or faunal elements. This category is in clear opposition to the presentation scenes on all three axes and is generally represented on light-coloured seals which tend to be dull, with a predominant red component. The nature of the occurrence of the hunting theme ("Theme_hunt") is very similar, but the logical and semantic internal homogeneity of this group does not seem solid enough at the moment to consider this a real clue for interpretation.

Apart from being easily recognisable, both the "presentations" and the "F-f-g" patterns are largely homogeneous in terms of their own chronological development. Their clear-cut opposition in the graphics might be due to the different historical periods and conditions in which they were mainly produced and used, but also to the fact that they were probably tied to different administrative uses and to different understandings of the relation between the seal and its owner.

Closing remarks

The perception and use of colour in the cultures of ancient Western Asia are very stimulating, but also largely unexplored research topics (except for comparatively few works, see e.g., [45-47]), particularly with regard to stone artefacts. This is not surprising considering how difficult it is to collect and interpret data on these issues. We must not forget that the various cultures of antiquity perceived and classified colours differently from us and from each other. It is possible, though unlikely at large scale, that none of the colour distinctions we make correspond to any kind of implicit or explicit classification of the cultures that produced cylinder seals. On the other hand, one must consider the possibility that the colour distinctions we find for a class of artefacts correspond to other significant differences in perception, construction or choice of materials.

The study presented here is merely a preliminary exploratory step of research which hopes to develop in a number of directions: the first stage focuses on understanding when and to what degree the colours of cylinder seals changed, and, consequently, whether there may have been any relation between seal colours and iconography or historical phenomena of any kind. At the moment, the perspective is too general and the stage of research too early to include the investigation of specific reasons behind the choice of colours and possible links to social, political, economic issues, or questions of contemporary fashion. Therefore, at present, the central subject of this research is seal colours, considered independently from their materials and other physical factors.

Significant opportunities for this study arise from the fact that cylinder seals are fairly well – and in large numbers – documented and known. For our investigation, it is essential to have a dataset of seal colours containing a good number of records (we plan to expand it significantly) and which has been built with due attention to the representation of different periods and production types. These starting conditions can lead to a well-grounded and solid picture of general chromatic developments in ancient glyptic craftsmanship, if one uses the proper methodologies to obtain information adequate for a representative synthesis. In the study presented here, PCA proved to be a suitable tool for identifying and graphically representing similarities and differences in the colours of seals according to their historical periods and, to a lesser extent, depending on the theme depicted.

The main weaknesses of this work and its procedures are – as has already been mentioned – the degree of arbitrariness in the definition of iconographic themes engraved on the cylinder seals and the fact that the original data we can presently use are only those already collected in research projects by scholars and institutions not involved in this work.

Although the type of data available limits the possibilities for expanding the dataset, the future substantial increase in number of records should in itself reduce possible biases and help to achieve the goal of a correct representation of the specimens for different periods and cultures. A higher number of seals coded and included in the dataset would also allow a more refined differentiation of periods, and thus a bettergrounded classification of the themes represented in glyptic.

Needless to say, the following steps of this research will start with an increase of the dataset in two directions: the number and variety of records and the number and quality of variables included. With such an approach, the possible biases caused by an excessive presence of artefacts from the antiques market in the dataset will further be limited. Other statistical methods are considered too, in particular to carry out analyses allowing the assessment of the degree of variability within historical periods or geographical areas. Together with a cautious and careful use of recent studies on colours in ancient Western Asia [48-49], this would help in the interpretation of the results.

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Beyond art technical sources: understanding colour production in Andalusi texts

Para além das fontes documentais de técnicas de produção artística: a produção de cor nos textos andaluzes

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Abstract

The study of colour production in al-Andalus has been mostly directed towards art technical documentary sources, such as al-Qalalūsī's *Tuḥaf al-Ḥawāṣ* (*The Treasures of the Select*), the 13th century Andalusi instructional book. The focus of the said research falls on the ingredients and procedures to create colour. However, the technical-centred approach tends to overlook social, economic, and cultural aspects of colour-making, such as the social perception towards dyers, prices, colour etiquette, besides the context under which such manuals were written. Other types of texts – such as geographical, normative, technical, and epistolary – can help to fulfil such gaps, by providing information regarding the production, commerce, transportation, symbolism, and further uses of raw materials used in colour production, such as alum, cinnabar, and indigo. A multifaceted approach which combines the analysis of different types of coeval sources, primarily Andalusi, can contribute for a more comprehensive insight on colour production in al-Andalus.

KEYWORDS
Colour production
Colour commerce
Colour use
Medieval pigments
Al-Andalus
Andalusi texts

Resumo

O estudo da produção de cor no al-Andalus tem maioritariamente incidido sobre fontes documentais de técnicas de produção artística, tal como o *Tuḥaf al-Ḥawāṣ* (*O Tesouro das Elites*), o manual de preparação de tintas do séc. XIII de al-Qalalūsī. O foco da investigação recai nos ingredientes e procedimentos para a criação de cor. Contudo, esta abordagem tende a descurar os aspetos sociais, económicos e culturais correlacionados, tais como a perceção social quanto aos tintureiros, preços, etiqueta da cor e o contexto da redação destes documentos. Outros textos – geográficos, normativos, técnicos ou epistolares – podem ajudar a preencher tais lacunas, fornecendo informação relativa à produção, comércio, transporte, simbolismo e demais utilizações de matérias-primas tais como o alúmen, o cinábrio ou o índigo. Uma abordagem multifacetada que integre a análise de diferentes fontes coevas, sobretudo andaluzas, pode contribuir para uma visão mais abrangente acerca da produção de cor no al-Andalus.

PALAVRAS-CHAVE
Produção de cor
Comércio de cor
Uso da cor
Pigmentos medievais
Al-Andalus
Textos andaluzes

Introduction

Colour production is intertwined with multiple dimensions of collective life. It is deeply embedded in economy, and, therefore, it intersects with agriculture, manufacture, commerce, and professional activities such as colour production. It also has a cultural dimension which refers to symbolic connotations given both to colours and raw materials from which they are made of.

Considering the omnipresence of colour, both in the Christian Middle Ages and in Islam, in architecture, clothing, manuscripts, and overall decoration, colour production holds a political dimension as well. The existence of colour-preparation manuals commissioned by rulers or governors, such as al-Qalalūsī's *Tuḥaf al-Ḥawāṣ* (d. 1308 CE) – or even written by sovereigns, such as *ʿUmdat al-kuttāb*, allegedly authored by Fatimid caliph al-Muʿizz Ibn Bādīs (d. 1062 CE) – reflects such importance.

The material and technique-centred approach emphasises physico-chemical characterization tests which seek to identify the components and processes for colour preparation. The study of art technical sources (from now on ATS) has contributed to the study of colour artifacts from multilayered and intricate historical contexts, such as the Medieval Iberian, which intertwined Ancient Greek and Roman, medieval Christian, and Islamic influence.

Attention towards the Islamic influence in colour production in medieval Christian milieu via al-Andalus has recently increased and has prompted the study of colour preparation Arab treatises, with a focus on inks used in manuscripts. Such is the case of the studies of Díaz Hidalgo et al. [1], and of Vieira et al. [2] on specific black and red inks and colours.

Despite its contribution to this field of study, this approach does not entail the fundamental process of comparison, addition, and crosschecking with other coeval sources. Furthermore, it does not address the multidimensionality of colour production.

Topics such as availability, price, transportation, multiple applications, and legal surveillance both on colour-production and colour-production ingredients are nearly absent from ATS. Moreover, ATS pose some obstacles regarding their practicality in a workshop environment. As Fani points out, this knowledge was commonly passed on "through empirical methods, direct observation and the repetition of traditional procedures in a transfer of knowledge that did not usually entail a written form" [3]. This means that such texts could be produced mainly to encapsulate and display theoretical knowledge on the matter, for the writer's or his patron's prestige. This is just an example of the multiple challenges posed by written technical sources previously discussed elsewhere [4-8].

In short, problems with analysis of documents relate to the subjectivity inherent in texts as they are highly dependent on the writer, his historical context, as well as his theoretical and practical knowledge of the subject. Some of the frequent problems (deliberate or not) are imprecisions, anachronisms, vague or incomplete information. Given the known complexity of interpreting documentary sources, this is particularly true when it comes to technologies no longer in use.

Consequently, research on the subject requires an additional set of sources which, in fact, attests to the existence of colour production in al-Andalus, and how it was conducted. This study seeks to provide an overview on the possibilities of other types of Arabic texts – geographical, normative, technical (other than ATS), and epistolary – mainly Andalusi, to support and enrich the inquiry on colour production in al-Andalus.

Al-Andalus and the Mediterranean world

Al-Andalus refers to the Iberian Peninsula territory which was under Islamic governance from 711 CE to 1492 CE [9]. The period of al-Andalus comprised different political stages which

corresponded to different territorial extensions and different dynamics with the remain Islamic and Mediterranean world. Therefore, political evolution impacted on trade and overall material and intellectual exchange, including in colour-production materials and techniques.

The first political stage – the emirate – is divided in two phases: during the dependent emirate (711-756 CE) al-Andalus was dependent on Qayrawān, in today's Tunisia, head of the province of Ifriqiyya. Qayrawān answered before the Umayyad caliph, settled in Damascus. In 750, the Umayyads were overthrown by the Abbasids, who transferred the head of governance to Baghdad. In 756, al-Andalus became an independent emirate settled in Cordoba, by the hand of a member of the Umayyads, who had escaped to the Maghreb during such events.

The second stage refers to the caliphate of al-Andalus, established in 929 by ʿAbd al-Raḥmān III as a response to both the Abbasid and the Fatimid rival caliphates settled in Baghdad and Cairo, respectively. In 1031, after a long civil war between different factions for the caliphal seat, the caliphate of al-Andalus collapsed, and around 30 independent kingdoms emerged. Al-Andalus transitioned from one ruler settled in Cordova to a multitude of petty kingdoms – taifas, after *ṭawāʾif* (sing. *ṭāʾifa*), which, in this context, means factions or parties – spread throughout the Andalusi territory. These party kings sought to replicate the Umayyad court model throughout al-Andalus, which prompted the construction of military and palatine buildings, the production and dissemination of luxury items, and both the displaying and sponsorship of written culture as a symbol of power [10].

In the following two centuries, al-Andalus was annexed to the Berber empires – by the end of the eleventh century, the Almoravid empire, and, by the middle of the twelfth, the Almohad empire. The Almoravids were a confederation of Lamtūna, Gudāla, and Massufa tribes originated near the Niger and Senegal rivers, which controlled the caravan Saharan trade. They professed an orthodox view on Islam and created an empire which reached al-Andalus in 1090. The Almohad empire was, in turn, formed by Maṣmūda tribes based on the Atlas Mountains. As opponents to the Almoravids, they had a literal and messianic stance on Islam and, since the middle of the twelfth century, they formed an empire which stretched from the Almoravid-founded city of Marrakesh until today's Libya.

Andalusi territory contracted as the Christians advanced towards the south, mostly after the fall of the Caliphate. However, the inclusion of al-Andalus in both Berber empires allowed it to widen its commercial and cultural network, which encompassed the Islamic west and connected to all *dār al-islām*. Circulation due to trade and religion promoted proximity between both north and south shores of the Mediterranean, encouraged East/West cultural transfer, and accentuated the ongoing orientalisation process in Iberia since the ninth century [11].

Colour-production in medieval Christian milieu may have also had eastern and North African influence, through al-Andalus. For example, al-Qalalūsī, born in Estepona, near Málaga, studied poetry, astronomy, and inheritance partition in Fez, Marrakesh, and Agmat [12]. He might have been introduced to colour making techniques in such travels.

Knowledge transfer had been key since the early centuries of Islam. Andalusi rulers were equally committed with such endeavour. Byzantine emperor Constantine VII offered caliph ʿAbd al-Raḥmān III (r. 912-961) a Greek copy of Dioscorides' *De materia medica*. However, there was no one in Cordoba able to read Greek. The byzantine monk Nicholas was sent to al-Andalus by the emperor to work in the Greek-Arabic translation with the Jew court physician Ḥasdāy b. Šaprūṭ [13, pp. 106-107]. The teachings of Dioscorides prevailed in the following centuries, and they are one of the main references in, for example, Ibn al-Bayṭār's (d. 1248) veterinary treaty *The complete book of medicines and simple foods* [14, pp. 62-63], which was also analysed for the present study.

After the Christian conquest, Arabic-Latin translations flourished in cities such as Toledo, Seville, and Murcia. Gerard of Cremona (d. 1187) was one of the most active translators, who rendered several Arabic texts into Latin, such al-Rāzī's *Kitāb al-Manṣūrī*. The so-called "Toledo School of Translators" synthetises the interest of the Christian monarchs, such as King Alfonso X, the Wise (r. 1221-1284), in preserving knowledge contained in Arabic books. Several works in

philosophy, astronomy, or cartography were translated from the Arabic to Latin, Hebrew, and, later, Castilian. Among these were the texts of Aristotle and Ptolemy, and their quoters such as Avicenna (Ibn Sīnā, d. 1037), which spread throughout Europe [14, p. 64]. Al-Andalus benefited both from an internal context and an intersecting geographical and cultural milieu, which favoured textual production on multiple topics, and possibly, on colour production as well.

Analysing Andalusi texts: method and text typologies

Al-Qalalūsī's treatise [15] was the starting point of this study, given its spatial and chronological overlapping with the medieval sculptures which are being studied within the Archaeology of Colour project.

Firstly, nearly 100 ingredients used to produce colour were identified, alongside with colour production techniques and other procedures such as ink removal and preparation of substitute components. Secondly, other types of texts were analysed, in the search for references of the abovementioned ingredients, and colour-making activities. These texts were classified as geographical, normative, technical, and epistolary.

Geographical texts

These texts correspond to the literary genre *al-masālik wa-l-mamālik* ("of roads and kingdoms"). The oldest surviving specimen was authored by Persian geographer Ibn Ḫurrdāḏbih (d. 912). It describes the main cities and villages throughout the commercial routes, their resources, peoples, history, and travel time [16]. So far, the following authors and works have been studied:

- Ibn Ḫurrdāḏbih, *Kitāb al-masālik wa-l-mamālik* (*The book of roads and kingdoms*) [17];
- Ibn Ḥawqal (d. 988), *Ṣūrat al-arḍ* (*The image of the earth*) [18];
- al-Bakrī (d. 1094), *Kitāb al-masālik wa-l-mamālik* (*The book of roads and kingdoms*) [19-20];
- al-Idrīsī (d. 1165), *Kitāb nuzhat al-muštāq fī iḫtirāq al-āfāq* (*A diversion for the man longing to travel to far-off places*) [21];
- Abū Ḥāmid al-Ġarnāṭī (d. 1170), *Tuḥfat al-albāb* (*Gift of hearts*) [22];
- al-Qazwīnī (d. 1283), *Āṯār al-bilād* (*The wonders of creation*) [23];
- Anonymous (fourteenth century), *Ḏikr bilad al-Andalus* (*Description of the land of al-Andalus*) [24];
- al-Ḥimyarī (d. 1495), *Kitāb al-rawḍ al-miʿṭār fī ḫabar al-aqṭār* (*The book of the fragrant garden with the description of the regions*) [25].

Normative texts

These sources deal with rules and law. Here, three types of texts have been studied: *ḥisba* texts, compilations of *fatāwā*, and taxation texts.

Ḥisba means in Arabic something like "common good". It also refers to the function of promoting the observation of the religious rules in urban milieu, especially, in the markets [26]. The *muḥtasib* – like Ibn ʿAbdūn (flourished. twelfth century) in al-Andalus – was the person entrusted with the *ḥisba*. In this study, two works were analysed so far: Ibn ʿAbdūn's *Risāla fī al-qaḍā' wa-l-ḥisba* (*Epistle on the office of judge and the market inspector*) [27], and al-Šayzarī's (d. 1193) *Nihāyat al-rutba fī ṭalab al-ḥisba* (*The utmost authority in the pursuit of hisba*) [28].

Regarding *fatāwā* compilations, a *fatwa* is a legal opinion issued by an expert in Islamic law. The *al-miʿyār al-muʿrib* (*The clear standard*), authored by al-Wanšarīsī (d. 1508), provides *fatāwā* issued in the Islamic west up to the fifteenth century [29].

Finally, considering that taxation must, ideally, observe the religious canon, *Kitāb al-ḫarāǧ* (*The book on land taxation*), by Abū Yūsuf Yaʿqūb (d. 798) was also examined in the search for references to colour production elements [30].

Technical texts

In this study, "technical texts" correspond to texts on specific matters, mostly linked to sciences and crafts other than colour production. So far, the following documents were analysed:

Filāḥa texts

Filāḥa texts provide information on gardening and farming. The contribution of the *filāḥa* treatises for the study of textiles and dyeing plants have already been explored by Expiración García [31]. The books on agriculture of two authors who lived during the eleventh century and early twelfth, namely, Abū ʾl-Ḫayr al-Išbīlī and Ibn Baṣṣāl, both entiled *Kitāb al-filāḥa*, were examined [32-33].

Medical/veterinary/pharmacological texts

As the name indicates, these documents display information on medical and veterinary uses of plants and minerals. The following books have been studied: 1) Ibn Ǧanāḥ (d. 1055), *Kitāb al-talḫīṣ* (*Book of the commentary*) [34]; 2) Ibn al-Bayṭār (d. 1248), *Kitāb al-ǧamiʿ li-mufradāt al-adwiya wa-l-aġḏiya* (*The complete book of medicines and simple foods*) [35]; 3) al-Nuwayrī (d. 1333), *Nihāya al-arab fī funūn al-adab* (*The ultimate ambition in the arts of erudition*) [36-37]. Although al-Nuwayrī is usually described as an encyclopaedist, we used mainly pharmacological data in this study. For that reason we classified his text as "technical".

Culinary texts

Culinary texts provide cooking recipes. So far, Ibn Razīn's (d. 1293), *Fiḍālat al-ḫiwān fī ṭayyibāt al-ṭaʿām wa-l-alwān* (*Best of delectable foods and dishes*) has been analysed [38].

Epistolary texts

Finally, epistolary sources, namely, the Geniza letters [39]. These refer to correspondence exchanged between medieval Jewish traders who operated in the Mediterranean milieu, which was discovered at the Ben Ezra Synagogue in Cairo. Many of these documents were written in Arabic and used the Hebrew alphabet. They survived because they had the name of God in it, and therefore, they could not be destroyed. They were, instead, deposited in storage places called the genizas. Those which have been analysed for the Archaeology of Colour project were studied and translated by Shelomo Dov Goitein (d. 1985).

Analysing Andalusi texts: results

The following quotations contain references to colour production in the abovementioned types of Arabic texts, mostly – though not exclusively – of Andalusi origin. These excerpts are mere samples of a wider universe of data available in such sources, which require further in-depth and multidisciplinary research.

Geographical texts

The geographical texts analysed in this study provide information mostly on the provenance sites of some of the more frequently mentioned ingredients in colour-making. Other topics, such as exports and uses in architecture, are also addressed.

Persian geographer Ibn Ḫurrdāḏbih referred to brazilwood's pharmacological properties, whose roots are "effective against deadly poisons" [17, p. 44]. The tenth century Nusaybin-born Ibn Ḥawqal reported that alum was found in Surt (presumably, Sirt, in today's Libya) "in large quantities", and was exported [18, p. 18]. He also mentions that leather fabrics, iron, lead, and

mercury were shipped towards the East [19, p. 50]. Moreover, iron, mercury, and lead could be found in al-Andalus [18, p. 66].

Granada-born traveller Abū Ḥāmid al-Ġarnāṭī briefly referred to Tunes being known for its corals [22, p. 112]. Al-Bakrī – eleventh century geographer and member of the ruling family of the taifa kingdom of Huelva and Saltés – mentioned the vast Andalusi production in alum, iron, and copper [19, p. 39]. Concerning the Maghreb, al-Bakrī informed that the inhabitants of Sebab (possibly in today's Tunisia) cultivated indigo [20, p. 27], and, according to him, "in the country of the Kutāma [a Berber tribe located in the north of present-day Algeria] excellent quality lapis lazuli is found, as well as copper and iron mines" [20, p. 83].

In fact, lapis lazuli (the Arabic word *lāzward*, which was also used to name other blue stones, as will be discussed further ahead in this study) is frequently mentioned by geographers. Al-Idrīsī, from Ceuta, affirmed that the Cordova main mosque ceiling had "cinnabar red, lead white, lapis lazuli, minium (red lead oxide), verdigris, and antimony black" [21, p. 201]. The anonymous author of the *Ḏikr* also reported that among the improvements that caliph al-Ḥakam operated in the said building, chapiters were "carved from a single block of marble, engraved and inlaid with lapis lazuli and gold in its upper and lower parts" [24, pp. 41-42]. According to him, this blue stone could be found in Lorca, Almeria, Baza, and Granada [24, p. 20]. Three centuries later, al-Ḥimyarī added that in the region of Lorca there was a yellow ochre quarry, and several red ochre quarries, whose product was exported [25, p. 343].

Not only Islamic western authors had a word to say about al-Andalus. The Persian geographer al-Qazwīnī wrote: "al-Andalus is rich in gold, silver, lead, and iron mines, which are found everywhere; there are also mines of mercury, red sulphur, yellow sulphur, excellent cinnabar, tutty (impure zinc oxide), and alum of all classes. There is also *kuḥl* that looks like the one of Ispahan" [23, p. 101].

Al-Idrīsī supplied information concerning mercury and cinnabar mines located near the fort of Abal (in Obejo, near Cordova), which employed around 1000 workers [21, p. 207]. Three hundred years after him, al-Ḥimyarī raised that number to 3000 [25, p. 33]. At the mine, work was distributed in the following way: "there is a team that goes down and extracts the mineral; another one that transports the wood needed for the oven; another one that manufactures the containers in which the metal is distilled and purified; finally, another one who builds the ovens and watches the boiler" [25, p. 33].

Normative texts

Most normative texts examined show concern regarding the quality and integrity of the colour-making products sold both in the market and in stores and prescribe techniques to evaluate them. Such products are also approached under the lens of tax status, and family life.

According to Kufa born Abū Yūsuf Yaʿqūb's taxation treatise, minerals such as "ruby, turquoise, antimony, mercury, sulphur, and red ochre, do not pay the fifth and are treated as clay and sand alike" [30, p. 34]. During the conquests, a fifth of the land was due to the conquerors. According to Abū Yūsuf Yaʿqūb, no further taxation was applied to minerals which were found in it, to avoid double taxation.

Regarding *ḥisba* texts, Ibn ʿAbdūn, the twelfth century *muḥtasib* of Seville, warns: "one must ban dyers who dye green with dyer's broom and sky blue with brazilwood because it is a fraud, as these colours immediately disappear" [27, p. 154]. Furthermore, "saffron should not be sold in a paste from which pieces are cut, because then it is counterfeit and bad, but rather in loose stigmas" [27, p. 181].

In Syria, al-Šayzarī alerts to perfumers' scams involving the use of brazilwood: "Some of them (perfumers) cut *akshūt* (unknown ingredient) like the hair of hairy saffron and cook it with cooked brazilwood. They then add something to it dyed with saffron water and sprinkle a little ground sugar on to make it become heavy and coagulate. After this they mix it with an equal amount of saffron and put it in the baskets" [28, p. 73].

Al-Wanšarīsī's *fatāwā* compilation also offers some information regarding substances used in dye-preparation. A *fatwa* of Fez issued by al-Waryāġilī (d. 1284) recorded that "a man who divorced his wife before the marriage had been consummated, demands from her the safflower that she had asked for to dye her clothes." Unfortunately, we have no information whether his claim was attended [29, p. 92].

Another *fatwa*, issued in Mahdiyya in the 1140s asked about the possibility of selling tartar to be used "as a fixative to dye wool red". The answer is ambiguous: "The question of impurity and purity of tartar is controversial. If we opt for its purity, like vinegar, its sale is permitted. If we declare it impure, we can authorize its sale by analogy with that of garbage, which we use out of necessity to manure the earth" [29, p. 127]. Finally, someone asked in an undated and unidentified *fatwa*: "Is it fraud to whiten clothes with sulphur? Answer: This is not permitted. It's a fraud" [29, p. 208].

Technical texts

Technical texts besides ATS provide a variety of material regarding colour making. Andalusi eleventh century *filāḥa* expert Abū l-Ḫayr describes the characteristics and uses of sumac: "Sumac leaf juice has the same benefits as acacia. [...] It abounds in different areas of Syria and al-Andalus.". While the Syrian kind has a more intense red, the Andalusian variety "is a plant similar to the Alexandrian laurel in the shape of its leaves and in the size of its tree, except that its wood is weak, of a colour similar to purple, hollow, very astringent. Leathers are tanned with its leaves and its thin bark. Dyers use it to dye clothes red [...]. It abounds in Córdoba and Jaén." [32, p. 877]. Toledo-born expert Ibn Baṣṣāl wrote about the two classes of safflowers, one thorny and the other non-thorny, being the latter more adequate to use as dye [33, p. 154].

Pharmacology texts are also an important source of data for the topic. For example, Córdoba-based Jewish rabbi, physician, and grammarian Ibn Ǧanāḥ described the ingredients and procedure to make suppositories, possibly to treat constipation, but which could also be used in laundry: "The soap, the use of which the physicians recommend as a suppository, is dry and hard soap. It is obtained in the following way: One part quicklime and one part alkali ash are taken. If there is more quicklime than alkali ash it is better" [34, p. 940].

Malaga veterinarian Ibn al-Bayṭār listed the pharmacological benefits of the pomegranate: for stomach and digestion problems, fever, itching, scabies, drunkenness, ears, and eyes inflammation [35, p. 182]. Additionally, its juice could be used as an appetite suppressor, since it "is beneficial against fat women's appetite" [35, p. 180-181].

The Egyptian encyclopaedist al-Nuwayrī [36, pp. 5-104] provided information regarding the acacia wood – "Egypt has acacia wood, which, when it is burned for a whole day, its ashes only amount to a single palmful. It is a hard wood, quick to light, slow to die down. It is said that it is actually ebony, but that its habitat transformed its nature and so its wood became intensely red" [37, p. 38] – and acacia resin: "This is the resin of the acacia tree, and it is used exclusively in compounds and is not suitable for anything else. That is because it dissolves in water very quickly without clotting, while other resins that are gathered from flowering trees will corrupt a compound when they are added to it, such as sumac resin, rue resin, and marshmallow resin" [37, p. 214].

Cookbooks, such as the one authored by Ibn Razīn, from Murcia, describes that pomegranate arrived in al-Andalus during the reign of the emir ʿAbd al-Raḥmān I (d. 788), who "collected in his garden rare plants from every part of the world", and "sent agents to Syria and other parts of the east to procure new plants and seeds" [38, p. 31].

Epistolary texts

Finally, the Letters of the Cairo Geniza show evidence regarding the Mediterranean trade of many ingredients used in colour-production. A letter from 1141 sent from Fez to Almería deals with the shipping of seven loads of alum. The product was cheaper than expected because the sender bought it before the official price had been announced. The sender, in Fez, said to the

recipient: "Had I had courage, I would have sent you 100 *quinṭārs* (1 quinṭār: c. 50 kgs). But I did not dare since there was a great demand for it" [39, pp. 267-268]. The writer was afraid that many Spanish merchants would do the same, shipped alum to Almeria, and its price would suddenly drop and secured no profit.

Another letter shows how Saʿdān, while drunk, promised his son he would introduce him to the overseas trade. He said to the recipient of the letter: "If a *bahār* of lac which had fallen into the water comes your way, buy it for him. In case it does not, and the boy goes down to Alexandria, kindly advise him to leave with you the money for such a buy, until the occasion for it arises. Then you will buy it and send it to him." In Goitein's interpretation, the father wished the boy to come home with a big sack – a *bahār* normally comprised 300 pounds (around 136 kgs) – though he did not want to spend much money on it. So, he asked the recipient to buy damaged lac, which was cheaper [39, pp. 256-257].

Conclusions and challenges

The abovementioned samples reveal the potential of Arabic texts beyond ATS as a tool to understand colour production in al-Andalus. Geographical sources display information regarding productive activities which involve colour-making ingredients. Normative sources provide the legal and moral frame for the economic life, in which ink making products and ink production and selling are key sectors. Colour-making materials serve multiple purposes, and, for that reason, are present in technical sources, such as agronomical, pharmacological, and culinary texts. Finally, epistolary texts are a window to the everyday life of the Cairo-based community of Jewish traders who operated in the Mediterranean, and, thus, they show how such commodities are perceived from the merchants' viewpoint.

However, these sources – and ATS as well – pose some challenges. Arabic texts tend to replicate themselves overtime. Respect for the *autoritates* is key, even if it is not clearly stated that they are quoting one. Vocabulary can be also misleading, as, for example, the word *kuḥl*, which is usually translated in sources such as the letters of the Cairo Geniza as antimony, may refer to the pencil used as eyeliner and not to the substance which is used for the said purpose. In fact, there is discussion whether *kuḥl* was made of antimony [40, p. 37, footnote 266] or of galena [41]. The Arabic term *lazward* (blue stone) is also subject of debate, as it has been translated as lapis lazuli, though in the Middle Ages, it was apparently used to name any blue stone, the same way as sapphire [42].

Among geographers, the use of secondary reports (instead of *in loco* observations, mostly in the case of non-Andalusi authors), may have distorted their view on reality. Normative texts, specially *fatāwā*, can also be challenging since they deal with specific situations. The legal opinion is frequently ambiguous, specially whenever the jurist addresses several inquiries in the same *fatwa*. Technical texts were written by an elite and they fulfil the desire both of sponsors in portraying themselves as patrons of arts and sciences, and of authors, in portraying themselves as polymaths, even if they did not master nor practised the subjects they wrote about. Most letters of the Cairo Geniza do not mention al-Andalus. Therefore, studies on the Andalusi context which rely exclusively on these documents may lack consistency.

Finally, most documentary sources analysed in this survey are dated from the eleventh-thirteenth centuries, which correspond to the taifa period, and the Berber empires period. The multiplication of the political, economic, and cultural centres following the collapse of the Umayyad caliphate in 1031 favoured textual production which presented the cultivation, extraction, circulation, and use of ingredients which are also used in colour-making. The increasing number of texts with such references during the Berber governance might also be a consequence of the attested diversification and expansion of the Andalusi – and overall Iberian – economy during this period.

Regardless of such limitations, this preliminary study shows evidence that a variety of other texts beyond ATS – geographical, normative, technical, and epistolary – can offer a multifaceted and broad view on colour production in al-Andalus. Research on this matter can be expanded by extending a similar inquiry to a set of texts from a wider chronological range, and by extending it to other types of sources, such as chronicles and poetry, with the aim of further advance in the subject and approach colour as a social product, instead of a purely technical one.

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The interventions on the medieval polychromy of the tomb monument of Isabel of Aragon: the historical sources

As intervenções na policromia medieval no túmulo de Isabel de Aragão: as fontes históricas

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Abstract

Over the centuries, the stone monument of Isabel of Aragon Queen Consort of Portugal (c. 1270-1336), a masterpiece of Portuguese Gothic sculpture from the first half of the 14th century, has been the subject of different types of interventions. They were intended to preserve the integrity and decorum of the sarcophagus which had held the "holy body", found intact inside the sepulchre, of the queen proclaimed blessed in 1516 and saint in 1625. Through the study of the historical sources (literary and iconographic), it was possible to propose a reconstruction of the sequence and the chronology of various actions, which focused mainly on the pictorial surface rather than on the structure of the tomb; to identify the areas of intervention; to reflect on their motivations, modalities and techniques; and to advance hypotheses about a new reading of the iconography of the queen's effigy and the permanence of the medieval polychromy.

KEYWORDS

Tomb monuments
Isabel of Aragon, Queen Consort of Portugal, the Holy Queen
History of conservation and restoration
Iconography
Memory and identity

Resumo

Ao longo dos séculos, o monumento fúnebre de Isabel de Aragão rainha consorte de Portugal (c. 1270-1336), obra-prima da escultura gótica portuguesa da primeira metade do século XIV, tem sido objeto de diferentes tipos de intervenções. O seu objetivo foi preservar a integridade e o decoro do sarcófago que tinha guardado o "corpo santo", encontrado intacto dentro do sepulcro, da rainha proclamada beata em 1516 e santa em 1625. Através do estudo das fontes históricas (literárias e iconográficas), foi possível reconstituir a sequência e a cronologia de várias operações que incidiram sobretudo na superfície pictórica e não na estrutura do túmulo; identificar as áreas de intervenção; refletir sobre as suas motivações, modalidades e técnicas; e avançar hipóteses sobre uma nova leitura da iconografia do jacente da rainha e a permanência da policromia medieval.

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Tumulária
Isabel de Aragão, raínha consorte de Portugal, a Raínha Santa
História da conservação e restauro
Iconografia
Memória e identidade

The stone monument of Isabel of Aragon, Queen Consort of Portugal

The tomb monument of Isabel of Aragon, Queen Consort of Portugal (c. 1270-1336), a masterpiece of Portuguese Gothic sculpture from the first half of the fourteenth century, is housed in the middle of the low choir of the church of Rainha Santa Isabel in Coimbra (Figure 1) [1, pp. 46-48; 2; 3, pp. 258-299; 4]. Currently, the sarcophagus is in a fair state of conservation thanks to its reputation as a "reliquary without relic". Indeed, the sepulchre had guarded until 1677 the earthly remains of the queen, dubbed the *Rainha Santa*, the Holy Queen, who died in 1336, was proclaimed blessed in 1516, and elevated to the ranks of the saints with the name of Saint Elizabeth of Portugal in 1625. However, over the centuries the funerary monument, which today as then is entirely painted, has been the subject of several interventions aimed at preserving its integrity, a metaphor for the incorruptibility of the queen's holy body found intact inside the sepulchre, and, as such, object of veneration by the faithful.

This paper traces the sequence and the chronology of some conservational actions which focused mainly on the pictorial surface through the study of the historical sources (literary and iconographic), a close-up observation of the artwork, and a reflection on its materiality. Indeed, the article could be intended as the preliminary art historical study that, according to the good practice of the discipline of Conservation and Restoration, must accompany the execution of the necessary and fundamental diagnostic analyses, in order to reconstruct the monument's conservation history, contribute to its global reading, and promote its enhancement.

Figure 1. Tomb monument of Isabel of Aragon, ca. 1325-28 (Coimbra, Church of Rainha Santa Isabel, low choir) (photograph: J. C. Vieira da Silva).

The reworkings of the sixteenth and seventeenth centuries

Soon after the death of Isabel of Aragon in 1336, the funerary chapel built in the church of the former monastery of Santa Clara and Santa Isabel at Coimbra to house her imposing sarcophagus (292 × 137 × 101 cm) became a pilgrimage destination as word of the Portuguese queen-widow's *fama sanctitatis* spread. In an effort to prevent damage and loss caused by the contact and the actions of the faithful, the bishop of Coimbra in agreement with King Afonso IV, son of Queen Isabel, ordered tall iron grilles to be placed around the mausoleum [5]. Nevertheless, this expedient proved useless against the cyclical flooding of the nearby Mondego River which inundated the church from its earliest years, damaging the building and everything in it. Finally, the religious community was compelled to abandon the medieval monastery and moved to the monastic complex founded in 1649 on the facing hill and named after Rainha Santa Isabel. The tomb monument already lacking the queen's holy body was also transferred at an unspecified date but probably before 24 of June 1696, date of the solemn consecration of the new church. [6, p. 507, sp. note 2]. However, earlier the tomb had undergone some interventions most likely performed at the same time or following the beatification and the canonisation of the queen.

Without excluding the possibility of other previous interventions, during the sixteenth century, a Latin epigraph was added along the edge of the four sides of the lid. It was a sort of poem which is still perfectly legible today:

> *Elisabela iacet sacro hoc regina sepulchro que meritis nitidi fulget in arce poli nempe ita dum vixit ceco se gesit in orbe virtute ud morum vixerit omne genus quo fit ut a sumo diva hec selecta tonante regnet et angelico nos iuvet usque choro*
>
> «Queen Isabel lies in this sacred sepulchre she shines for her merits in the high and brilliant heavens certainly as long as she lived she behaved in the mundane world with virtue so that she cultivated all kinds of good morals because of which it happens that from the heights of heaven this divine chosen one reigns and always helps us with the choir of angels»

The inscription was transcribed in the report of the first opening of the queen's sarcophagus in 1612 as part of the enquiry launched in the diocese of Coimbra with the aim of achieving the canonisation of the already proclaimed Blessed Isabel [7, pp. 848-852]. This means that it had been added previously. Moreover, the encomiastic tones of the epigraph as well as the fact that it is not a biographical note, but rather a "hymn" to the virtues and sanctity of the deceased, not justifiable in the fourteenth century – all the more so that Isabel of Aragon commissioned and assisted in the making and setting up of her sepulchre – lead to the claim that it dates from a later period, referable precisely to the sixteenth century because of its courtly style combined with the use of Latin. This assertion can be verified by comparing the tone, style and terminological choices of the officies, poems and prayers [8, pp. 37-42, 45-57, 67-69] composed during the sixteenth century in the occasion of the beatification of Isabel of Aragon, already called the Holy Queen).

In addition to transcribing the text, the record mentions that the *letreiro*, i.e. the «inscription», was written in *letras grandes*, i.e. «capital letters» or square capitals, which were *pretas*, i.e. «black». This remark suggests that the epigraphy was not necessarily engraved, but painted, just as it presently appears (Figure 2).

Figure 2. Tomb Monument of Isabel of Aragon, detail of the inscription.

This circumstance supports the hight probability that it was placed on a smooth surface properly prepared to receive it. However, more intriguing is the detailed description of the mausoleum in the report:

> *Esta caxa e a arca se cobre com huuma soo pedra da mesma grandeza, na qual da parte superior esta esculpida do relevo inteiro a imagem e figura da mesma Rainha que se entende ser ao natural. Esta vestida do habito das freiras de santa Clara e com veu preto, e sobre elle na cabeça huma coroa dourada, e esta cingida com cordão da mesma ordem, e nelle da banda esquerda pendurada huma bolsa e sobre ella lavrada huma concha de Santiago dourada, e as mãos postas huma sobre a outra sobre o corpo, e de baxo da direita hum livro, e da esquerda, hum bordão da mesma feição, de outro bordão ebolsa que se achou dentro da sepultura sobre o ataude. E a cabeceira da dita Rainha estão dous Anjos hum de cada parte com seus toribulos prateados nas mãos encensando o corpo da dita rainha* [...] *A qual imagem de vulto da dita santa, esta encarnada e pintada a oleo e representa en si grande Magestade e veneração.* [7, p. 849]
>
> «This casket and ark is covered with a single stone of the same size upon whose upper part is carved the image and figure of the Queen herself, which is understood to be lifelike. She is dressed in the habit of the nuns of St Clare and wears a black veil, and above it on her head is a golden crown, and she is girded with a cord of the same order, and on it [the cord] on the left side hangs a purse and on it is designed a golden shell of St James, and her hands are placed one on top of the other on her body, and under the right hand there is a book, and under the left [hand] there is a staff of the same type as another staff and purse which were found inside the tomb on the coffin. And at the grave headboard of the said Queen there are two angels, one on each side with their silver thuribles in their hands, cradling the body of the said Queen [...] The effigy of the said Saint is in flesh and painted in oil and represents great majesty and veneration.»

The report reminds us that, at the time, the tomb monument was sustained aloft by eight lions, two more than the current six. It is also stated that Queen Isabel was "portrayed" *ao natural*, i.e. «life-like», and her statue was *encarnada e pintada a óleo*, i.e. «in flesh and painted in oil», wearing the habit of the Order of Saint Clare with a black veil secured by a golden crown around the head.

The fact that the recumbent figure was life-like, coloured and painted «in oil» – generic words most likely the result of considerations by the author Tomás Nunes, who was a notary,

and the witnesses to the act, mostly religious neither professionals nor experts in arts – is confirmed by the Franciscan writer Manuel de Esperança (c. 1585-1670) in a passage of his *História Seráfica da Ordem dos Frades Menores* (1666). More specifically, the chronicler wrote that the sarcophagus had lost its original colour at some undefined moment in the past and therefore had been recently repainted:

> *Toda esta obra esteve descolorida, somente com uma alvura natural da mesma pedra, e nesta nossa idade lhe forão dada sas cores: a o hábito, de pardo, a o véo, de preto; e tudo o mais conforme são as figuras.* [9, pp. 310-311]
>
> «The work was discoloured, save for the natural whiteness of the stone itself, and in our time it was given its colours: the habit, brown, the veil, black; and everything else as the figures are.»

Considering the date of the chronicle, it is legitimate to assume that the action was carried out at the time of the beatification, when the black epigraphy was added, or at the latest at the time of her canonisation. The repainting affected especially the statue of the queen, focusing in particular on the robe and veil, applying the colours proper to the habit of the Order of Saint Clare. We find confirmation of this hypothesis in the description contained in the *Jardim de Portugal* by Luís dos Anjos, religious of the Order of the Hermits of St Augustine (c. 1580-1625), published in print in 1626, but written earlier. In fact, the author dwells on the detail of the «black veil of the nun of Saint Clare that she never wore» [10, p. 240], evidence that, in his opinion, the colour black had been added to the queen's effigy. The intervention referred to by Luís dos Anjos dates clearly from before the canonisation, which occurred on 25 May of 1625, after the friar's death on 8 January of the same year.

The purpose of this operation was to ensure that Isabel of Aragon could immediately be associated with the Poor Clares represented on one of the long sides of the tomb chest. In any case, certain precious details were preserved, and perhaps even revived, such as the gold embroidery on the edge of the sleeves and the tunic, the white outline of the veil which, according to Manuel de Esperança, was originally intended to be entirely white, and the six-knot rope: "Repara mais no véo preto, quel he vemos na cabeça, o qual nunqua trouxe […]. O certo he que a Santa se mandou figurar com o véo branco, que ella trouxe em vida" [9, p. 312] («Look at the black veil we see on her head, which she never wore […] What is certain is that the Saint had herself represented with the white veil she never wore in her life»). All these elements allowed Queen Isabel to be identified as a tertiary, not as a professed nun, a historical truth also emphasised by Luís dos Anjos.

Taking advantage of the discolouration of the sarcophagus recorded by the Franciscan chronicler, in the seventeenth century, on the occasion of this intervention, or more probable as early as the sixteenth century, Queen Isabel was "restored to life" by painting-in the pupils of her eyes, complemented with eyelashes and eyebrows (Figure 3).

There are several stylistic and formal arguments that persuade me to formulate such a hypothesis. First, the solemn composure and gravity of the figure, the position of the arms crossed under the chest, with the left hand clutching a small, closed prayer book, the presence of two thurifer-angels looking upwards, incensing the body of the deceased, are all features suggesting that Isabel of Aragon originally had her eyes closed, being displayed "asleep" awaiting the Resurrection. Furthermore, the recumbent effigies of her husband King Dinis (1261-1325), her brother King Jaime II of Aragon (1267-1327), and her sister-in-law Queen Blanche of Anjou (1280-1310), carved in a very close time frame, are all portrayed with eyes closed (Figure 4).

Figure 3. Tomb monument of Isabel of Aragon, detail of the effigy (photograph: J. C. Vieira da Silva).

This circumstance reinforces my conviction that the queen's effigy, frequently attributed by the historiography to the same Catalan-Aragonese Master Pero who crafted the Queen Blanche statue [11], likewise originally presented closed eyes. The recumbent effigy of Archbishop of Braga Gonçalo Pereira, whose tomb monument was commissioned in 1334 and saw Master Pero at work, displayed closed eyes. Moreover, from a purely technical point of view, if we compare the treatment of Isabel's eyes with the treatment of the eyes in certain coeval sculptures, such as the fragment of the Virgin Mary, the Saint Martyr, proceeding from the former monastery of Santa Clara, or the Saint Agatha, all three of which are attributed to Master Pero and/or his workshop, and are now in the Museu Nacional de Machado de Castro in Coimbra, we can observe that the definition of the eyelids and ocular orbit are crafted in a very different way. Similarly, focusing on the treatment of the eyes of another recumbent figure, that is the authentic effigy of King Pedro I of Portugal (1320-1367), dating from the second half of the fourteenth century and displaying open eyes, it is noticeable that the engraving of the disc of the iris is perfectly visible as opposed to the case of Isabel. Finally, there is one last detail that leads me towards this iconographic proposal: Isabel's gaze is not focused on an indefinite frontal point, as in the case of King Pedro, but is clearly turned upwards (Figure 5).

Figure 4. Tomb effigies of: *a)* Isabel of Aragon (ca. 1325-28); *b)* King Dinis of Portugal (ca. 1319-24); *c)* King Jaime II of Aragon (ca. 1311-15); *d)* Blanche of Anjou (ca. 1311-15).

Figure 5. Tomb monument of King Pedro I of Portugal, ca. 1360-67 (Alcobaça, Church of Santa Maria).

The pupils are drawn in such a way that one has the impression that the eyes are turned to heaven, just like those of the angels accompanying her, despite the fact that the head, resting on a double pillow, is raised and slightly inclined forward, indicating an opposite movement from the gaze and thus suggesting an unnatural posture.

Only precise diagnostic analyses of the pigments could confirm or disprove my hypothesis, since the written sources examined did not dwell on this specific aspect, and for obvious reasons. Nevertheless I believe that (i) the iconographic elements and technical aspects noted above, (ii) the comparisons with coeval funerary sculpture, which specifically testifies to how the royals queen's relatives showed themselves in their effigies, as well as in non-funerary sculpture, and (iii) the background of celebrations for the newly proclaimed saint against which the decision must have matured to proceed with such an intriguing reworking of the *Rainha Santa*'s statue – already certified at the level of the robe and veil – are persuasive in advancing this new reading of the iconography of Queen Isabel's effigy.

The overpainting of the eighteenth century

A date still clearly visible on one side of the sarcophagus lid at the end of the Latin epigraph informs us that the tomb was repainted again during the eighteenth century. The year – 1782 – is accompanied by some words this time added in Portuguese. Transcribing the text as it appears, it reads:

> HEC SELECTA TONANTE REGNET Ꞓ ANGELICO NOS IUVET USQUE CHOROFOIPINTADANAERAD1782 (Figure 2)

The sentence in Portuguese continues on seamlessly from the last Latin word (*choro*) being written in the same font type, size and colour used for the inscription. This means that: either the text recorded as early as 1612 was repainted in the eighteenth century at the time of the addition of the Portuguese words, and the person charged with the task miscalculated the space and was forced to "squeeze in" the Portuguese text to the partial detriment of its reading; or that only the Portuguese words were added in the space left available by the Latin epigraph (about 20 % of the entire strip). If this was the case, it provided *a priori* for an empty space, not aesthetically pleasing, unlike on the other sides of the lid where the inscription fills the entire strip. However, the use of the Portuguese instead of the Latin indicates that, through this expedient, there was a clear intention to mark a difference in substance and chronology between the two texts.

The Portuguese sentence *foi pintada na era d 1782* can be translated into «it was painted in the era of 1782». It is particularly interesting the use of the feminine form *pintada* (*pintado* masculine) of the past participle of the Portuguese verb *pintar*, i.e. «to paint», referring to the implied subject. Whatever it was, it would have been a Portuguese feminine noun, not a masculine term. In fact, the Portuguse nouns *túmulo, monumento, sarcófago, sepulcro*, i.e «tomb», are all masculine nouns. Continuing this line of reasoning, another aspect to reflect on is that a generic impersonal form, which in Portuguese would take the masculine, was not used to describe the action. To sum up, in my opinion this means that the implied subject of the passive form of the verb «to paint» – *foi pintada* – was clearly a feminine noun: the *obra*, i.e. the «work»? The *rainha*, i.e. the «queen» herself?

In absence of records or reports revealing who was responsible for the overpainting, it is not immediately clear why it was decided to undertake this intervention in 1782. Indeed, unlike the other years reported – 1516, 1612, 1625 –, this date does not seem to have been a particularly relevant moment either in the history of the monastery or for the cult of Saint Elisabeth of Portugal. However, after studying the historical context, I have found two possible explanations, one somewhat less intriguing than the other, it has to be admitted.

One hypothesis is that the overpainting was not carried out in 1782, but in 1744, since quite strangely the date of the intervention was indicated on the lid not according to the Christian Era, but to the Hispanic Era, or the Era of the Caesars. This was the antique reckoning of the years in use in the Iberian Peninsula which started counting from 38 BCE. The Portuguese formula *na era d* used to introduce in Medieval times the Iberian computation seems to allude to this circumstance. Otherwise, it would not have been necessary to insert any words before the date. In contrast to 1782, the year of 1744 was a key year in the spread of the cult of the *Rainha Santa*. In fact, at that time King João V of Portugal (1689-1750) addressed a petition to Pope Benedict XIV and the Congregation of Rites in order to obtain permission to celebrate the solemnity of Saint Elizabeth of Portugal (4th July) throughout the territory of the kingdom and the dominions of the Portuguese Overseas Empire. On 26 August 1744, the pontiff agreed to the monarch's plea [8, p.341]: from that moment on, the cult of Saint Elizabeth became "global". Therefore, it is reasonable to believe that the repainting of the tomb could be one of the initiatives commemorating the concession of the prestigious apostolic decree enhancing the Holy Queen.

Another explanation, less erudite and more banal, is a very short notice which I intend to research further in the near future. It says that in 1782 the Abbess Ana Mariana de Lancastre ordered the repainting of the vaults and the walls of the low choir. Inside, a commemorative inscription written in gold on stucco is still visible today: "*Este coro mandou pintar a Ilustríssima excelentíssima Senhora Dona Ana Maria de Lancastre em 1782 no seu 6 ano de abadessa*" («This choir was painted by the illustrious *Dona* Ana Máxima de Lancastre in 1782 in her sixth year as abbess») [12].

Figure 6. Tomb monument of Isabel of Aragon, Photo-type [7, est. III, p. 57].

Reflecting on this circumstance, one can speculate that she ordered also the repainting of the tomb which had been housed in the low choir since the end of the seventeenth century.

As in the past, the intervention did not affect the structure of the sarcophagus, despite the fact that some parts were damaged, especially at the ends, due to its various displacements. It is probable that on the occasion or upon completion of this operation, the tomb was placed on a platform with two steps along one wall of the room, resembling a kind of altar. Bearing witness to this arrangement are two photo-types included in an article by the historian António Garcia Ribeiro de Vasconcelos transcribing the report of the first opening of the tomb and published in 1891 [7, est II, p. 54, est III, p. 57]. These images also clearly show the damage suffered by the canopy and the edges of the tomb chest (Figure 6).

In both pictures we can notice that the funerary monument rests on four lions – not six or eight – and that the position does not allow us to see one of the long sides of the tomb chest (the one where Saints Francis, Louis of Toulouse, Clare and the Poor Clares are displayed). Furthermore, the photo-types show that, after the last opening of the sepulchre, the lid was mounted incorrectly, i.e. the opposite of how it was described in the report of 1612.

The repurposing of the beginning of the twentieth century

The sarcophagus retained this arrangement until 1921 when a new act of conservation was carried out, as a result of the pressure exerted especially by the world of culture since the end of the nineteenth century. Again, we do not possess a record but this time we know who was responsible, inferred from a very short news report published in a local newspaper [13]. This was João Machado, a famous sculptor from Coimbra [14-15], who accepted to work on the tomb of the city's patron saint despite not being a great admirer of Gothic art. By comparing the photo-types previously analysed with some current images of the monument, we can deduce that the artist intervened on the sepulchre in various ways. First, he correctly repositioned the lid agreeing with the 1612 description of which he was evidently aware. To do this, he had to chisel off the edge of the chest and then grout it again. Furthermore, considering how the tomb looked in 1891 and the time span between this date and 1921, it is reasonable to believe that he could also add two lions displaying a different type of work to provide the sarcophagus more stability, thus arriving at the current six supports. Finally, he arranged to move the monument from the side wall to the centre of the low choir to promote better lighting and, in general, a better visibility of the artwork. It is not known whether and to what extent Machado intervened on the polychromy, but it is certain that the edge of the lid was, at least, partially repainted. All the sculptural actions focused mainly on the repurposing of the tomb within the space that housed it: despite being gifted and possessed of the skills to carve the stone in the manner of the ancient masters – reasons why he and not another artist was chosen –, João Machado preferred not to reconstruct the damaged parts of the tomb, but limited his intervention as much as possible. In fact, the sculptor did not ribuild the splintered edges nor the canopy nor the pillow, all currently looking broken and chipped in different spots exactly as they did in the 1891 photo-types.

Following the arrangement in the low choir – an *ante litteram* act of enhancement, the tomb monument of Isabel of Aragon, revived in colour, definitively assumed the status of a "reliquary without relic" which, rather than extolling its value as a masterpiece of Gothic art, magnified the aged and precious sacred urn that served to nourish the local, national, Iberian and global cult of the *Rainha Santa*.

The interventions on the tomb over the centuries: between moral imperative and identity value

In 2009, random diagnostic tests were conducted on the polychromy of Isabel of Aragon's monument, the results of which, however, have not been published but only presented publicly within a seminar in 2010 [16]. Years later, in the context of investigations into physico-chemical aspects, new sample analyses were carried out [17-19]. These analyses have revealed that the sarcophagus has at least five layers of colour, if not more. Thanks to the study of the historical sources, it was possible to propose four if not five paint layers applied during different interventions. Proceeding from last to first: the 1921 layer, located in the edge of the tomb chest which was repainted when the lid was repositioned; the eighteenth-century layer documented by the Portuguese inscription (possibly locally subject to overpainting in 1921); the layer applied during the seventeenth century, reported in the Franciscan chronicle of 1666, and/or the sixteenth-century layer recorded in the minutes of the 1612 tomb opening and to which the Latin epigraph bears witness; and the layer of the original medieval painting of which the sarcophagus still retain vestiges. Traces of medieval colour might be found in all those spaces difficult to reach by the brush during the various reworking and repainting, i.e.: inside the canopy, on the back of the red double pillow ornamented by an articulated golden embroidery (Figure 7); in the lower edge of the tomb chest (Figure 8). I think also that the backgrounds of the aediculae housing the images of the Poor Clares and the apostles in the long sides (Figure 9), the painted landscape behind the Calvary scene visible on one of the two short sides of the chest, and the shields of the kingdoms of Portugal and Aragon also might retain traces of the original colours (Figure 10). These statements are based on a close observation of the artwork as well as on considerations with respect to the possible difficulty of paint application. As an example, to fully repaint the double cushion would have required disassembling the canopy. Likewise, it was not to be deemed particularly useful to repaint the bottom edge of the sarcophagus because it was not immediately visible anyway.

Figure 7. Tomb monument of Isabel of Aragon, detail of the canopy (photograph: J. C. Vieira da Silva).

Figure 8. Tomb monument of Isabel of Aragon, detail of the lower edge of the chest.

Figure 9. Tomb monument of Isabel of Aragon, detail of the decoration of the aedicule (photograph: J. C. Vieira da Silva).

Figure 10. Tomb monument of Isabel of Aragon, detail of the painting behind the Calvary scene (photograph: J. C. Vieira da Silva).

All the interventions – relocation, reworking, repainting and restoration – carried out on Queen Isabel's tomb monument have been reconstructed mostly through written sources, often indirect, or even fleeting mentions, in which, except in the last case, the names of those responsible were missing. However, I have reason to believe that the artists-restorers were

active or resident in the region of Coimbra, not only because of the undoubted validity of the local art school, but also because their choice amounted to a precise strategy related to skills and knowledge of raw materials, starting with the famous Ançã stone from which the tomb was carved.

Nevertheless, I think that this choice was also dictated by other, deeper motivations of a cultural nature. Indeed, it would hardly have been allowed for a non-native artist to intervene on an artwork that is fundamental to local tradition, history and devotion. In fact, it is still considered as much a religious symbol as an identity symbol of Coimbra, being representative of the material and intangible heritage of the place and its city community.

In this regard, over the centuries the various interventions mainly affected the polychromed surface more than the structure to the point that it could be said that those in charge operated on the tomb as if it were a *retábulo pintado*, a painting, thus referring to the centuries-old and proven Portuguese tradition of pictorial restoration [20-21]. The Franciscan chronicler Manuel de Esperança himself, reporting on the reworking and repainting carried out on the effigy of the queen, attributed these operations to a "painter" not otherwise identified [9, p. 312]. This circumstance was due not only to the not particularly critical state of the structure of the tomb monument as opposed to the painted surface, which was deeply damaged since the fourteenth century due to river flooding, but perhaps it was related to the symbolic value of the object on which the restorative artists were called upon to apply their skill. Indeed, it was the medieval sepulchre that had kept for centuries the 'incorrupt and incorruptible' body of the Holy Queen, the same funerary monument which in the past as in the present is considered an extraordinary relic to be offered "intact and intangible" to the veneration of the faithful.

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A study of the polychromy of Campana's panels

Estudo da policromia dos painéis de Campana

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Abstract

The study focuses on the colour of architectural earthenwares known as Campana slabs, which often show polychromy remains. We have analysed several fragments of simas, crowning and revetment panels found between 2001 and 2013 on the northeast slopes of the Palatine Hill (Sapienza Università di Roma), in the excavation pit of the Arch of Constantine and in the House of Augustus. In this work, we have reported the results obtained on 21 samples by means of Optical Microscopy (OM), X-ray fluorescence spectroscopy (XRF) and Raman Spectroscopy. The analytical approach used has enabled to understand the palette and techniques used by ancient artists.

KEYWORDS
Earthenware
Campana reliefs
Non-destructive analysis
Polychromy of Roman architecture
X-rays

Resumo

O estudo incide sobre a cor das louças arquitectónicas conhecidas como lajes Campana, que apresentam frequentemente vestígios de policromia. Analisámos vários fragmentos de simas, coroamentos e painéis de revestimento encontrados entre 2001 e 2013 nas encostas nordeste do Monte Palatino (Sapienza Università di Roma), no fosso de escavação do Arco de Constantino e na Casa de Augusto. Neste trabalho, descrevemos os resultados obtidos em 21 amostras por meio de microscopia ótica (MO), espetroscopia de fluorescência de raios X (XRF) e espetroscopia Raman. A abordagem analítica utilizada permitiu compreender a paleta e as técnicas utilizadas pelos artistas desse tempo.

PALAVRAS-CHAVE
Faiança
Relevos de Campana
Análise não destrutiva
Policromia da arquitetura romana
Raios X

The Campana's slabs: a short introduction

The architectural earthenwares commonly known as "Campana slabs" include various types of clay-based revetments produced between the late Republican age and the first half of the second century CE. So called from the name of the collector and first publisher the Marquis Campana, a leading figure of nineteenth-century collecting [1], whose changing fortunes led to the dispersion of the collection in the largest museums in Europe. In his publication, the slabs are represented graphically, sometimes with colors. The slabs in his collection were sometimes integrated and colored, so that the archeologists often have doubts about their authenticity. We must thank Rohden-Winnefeld for the first complete edition of the Campana slabs, a large catalog with black and white photos [2]. Much later, Siebert's edition of the Kestner Museum of Hannover (2011) finally shows a complete collection in color [3]. Today, the number of editions, especially on excavations, showing slabs with polychromy has grown considerably.

Campana slabs are a serial product linked to brick manufacturing that combines easy reproducibility with high-quality artisanship, but the mechanisms of dissemination of moulds or models still elude us.

The use of these earthenwares represents an elitist phenomenon, essentially linked to the great aristocratic residences and the non-sacred spaces of sanctuaries and develops from earthenware decoration attested in central Italy during the third and second BCE combined with the Etruscan-italic decorative tradition.

In some way, the contexts where they express the highest level of modelling and workmanship, are always linked to the imperial family or families close to it, either directly, or in restructuring programs where the imperial will occupy a prominent place [4].

A peculiar figurative heritage is reflected in the Campana slabs, largely inspired by Greek mythology, which is often associated in an iconological key with a meaning alluding to the historical and political realities of the time.

Other slabs have a narrative flavor and depict aspects of Roman life, such as chariot races, hunts, theatrical scenes and Nilotic landscapes, found mainly in secondary contexts, such as tombs, thermal baths, and rustic parts of villas.

The decorative schemes show compositional principles typical of marble reliefs, toreutics, ceramics, and plaster, while stylistically they are largely inspired by Neo-Attic classicism, but also by the Hellenistic style and, to a lesser extent, by traditional italic characters [5].

There are five types of terracotta among the Campana slabs categorized by their position in the roof or by their supposed function, all of which were colored. Although the position of the two simae on the roofs of the buildings is certain, it remains more difficult to define the placement of the crowning and revetment slabs. In general, the crowns and bases were added to the decorated slab, so we can have the same decoration on different types of earthenware (Figure 1).

The raking simas were modeled in one piece with the tile, often with a groove on the top, for the cimasa, or provided with drip noses when attached to the eaves. The revetment slabs had a crown usually in the form of an ionic kyma, and a base in the form of a pattern of palm leaves and calyxes. These slabs were usually fixed on the wooden structure with nails, at the head of the beam or on the architrave as a frieze, with the primary function of protecting the wood.

Less clear is the function of the crowning slabs, which should be fixed to the wall with mortar and thanks to the listel at the base, as a single relief, in pairs, in repeating series forming an ionic frieze, at different heights of the wall, from the base of the wall to the top [5].

None of these reliefs were ever found *in situ*.

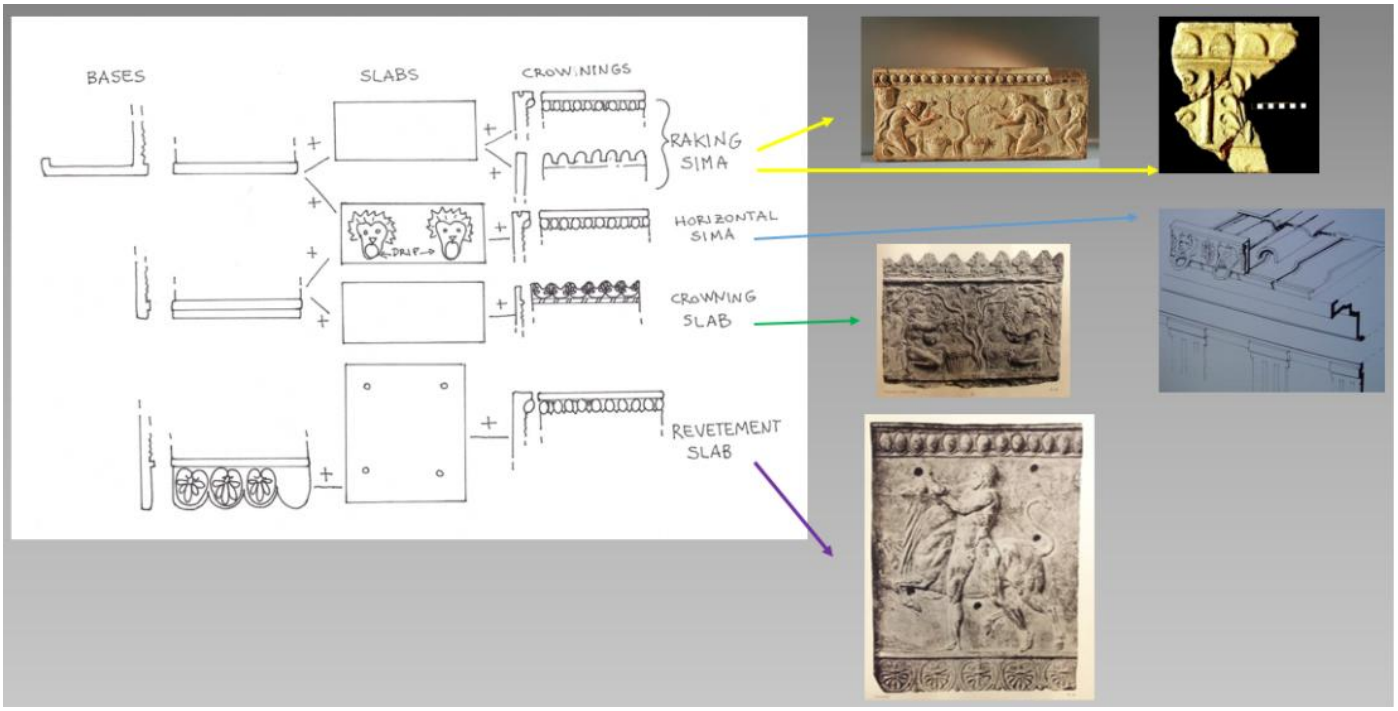

Figure 1. Campana's slabs typology. The scheme shows the different types of slabs resulting by the combination of different bases or crowns with different kind of decorated slabs.

The technical point of view

For the study, due to the doubts we already expressed about the authenticity of the colour on the Campana's collection slabs, we chose to analyse only slabs coming from recent excavations: the north-eastern slopes of the Palatine hill (Sapienza Università di Roma, Prof. C. Panella), the foundation pit of the Constantin's arch (SSBA Roma) and the House of Augustus (Parco del Colosseo). All of the contexts are in some way related to the first emperor. The slabs from the north-eastern slopes come from different contexts, even chronologically very far from their first use, but were probably connected to the birthplace of Augustus, *ad capita bubula*, and the restoration of the house held in first imperial age. The slab form the Constantin's arch pit is a single object of uncertain place of origin, but not far or from the previous one, anyway connected by the theme to the Apollo's cult. The last ones come from the first phase of the Augustus house, dated 36-28 BCE; they were dismantled from the *peristilium* of the house and reused to close the first and previous entrance to the Apollo's temple, along the corridor of the fallen vaults.

On the technical side, the slab is mould modelled but, as we can see observing the section, the tempers abundantly present in the matrix are never visible on the surface of the relief. Thus, we must think that, at first, a thin layer of dense and fine clay was spread in the mould and just after that the usual mix with tempers.

Starting from the technique of paint application, it has been proven by many studies the application of compounds of pigments, solvents (water) and organic binders (difficult to identify, but probably egg) on a surface, often but not always, prepared with lime wash, which improves pigment adhesion [6-7]. This background, when abundant, is often the only trace that has survived. Figure 2 shows two slabs: in the first the lime wash is visible under and around the blue of the background, the only surviving color (Figure 2a), in the other, the blue background has completely disappeared, but the other colors have survived (Figure 2b).

Figure 2. Lime wash on slab's surface: *a*) lime wash under blue pigment; *b*) pigment disappeared, lime wash lasting.

Figure 3. Slab with scene of grape harvest. Red color overtaking the edges, it will be covered by the blue of the background when the slab is completed.

The application probably follows an order of convenience: first the light colors, then the dark ones, with little attention to respecting the edges (Figure 3), and lastly the background, which would correct any error.

The polychromy

The palette used is that of architectural decorations, based on the primary colors of yellow, red, and blue, joined by orange, green, pink and white. The fact that this palette is related to the three-dimensional nature of the support, the tile or slab, and not to the motifs depicted on it, can be seen in the transfer of the same to a two-dimensional pictorial surface. The backgrounds

of the paintings often become black or dark red. From this point of view, the slabs are much closer to the plaster, so that the three-dimensionality is the distinguishing element. Due to the neo-attic style of most of the slabs, we can imagine that they also followed the color rules and the sobriety of classical Attic architecture, especially the Parthenon [8].

The choice of colors for the individual elements of the figuration is based, as far as possible, on a naturalistic principle, but above all on the differentiation of the figures and the levels of the relief.

Figure 4 shows two different crowning slabs, both with a symmetrical decoration and probably to be displayed together. Figure 4a shows a Nike facing a missing central object. We can recognise the light pink of the skin, the white dress of the Nike, but at the same time, the wings of the Nike have a different color, yellow and reddish brown to distinguish them. The other slab (Figure 4b) shows the central object, a shield, held by light pink arms.

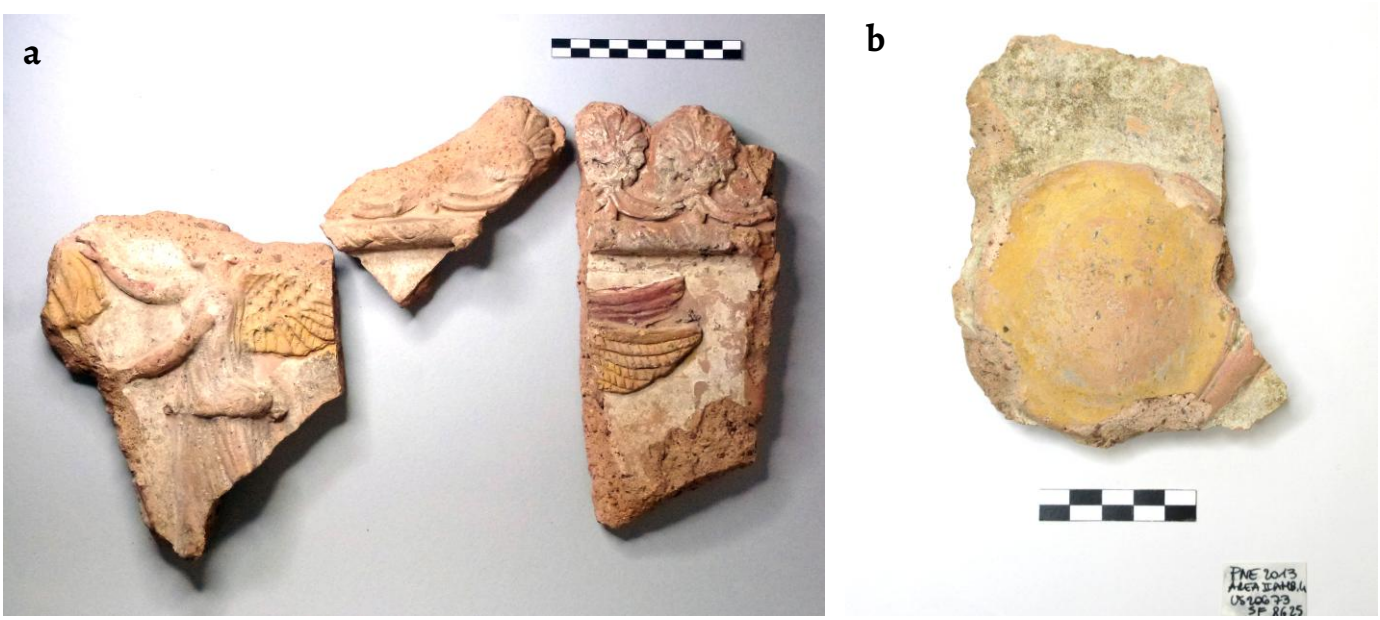

Figure 4. Polychromy on crowning slabs: a) Nike with wings of different colour; b) naturalistic colouring of the skin.

Figure 5. Shields of different colour in a crowning slab with triumph scene (unpublished).

In Figure 5, a slab with prisoners and soldiers shows a panoply with shields of different color (yellow and red), to make them all visible and distinguishable.

The freedom of the painter in the composition of the colours is shown also in slabs with the same theme but coming from different contexts. An example of this is the panel with the theme "The Tripod Dispute between Apollo and Heracles". On the panels displayed in the Antiquario Palatino, the colour of the space under the basin of the tripod is blue, while on other fragments it is orange. Another example is the coloration of the Ionic kyma. One is completely white and made with white lead, another with white ovoli and an orange and pink frame and a red pin.

We have no elements that indicate a usual detailed coloring of the figures (eyes, eyebrows, and lips): the silhouette and thickness of the relief probably being sufficient to make the figures recognizable, as on the plasters or, as seen, on pictorial surfaces with the same motifs.

Examination of the available bibliography with color photos has so far revealed a detailed overpainting in only one case, namely in a small fragment of a slab from the Palatine Hill with a horse in strong relief [9], in which the bridle is highlighted with a dark red color, probably red ochre. The slabs from the House of Augustus show the highest level of workmanship and painting so far and they are exceptional: together with a larger variety of colors, the eyes of the Gorgon are painted, the edge of Hermes' cloak shows a red strip at the edge, and the faces of the gods are naturalistically rendered (Figure 6).

The usual state of preservation of the panels in general does not allow to assess the presence of nuances that, for the same reasons as the physiognomic details, perhaps had no reason to exist.

As far as we have been able to analyze, the backgrounds of the panels are usually blue and occasionally orange; the situation is different for the slabs with the doric frieze, where the red background is typical of the metopes and follows the decorative canon of the metopes of the Parthenon [8].

Figure 6. Physiognomic details on slabs from the House of Augustus.

A long tradition of architectural studies has tried to investigate the meanings of the colours used, reaching the conclusion of the "non-significance" of red or blue or even absent backgrounds, highlighting however that the transition from red to blue backgrounds took place in ancient Greece at the end of archaic age, simultaneously with the transition from black-figure to red-figure pottery [10]. The metalinguistic value of the blue backgrounds in late-republican roman art has been well investigated by P. Liverani in multiple occasions [11]. The colours used in the creation of the figures in the marble friezes do not follow naturalistic principles, but are a narrative and compositional sign, capable of distinguishing the figures placed high on the architraves; instead, in Campana's slabs we have seen a mix of naturalistic and compositional sign.

Experimental

We began with direct observation of the slabs with the naked eye and optical microscopy, then we performed elemental and molecular point-by-point analyses directly *in situ*, such as X-ray fluorescence and Raman spectroscopies. Other analyses involving also micro-destructive techniques were published in a previous work [12].

Optical microscopy (OM)
The surfaces of plaques were viewed using a Bresser optical microscope with 40× zoom and a movable light guide system. The photos were taken with a professional Nikon camera.

X-ray fluorescence spectroscopy (XRF)
XRF is a very popular technique in the field of cultural heritage because it is non-invasive, and we can perform the analysis directly on the surface of the objects. We identify the elements present on the examined point and can indirectly trace them back to the pigment used. The elemental analysis was performed using a portable device with a Pd-anode X-ray generator (EISS srl) and a Peltier-cooled silicon pin (Si-PIN) detector (Amptek, mod. XR-1000CR). The XRF spectra were obtained at a voltage of 40 kV and a tube current of 350 mA with a data acquisition time of 200 s. The sample area had a diameter of about 2 mm.

Raman spectroscopy (Raman)
A Raman system (AvaRaman-532TEC), with a spectrometer (AvaSpec-2048TEC) was used. It is composed by a 25 μ slit, an NC grating that covers the spectral range 535-750 nm (corresponding to a shift from the 532 nm laser line of 100 to 5400 cm^{-1}), a DCL-UV/VIS filter, and a CCD detector with 2048 pixels. The excitation laser is a TE-controlled diode laser, emitting at 532 nm, with adjustable output power from 0 to 250 mW. The spectra processing was performed using the AvaSoft-Raman Software, with which the intensity values of the peaks related to the elements were obtained. The Origin software was used for the spectra processing, which allowed us to average the multiple spectra for individual points to obtain an average spectrum from which the intensity values of the peaks were derived.

Results and discussion

Based on OM observation we could prove that pigments were applied in two ways: directly the ceramic matrix surface or on a ground of lime wash. The ground probably was used to smooth the surface, to improve the adhesion of the pigment, and to make the colour lighter. In Figure 7 some examples are reported.

The XRF analysis shows that iron is the main element for the yellow and dark red colour suggesting the use of ochres. For the dark red hues, Raman spectra show the following peaks: 210, 297, 407 and 600 cm^{-1} attributable to red ochre [12-13].

For yellow hues, Raman peaks at 297 and 395 cm^{-1} are recorded suggesting the use of goethite [12].

Among the red hues, in some cases we observe traces of an orange pigment that contains high counts of lead (Table 1). Raman spectra show that the most intense peak is at 543 cm^{-1} ascribable to minium [13].

The blue pigment is characterised by the presence of copper (Table 2), however XRF reveal also high counts of calcium and iron (relative percentage major or equal to 30 %). Raman spectra show the presence of the following peaks: 429, 607 and 1083 cm^{-1} (Figure 8a). The peaks at 430 and 1084 cm^{-1} are attributed to Egyptian blue and calcium carbonate [13], whereas 607 cm^{-1} could be related to the presence of hematite. This hypothesis is confirmed for some fragments that present a blue-violet hue by a previous work [12].

Figure 7. Application of pigments: *a-b)* blue and orange pigment applied directly on the ceramic surface; *c)* white pigment applied on the ground (OM).

Table 1. Significant examples of XRF results for the identification of pigments with high counts of lead, in bold are the main detected element (chromophore).

Sample	Colour	Detected elements (%)										
		K	Ca	Ti	V	Mn	Fe	Cu	Zn	Sr	Zr	Pb
Museo 03	Dark red	0.9	18.9	0.6	0.3	0.9	**72.2**	0.4	0.9	0.8	0.3	3.8
Museo 06		0.6	10.4	0.6	0.1	0.7	**83.8**	0.1	0.9	0.4	0.2	2.2
Museo 07		0.4	8.6	0.6	n.d.	1.1	**85.8**	0.2	0.8	0.6	0.2	1.8
Museo 22		0.5	7.5	0.5	0.4	1.0	**86.8**	0.3	0.3	0.5	0.2	2.0
Museo24		0.5	11.3	0.5	2.4	0.7	**59.9**	0.4	0.8	0.7	n.d.	22.8
Museo 25		0.5	6.9	0.5	0.2	0.7	**85.3**	0.5	0.9	0.3	n.d.	4.2
Cer_07	Yellow	1.7	33.6	0.5	n.d.	1.0	**57.8**	0.6	0.3	0.8	n.d.	3.7
Museo 27		1.5	28.5	1.4	0.2	1.2	**63.8**	0.3	0.4	1.5	0.4	0.8
Museo 28		0.4	6.7	0.4	0.1	0.8	**89.7**	0.1	0.4	0.5	0.2	0.7
Museo 32		1.4	11.7	1.1	0.1	1.1	**81.7**	0.1	0.5	0.9	0.2	1.2
Museo 34		1.0	12.7	0.8	n.d.	1.1	**81.7**	0.3	0.6	0.8	0.2	0.8
Museo 31		0.9	10.0	1.0	5.9	0.9	**46.9**	0.2	0.6	0.9	0.2	32.6
Museo 37		0.4	9.4	0.7	7.7	0.9	**42.5**	0.2	0.5	0.7	0.2	36.8
Cer_4	Orange	1.5	25.3	1.0	0.4	1.1	**37.2**	0.2	0.4	1.4	n.d.	**31.5**
Museo 19		n.d.	4.1	0.3	0.6	0.4	16.2	0.5	0.2	0.2	n.d.	**77.5**
Museo 36		0.2	7.6	0.2	1.6	0.2	8.1	0.4	0.2	n.d.	n.d.	**81.5**

Table 2. Significant examples of XRF results for the identification of pigments on blue colours, in bold is the chromophore element. The results are reported as relative percentages (%).

Sample	Detected elements (%)										
	K	Ca	Ti	V	Mn	Fe	Cu	Zn	Sr	Zr	Pb
Cer_3	0.8	18.3	0.2	n.d.	0.5	17.5	**59.9**	0.3	0.7	n.d.	1.8
Museo02	0.4	8.8	0.2	0.1	0.2	10.2	**77.9**	0.3	0.5	0.2	1.2
Museo23	1.2	20.4	0.8	n.d.	1.1	**43.4**	**30.1**	0.4	1.4	0.5	0.7
Museo35	0.8	23.2	0.5	0.2	0.7	**27.0**	**44.8**	0.4	0.9	0.2	1.3
Museo38	1.2	19.4	1.0	0.2	0.9	**41.8**	**35.1**	0.4	n.d.	n.d.	n.d.
Museo08	1.7	**30.5**	0.9	0.2	1.4	**47.6**	**15.5**	0.3	1.1	0.3	0.5
Museo14	1.4	**20.6**	1.3	0.3	1.2	**42.7**	**30.0**	0.4	1.1	0.4	0.6

Table 3. Significant examples of XRF results for the identification of pigments on white and grey colours, in bold is the chromophore element. The results are reported as relative percentages (%).

Sample	Colour	Detected elements (%)										
		K	Ca	Ti	V	Mn	Fe	Cu	Zn	Sr	Zr	Pb
Cer_5	White	1.8	**57.1**	n.d.	0.9	n.d.	7.2	0.2	0.3	0.7	n.d.	**31.8**
Cer_6		1.6	**56.4**	n.d.	1.2	n.d.	5.6	0.4	0.6	0.8	n.d.	**33.4**
Museo20		1.6	**65.7**	n.d.	1.6	0.4	14.2	0.3	0.8	3.8	0.3	11.3
Museo05	Grey	0.4	4.3	0.4	0.2	0.8	33.3	0.4	0.3	0.5	n.d.	**59.4**
Museo12		0.7	12.7	0.9	6.0	1.0	43.1	0.4	0.4	1.0	n.d.	33.8
Museo33		0.3	7.6	0.5	0.4	0.5	24.0	0.3	0.5	0.5	n.d.	**65.4**
Museo16	White-yellow	1.3	16.2	1.2	1.9	1.4	**60.3**	0.4	0.5	1.1	0.4	15.3
Museo17	White-red	0.8	11.3	1.0	1.8	1.4	**72.8**	0.9	0.5	1.0	0.3	8.2

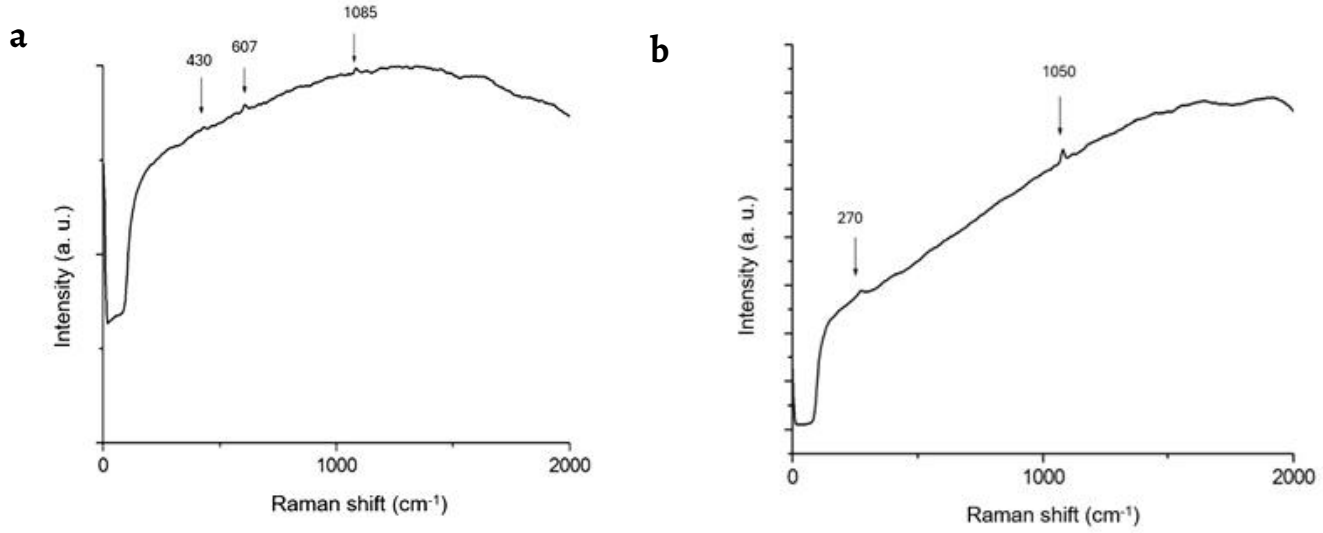

Figure 8. Raman spectrum of the: *a)* blue layer; *b)* white layer.

Finally, XRF analysis revealed that calcium is the main elements for the pure white layers, while the grey hues are enriched in lead. For the white-yellow and red, iron was detected suggesting the use or a contamination from ochres (Table 3). Raman spectroscopy reveals mainly the peaks at 271 and 1080 cm^{-1} (Figure 8b) related to calcium carbonate [13]. This aspect could indicate that the lead white may have been used as preparatory layer.

The white-grey colour is the result of the darkening of an originally white surface due to the burial environment or the degradation of Pb layers. XRD examination performed in a previous work [12] confirmed the presence of PbS (galena) according to the chemical reaction: $PbCO_3{\cdot}Pb(OH)_2 + H_2S \rightarrow PbS + CO_2 + H_2$ and calcite ($CaCO_3$) due to the surface preparation [15].

Conclusion

Over the years, we have studied some Campana plaques, mainly in fragments, using non-invasive techniques such as X-ray fluorescence analysis and Raman spectroscopy. The number of examples, the repetition of the analysis and the consistency of the results reinforce some of our points.

The slabs are decorated with natural and synthetic pigments typical of the colour palette of Roman architecture; the red and yellow colours are characterised by ochre, the white pigments are calcium-based compounds and lead white, the orange is minium, the blue is Egyptian blue, and the grey hues are the darkening of lead white.

Figure 9. Virtual restoration examples of Palatine plates: *a)* canefore on the sides of a *tymiaterion*; *b)* girls decorating a betilo; *c)* the tripod dispute (1- real plate, 2 - integrative virtual restoration, 3 - coloured virtual restoration).

The painting technique used on the panels is similar to mural painting, in both cases using calcium compounds or organic compounds as binders. We can confirm that all the panels were painted by looking at the traces of Egyptian blue found on fragments with no visible traces of paint [12].

Less certain is the distribution of colour on the various elements of the decoration: as seen in the discussion, we cannot assumed today that a paint without traces is present, despite the general rules

To advance the study, we have attempted a virtual restoration of the images of the Palatine panels available to us (made by ourselves or found online). We first restored all or part of the plate with the missing parts and then applied the colours based on the traces of pigment left on the plates or fragments of the same theme. Where no traces of pigment are visible, we did not apply any paint in view of the limitations just pointed out in our reconstruction. Figure 9 shows our results.

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New findings on the original surface finish of a wooden sculpture by Tilman Riemenschneider

Novas descobertas sobre o acabamento original da superfície de uma escultura de madeira de Tilman Riemenschneider

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Abstract

The Germanisches Nationalmuseum Nuremberg (GNM) owns a total of eight sculptures from the workshop of Tilman Riemenschneider. The depiction of Saint Elizabeth of Thuringia, created around 1510, is considered his own work and most probably comes from the central shrine of an altarpiece. The preserved layers of paint can be attributed to two different phases of polychromy. The technological and stylistic characteristics of the oldest polychromy point to its creation in the 17th century. Underneath, there are remnants of a reddish coating on the smoothed wood. Material analyses (SEM/EDX, FT-IR, Raman-spectroscopy, HPLC-PDA-HRMS, LC-MS/MS) identified a thin, sparsely pigmented protein coating directly on the wooden surface without any dirt or dust in between. This glaze seems to be the original finish that protected, refined and slightly coloured the raw limewood. The findings provide a contribution to the understanding of the type of monochrome sculptures, in particular from the workshop of Tilman Riemenschneider.

KEYWORDS
Riemenschneider
Monochrome
Unpolychromed
Holzsichtig
Sculpture
Altarpiece

Resumo

O Germanisches Nationalmuseum Nuremberg (GNM) possui um total de oito esculturas da oficina de Tilman Riemenschneider. A representação de Santa Elisabete da Turíngia, realizada por volta de 1510, é considerada uma obra sua e provém, muito provavelmente, do altar central de um retábulo. As camadas de pintura conservadas podem ser atribuídas a duas fases diferentes da policromia. As caraterísticas tecnológicas e estilísticas da policromia mais antiga apontam para a sua criação no século XVII. Por baixo, há vestígios de um revestimento avermelhado sobre a madeira alisada. As análises do material (SEM/EDX, FT-IR, espetroscopia Raman, HPLC-PDA-HRMS, LC-MS/MS) permitiram identificar um revestimento proteico fino e pouco pigmentado aplicado diretamente sobre a superfície da madeira, sem qualquer sujidade ou poeira entre eles. Esta velatura parece ser o acabamento original que protegeu, refinou e coloriu ligeiramente a madeira de tília. Os resultados contribuem para a compreensão do tipo de esculturas monocromáticas, em particular da oficina de Tilman Riemenschneider.

PALAVRAS-CHAVE
Riemenschneider
Monocromático
Não policromado
Holzsichtig
Escultura
Retábulo

Introduction

The Germanisches Nationalmuseum Nuremberg owns a total of eight sculptures from the workshop of Tilman Riemenschneider. The approximately 110 cm high depiction of Saint Elizabeth of Thuringia (Inv.No. Pl.O.2413), created around 1510, is considered his own work. It most probably comes from the central shrine of an altarpiece to which two further sculptures may be assigned, which are now in private ownership in the US (Saint Catherine) and in the Compton Verney Art Gallery in the UK (Unknown Female Saint) (Figure 1).

The three sculptures were presented together for the first time at the major Riemenschneider exhibition at the MET in 2000. Even though the surfaces look quite different today after individual treatments over time, there are several indications that the sculptures originally belonged together [1, pp. 326-331]. Due to the very finely crafted surfaces, it was assumed that they were formerly unpainted. The aim of this study is to address these issues. Due to the lack of relevant traces on Saint Catherine and the Female Saint, the examinations at Saint Elizabeth are of particular importance. The investigations are being carried out as part of the current conservation treatment of the sculpture.

Figure 1. Sculptures from the workshop of Tilman Riemenschneider: *a)* Female Saint (Compton Verny Art Gallery, UK; CVCSC:0271.N, photograph: J. Woodley); *b)* Saint Catherine (Private Collection, USA, photograph: bpk/ Metropolitan Museum of Art); *c)* Saint Elizabeth (GNM, Pl.O.2413).

Phenomenon of so called "Holzsichtigkeit"

For a better understanding of the results presented below, the phenomenon of the unpolychromed sculpture should be introduced. This phenomenon, known in German as “Holzsichtigkeit”, began to appear in the second half of the fifteenth century in Germany and reached a peak shortly after 1500, especially in Franconia and Swabia. With the rapid development of carving techniques in the late fifteenth century, the sculptures attained such great refinement and naturalistic detail that no polychromy was needed to enhance their effect. Surface areas could be delineated and organized by means of stippling, appliqués and cut decorations or fabric imitations instead of different coloured paint layers or metal leaves. Such unpolychromed surfaces were certainly never left bare and untreated but were at least given a (protective) transparent coating.

There are several examples of late medieval altarpieces that remained without polychromy for several years and decades after their production. The Lorch altarpiece from 1483 is still considered to be the oldest altarpiece designed without polychromy that has survived to this day. A yellowish-transparent, glossy coating was found directly on the wood of the sculptures and the outside of the wings, which optically unified and preserved the surface [2]. The oldest, now lost polychromy of the carving work dates back to 1719 [3, p.122]. Holes in the wings indicate that the reliefs were once attached to the inside. The oldest paintings on the wings date from 1597 and are executed as grisailles, so were probably made in relation to the monochrome effect of the carving. The findings show that the altarpiece was not polychromed until the eighteenth century.

Characteristics and intentionality

The still highly controversial question of whether the altarpieces, which initially remained unpainted, were planned and commissioned without polychromy and were considered finished in this state, cannot be answered in general terms. This topic has been the subject of much controversy in recent decades, with the arguments being strongly influenced by the respective professional backgrounds and the associated subjective perspectives of the debaters. In addition to the effects of Reformation developments on the intentions of the patrons, two main explanatory approaches have been pursued in the more recent debate: One cites practical external circumstances such as funding difficulties as the trigger or at least companion to this development; the other points to a fundamental change in the aesthetic perception of sculpture that went hand in hand with the increasing technical mastery of the sculptors. A more detailed summary of the positions is not provided here, and reference is made to the relevant literature [4-16]. It is undisputed that larger altarpieces, in particular, were often set up without polychromy but were polychromed a few to several years later. Georg Habenicht cites several examples for this procedure [6, p. 104]. There may have been different reasons for this in individual cases. It is certain, however, that these altar pieces which were delivered without polychromy, initially had to be convincing on its own merits. It therefore seems only logical that the carvers not only had the ambition to complete their works as perfectly as possible but wanted to protect their surfaces against dirt and dust and, also sought to enhance the surfaces appearance in some way – for example with thin coatings and coloured accentuations.

Terminology

The issue of the terminology is just as controversial as the intentionality of the phenomenon. The difficulties in defining a uniform term arise on the one hand from the many uncertainties that still prevail about the actual original appearance and the motifs for this, and on the other hand from the diversity of characteristics of an unpolychromed surface, which can vary from transparent to slightly coloured to clearly pigmented coatings. In addition, there can be brighter coloured accentuations of the eyes, mouths and sometimes of additional details, which makes the transition to a "partial polychromy" fluid. These accentuations can be made directly

on the wood surface or on the coating. In order to find a valid terminology, the uncertainties about the various manifestations of the phenomenon must be reduced by new and comparative findings.

As almost all the sculptures thought to have been unpolychromed were overpainted over time (often several times) and the layers of paint were later removed from many of them, most traces of the original surface design have been lost. As a result, there are only a few examples where it is possible to determine with a high degree of probability what the original surface may have once looked like.

New findings on Saint Elizabeth

The wooden support

The figures of Saint Elizabeth, Saint Catherine and The Female Saint are each carved from a block of limewood with their backs hollowed. In the case of Saint Elizabeth, a larger piece of a robe fold has been added originally (Figure 2a). Also, there is a smaller original repair in the area of her right shoulder, where a knot had apparently been removed (Figure 2a).

The Female Saint also had an originally added piece of a fold, which is now lost. Several knots, however, remained in the wood [17].

Figure 2. Mapping of original wooden addings and repairs at: *a-b)* St. Elizabeth (GNM, Pl.O.2413); *c)* Seated Bishop (The Metropolitan Museum of Art, The Cloisters, 1970.137.1).

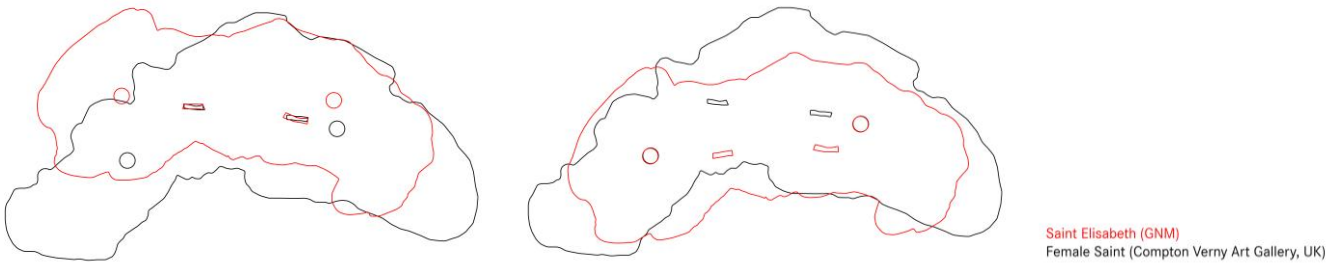

Figure 3. Tracings of the original impressions of a two-pronged clamping tool (slim, rectangular) from the workbench and younger drill holes (circular) at Saint Elizabeth's bottom and the Female Saint's bottom.

Two pieces of wood are added in Elizabeth's back, where the wood became too thin and was carved through (Figure 2b). This technique of repairing with rather large pieces of wood is not unusual for the Riemenschneider workshop, even though there are only smaller repairings at Saint Catherine and the Female Saint. But you can find it for example at the Seated Bishop from The Cloisters at The Metropolitan Museum of Art (Figure 2c)

From a technological point of view, in addition to the matching dimensions and similar manufacturing techniques, one feature confirms the assumption of togetherness of Elizabeth, Catherine and the Unknown Saint: There is a vertical slit of about 5.7 cm in the middle of their backs at the shoulders to attach them with a hook or similar. These slits seem to be very specific as there are no similar marks on other sculptures from the Riemenschneider workshop known [1, p. 329, footnote 2]. Also, the impressions of a two-pronged clamping tool from the workbench match exactly (Figure 3).

Surface tooling and embellishment

The surfaces of all three figures are very finely crafted and carefully smoothed. The garments and attributes are decorated using both: freehand carving techniques and various punchwork. Michele Marincola was the first to describe these decoration techniques in detail and identified nine different tool marks that were used, including three different motif punchmarks in the shapes of flowers, circles and stars [18]. One pattern appears on both the Saint Elizabeth and the Female Saint but is otherwise not to be observed on other Riemenschneider sculptures, namely a punched pattern of rhombs with little circles in their centers.

As the current comparison has confirmed the assumption that exactly the same tool was used for both sculptures, this technique will be described in more detail here. In the case of Saint Elizabeth, the punched pattern on the high-necked undergarment can only be seen in the X-ray image, as it is covered by later polychromy. To illustrate it, the pattern of the punch was digitally reconstructed (Figure 4a).

The wide side of the tool measures 10 mm, the short side 7 mm. At the Female Saint you find this pattern rotated by 90 degrees at the book's cover and – in the same orientation – at the cloak's border. The black and white raking light of a detail at the Female Saint's cloak border shows very clearly how the tool was formed (Figure 4b).

The points marked with red arrows are raised, as the punchtool was struck into the wood with a minimal offset. In the case of Saint Elizabeth, the tool appears to have been struck with less distance, and in some cases, there is even a slight overlap (Figure 4a).

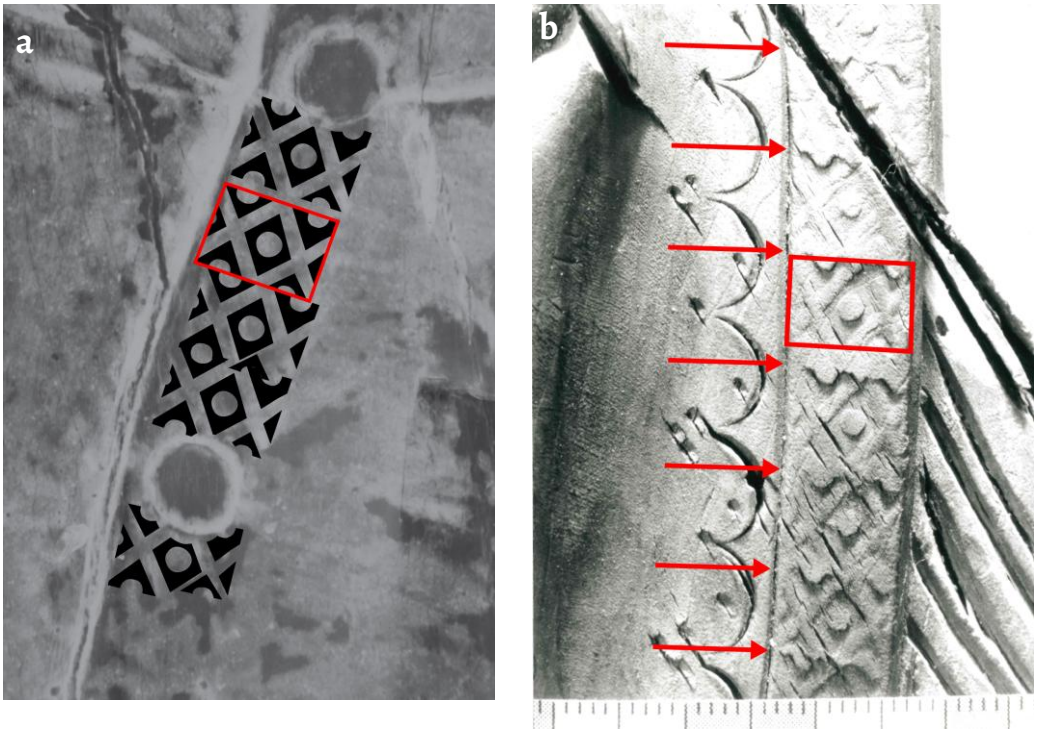

Figure 4. Punch tool with pattern of rhombs with circles in their centers at: *a)* Saint Elizabeth's undergarment's collar; *b)* the Female Saint's cloak's border (photograph: GNM).

Although the wood quality was not perfect with remained knots and added pieces of wood, due to the highly detailed surfaces with the subtle and shallow tooling, it was assumed early that these three sculptures were formerly not polychromed. However, neither wood defects and their repairs are reliable indications of a surface to be painted, nor are extremely finely finished surfaces exclusive indications of a surface not to be painted. Instead, only the characteristics of the oldest polychromy found in addition to the original surface treatment beneath it can provide reliable information. As the polychromy on the Female Saint and Saint Catherine had been completely removed, no evaluable remains of the original surface have survived here. This is why the examination of the polychromy of Saint Elizabeth is so important for the characterization of all three sculptures.

Polychromy – stylistic and technological characteristics

Significant indications that the sculptures were not painted originally, are the stylistic and technological characteristics of the oldest polychromy found on Saint Elizabeth. It was possible to characterise this first polychromy almost completely using portable X-ray fluorescence (pXRF), scanning electron microscopy combined with energy dispersive X-Ray (SEM-EDX) and Fourier transform infrared spectroscopy (FT-IR). The cross-sections of the paint layer samples were prepared by the author at the Institut für Kunsttechnologie und Konservierung (IKK) of the Germanisches Nationalmuseum Nürnberg (GNM). The pXRF-analyses were carried out by Markus Raquet at the IKK. SEM-EDX, FT-IR and Raman Spectroscopy on the cross sections were carried out by Dr. Sylvia Wieland, and Dr. Bernadett Freysoldt (Kunstgutanalytik). All analysis reports are filed in the object file (Pl.O.2413) at the IKK, GNM. Based on the results of these analyses, the polychromy can be described as follows: The paint is oil-bound and based on a thin oil-bound lead-white ground layer. It is dominated by gold and silver leaves that were applied to a thick orange-brown mordent, as well as red glaze. The glaze was both applied directly on the white ground (coat) and on the metal leaves (dress, undergarment, shoe). In contrast to these bright and shiny surfaces, the coat lining was painted matte blue (smalt) and the grass plinth with copper-green. For a better imagination, the surfaces have been digitally reconstructed in colour (Figure 5).

The observations that Marincola made in 1998 about the residues of paint on Saint Catherine and the Female Saint show some similarities. She described a very thin white ground layer, a thick orange-brown mordent, gold leaf and a red glaze on it. The observations essentially correspond to the findings on the oldest polychromy at Elizabeth, as described. Above this oldest polychromy, there is a later one that changed the appearance remarkably. While the former silver veil became a plain white scarf with dark and bright blue stripes, the dress was painted brown with black floral ornaments and the button panel of the undergarment was framed by a black and red coloured diamond pattern. The formerly blue coat lining was painted blue again (smalt). Above this later polychromy, there are residues of several further overpaintings. Two different layers of blue overpaint (one bright, one dark) was found on the former reddish outside of the cloak. The darker blue pigment could be identified as Berlin blue (The pigment identification was carried out using FT-IR on a scattered sample by Frank Mucha in the natural science laboratory of the Department of Conservation and Restoration at the Erfurt University of Applied Sciences. The analysis report is filed in the object file (Pl.O.2413) at the IKK, GNM.) and therefore dates to the eighteenth century at the earliest . This finding also corresponds to Marincola's notes on the paint residues on Saint Catherine and the Female Saint. Two different later layers of blue overpaint are mentioned on the outside of each of their cloaks.

Figure 5. Colour reconstruction of the oldest polychromy of St. Elizabeth.

In summary, the oldest polychromy does not appear to date back to the early sixteenth century. It differs significantly from comparable works from the same period, both from a stylistic and technological point of view. The use of oil as a binder for the primer and paint layers and as an application medium for the large areas of gilding and silvering do not suggest that the work was created in the early sixteenth century, nor does the use of smalt as a pigment for the coat lining. In comparable works from the same region and period, the primer and paint layers are glue-bound, and azurite is used as a blue pigment. From a stylistic point of view, too, the predominantly metallic character (even the headscarf was silver-plated) points to an origin in the late sixteenth or seventeenth century. As there are no further layers of paint under this polychromy, it must be assumed that the sculpture was originally unpolychromed.

Original surface finish

In fact, there are findings of an original monochrome coating under the ground layer directly on the wooden surface that confirm this assumption. The remnants of a reddish coating can be found on the entire frontal surface. In most areas, the remains of the reddish coating are extremely thin or lost completely due to former cleaning and removal of paint layers. However, few remains are still quite thick and shiny with a pronounced inherent craquelure (Figure 6a). Occasionally, there are also accumulations such as drops or running marks (Figure 6b) Samples were taken in four different areas, namely on the outside of the cloak, the dress, the veil, and the face to compare the composition of the findings.

Cross-sections of the samples, analysed through optical microscopy (OM) with ultraviolet (UV) light show a very thin, sparsely pigmented coating directly on the wooden surface – without any dirt or dust in between (Figure 7a-b, marked with white arrows).

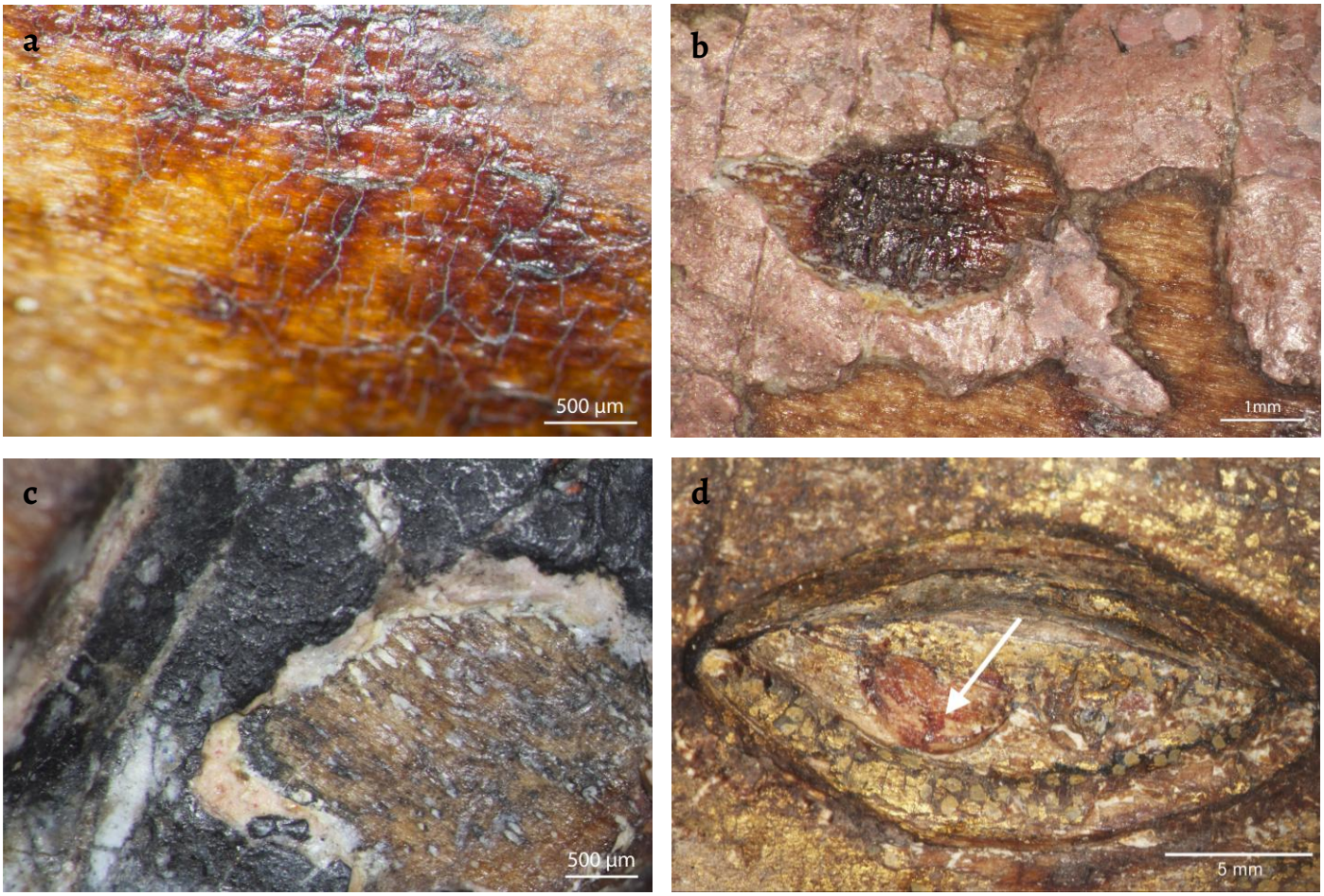

Figure 6. Detail (optical microscopy) of original reddish coating on the dress (a) and face (b), black eye mark (c) and gemstone's red glaze at the cloak's border (d).

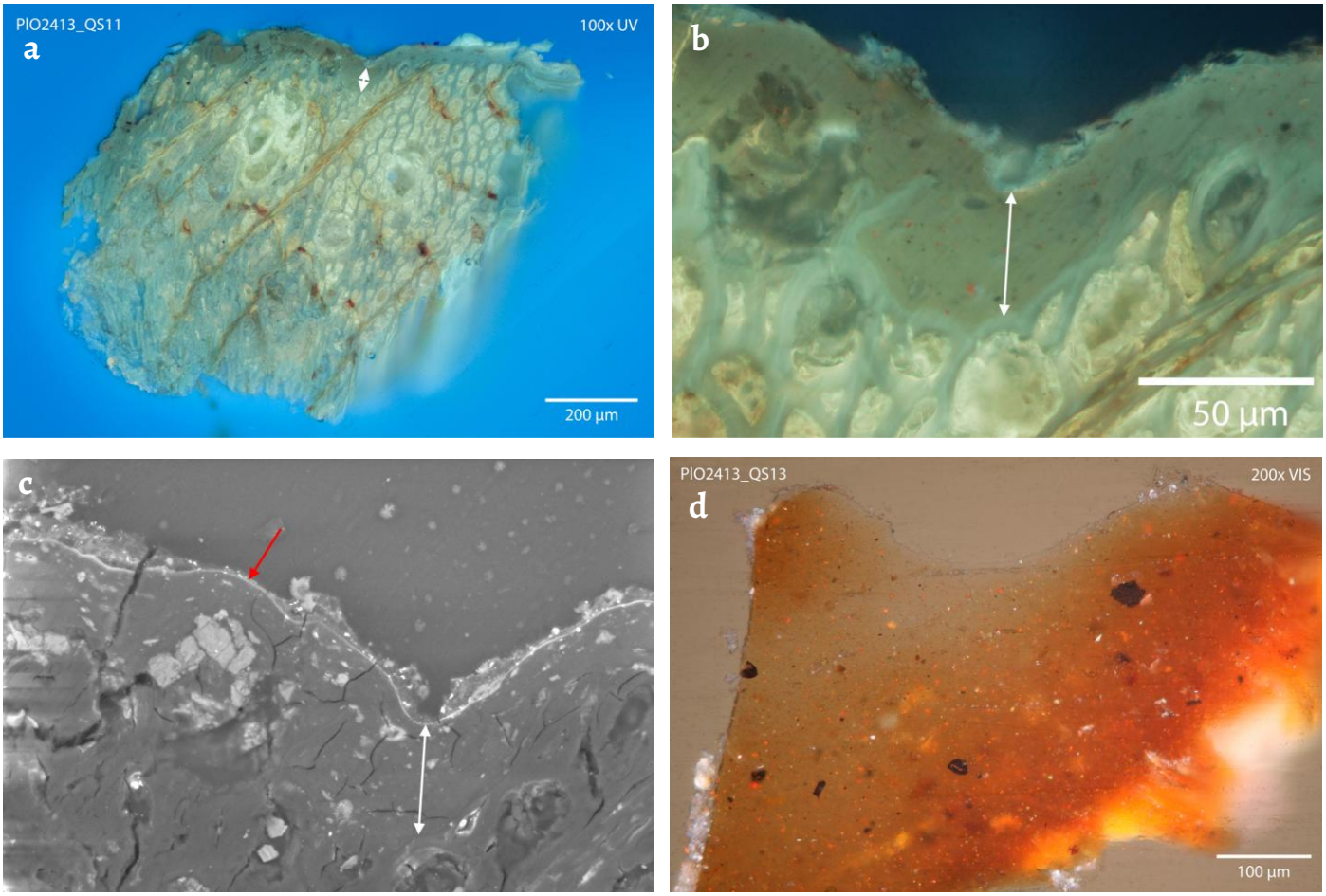

Figure 7. Cross-sections from: *a-b)* the mantle, with original coating marked with white arrows with two different magnifications (OM-UV, photographs: GNM); and *c)* SEM-BSE (photograph: Kunstgutanalytik); *d)* the face (OM-VIS).

This coating was applied to the wood surface as a semi-transparent, film-forming glaze; there is no evidence of a multi-layered structure. In the scanning electron microscopy combined with backscattered electrons (SEM-BSE) image, a very fine white line can be seen on the top of the coating layer (Figure 7c, marked with the red arrow).

This could be a so-called plaster horizon, meaning airborne particles that have accumulated on the surface. This may indicate that this layer has been exposed to the atmosphere for a long time.

The colouring particles can easily be seen in today's orange-brownish binder (Figure 7d). There are tiny red-brown and tiny light orange particles as well as larger black ones. SEM-EDX shows that the tiny light orange particles are minium and the darker red-brown particles are clay minerals. The black particles are carbon black, which could not be identified in more detail so far (The pigment identification was carried out using SEM-EDX and Raman Spectroscopy on the cross sections by Dr. Sylvia Wieland and Dr. Bernadett Freysoldt (Kunstgutanalytik). The analysis reports are filed in the object file (Pl.O.2413) at the IKK, GNM). Due to the morphology, it does not appear to be vine black, but perhaps soot or bistre. A more precise identification was not possible with Raman spectroscopy on the cross-section used and would require analysis with gas chromatography – mass spectrometry (GC-MS), as described by Baumer et al. [19].

The binding agent is Protein, as the FT-IR-spectrum shows. The collagens were identified as bovine (*Bos Taurus*) and the binder is most probably animal glue from cattle (The analysis was carried out at Bordeaux Proteome platform, directed by Caroline Tokarski and mediated by Wim Fremout from KIK-IRPA in Brussels. The method used was a proteomics-based method using the enzyme "trypsin" to break down the proteins in the sample into polypeptides. The resulting mixture of dissolved polypeptides was then separated and analysed by LC-MS/MS.

The analysis report is filed in the object file (Pl.O.2413) at the IKK, GNM). It contains neither egg, nor oil nor gum additives as has been published on other Riemenschneider sculptures in the past [2, 20-22].

While the reddish coating can be found on all frontal areas of the sculpture, the large gemstone on the mantle edge is accentuated more brightly (Figure 6d and Figure 8). The redder colouration is not due to a more concentrated pigmentation of the coating but was achieved with a red glaze. According to the UV image of the cross section (Figure 8b), it could be a red lake pigment in a resin.

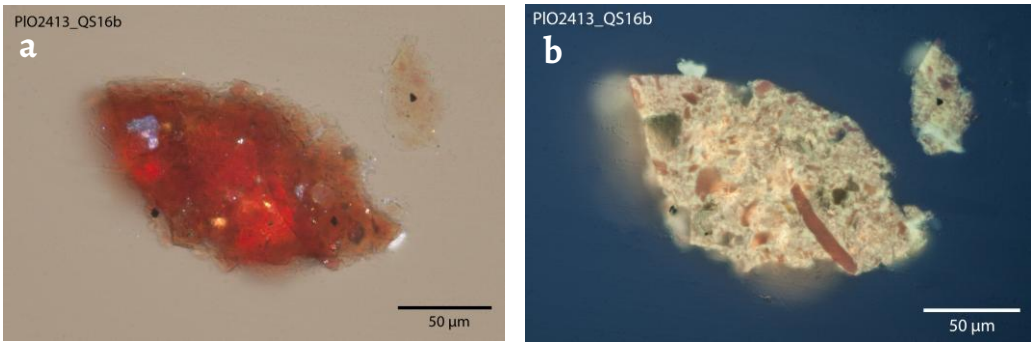

Figure 8. Cross-section of the gemstone's red glaze with: *a)* visible light; *b)* reflected light.

The eyes were painted black (Figure 6c). It looks as if the black paint is lying directly on the wood. No clear remains could be found on the lips; here the findings rather indicate that just the reddish coating was used, perhaps a little more pigmented.

Overall, the sculptures must therefore have had a monochrome reddish overall impression, whereby the coating was perhaps pigmented to varying degrees depending on the section.

Contextualising

The results were compared with the findings on other monochrome sculptures from this period with a focus on Riemenschneider. It should be noted that monochrome coatings were found on almost all the sculptures examined, in which polychromy was either never applied or applied long after the carving was completed.

Rothenburg altarpiece (1501-1504)

As early as 1965, Eike Oellermann described a transparent, brownish-yellowish coating for the Rothenburg altarpiece of the Holy Blood, made by Tilman Riemenschneider and his workshop around 1501-1504. According to analyses at that time, this coating contains egg white, oil, very little ochre, gypsum, white lead (maybe as a siccative?) and vine black [22]. This coating is said to have been applied in a modelling manner and probably twice in some cases when the shrine was already assembled. Those parts of the sculptures that were later concealed in the shrine are not coated; drops and traces of the glaze could be found on these areas. A red lip mark and a black eye mark could be found under the coating directly on the wood. The interpretation of the analysis results has often been questioned [14, p. 26; 23, p. 11; 24, p. 204]. The low concentrations and the complex mixture of components gave reason to interpret the colouring components as impurities of a transparent binder coating. In addition, the analytical possibilities at the time were naturally less accurate than they are today.

Münnerstadt altarpiece (1492)

Oellermanns 1981 published findings on Riemenschneider's Münnerstadt altarpiece were supplemented by Rudolf Göbel since the late 1990s. While Oellermann described a transparent yellowish coating that is said to have penetrated deep into the wood and to contain mainly

protein with small amounts of oil as well as iron oxide pigments, lead white and vine black [21], Göbel used high performance liquid chromatography (HPLC) to detect a yellow natural dye in the uppermost wood substance (maybe Morin) [25-27]. Since the dye was found in the wood substance and the pigments in the layer on the surface, it is not entirely clear, whether there are two layers or processes involved. The common interpretation is of one yellow dyed medium, similar to a stain, which penetrated into the wood and one proteineous, pigmented coating above it. This raises the question, whether the structure of the wood, as well as knots and repairs, would have been intensified by a coloured stain if it had been applied first. Bernd Bünsche, who has already discussed this in 2005, suspected that this glaze was merely a dye dissolved in an animal glue solution or in oils, which is why, in his opinion, it did not have the structure-reinforcing effect of a stain [28, p. 111]. However, the medium would then only have had the penetration depth of a pure low concentrated animal glue solution, which would not explain the high penetration depth described.

As in the Rothenburg altarpiece, the eyes were accentuated under the coating in black and the lips in red.

Creglingen altarpiece

The time and place of the Creglingen altarpieces creation are the subject of controversial debate following the most recent study by Volker Schaible [29]. While the altarpiece made by Tilman Riemenschneider was previously dated to around 1505-1508, Schaible interprets it as a predecessor of the Rothenburg Altarpiece of the Holy Blood and dates it to 1496. Schaible also presents new results regarding the technological findings: according to him, the altarpiece was never painted and never glazed. He concludes this from the lack of evidence of a surface coating. Apart from residues of wood preservatives, no evidence of any binding medium, pigments or even caustics could be found. The absence of caustic residues in particular is interpreted as evidence that the altar was never painted. In fact, despite these findings, it is difficult to imagine that the raw wooden surface was left untreated and has remained so to this day.

Goschof altarpiece (about 1512-1517)

The Goschof altarpiece by Hans Brüggemann was made of oak around 1512-1517. The most recent findings of an original pigmented coating should be mentioned here because very thorough analyses were carried out in an attempt to compare the findings with those on Riemenschneider's works. A dark, semi-transparent glaze-like coating was found on both the body of the altarpiece and the group of figures. Lips and eyes are marked in colour, and the pupils are even carved. In 1998, protein respectively animal glue was identified as a binding agent and carbon black as a colouring pigment. With the discovery of the dye on the Münnerstadt altar in mind, particular attention was paid to indications of the presence of a dye. However, initial indications of the presence of a natural dye could not be confirmed in 2001 (pub. 2005), even with HPLC analyses [28, p. 108].

Discussion of the findings

Comparing the results of the investigation of the sculpture of Saint Elizabeth with the findings on other altarpieces, similarities but also differences can be identified. The sparse pigmentation and the use of animal glue as a binder for a monochrome coating of the wooden surface are consistent with most of the other results.

Of particular interest in this context is the question of the presence of a natural dye, as has been identified in the Münnerstadt altarpiece [21, 26], using HPLC analyses carried out on scraped samples of the wood surface. The dye apparently caused a yellowish appearance of the wooden surfaces. In contrast to this, the wood surface of St. Elizabeth, which is exposed in

large areas, appears brown-reddish. The colouration can have various causes. It may have been caused by components of the original coating or a medium, similar to a stain, that was applied to the wood surface underneath, or by more recent coatings that have penetrated the wood, or by the wood preservative with which the sculpture was once treated.

Considering the high quality of the sculpture, it was decided not to further harm the original wooden surface by taking samples for HPLC analyses. Instead, another method was tested, which keeps the sculptural surface intact: Extraction with Nanogels. The idea for this arose during the conservation treatment of the sculpture. Nanorestore Gels were used to soften the modern brown coating, that was supposed to be removed from the surface of the sculpture. When being used on the already cleaned wood surface they turned strongly yellow, leaving behind a lighter and matter wooden surface. It became obvious that water soluble colouring components in the wood were extracted into the nanogel. Therefore, samples of the "coloured" Nanogel were analyzed with HPLC-PDA-HRMS. The results do not show traces of natural dyes. The yellow colouration therefore must have other causes than the original coating or a dyed medium, similar to a stain, applied to the wood surface.

Conclusions

To summarize, the most recent investigation confirmed the assumption that the sculpture of Elizabeth was originally not polychromed. This can also be assumed for the two associated sculptures of Catherine and the Unknown Saint. The findings suggest that the sculptures had a monochrome, slightly reddish wooden surface with lips and eyes marked as well as small decorative details like gemstones highlighted in red. Due to the small amount of material residues, it is difficult to visualize what the coating of the wooden surface might have originally looked like. A digital reconstruction gives an impression of the original surface finish (Figure 9). As the sculpture of Elizabeth is largely covered with later polychromy, the Female Saint from Compton Verney was chosen for this reconstruction.

Figure 9. The Female Saint: *a)* current state (Compton Verney, Jamie Woodley); *b)* digital reconstruction of what the original surface might have looked like.

The analyses carried out on the sculpture of Elizabeth showed that the coating is based on bovine glue, coloured with traces of red and black pigments. As the question of a colouration with dyes has been discussed at least since a yellow dye was discovered on the Münnerstadt altarpiece, an attempt was made to investigate this issue for Elizabeth. Once it became clear that no natural dye is present in the uppermost wood substance, it seems more likely that the pigmentation of the glue coating was the main factor for the reddish colouring of the wood surfaces and not the addition of a dye.

It seems reasonable that Tilman Riemenschneider used different surface finishes on monochrome retables - different in colour and technique.

Questions as complex as the analyses of original surface coatings, which have usually been altered, superposed, and partially removed by previous (conservation) treatments of the artefact, cannot be answered easily. It is important to complement older findings with new investigations and methods, although the comparison of analytical results remains a challenge, as object histories differ and methods of sampling and analysis are evolving. Therefore case studies as the one presented above enhance our knowledge about monochromed sculptures – even if they do not provide all the answers we were looking for.

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Colour in Iberian Iron Age architectural sculpture: the case of Cerro de la Merced

A cor na escultura arquitetónica da Idade do Ferro Ibérica: o caso do Cerro de la Merced

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Abstract

Recently, analytical research has confirmed the use of pigments in Iberian Iron Age freestanding sculpture. However, hard evidence of polychromy on the many preserved remains of architectural sculpture is still scarce. We focus on the case of a large block decorated with reliefs, probably dated to the end of the 5th or the beginning of the 4th century BCE, recently found at Cerro de la Merced (Cabra, Córdoba). Employing optical and electron microscopy analyses, FTIR spectroscopy, and GC-MS, it has been possible to confirm the existence of traces of red and white colour covering the entire surface, analyse the composition of the pigments employed, and to reconstruct the colour patterns of the different elements of the relief. Our aim is to deepen our understanding of the use of colour in Iberian architecture and to shed light on the colours employed, the techniques used to apply them and their arrangement patterns.

KEYWORDS
Iberian Iron Age
Monumental architecture
Iconography
Pigments
Reliefs

Resumo

Recentemente, investigações analíticas confirmaram a utilização de pigmentos na escultura autoportante da Idade do Ferro Ibérica. No entanto, as provas concretas de policromia nos muitos vestígios preservados de escultura arquitetónica, são ainda escassas. Centramo-nos no caso de um grande bloco decorado com relevos, provavelmente datado de finais do século V ou inícios do século IV AEC, recentemente encontrado no Cerro de la Merced (Cabra, Córdova). Através de análises de microscopia óptica e electrónica, espectroscopia FTIR e GC-MS, foi possível confirmar a existência de vestígios de cores vermelha e branca em toda a superfície, analisar a composição dos pigmentos utilizados e reconstruir os padrões de cor dos diferentes elementos do relevo. O nosso objetivo é aprofundar o conhecimento sobre a utilização da cor na arquitetura Ibérica e esclarecer as cores utilizadas, as técnicas de aplicação e a organização dos seus padrões.

PALAVRAS-CHAVE
Idade do Ferro Ibérica
Arquitetura monumental
Iconografia
Pigmentos
Relevos

Introduction

True colours

Although known or suspected for a long time (in Spain ever since early colourized pictures of the *Dama de Elche* were published very early in the twentieth century [1-2]), the systematic use of paint to highlight, emphasize or create details and volumes in ancient Mediterranean sculpture, be it stone or terracotta, Greek or Italic, has only recently been studied in detail [3-9]. The sculpture of the Iberian Iron Age Culture is not an exception to this rule, and recent research has shown its complexity, as in the case of *Dama de Baza* and many other examples dated between the early fifth and the first centuries BCE [10-17]. Red is the predominant colour, but true polychromy has also been documented, although in many cases only faint traces of pigment, almost invisible to the naked eye, have been discovered. Negative analysis results on other sculptures, discovered a century ago or more, and which suffered abusive cleaning, are not real proof of absence of painting in origin [17].

The act of painting a sculpture (or relief) was not merely for aesthetic effect, but rather a very important and necessary step for its completion. Sculpture lacking polychromy lacked "soul" and was incomplete; sculpted architectural elements were deprived of an emphasis on their syntax. Any sculpture to be exhibited in a public or private context had to be adequately painted, sometimes with a very high degree of complexity. As many recent works and exhibitions have proved beyond doubt, the ancient world was a world of colour and pigments.

Painting in Iberian sculpture could be quite plain, simply colouring ample surfaces in red, such as the caprine in the early *Porcuna* reliefs or the *Salobral Sphinx*. But it could also add relevant information such as the male lions' mane in a feline from Elche; or depicted textile detail (*Osuna*, *Dama of Baza* and *Baza Warrior*), sometimes emphasizing the guides provided by almost invisible incised lines, or subtle raised detail [15-17].

It is understandable that this branch of research has traditionally focused on zoomorphic and antropomorphic scultpture, rather than on more modest architectural elements carved with phytomorphic and/or geometric motifs in relief [18], and this is particularly evident in the Iberian Peninsula. However, our recent discovery of heavily decorated constructive blocks in archaeological context at Cerro de la Merced, combined with the recent studies on this type of reliefs [19] has given additional impulse to these studies, including their original colours.

The Iberian Iron Age complex at Cerro de la Merced (Córdoba)

Cerro de la Merced is an archaeological site located on a hilltop 4 km due east from modern Cabra (Córdoba). Cabra has been reliably identified as the ancient Iberian *oppidum* of *Licabrum* and later Roman *Municipium* of *Igabrum* [20]. The small, rounded conical hill lies squarely across the ancient and modern road linking the fertile *Campiña* plains to the east (Cabra, Lucena) and the hilly *Subbéticas* to the west, via the "El Mojón" pass. Although surrounded by higher mountains, particularly to the southeast, is isolated and clearly visible from the surrounding areas, its profile silhouetted against the sky. Any structure built in the hilltop was not meant to act as a watchtower, but on the contrary, it was designed to be seen from afar, as a territorial and symbolic marker [21] (Figure 1).

Site occupation dates back to the Neolithic period, but most preserved archaeological evidence corresponds to the Second Iron Age or "Iberian Culture". Excavations carried out since 2013 by our research group have proved that the remains do not correspond to a watchtower or Late Iberian small fortified enclosure as initial information and remains suggested [22], but rather to a monumental architectural complex with two main phases in the Second Iron Age, with further work currently in progress [23-26].

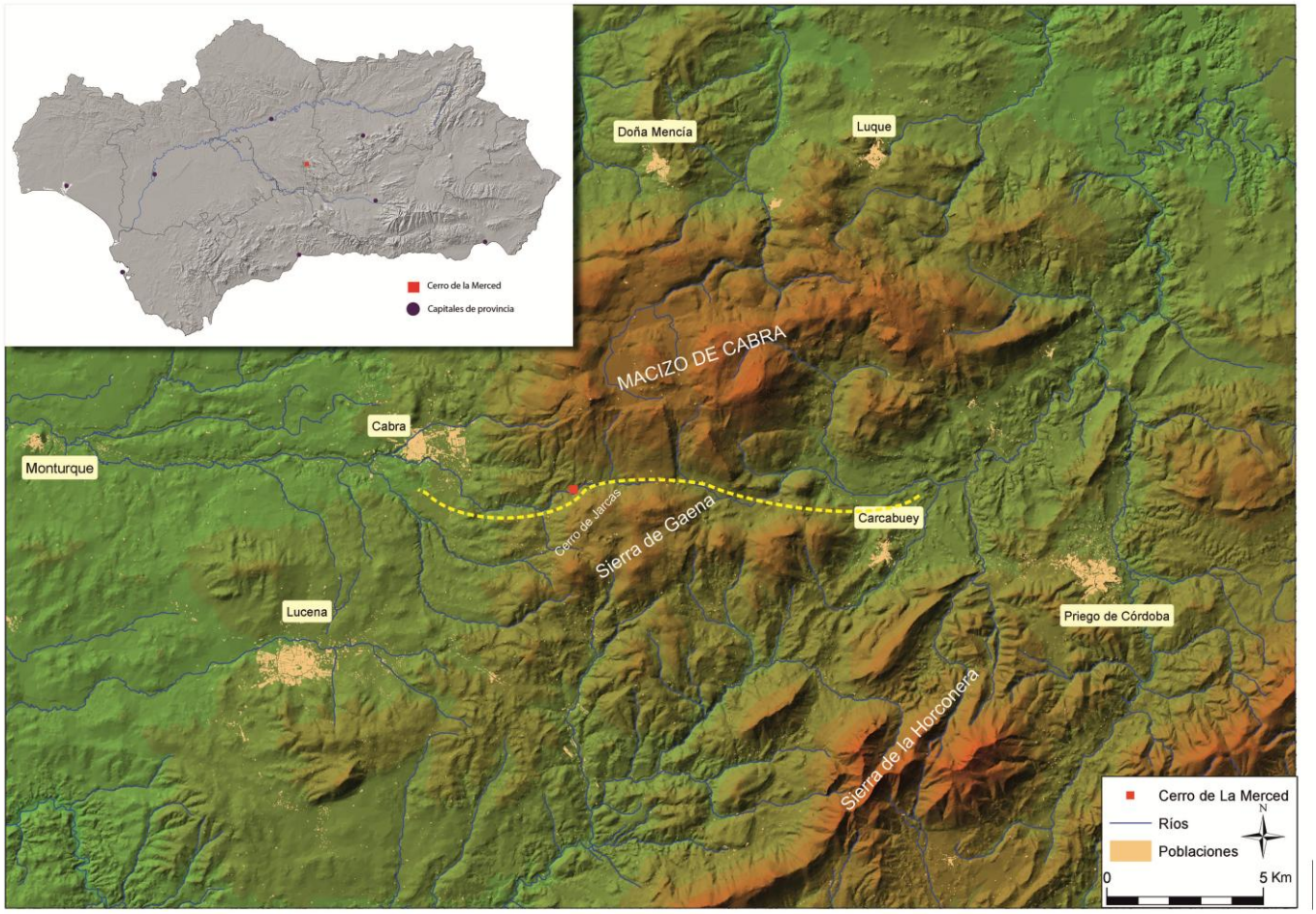

Figure 1. Location of Cerro de la Merced in Central Andalusia (Cabra, Province Córdoba). Cartography: F. Quesada and M. Camacho.

The first phase (provisionally "Building A") dates to the late fifth century BCE and the first half of the fourth century BCE, a dating supported both by the presence of Attic pottery imports and 14C dating. It is square, 14 metres on each side, one-storey building, well aligned with the cardinal points, its single entrance facing East. It led to a big open-air courtyard paved with large stone slabs and, at the other end, three large rooms, the central one almost double the size of the lateral ones. The basic layout of this edifice has parallels in sanctuaries of the Late Orientalizing period in the south-western part of the Peninsula. To the south, close to the building, an ashlar stone monument was erected, decorated with reliefs and a plain cavetto cornice of Phoenician-Punic tradition and Egyptian origin as the so-called "Egyptian gorge moulding". It is probable that this monument had a commemorative purpose, and was connected to Building A.

In the mid-fourth century BCE, a major reform took place. A larger, more complex edifice was built ("Building B") using "A" as a base. The open courtyard was divided into four rooms (one of them a lightwell), the perimeter wall was massively reinforced with cyclopean-type masonry up to four metres wide, and a second floor was added. The result was a massive two-storey, 20 metres square edifice with still just one entrance to the east. Around this new building substantial retaining walls were built against the hillside (proven archaeologically at least to north and south), using the same cyclopean masonry; these terracing efforts created a wide platform around Building B where ancillary structures were erected. In the southern side, a staircase made of large stone slabs, overlooked by a "small porter's lodge" or "guardroom", linked the lower access with the main entrance of Building B (Figure 2). We interpret these series of terracing walls, smaller buildings, stone staircase and massive edifice as an Iberian aristocratic complex that functioned as such until the late third or early second century BCE, when it was sacked, demolished and ceased to function as a centre of local or regional power [25, 27].

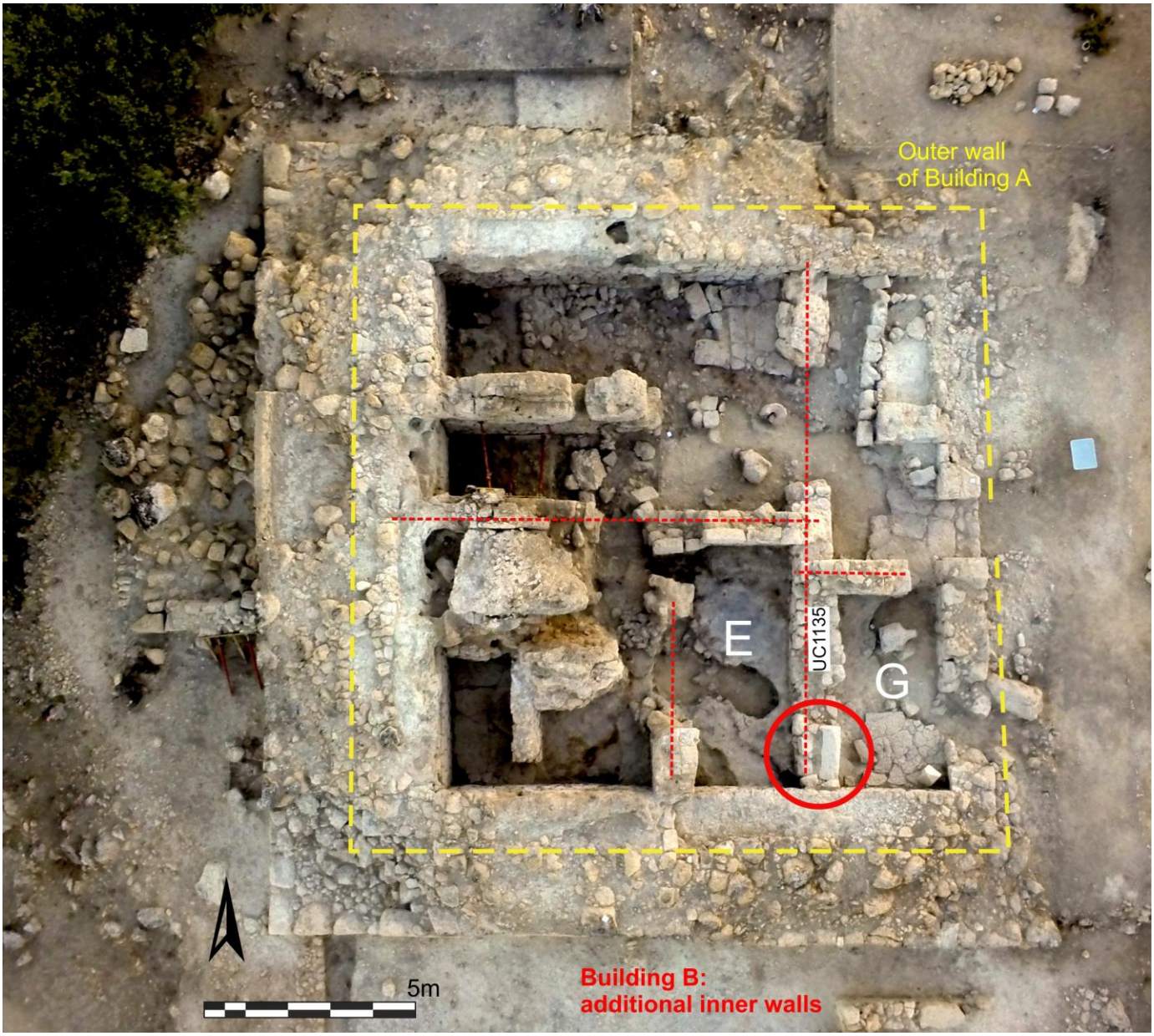

Figure 2. Cerro de la Merced, main building as of 2015. Location of reused relief block marked within red circle (photo: D. Gaspar and F. Quesada).

Reused ashlar blocks with relief decoration

During the construction of Building B a number of blocks from the earlier decorated monument were reused in the new walls. Some of them, such as the large blocks of the cavetto or "Egyptian" cornice were just fitted as they were into the masonry structures. In some other cases the ornaments from the relief frieze were chiselled away *in situ* to create smoother, flat surfaces to ensure a better fit in the new walls both mutilated blocks and stone relief chips from volutes and ionic eggs and darts have been excavated (Figure 3). These chips, originally abandoned among the construction debris and probably left on the surface of the ground for a long time show no traces of pigment.

Finally, at least one 163 × 45 cm, 480 kg calcarenite block, in which some chiselled elements and one end were missing from the original carved ashlar (inventory nr. 5219) was reused as part of wall (UC1135 – Unidad Constructiva 1135). On its main concave moulding, densely intertwined vegetal ribbons or taeniae are framed between prominent volutes in high relief that stand out and project outward; at the bottom we find a partly chiselled Ionic cyma with egg and dart motifs carved in an inverted position when compared to with canonical Greek art. This kind of interpretation of Classical motifs is typical of Iberian art.

Figure 3. Reused and chiselled blocks: *a)* room G looking S-SW, main calcarenite block inv. Nr. 5219 is marked with an arrow, still forming part of wall UC1135; *b)* from the same room, a block showing the chiselling marks; *c)* stone chip with traces of a band or taenia, probably part of the block to the left (photos: F. Quesada).

This piece is particularly relevant because it is one of the extremely rare examples of this kind of decoration found in a controlled archaeological excavation. As it was recycled in the above-mentioned wall, it has to be dated between c. 450 and 350 BCE, and not in the Late Iberian period as has been sometimes assumed for these motifs (Figure 4a). Based on typological and stylistic criteria, such as the presence of Ionic egg and dart motifs, it is possible to tentatively place it in the later part of fifth century BCE. We are not certain about the exact type of building to which it belonged, although given its dimensions and its probable relationship with the Egyptian gorge moulding blocks, it most probably belonged to the monument mentioned above, a tower-shaped with a square plan.

Figure 4. The block: *a) in situ* after removing the interior mud and gravel filling (photo: F. Quesada); *b)* location of pigment samples (photo: F. Quesada and A. Moreno).

The block had been inserted as part of wall UC1135, its plain back facing outside and thus its reliefs facing inside and protected with a mud fill. This is probably the reason why the decorated side showed on discovery very faint traces of colour, that we have analysed in meticulous detail.

Sampling and techniques

Our research group sought the collaboration of ARTYCO, a specialized Heritage Research & Conservation company that has also conducted this kind of studies for the MAN (Spanish National Archaeological Museum in Madrid) among other Institutions. Following a careful visual examination, three different paint samples were taken: two of them (YAM-1 and YAM-2), which appeared to be red in colour, were taken from the interior of the volutes, where the polychromy was best preserved. A third sample (YAM-3) that appeared to be whitish, was taken from the bottom part of the decorated surface (Figure 4b).

Four complementary analytical techniques have been employed in the study of polychromy: optical microscopy (OM); Fourier transform infrared spectroscopy (FTIR); scanning electron microscopy /energy dispersive X-ray analysis (SEM-EDS); and gas-phase chromatography coupled to mass spectrometry (GC-MS) [28-29]. All help to determine the existence or absence of polychromy, to identify the inorganic and organic materials components of the paint, and the application method. This study is, to date, the most detailed study conducted on the polychromy of an element of Iberian Iron Age architecture. In this paper we are presenting a brief synthesis of the main data obtained and interpretative results [28].

Results and discussion

The first relevant observed result is that the three samples show what can be interpreted as a preparatory layer preceding the application of paint. The composition of the layers in the three samples is summarized in Table 1. In all three samples, a thick preparatory coat (Layer 1) is visible (Figure 5, Table 1). It is composed of a heterogeneous white-brownish lime mortar, with abundant calcite and smaller amounts of quartz and silicate minerals, the remaining elements being saline impurities, probably due to the nature of the surrounding soil in which the block was buried. The use of preparation layers has been also documented elsewhere, for example the sphinx from El Salobral (Albacete) [30].

The second layer corresponds to the paint layers, which show two different compositions and colours. YAM-1 and YAM-2 show red paint, applied as a very thin coat of a mixture of red ochre and some calcite. This is similar to other documented Iberian Culture polychrome examples, such as the *Dama de Elche*, where these ochers are mixed with gypsum and intensified with vermilion to enhance the mouth of the figure [1]. However, with attention to our case study, we should remind that gypsum is different from calcite and, despite the significant amount of calcite found here, a reflection of the use of calcite is needed. Calcite could have been used as the binder (*vide supra*), as a filler or, as we suggested before, as a pigment in order to lighten the red. Cinnabar, also used for red in Iberian sculpture [1-2], is absent in our block.

In contrast, YAM-3 has a very thin and irregular brownish layer over a much thicker white layer, calcite-rich with traces of gypsum, probably part of a white paint layer.

Table 1. Composition of samples.

Sample	Layer	Colour	Thickness (μ)	Minerals (bold - main components; light - traces)	Organic substances
YAM-1	1	White-brownish	1500	**calcite**, **quartz**, **clays**, **micas**, iron oxides, dolomite, gypsum, chlorides, calcium phosphate, borates, oxalates	Acid metabolites Fatty acids
	2	Red (Paint)	0-40	**iron oxides** (red ochre), **calcite**, dolomite, gypsum, calcium phosphate, borates, oxalates	
YAM-2	1	White-brownish	2000	**calcite**, **quartz**, **clays**, **micas**, iron oxides, dolomite, gypsum, chlorides, calcium phosphate, borates, oxalates	Acid metabolites Fatty acids
	2	Red	0-40	**iron oxides** (red ochre), **calcite**, dolomite, gypsum, calcium phosphate, borates, oxalates	
YAM-3	1	White-brownish	200	**calcite**, **quartz**, **clays**, **micas**, iron oxides, dolomite, gypsum, chlorides, calcium phosphate, borates, oxalates	Acid metabolites Fatty acids
	2	White	60	**calcite**, **quartz**, **clays**, **micas**, dolomite, gypsum, chlorides, calcium phosphate, borates, oxalates	
	3	Brown	0-20	**iron oxides** (red ochre), **calcite**, dolomite, gypsum, calcium phosphate, borates, oxalates	

The binders used in this case could be either the lime (or limewash) mixed with the pigment (as suggested by the presence of calcite on the paint layer) [28-29] or even organic binders. The latter is suggested by the presence of fatty acids and metabolites that appear in all samples. However, further investigation is required regarding these results, as these fatty acids could be also a result of a latter addition.

Figure 5. Microphotographs (300×) of the layers analysed in each samples: *a)* YAM-1; *b)* YAM-2; *c)* YAM-3 (photos: E. Parra Crego).

Apart from the brownish layer document in YAM-3 sample that needs to be further addressed to determine whether it is a layer of contamination or original pigment, these data indicate the existence of two different coloured paints on the piece: red and white. This is consistent with the location of the samples YAM-1 and YAM-2 (red) (Figure 5a-b) were taken from the main frieze, in the interstices between the ribbons and the volutes, while YAM-3 (white) (Figure 5c) belongs to the lower part, close to the ovolo moulding with eggs and darts in the shape of an inverted Ionic cyma. The identical lower preparation layer in the three samples is also consistent. This suggests a pattern for a tentative bichrome polychromy: the relief-carved elements (bands/ribbons and volutes) were originally painted red, while the background on which these motifs appear would be white. This probably also applies to the Ionic egg and dart motifs in the lower part, where no samples were taken, but where traces of red pigment can still be observed with the naked eye.

This red/white bichrome pattern is a simple but quite effective colour combination, that helps to enhance the carved parts of the piece, its syntax. We must also consider that this is only one block of a larger building where, perhaps, other colours were applied, resulting in compositions with a richer polychromy.

Red, in fact, seems the predominant colour in Iberian sculpture [1-2,10-14] sometimes covering entire surfaces and in certain cases red paint on volutes has been observed in architectural reliefs, such as in a capital from Cástulo [31]. This was probably not just an aesthetic decision, and long-ago researchers such as R. Ramos [32] or J. Blánquez [33] drew attention to this choice and sought a symbolic explanation for the predominance of this colour (Figure 6). Considering that many of the architectural pieces close to the one discussed here were part of funerary or commemorative monuments, it would not be surprising that red held a special symbolism related to ritual or sacred contexts, to the world of deities and/or the afterlife. Only further research and analysis will allow for a more in-depth examination and explanation. Other recent works, however, while accepting the symbolic nature of colour, do not place particular emphasis on red, other than it is usually the most stable and best-preserved pigment [30].

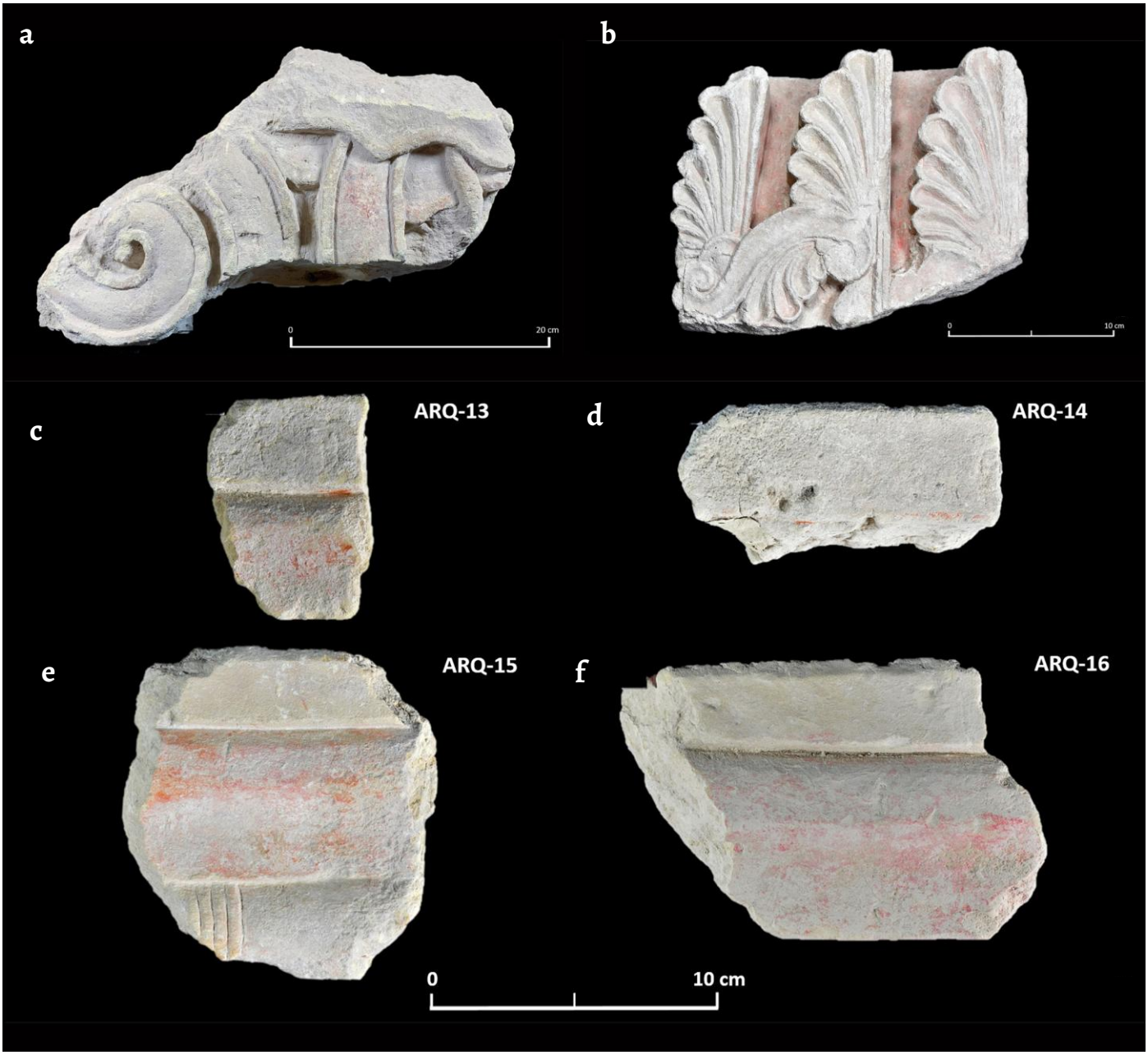

Figure 6. Selection of architectural elements with painted, mainly red, decoration from different sites: *a)* from La Alcudia (Prov. Alicante); *b)* Camino del Río (Monforte, Prov. Alicante); *c-f)* Cigarralejo (Mula, Prov. Murcia) (photos: J. Robles).

While the original block has been transferred to the Cabra Archaeological Museum, a full-scale replica has been cast in resin from a silicone elastomer S-421 mould. It has been partially painted using the colours suggested by the analysis, and then placed on site for the benefit of visitors after it was presented in a Temporary Exhibition (2022) in the Iberian Culture Museum (Jaén) when it was displayed close to the original (Figure 7). Although we do not know the exact hue of these colours, especially the red pigment, and we do not know if other colours could have been applied to certain details, we believe that this image of the block is powerful and closer to what it may have looked like in the Iberian period.

Figure 7. Carved block and partially painted replica in Iberian Culture Museum in Jaén (Exhibition 2019-2020) (photo: F. Quesada).

Concluding remarks

The case of the early, Phase A monument at Cerro de la Merced and its reuse as building material is relevant because it has provided us with the opportunity to put forward a good chronological frame for relatively frequent type of architectural relief decoration found both in Andalusia and the southeastern part of the Peninsula but often lacking proper archaeological context. It has also been possible to analyse traces of pigment and put forward a decorative bichrome pattern (at least) that is consistent with other examples. All this fits into a wider line of research that includes:

1. Documentation of painted patterns on Iberian stone architecture, not just on zoomorphic or anthropomorphic sculpture. There are many pieces where traces of colour can be observed, but thanks to the new technologies, we can begin to see the "invisible" and to document pigments where traces are no longer visible to the human eye.
2. Reconstruction of the original appearance of the monuments. Using procedures such as those employed here, we get closer to the original image these buildings and monuments displayed in their prime. When we have more sources, a sculpture in the ancient world - or architectural monument - was not conceived as "finished" unless it was painted. Therefore, it is necessary to consider preparing and polychroming as a very important phase of the production process.

Furthermore, it is necessary to delve systematically into the analysis of pigments and binders to understand how they were made and how they were applied. In this case, in addition to the paint layers, we have been able to document a preparatory layer. The binder used here could be lime mixed with the pigment, as suggested by the amount of calcite found on the paint layer, or, perhaps, an organic binder, as suggested by the presence of fatty acids.

And finally, the question of meaning. Even if conceived to enhance the elements of a relief, its syntax, some colours -particularly red- seem to have had in Iberia a particular symbolism that is difficult to grasp today.

These are, ultimately, pending tasks that need to be further explored. It is an area barely explored in the Iberian world, but one that offers interesting and new perspectives of study as some quite recent studies are revealing.

Acknowledgements

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Pigments from Pasargadae and Persepolis in the Metropolitan Museum of Art (NY): recent scientific investigations on four paper squeezes

Pigmentos de Pasárgada e Persépolis no Metropolitan Museum of Art (NY): investigações científicas recentes em quatro moldes em papel

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Abstract

Paper squeezes from architectural features and fragments from Pasargadae and Persepolis in the Metropolitan Museum of Art (MMA) in New York City were examined using microscopic investigation, imaging techniques, and chemical and molecular analyses. The study focused on pigments from (1) an anthropomorphic ear from a relief fragment in Palace P, (2) a fragment of a rosette from the crown of a Lamassu from Gate R ("Gate House"), both in Pasargadae; (3) a stone axe from a delegation depicted on the north façade of the Apadana, and (4) a stone block with a Hebrew inscription from one of the standing door or window jambs of the Tachara at Persepolis. Analyses confirmed red pigments identified in previous studies and revealed new evidence of lazurite as a blue pigment and magnetite as black. The findings can help us construct further aspects of specific ancient polychromatic contexts at Pasargadae and Persepolis.

KEYWORDS
Pasargadae
Persepolis
Pigments
Lazurite
Hematite
Goethite

Resumo

Os moldes em papel retirados de fragmentos arquitetónicos de Pasárgada e Persépolis do Metropolitan Museum of Art (MMA) de Nova Iorque foram caracterizados através de investigação microscópica, técnicas de imagem e análises químicas e moleculares. O estudo centrou-se nos pigmentos de (1) um relevo de uma orelha antropomórfica de um fragmento do Palácio P, (2) um fragmento de uma roseta da coroa de um Lamassu da Porta R ("Casa da Porta"), ambos em Pasárgada; (3) um machado de pedra de uma delegação representada na fachada norte da Apadana, e (4) um bloco de pedra com uma inscrição hebraica de uma das molduras de porta ou janela do Tachara, Persépolis. As análises confirmaram pigmentos vermelhos já identificados em estudos anteriores e revelaram novas evidências de lazurite como pigmento azul e magnetite como pigmento negro. Os resultados podem ajudar a construir outros aspetos de contextos específicos de policromia antiga em Pasárgada e Persépolis.

PALAVRAS-CHAVE
Pasárgada
Persépolis
Pigmentos
Lazurite
Hematite
Goetite

Introduction paper squeezes as evidence for monumental painting in ancient Iran

Carved between the sixth and fourth centuries BCE, the surfaces of the limestone facades of the monuments built under the Achaemenid rulers in Pasargadae and Persepolis in Fars, Iran – both UNESCO world heritage sites today (Figure 1), were originally covered with abundant paints [1]. Work has been done to analyze some of the pigments in the twentieth century. Recent investigations have summarized the potential for new work on reconstructing aspects of the original polychromies, the painting process, and the people involved [2].

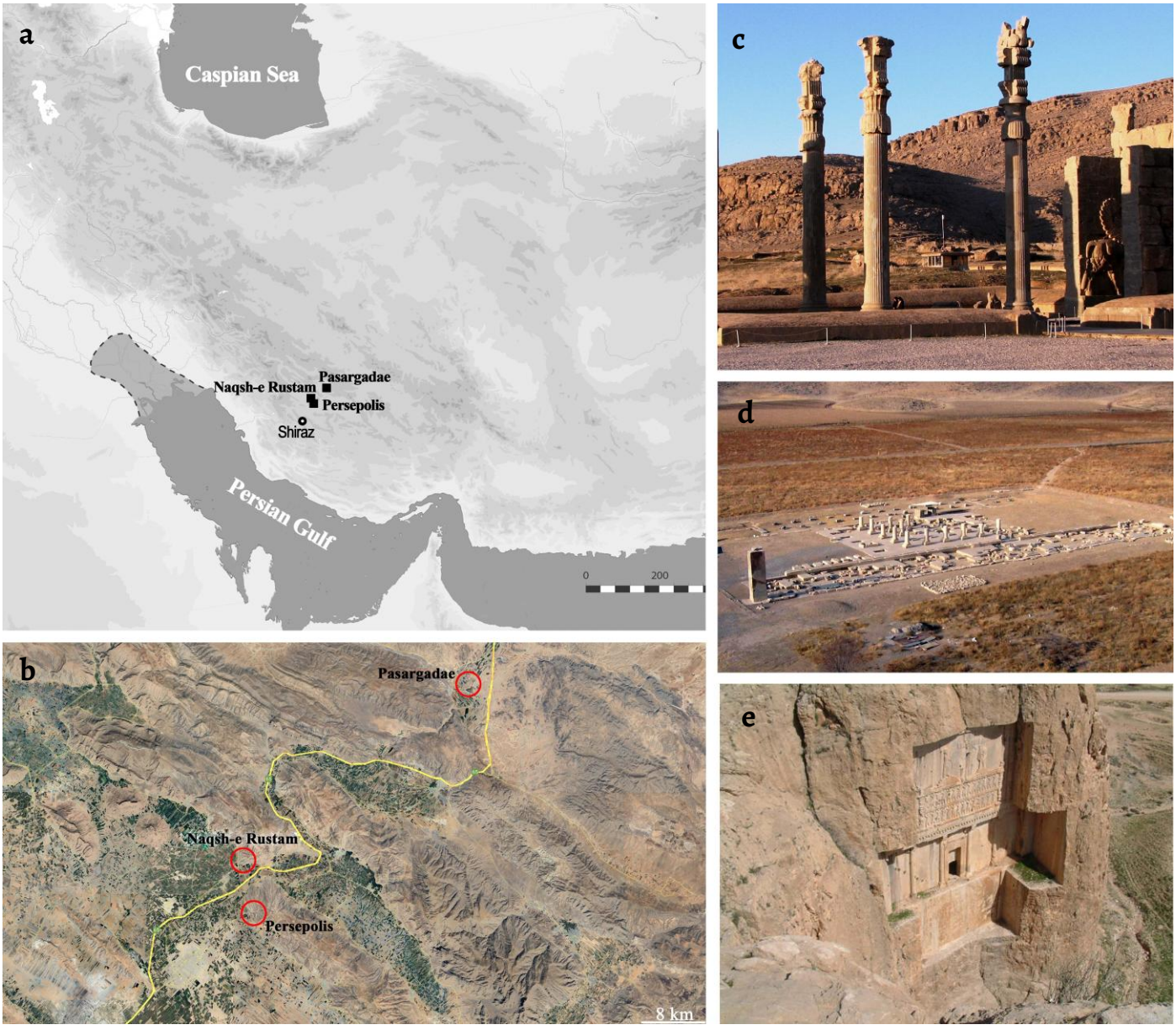

Figure 1. UNESCO world heritage sites: *a)* the sites of Pasargadae, Persepolis and Naqsh-e Rustam in Iran; *b)* satellite map of heritage sites in Fars province (photograph: Google Earth); *c)* Persepolis, Gate of All Nations; *d)* Pasargadae, Palace P (photograph: Archive of the Pasargadae WHS); *e)* Naqsh-e Rustam.

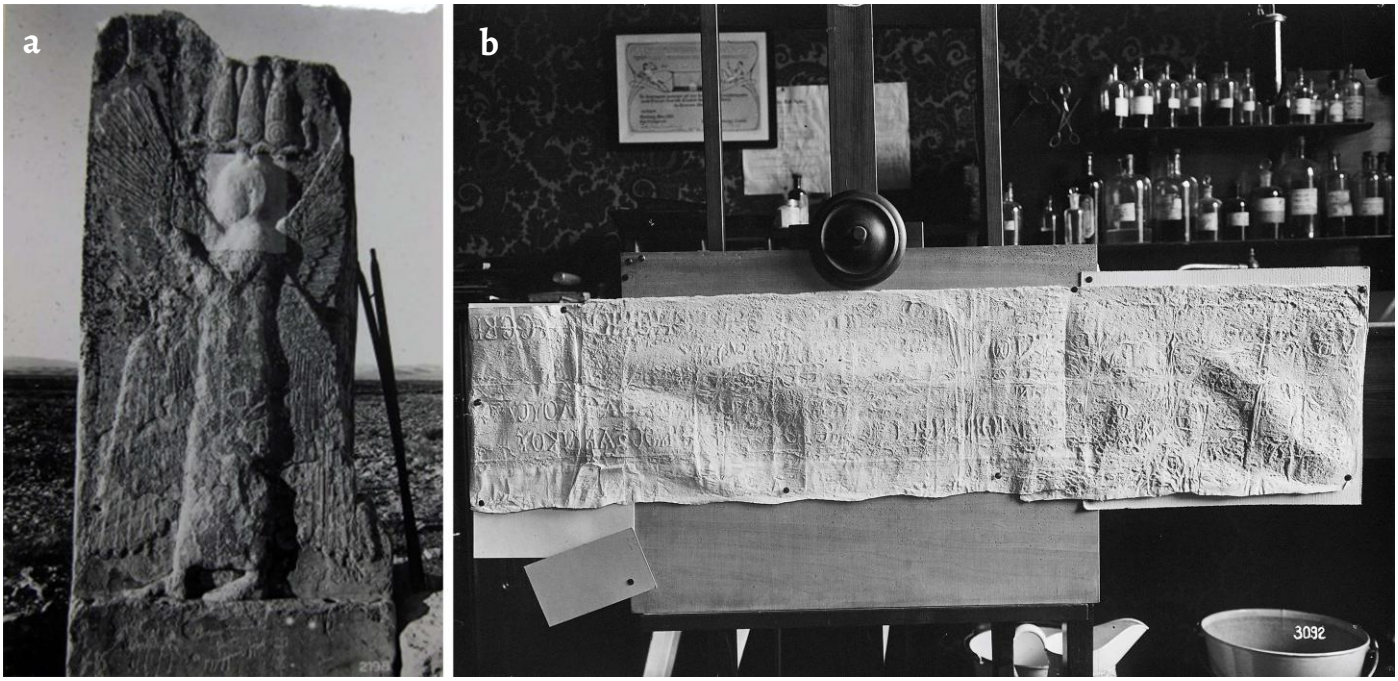

Figure 2. Paper squeezes applied: *a)* excavation of Pasargadae, Gate R (Gate House, Palace with the Relief): view of Winged figure with paper squeeze applied on the face, c. 1923 (photograph: E. Herzfeld [3, photo 2198]); *b)* Palmyra (Syria): view of a paper squeeze with a Greek inscription (photography: E. Herzfeld, [3, photo 3092]).

During archaeological fieldwork and early modern interventions on monuments and buildings on both sites in the early twentieth century, Ernst Herzfeld (1879–1948) and his team took paper squeezes of free-standing monuments and excavated objects to document epigraphical and iconographic features of interest. In diaries and notebooks, we found information about the process of squeeze-making, and how Herzfeld would read these squeezes later. During a longer visit to Persepolis in 1923, Herzfeld notes that "… the entire day, Djawad and Djuml made molds of the great terrace inscription. I read them in the tent in the evening" (December 19, 1923, trans. A. Nagel) [4]. In a letter to his father, photographer Hans-Wichart von Busse (1903–1962), who assisted Herzfeld during an excavation season in 1933 describes: "…one takes large sheets of thin cigarette paper, that was carefully hammered on [the surface of the stone] with a hard brush, while damp. When it was well molded to the form, new layers were added … Once dry, one could lift off the paper layer … and had an exact reproduction of the original" (September 23, 1933, trans. A. Nagel) [4]. In essence, these paper squeezes are cast impressions from (often inscribed) surfaces of ancient monuments. There is no documentation that the stone facades would have been cleaned before the papers were attached and wetted though we can assume that some light brushing happened to remove any dust or dirt (Figure 2).

After Herzfeld's permanent relocation to the Institute of Advanced Studies at Princeton in America in 1936, he sold some of the paper squeezes to the Metropolitan Museum of Art (MMA) in New York City in 1944, while he donated others to the Smithsonian Institution's Freer Gallery of Art, today's National Museum of Asian Art in Washington, D.C. (NMAA) [2, 5]. In recent years, the research potential of such paper squeezes has been recognized [2, 6-9]. In 2023, four of Herzfeld's paper squeezes housed in the MMA's Department of Ancient Near Eastern Art were investigated for possible traces of ancient paint residues (Figure 3). It is important to reconstruct the archaeological context of the paper squeezes first since it will help us evaluate the new evidence. Some of the structures introduced were hitherto never examined for evidence of painting.

Figure 3. Four paper squeezes from carved limestone facades at Pasargadae and Persepolis, MMA: *a)* ear from Palace P in Pasargadae; *b)* rosette from a lamassu crown fragment at Pasargadae's Gate R; *c)* axe from the North façade of the Apadana in Persepolis; *d)* limestone block with a Hebrew Inscription from the Tachara at Persepolis.

The archaeological contexts of the paper squeezes

A paper squeeze from Palace P in Pasargadae (A)

According to a notebook entry written while excavating and opening a trench in Palace P on the site of Pasargadae on April 26, 1928, Herzfeld, his assistant Friedrich Krefter (1898-1995) and their team discovered a white limestone fragment with a human ear, slightly larger than life-size by the east door, deep in the foundations. As a note next to a sketch of the ear in the find notebook indicates, a paper squeeze (*Abklatsch*) was made immediately (Figure 4).

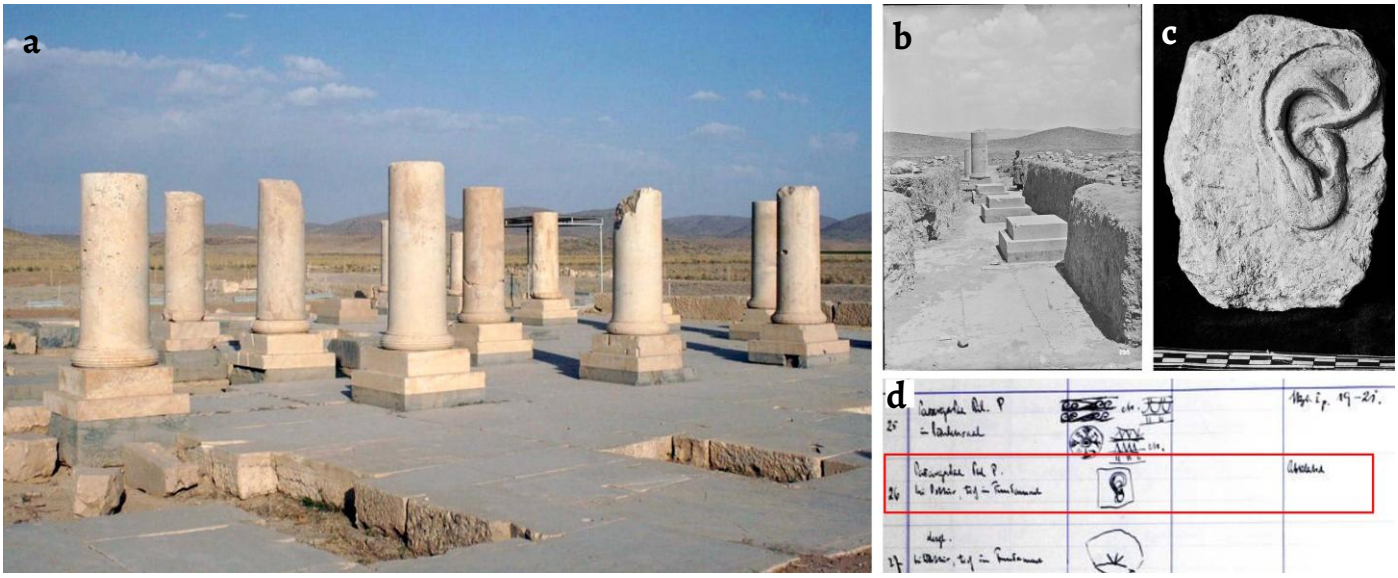

Figure 4. Pasargadae, Palace P: *a)* in 2018; *b)* during excavations in April 1928 [3, photo FSA A.6 04.GN.0295]; *c)* limestone fragment [3, photo FSA A.6 04.GN.0455] *d)* Herzfeld's Find Notebook from Pasargadae (N-92) with a sketch of the limestone fragment with the carved ear. Note the reference to the paper squeeze ("Abklatsch") [3, photo FS-FSA_A.6_03.92.05, 10].

It is unknown how and where the objects from the Spring 1928 excavation season were first deposited, and it is also unknown how and when Herzfeld was able to transport them out of Persia. Visiting Pasargadae in 1905, 1923, and 1928, and later, Herzfeld documented and collected materials at Pasargadae during all his visits. Today, materials from Pasargadae are in museums in Berlin, Washington, D.C., Jerusalem, and Chicago. A photograph of the limestone fragment of the ear was likely taken in the field shortly after excavations. It is unknown to us where this limestone fragment with the ear is today. In Herzfeld's publications on his fieldwork at Pasargadae, objects excavated were dealt with only summarily if they were mentioned at all [11]. The ear was not mentioned in any of Herzfeld's publications or subsequent publications on fieldwork on the site [10, 12-13]. In a caption to the photograph added (in English) at some unknown time later it is described as a "Sculptor's model of an ear".

Palace P, in which the ear was excavated, consisted of a central columned hall with doorways on four sides. The building had two porticoes, one facing a large green garden area. Recently analyzed fragments of painted plaster found in the debris of the same palace, housed in Washington, D.C., indicate that the upper portions of the columns of Palace P were made of plaster-covered wood rather than stone [14]. There is currently no consensus about the exact chronology of Palace P. Since the ear was excavated deep in the foundations, we conclude that it likely stems from one of the early phases of the building, maybe under the time of Cyrus the Great (c. 590-530 BCE). Later excavator David Stronach [12] suggested, "Palace P was begun during the reign of Cyrus, its construction was halted, probably at the time of Cyrus' sudden death, and that the structure was only completed, with certain evident economies, by Darius". Only the lower parts of the doorway reliefs from Palace P are preserved depicting a king dressed in a long-pleated robe originally adorned with gold inlays, followed by an attendant. According to Stronach, "inscriptions on the pleats of the robe identify the depicted monarch as Cyrus but the style of the pleats can be associated with the reign of Darius" [13]. Herzfeld had noted traces of paint on the robe. Judith Lerner was allowed to remove traces of paint from a stone relief in Palace P, and she gave them to Harvard University where they were analyzed by a scientific team [1]. Their results indicated that parts of the surface of the stones were decorated with red ocher – a naturally occurring mixture of iron oxides (hematite). Traces of cinnabar were also identified on Palace P surface carvings. Our first question was whether our previously unpublished paper squeeze of the limestone ear of Palace P would provide additional information on the polychromy of the monument.

A paper squeeze of a Lamassu crown rosette fragment at Pasargadae (B)

The original stone fragment from which this paper squeeze was taken was excavated by Herzfeld at Gate R, referred to as the "Gate House" or "Palace with the Relief" in 1928. It was photographed shortly after (Figure 5). A handwritten note on a blueprint of the photo (in English) reads "Pasargadae, R. Frgm. of a crown of Lamassu". A sketchbook preserves a hand-made drawing of the fragment, where it is described as *Kronenrand* (crown rim) and a note that a *Abklatsch* (paper squeeze) was made. All sculptural fragments excavated at this Gate House at Pasargadae were only briefly mentioned by Herzfeld but never published [11-12]. Again, the current location of the crown fragment is unknown. There is significance in the fact that Herzfeld's documentation including the paper squeeze is currently our only important evidence for the colossal winged lamassu which once flanked the outer portal of the monumental Gate. During later excavations on the same structure, Ali Sami and David Stronach discovered more fragments of winged beasts [12, 44n. 7, Pls. 47c-d]. The much better-preserved crowns of the lamassus flanking the Gate of Xerxes at Persepolis provide an idea of the original layout of the animals at Pasargadae, now almost completely lost (Figure 5c).

Only four petals of a rosette and parts of the feathers of the crown are visible in the Pasargadae Gate R paper squeeze preserved at the MMA. Rosettes with twelve petals were featured on multiple stone animals excavated on the site of Persepolis. Sketches in Herzfeld's find notebooks preserved at the University of Chicago refer to pigments still visible on the surface of these rosettes at Persepolis: according to Herzfeld, the petals and background of the framed rosettes on one of such animals as excavated in March 1932 near "the great Gate" preserved red paint, while the carpel or interior of the rosette was blue [2, p. 95 fig. 3.3]. Much like in Palace P at Pasargadae, the excavated limestone fragments of the Gate R structure indicate that the stone facades were originally painted. Of his sketchbooks from 1923 and his 1928 season at Pasargadae (SK, IV, IX, X, and XI) in the NMAA, one (IV, p. 8) contains references to pigments he observed at Gate R's standing remains ("Pasargadae, palace with the Genius … traces of red color on fringes and wings") [15]. No reference to samples or paint on Gate R was made in Stodulski's study of paint materials from Pasargadae and Persepolis [1].

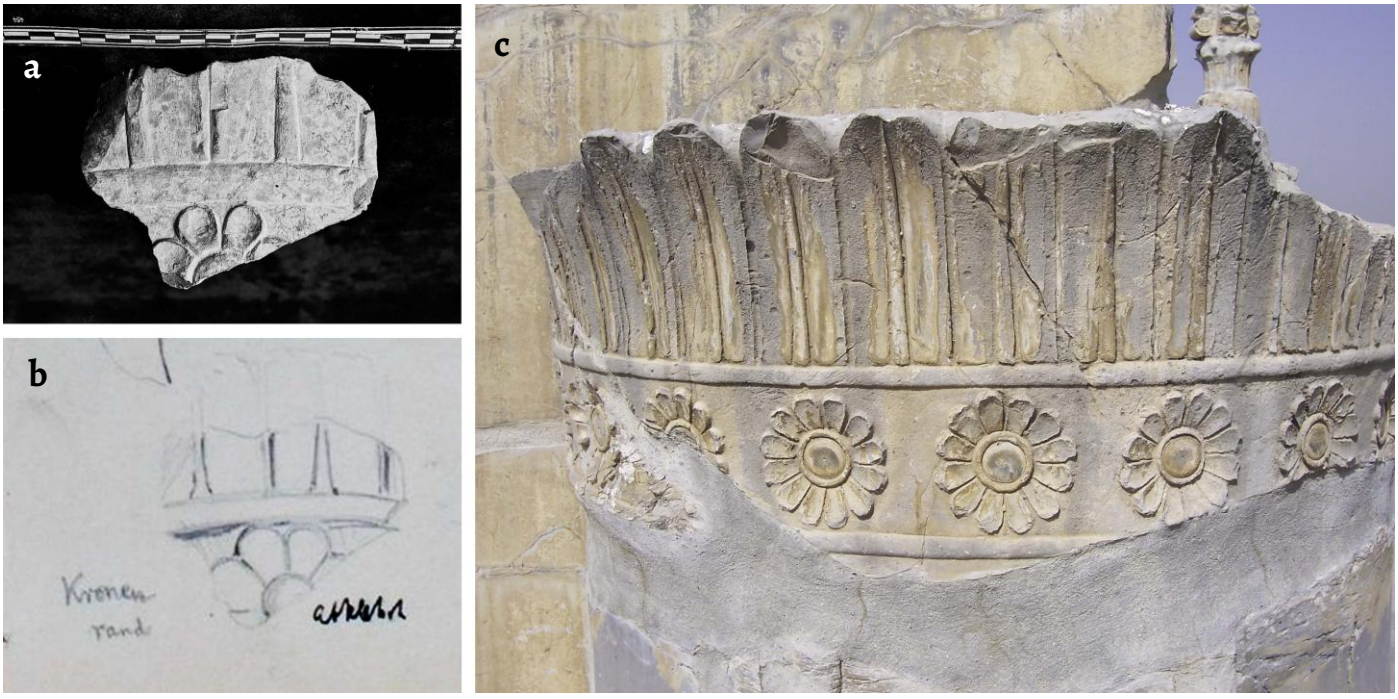

Figure 5. Original limestone fragment excavated by Herzfeld in Gate R, Pasargadae in 1928 [3, photo FSA A.6 04.GN.0454] *(a)*. Herzfeld's sketch of the fragment in a sketchbook (SK IX "Pasargadae I", p. 28) [3, photo FS-FSA_A.6_02.02.09.027] *(b)*. Close up to the Crown of one of the Lamassus at the Gate of Xerxes at Persepolis (photograph: A. Nagel) *(c)*.

A paper squeeze of a stone axe from the north façade of the Apadana in Persepolis (C)

While the Pasargadae paper squeezes themselves were not written upon, two paper squeezes from Persepolis in the MMA were labeled by Herzfeld. On one paper squeeze, we read the label "Tributzug II i 3". Connecting the label to drawings made by Herzfeld in his sketchbooks, notebooks, and other circumstances, the paper squeeze likely corresponds with a stone axe depicted on delegation XVII ("Sogdians") on the west wing of the north façade of the Apadana at Persepolis [16, pl. 43; 17, p. 49 No. 9; 18, pp. 93-94, pl. 24; 19, p. 335, fig. 8d (east façade)] (Figure 6).

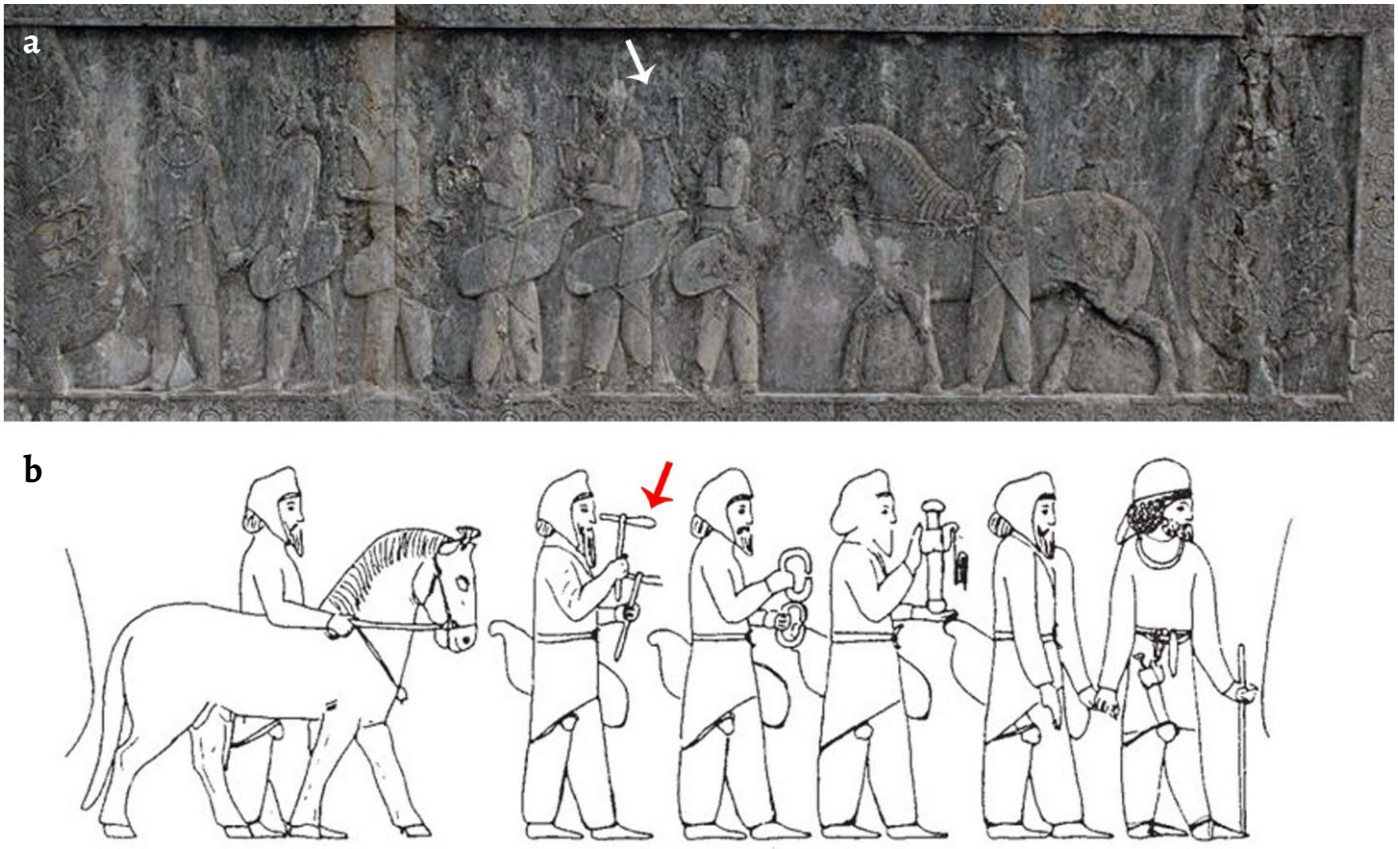

Figure 6. Stone axes carried by the Sogdian delegation, north façade, Apadana, Persepolis (photography: J. Lenderling [20]) *(a)*. Stone axes in the same delegation on the better-preserved east façade of the Apadana [21, p. 335 fig. 8d] *(b)*.

Construction of the Apadana began shortly after 520 BCE. Construction of the north façade was finished under Xerxes I between c. 486 and 465 BCE. The facades on the north side of the Apadana were exposed to weathering conditions and molding by multiple expeditions in modern times thereby destroying much of the evidence of original paint. British and French explorers molded standing stone sculptures throughout the nineteenth century. At the same time, fragments were hacked off; accumulated debris with fragments was cleared and the stone items were transported to museums in London and elsewhere. The largest set of molds was made by Lorenzo Giuntini (1843-1920) on behalf of a delegation from the British Museum in London in 1892 and 1893. In 1899 and 1900, Friedrich Sarre (1865-1945) took an additional set of molds from the north façade. Finally, following a complaint by Herzfeld that there is no complete cast of the tribute bearers depicted on the north façade, Herzfeld was the latest in a series of Westerners who made molds and paper squeezes of individual parts of the north façade [16, 18, 22].

While testimonies of early modern visitors commenting on the remains of the standing stone columns are preserved, the facades on the east side of the Apadana were completely buried by debris until 1932 when Herzfeld and his team of workmen financially supported by the University of Chicago began excavations. During his fieldwork, Herzfeld noted traces of

paint preserved on the lower parts of the east façade. Ceramic bowls with pigments deposited in front of the monument provide evidence of the painter's activities decorating the facades [2, pp. 101-104]. Describing what was depicted on these facades, especially after Herzfeld had fully excavated the better-preserved east facade in 1932, became a lifelong endeavor that was only fulfilled by Gerold Walser (1917-2000) and conducted long after Herzfeld died [19].

A paper squeeze of a Hebrew inscription block from the Tachara at Persepolis (D)

The fourth paper squeeze has a handwritten note by Herzfeld describing it as an inscription from the Tacara in Hebrew (*Persep. Tacara Hebr*).

South of the monumental Apadana, the Tachara at Persepolis has often been referred to as the "Palace of Darius." Begun under Darius the Great (c. 550-486 BCE), the building underwent multiple changes. A large facade with a staircase was added to the west side of the building under Artaxerxes III (359-338 BCE). Like the Apadana, the function of the Tachara changed. For a brief period in modern times, before a more permanent expedition camp was built in the so-called Harem building in 1932, the Tachara was used for tents set up by Herzfeld's excavation team (Figure 7). The high quality of the carvings on the standing door- and window jambs and the polished stone floors indicate the importance of the structure in ancient times [2, 23-25]. Multiple fragments from the building's stone facades are in museums in Berlin, Detroit, and elsewhere, including a fragment of a shoe, Herzfeld himself removed from one of the door jambs and sold to the MMA in 1944 (No. 45.11.17) [23].

Figure 7. Standing doorjambs, Tacara, Persepolis *(a)*. Drawing of the Tachara by Herzfeld, unknown date [3, photo FSA A.06 05.0860] *(b)*. Example of a Late Inscription on one of the door or window jambs at the Tachara [3, photo FSA A.6 04.GN.2671] *(c)*. Sketch of Hebrew inscription in the Tachara in Herzfeld's Notebook [3, photo FS-FSA_A.6_02.01.06.025] *(d)*.

A series of sketches in Herzfeld's notebooks from 1923 preserved in the NMAA, provide additional context for these post-Achaemenid graffiti in the Tachara and Hebrew graffiti at Persepolis in general (SK V; SK VI). One notebook (N-87, pp. 18-22) lists all Hebrew inscriptions Herzfeld had recorded at Persepolis. Another notebook by Herzfeld contains modern transcriptions of some texts (N-30).

Methodologies: examining and investigating the paper squeezes

The surface of all four paper squeezes was examined using a combination of imaging and analytical instrumentation to identify possible pigments. We were especially interested in detecting further evidence of paint since the surfaces of the monuments from which the squeezes were taken were not previously studied. Multiband imaging (MBI) is a non-destructive method for investigating and differentiating materials. It involves making a series of images, each recording reflectance, and luminescence within a different limited range of wavelengths. Using a Canon R5 camera, a series of band-pass camera filters (Midopt 550, X-Nite BP1, X-Nite 330, X-Nite 830), and a set of LED lights and Tricolor lights, we recorded variations in the absorption of materials at different wavelengths. Visible (VIS), Infrared reflectance (IRR), Visible-induced infrared luminescence (VIL), and Ultraviolet reflectance (UVR) techniques were used, too. Combined, these imaging techniques can help to distinguish between the paper (substrate) and probable pigments.

The paper squeezes were also investigated under a stereomicroscope. Pigment samples were then observed under Polarized Light Microscopy (PLM) to identify the particle size of the pigments and the presence of other mineral inclusions utilizing a Zeiss Axio Imager M2M microscope, with 50×, 100×, 200×, 400×, and 500× magnifications, an Axiocam HRc digital camera, and AxioVision 4.X.X software.

Raman analyses were performed on the paper squeezes using a Bruker Optics "Senterra" spectrometer equipped with an Olympus 50× long working distance microscope objective and a charge-coupled device (CCD) detector. A Spectra-Physics Cyan solid-state laser and a continuous wave diode laser emitting at 785 nm were used as the excitation source, and two holographic gratings (1800 and 1200 rulings/mm) provided a spectral resolution of 3-5 cm^{-1}. The output laser power was 1 and 10 mW, and the number of scans, and integration time were adjusted according to the Raman response of the different particles.

As part of the materials analysis micro-samples were collected from all paper squeezes for scanning electron microscopy with energy dispersive microanalysis (SEM-EDS). This included one red (REP) and one blue grain (BEP) from the paper squeeze of the ear from Palace P at Pasargadae; one red from the rosette (RLR) and one blue particle from the feather fragment of the Lamassu crown (BLR) of Gate R at Pasargadae; one blue particle from the stone axe from the Apadana (BAA); one blue (BIT), one red (RIT), and one black (Bk.IT) from the Hebrew inscription of the Tachara at Persepolis. Selected micro samples were mounted on stubs, carbon-coated, and analyzed by scanning electron microscopy-energy dispersive X-ray spectrometry analyses (SEM-EDS) with an FE-SEM Zeiss Σigma HD, equipped with an Oxford Instrument X-MaxN 80 SDD detector. Backscattered electron (BSE) images, EDS analysis, and X-ray mapping were conducted with an accelerating voltage of 20 kV in a high vacuum. The surface of the samples was carbon-coated before the analyses.

Results

Multi-band imaging (MBI)

No pigments were specifically identified through infrared and ultraviolet imaging. VIL digital imaging, however, revealed fluorescing remnants. The fluorescing remnants visible in Figure 8d3 and d5 were mainly caused by contamination. The pink stains in Figure 3a were also detected on the rosette paper squeeze which is a result of contamination (Figure 8d5). Some other spots investigated showed fluorescent remnants (Figure 8d 1, 2, and 4).

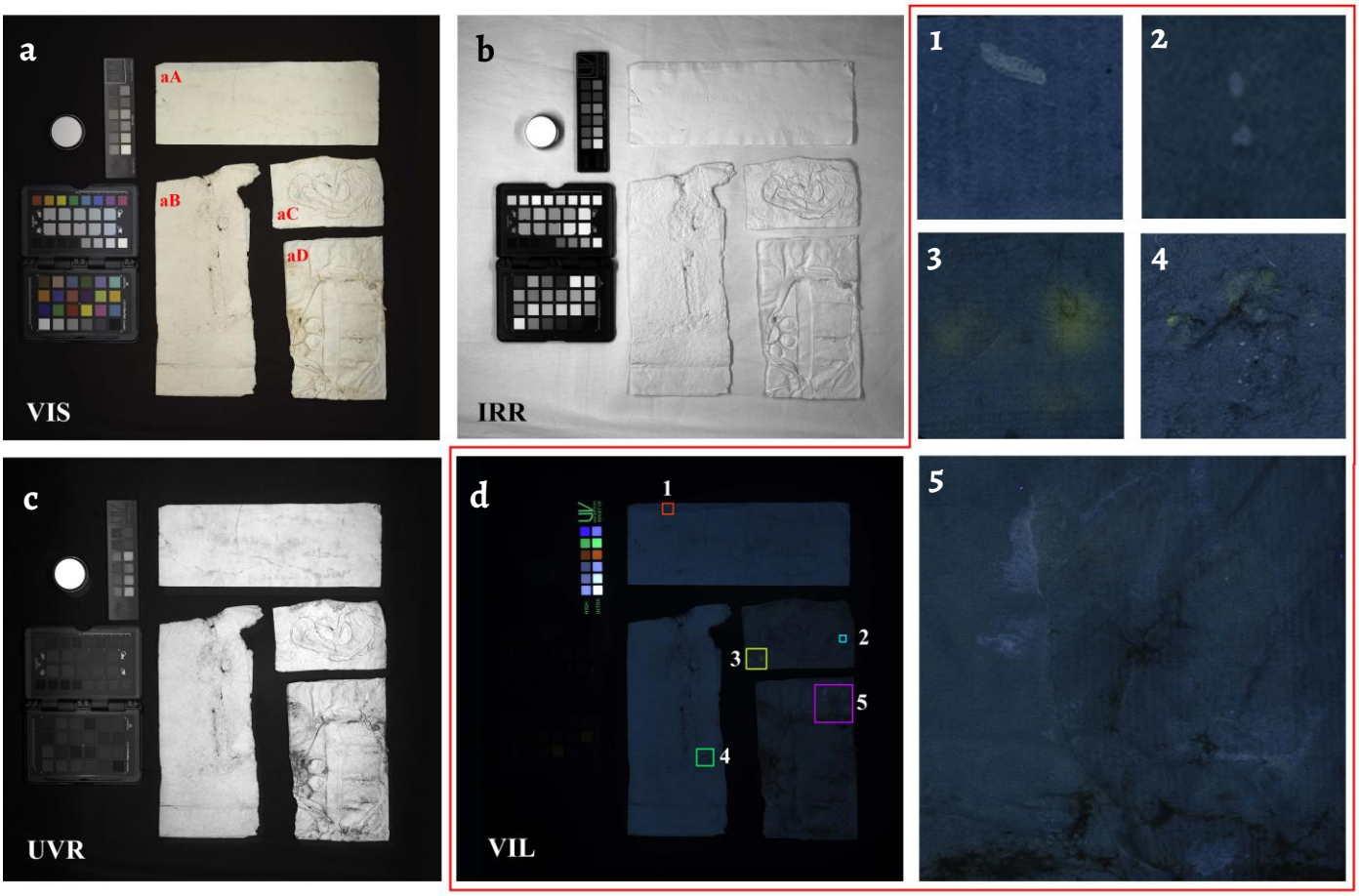

Figure 8. Multi-band images from the paper squeezes: *a)* VIS photo: aA – block with Hebrew inscription paper squeeze, aB – stone axe paper squeeze, aC – ear paper squeeze, aD – rosette paper squeeze; *b-c)* IRR and UVR photographs do not show any trace of pigments, the dark area of the rosette paper squeeze is dust in URV; *d)* VIL photograph show fluorescence particles and spots specified by numbers; *d1-5)* points 1, 2, and 4 can be traces of pigment, 3 and 5 points are contaminations.

Raman spectroscopy

Raman spectroscopy (Raman) of the paper squeeze of the limestone ear showed a density of blue (less than 100 µm in size) and two red particles. The red particles came in two varieties: dark and bright (Figure 9). The Raman spectra of the dark-red particles (225, 245, 292, 411, 496, and 610 cm^{-1}) are attributed to hematite (α-Fe_2O_3) [26] which had been identified on other architectural features from the site of Pasargadae earlier. The Raman spectra of the bright-red particles are attributed to goethite (α-FeOOH) with wavenumbers 248, 299, and 387 cm^{-1}, of which the strongest band is 387 cm^{-1} [27]. The Raman spectra of the blue samples (378, 549, and 582 cm^{-1}) are strikingly consistent with reference spectra of lazurite ($Na_8[Al_6Si_6O_{24}]S_n$) [28].

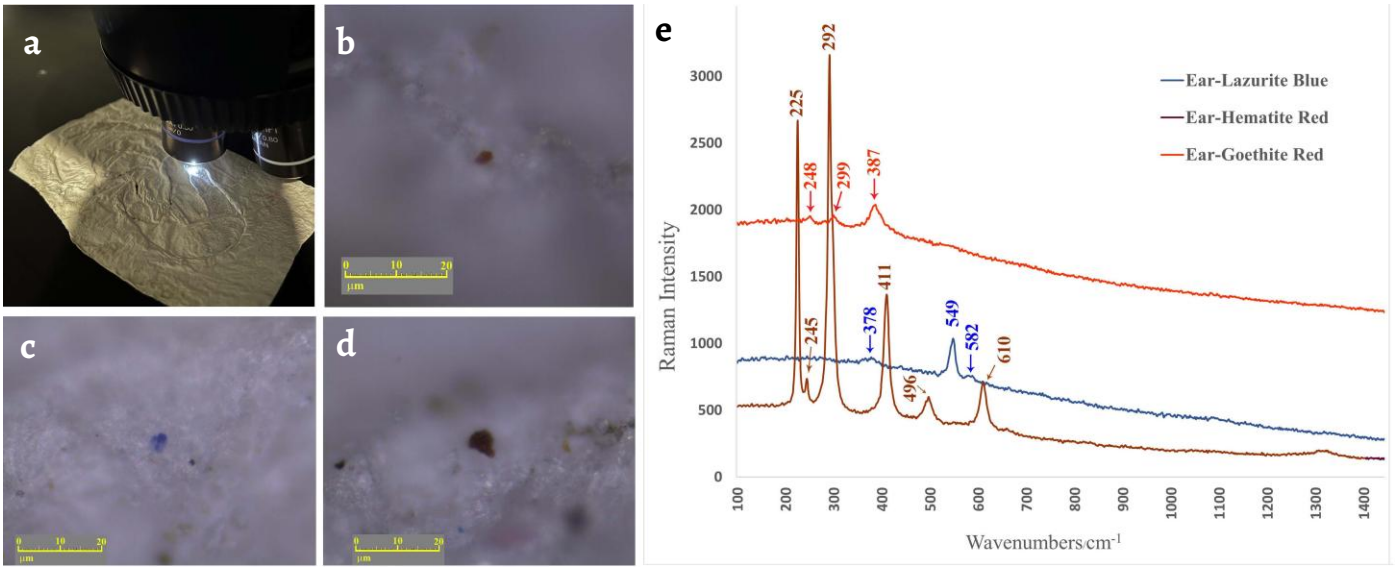

Figure 9. Raman analysis: *a)* close-up image of the paper squeeze of the stone ear; *b)* bright goethite red pigment; *c)* lazurite blue pigment; *d)* dark red of hematite grain; *e)* Raman spectra of the pigments representing hematite, goethite, and lazurite.

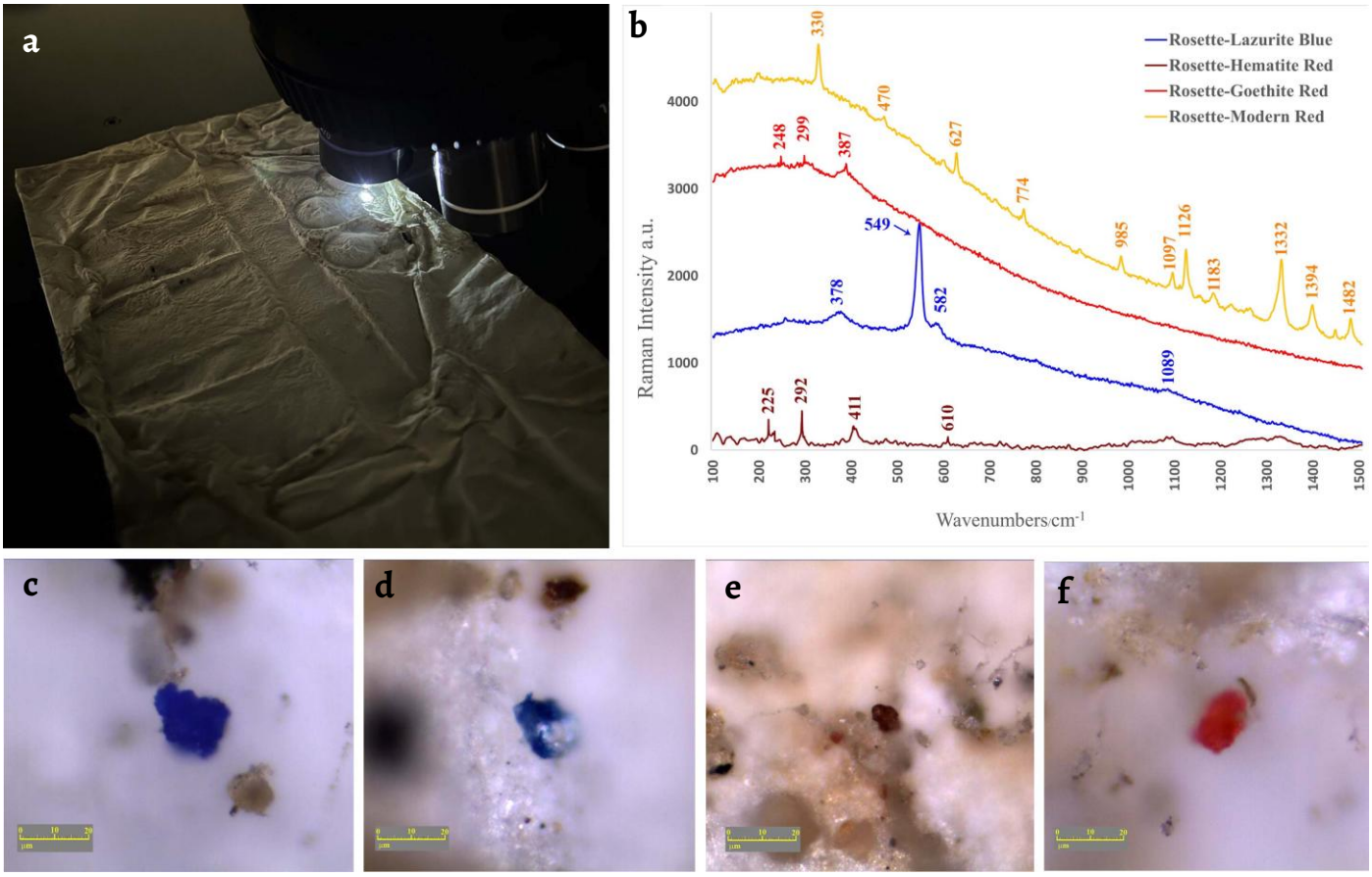

Figure 10. Raman analysis: *a)* close-up image of the paper squeeze of the rosette; *b)* Raman spectra of the grains; *c)* lazurite blue pigment on the paper; *d)* blue color of modern ink (Prussian blue); *e)* hematite red pigment; *f)* red color (modern pigment).

Microscopic investigation of the paper squeeze of the rosette showed a dense layer of red particles within the rosette pattern and blue particles on the feathers area (Figure 10). It is worth noting that there was a range of red colors in the particles, one of them pink-red. The Raman spectrum of pink-red grains in 330, 627, 774, 989, 1097, 1126, and 1332 cm^{-1} revealed a modern red pigment BR4 (Beta-naphthol) [29]. Most red grains were identified as hematite-dominant by Raman spectroscopy, one was attributed to goethite (248, 299, 387 cm^{-1}). The Raman spectra

of the two blue particles were 257, 378, 549, 584, 802, and 1087 cm^{-1} of which the strongest bond (549 cm^{-1}) is consistent with lazurite, and 1087 cm^{-1} represents calcite.

Red, blue, and black particles were documented on the paper squeeze of the stone axe from the Apadana at Persepolis. The Raman spectrum of a red particle of the stone axe (Figure 11) showed 218 and 310 cm^{-1} Raman bands representing hematite (Fe_2O_3), as well as 252 and 343 cm^{-1} bands indicating cinnabar (HgS) [28-30]. Furthermore, the Raman spectrum in 380 cm^{-1} could be attributed to goethite [31].

One black particle was analyzed using Raman spectroscopy. Six Raman spectra were identified in 284, 462, 1086, 1185, 1287, and 1328 cm^{-1} respectively. These Raman spectra did not match clearly with previously identified Achaemenid black pigments such as carbon black, but 284 and 1086 cm^{-1} Raman bands could be attributed to calcite, and 462 cm^{-1} represents quartz. The Raman spectrum at 1330 cm^{-1} could refer to a carbon-black or a black earth pigment [32]. Referenced carbon-based pigments show similar Raman spectra with characteristic first-order bands in the range 1300-1600 cm^{-1}. Two broad and overlapping bands with maximum intensity at approximately 1580 cm^{-1} (G band) and 1350 cm^{-1} (D1 band) are in amorphous carbon. The position, width, and relative intensity of D and G bands can be different from sample to sample [33]. These parameters are influenced by several phenomena leading to disorder in carbonaceous materials, especially on D band intensity [34].

The black particle was analyzed in the range of 1-1500 cm^{-1}. It was not possible to run a second Raman spectrum to identify the G band. However, the fourth disorder band of carbon, D4, shows likely a carbon black pigment since D4 is found below 1290 cm^{-1} as a shoulder on the D1 band [32, 34]. The Raman spectrum in 1287 cm^{-1} (Figure 11) indicates the presence of carbon black that this D4 band observes in disordered materials such as soot and wood charcoal [32]. The additional band at 1185 cm^{-1} might be caused by impurities.

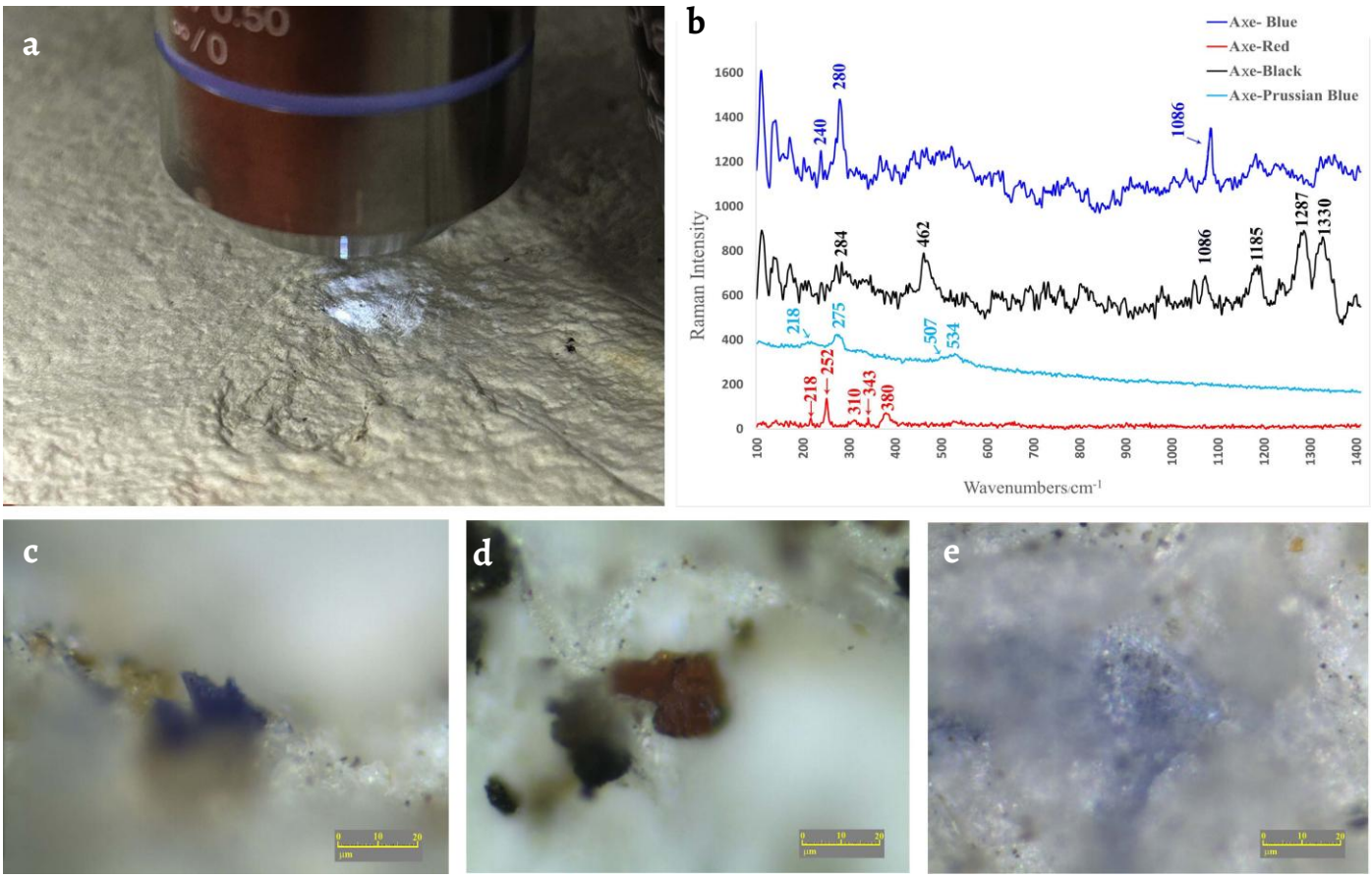

Figure 11. Raman analysis: *a)* close-up image of the curved shape of the paper squeeze of the stone axe; *b)* Raman spectra of the pigments; *c)* blue pigment within the texture of paper; *d)* hematite red and black particle within the texture; *e)* trace of Prussian blue ink absorbed inside the paper texture.

The Raman spectrum of the blue particles penetrating the paper indicated the presence of Prussian blue with Raman spectra in 218, 275, 507, and 534 cm^{-1}. The strong vibrational band of Prussian blue at 2154.96 is not there because the Raman spectra were taken from 1-1500 cm^{-1}.

Analyzing the blue pigments, we detected wavenumbers 240, 280, and 1086 cm^{-1}. These Raman spectra do not provide clear evidence for a second blue pigment, possibly due to a poorly crystalline form. However, the first band (240 cm^{-1}) could be referred to as azurite and the two bands of 280 and 1086 cm^{-1} indicated calcite. Nevertheless, because azurite shows a strong Raman band on 403 cm^{-1} [28], it is impossible to confidently identify this particle as azurite (Figure 11). During the second run, it was difficult to focus due to the curved shape of the paper squeeze. A sample was taken for elemental analysis, however (see below).

The paper squeeze of the Hebrew inscription block showed consistent microscale blue particles (less than 100 µm in size) and two red particles. Raman spectra of 225, 292, 410, and 610 cm^{-1} were identified as hematite. Raman spectra at 378, 549, 582, and 1089 cm^{-1} from the blue particle indicated lazurite on the strongest band (549 cm^{-1}) and calcite at the 1089 cm^{-1} band (Figure 12). A black particle was identified. Its texture was not like carbon black. Based on the morphology, it was rather assumed to be magnetite black. Since light and heating effects on magnetite and its transformation into maghemite and hematite with temperature increase was proven by Raman spectroscopy [35], we just carried out an elemental analysis on this sample.

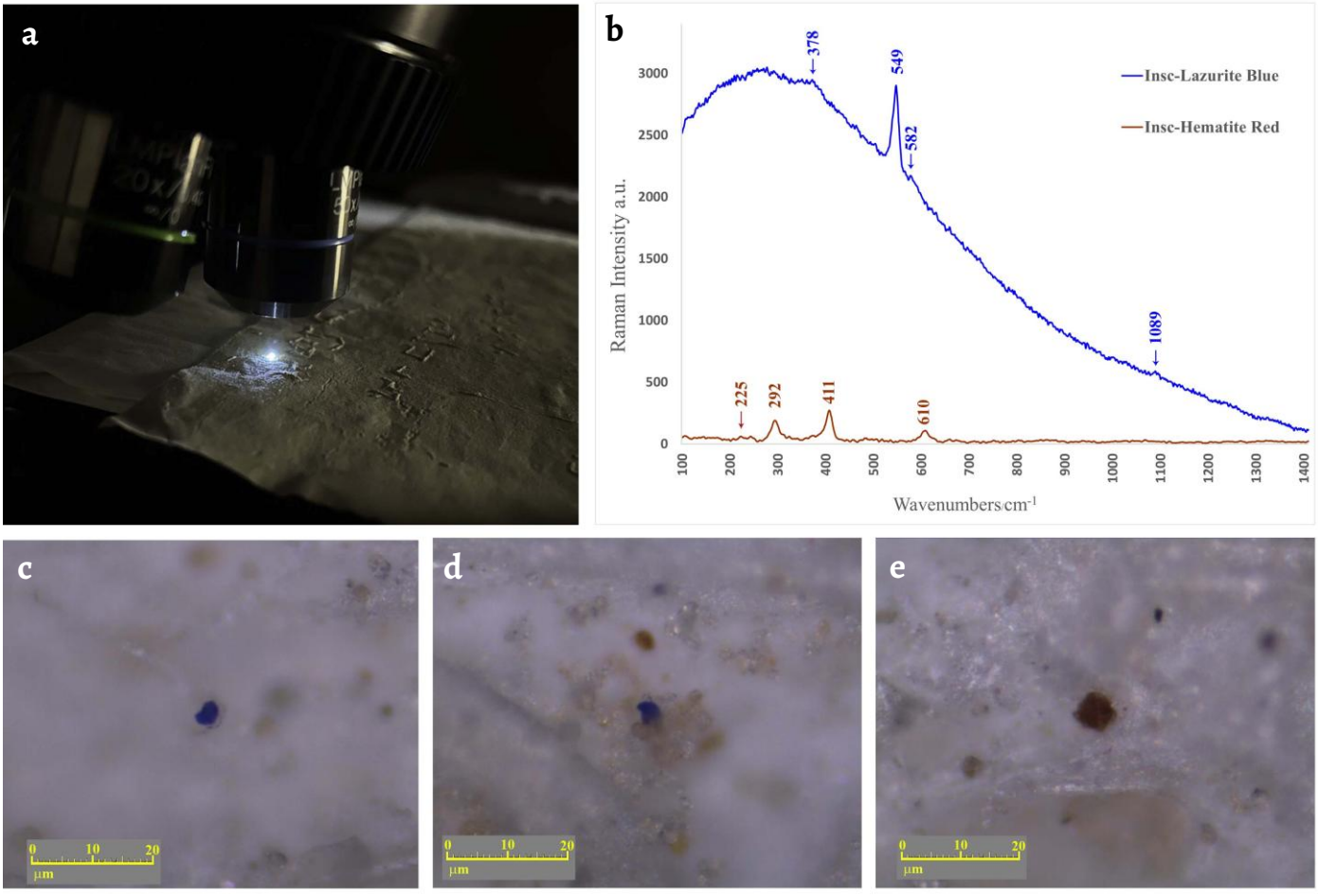

Figure 12. Raman analysis: *a)* close-up image of the paper squeeze of the Hebrew Inscription block; *b)* Raman spectra of red and blue pigments; *c-d)* lazurite blue pigments are widespread within the paper fibers; *e)* hematite red pigment.

Elemental analysis

The SEM-EDS analysis of point 1 (Figure 13) on the blue grain (BEP) identified Si, S, Ca, and Na as major constituents and Cl, K, Mg, Ti, Al, Fe, and Zn as minor constituents. Accordingly, Si, S, Ca, Na, Al, Cl could be attributed to lazurite $(Na, Ca)_8(AlSiO_4)_6(S, SO_4, Cl)_{1-2}$ verifying the result of the Raman analysis. Analysis of point 2 identified Na, Ca, P, S, K, Cl, and Si as major constituents respectively, and Ti, Al, Cu, Zn, and Fe as minor components (Table 1) that are also consistent with the presence of lazurite. The presence of Cu as a minor element could not be considered as contamination (Table 1). EDS analysis point 3 in the red particle (REP) identified Fe as a major constituent besides some earthen components such as Si, Al, and Ca indicating hematite or goethite.

Iron oxide (FeO) is the main constituent of the red particle (RLR) that was earlier identified as hematite or goethite, along with a minor silicate compound due to the presence of Si, Al, and Mg (Figure 14). A tiny blue particle (BLR) was also analyzed, and Si and Al were detected as major elements and Mg, Fe, Ca, K, S, and Na as minor constituents which could be attributed to lazurite (Table 1).

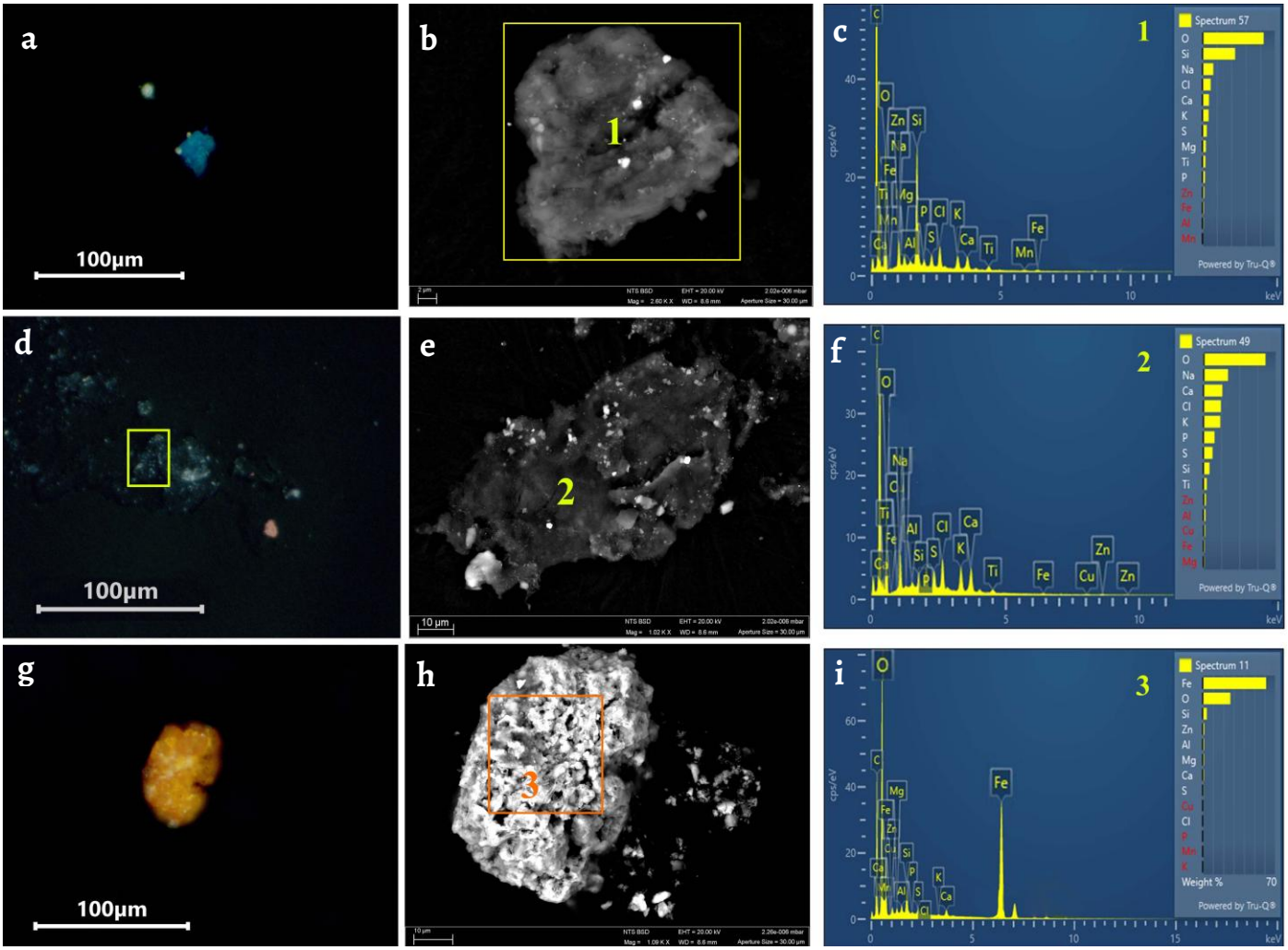

Figure 13. Paper squeeze of the limestone ear: *a)* blue particle (BEP) under PLM and *b)* SEM image; *c)* EDS spectrum of the bulk analysis of the rectangle 1 in b; *d)* shows both blue and red particles under OM and *e)* SEM image of yellow rectangle in d; *f)* EDS spectrum of point 2 in e; *g)* red particle (REP) under OM; *h)* SEM image of g; *i)* ESD spectrum of bulk analysis of point 3 in h.

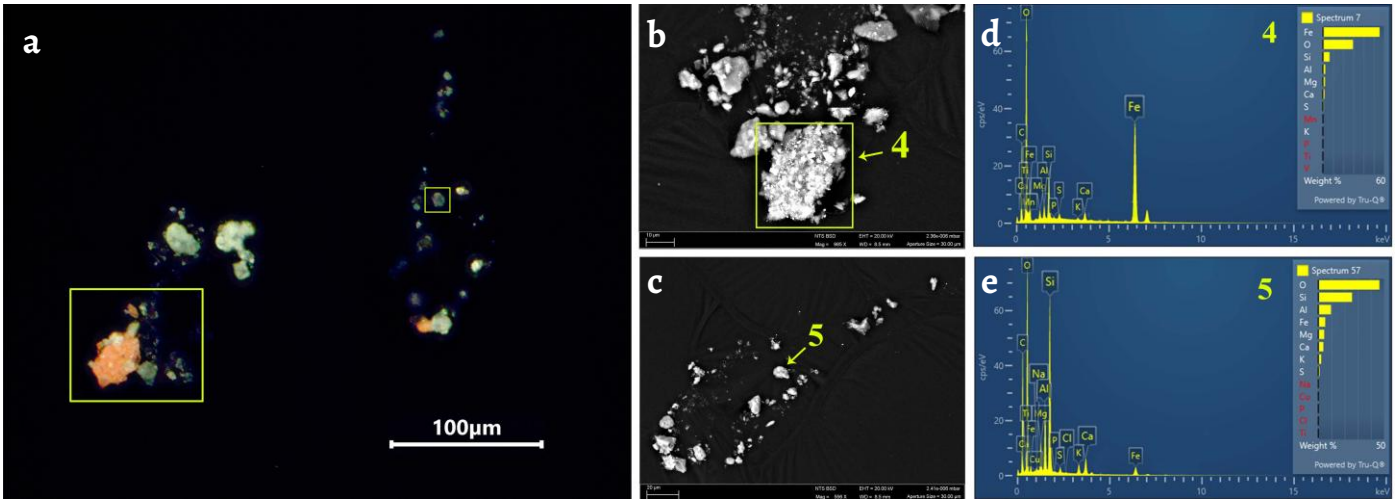

Figure 14. Paper squeeze of the rosette: *a)* red (RLR) and blue (BLR) particles under PLM; *b)* SEM image of the red particle specified with a big rectangle in a; *c)* SEM image of the blue particle specified with a small rectangle in a; *d)* EDS spectrums of point 4 in b; *e)* EDS spectrum of point 5 in c.

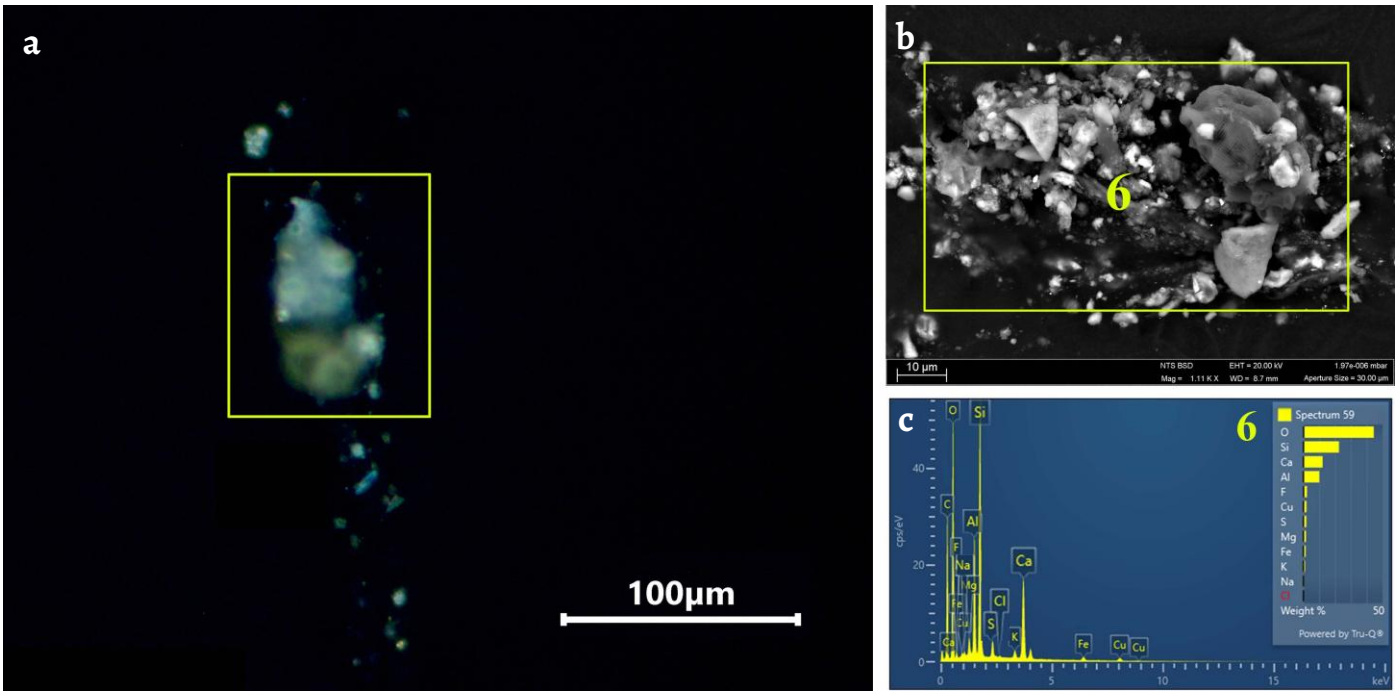

Figure 15. Paper squeeze of the stone axe from the Apadana: *a)* blue particles (BAA) under PLM; *b)* SEM image of the yellow rectangle in a; *c)* EDS spectrum of yellow rectangle in b (point 6).

EDS analysis point 6 of a blue assemblage of particles (BAA) detected Si, Al, and Ca as major and S, Na, Mg, Cu, Fe, and K as minor elements respectively (Table 1). Since it is not a single particle, probably due to the disintegration while sampling, accordingly it is composed of separate particles in the SEM micrograph. Thus, it is not possible to precisely characterize all particles or unambiguously attribute them to specific minerals. Although blue particles were observed under the microscope, these complex constituents are associated with blue particles that may be consistent with lazurite except Cu (Figure 15). Since the copper content is higher than the trace amounts found in lapis lazuli stones excavated from Persepolis [36], if we consider the same lapis lazuli resources (Badakhshan) as the source for producing pigment.

Table 1. EDS and Raman results of the pigments found in the squeezes.

Name of squeeze	Pigment	EDS*	Raman Bands (cm^{-1})	Results
Ear	Blue *(BEP, EDS: point 1)*	**Si, Na**, **S**, (**Cl**, **Al**, **Ca**, K, Mg, P, Ti Zn, Fe, Mn)	378, 549, 582	Lazurite
	Red *(REP, EDS: point 3)*	**Fe**, Si, (S, Ca, Mg, Al, Zn, P, Cl, K, Mn, Cu)	225, 245, 292, 411, 496, 610	Hematite
	Red	-	248, 299, 387	Goethite
Rosette	Red *(RLR, EDS point 4)*	**Fe**, Si, (S, Ca, Mg, Al, P, K, Ti, Mn)	225, 292, 411, 610	Hematite
	Blue *(BLR, EDS: point 5)*	**Si**, **Al**, (Fe, Mg, **Ca**, K, **S**, **Cl**, **Na**)	378, 549	Lazurite
	Red	-	248, 299, 387	Goethite
Axe	Blue *(BAA, EDS: point 6)*	**Si**, **Al**, **Ca**, (K, **Cl**, Fe Cu, **S**, Mg, **Na**)	240, 280	Lazurite, Azurite?
	Red	-	218, 310	Hematite
		-	380	Goethite
		-	252, 343	Cinnabar
	Black	-	1330	Carbon-Black
Hebrew inscription	Blue *(BIT, EDS: point 7)*	**Si**, **S**, **Ca**, **Al**, **Na**, **Fe**, (**Cl**, K, Mg, P, Cu)	378, 545	Lazurite
	Red *(RIT, EDS: point 8)*	**Fe**, Si, (Al, Mg, K, S, Na, Ca, Cu, Ti, Mn)	225, 292, 410, 610	Hematite
	Black *(Bk.IT, EDS: point 9)*	**Fe**, (Si, Ca, K)	-	Magnetite

* Elements responsible for the coloring are in bold; minor and trace elements are in parentheses.

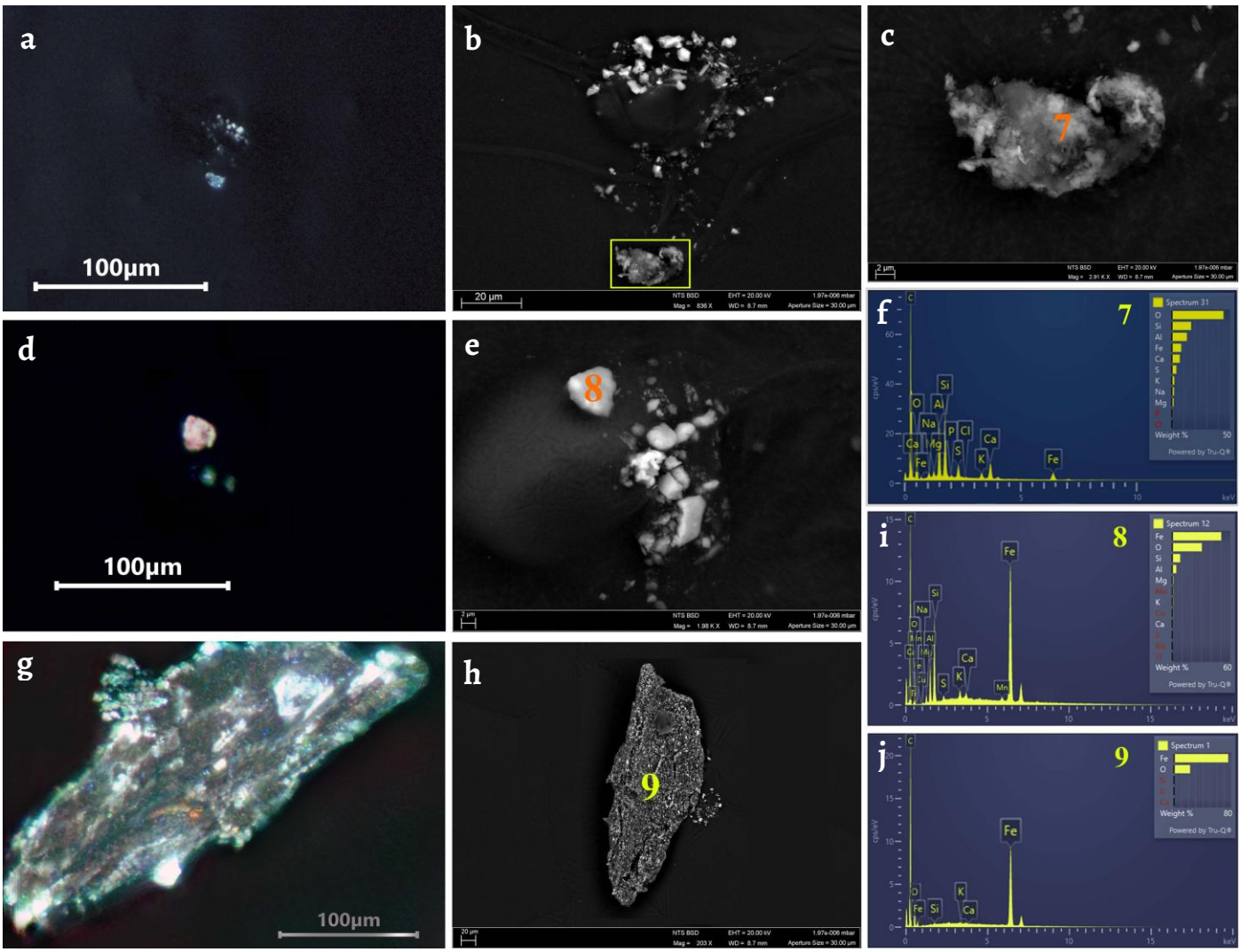

Figure 16. Paper squeeze of the Hebrew inscription block: *a)* blue particle (BIT) under PLM and *b)* SEM image; *c)* high magnification of yellow rectangle in b; *d)* red particle (RIT) besides some blue particles under OM; *e)* SEM image of d; *f)* EDS spectrum of point 7 in *c*; *g)* of a black particle (Bk.IT) under OM; *h)* SEM image of g; *i)* EDS spectrum of the red particle in e (point 8); *j)* EDS spectrum of point 9 in h.

Analysis of point 7 from the blue particle (BIT) indicated Si, Al, Fe, Ca, and S, as major constituents and Mg, K, and Na as minor elements respectively as well as traces of P, Cl, and Cu components (Figure 16). This composition is consistent with the EDS of point 8 (RIT) that identified Fe, Si, and Al as major and Mg, Mn, K, Cu, S, Ca, Ti, and Na as minor constituents respectively. The high content of iron (Fe) in point 8 could be related to hematite as it was identified with Raman analysis. The other constituent represents the lazurite blue component. Figure 16d shows how close the red particle is located next to the blue particles. This may be contaminated. EDS analysis of point 9 from black particles (Bk.IT) identified mainly iron (Fe) and trace constituents of Si, K, and Ca (Table 1). According to the EDS result, it is magnetite (Fe_3O_4).

Discussion

High-magnification microscopic investigation and microchemical analysis techniques were used to identify pigments within the fibers of four paper squeezes molded from limestone monuments at Pasargadae and Persepolis. Red, blue, and black pigment particles previously identified on the facades of certain monuments have now been documented on architectural features of four additional, previously unstudied monuments (Palace P and Gate R at Pasargadae; Apadana and Tachara at Persepolis) on the sites here, too.

An ear from Palace P in Pasargadae and a block with a Hebrew inscription from the Tachara at Persepolis were found to have been painted with widespread and abundant blue pigment particles. The surface of a rosette from the feather crown of a lamassu on Gate R at Pasargadae was covered with red and blue pigments.

Materials analyses of the blue pigments revealed a complex chemical composition indicating that lazurite was used which Raman spectrums confirmed it. Raman spectroscopy revealed that the red on the ear and the rosette from Pasargadae contained a mixture of goethite and hematite particles. Hematite was identified as red in the stone block with the Hebrew inscription from the Tachara at Persepolis. It is worth noting that the spectra of red particles from the stone axe on the Apadana showed three different minerals: goethite, hematite, and cinnabar. Magnetite was identified as black pigment on the squeeze of the Hebrew inscription stone block from the Tachara at Persepolis.

Analytical investigation showed that parts of the surface of the limestone ear from Palace P at Pasargadae and the block with the Hebrew inscription from the Tachara at Persepolis were originally painted in blue. The blue particles were mainly composed of lazurite. Lazurite was never reported as a pigment either in Pasargadae or in Persepolis. Only Egyptian blue and azurite were hitherto identified [1, 37-38].

The lazurite formula is $(Na,Ca)_8(AlSiO_4)_6(S,SO_4,Cl)_{1-2}$. The mineral responsible for the blue color of lapis lazuli is lazurite. Although lazurite is the main mineral in the composition of lapis lazuli rocks, most lapis lazuli rocks contain calcite (white phase), sodalite group minerals (blue phases), pyrite (metallic golden), and other silicates such as augite, diopside, enstatite, mica, hornblende, sanidine and nosean [36, 39-40]. Extracting a natural ultramarine, blue pigment (lazurite) from lapis lazuli was common in the past [41]. The method of purifying ultramarine has been described in Persian scientific texts on mineralogy and glazing, medicine and pharmacology, colorant making, and art resources. Badakhshan in Afghanistan has been identified as the main source of natural lapis lazuli in ancient West Asia and Egypt [42-45]. Recently, traces of lazurite were identified on paper squeezes from the Frataraka complex below the platform of Persepolis in Berlin [46]. Reference Raman spectra from samples of ultramarine (pure lazurite) from later periods in Iran show a Raman peak at 1096 cm^{-1} [47-49]. Such was not the case in our results where the Raman spectra showed a peak at 1086/1089 cm^{-1}. This could be due to a mineral inclusion related to calcite [50]. The impurities, it identified as signatures of other components of the rock matrix, both elements (Ca, Mg, K, and trace

elements) and minerals (like calcite), accordingly the blue pigments cannot be a purified ultramarine. Therefore, these blue pigments are ascribed to an insufficient purification of the finely ground natural pigments. Provenance studies on ultramarine pigments indicate slight differences in the elemental composition from each source studied in the past (i.e., Afghanistan, Siberia, and Chile). Samples from Afghanistan are generally characterized by a higher concentration of potassium (K) and the trace element magnesium (Mg) [50-51]. The minor elements of the blue particles (K and Mg) found on our paper squeezes can suggest that either the blue pigment or its source originated from Badakhshan.

The fact that the paper squeeze of the ear excavated at Palace P in Pasargadae contains blue pigments makes an earlier suggestion that it was a model of the sculptor unlikely: why would a sculptor's model have been painted? If the limestone ear was originally painted it likely stemmed rather from the head of an anthropomorphic feature in an earlier building phase of Palace P.

EDS results confirmed that Cu was a significant constituent (minor) of the blue on the stone axe depicted on the Apadana and the stone block with the Hebrew inscription from the Tachara besides lazurite. Some lapis lazuli objects from Persepolis were analyzed previously and copper was reported as a trace element in their composition [36]. Accordingly, the copper identified by EDS could not be linked to the source of pigment, but it could be attributed to some blue copper-bearing pigments such as Egyptian blue ($CaCuSi_4O_{10}$) or azurite ($Cu_3(OH)_2(CO_3)_2$). Earlier examinations identified Egyptian blue as a blue pigment on a painted plaster from the same palace P at Pasargadae and on the facades of the Persepolis terrace [1, 52]. MBI technique identified tiny fluorescence particles on the two paper squeezes through VIL images (Figure 8). The fluorescence particles might represent copper and a low percentage of Egyptian blue in the blue particle. Alternatively, since a band of azurite was identified besides lazurite in one Raman spectrum (Figure 11), and since a combination of azurite and Egyptian blue was already identified in Persepolis [1], using either one of the copper-bearing pigments or a mixture of two blue copper-bearing minerals of Egyptian blue/azurite with lazurite is likely. On the other hand, this can occur by contamination by using the same paint bowls or brush containing a vestige of Egyptian blue/azurite for the lazurite blue during the painting of the stone facades. It is also possible that two different layers of blue were on top of each other. Because of the low concentration of pigments, the analytical results cannot be used to support any of these hypotheses.

The rosette of the feather crown from Gate R at Pasargadae was decorated with red and blue paint--such was also noted by the excavators shortly after the excavation at Persepolis [2, p. 95 fig. 3.3]). Both goethite and hematite (iron oxides) were identified on the rosette and the ear from Palace P at Pasargadae. The presence of both goethite and hematite may be a result of heating goethite to produce hematite [28]. It has been proven that heating the natural goethite leads to a similar spectrum as measured for the natural hematite [53]. However, one should bear in mind that natural iron minerals are sometimes poorly crystallized and transform rapidly during Raman measurements [35], although it is measured under low laser power (ca. 1 mW). On the other hand, goethite could stem from contamination from the ore, but it was reported in previous studies that show a significant content of goethite in red pigments. Therefore, it is impossible to verify this hypothesis. We can only conclude that two hematite and goethite minerals were identified as red at Gate R, Pasargadae.

Hematite was identified as a red pigment on the block with the Hebrew inscription from the Tachara at Persepolis. Interestingly, cinnabar was also identified besides goethite and hematite in a single particle of the stone axe from the Apadana. The presence of hematite and goethite follows the same idea that either hematite was produced from goethite or goethite converted to hematite under the Raman measurement.

Hematite exists in many deposits throughout Iran, often within easy reach. Cinnabar, however, is much rarer. Small deposits of cinnabar have been identified in Zarehshuran, Agh-Darreh, and Shakh-Shakh, in northwestern Iran [54]. Such a combination of pigments of

hematite and cinnabar was also identified in the red-surfaced plaster floors of the Tachara at Persepolis and on the paint surface of Pasargadae [23-24, 52]. There, a thin layer of cinnabar was used on top of a hematite layer [1]. Hematite was used as a primer coat to provide a smooth surface on the plaster for the final paint layer. In this way, a rare and expensive pigment would not have been wasted on the non-visible layer. However, neither the stones of Persepolis nor the stones of Pasargadae are as porous as the plaster [55]. Therefore, hematite was not used to provide a smooth layer in this case. It has been assumed that purer hematite was used for darker red, whilst lead red was used for a reddish-pink decoration on painted plaster at Pasargadae [52]. Accordingly, the reason for combining different reds can be simply a creation of intended different red hues in a painting. The cause for observing dark-red cinnabar instead of reddish-pink, in the paper squeeze of the stone axe, could be either because of mixing hematite and goethite with cinnabar or cinnabar degradation. It is worth noting that cinnabar may have degraded and changed into the dark red metacinnabar (HgS) phase by exposure to light and weathering over a long period, the original bright red color darkens and transforms into black [55-57]. Due to the small size of the particles, it is not possible to trace this phenomenon on the paper squeezes. Different red hues open a question about the stratigraphy of the polychromy surface of the northern facade of Apadana. Scientific examination of remaining pigments on the surface of the palace or other paper squeezes would help us answer this question in the future.

The black pigment of the block with the Hebrew inscription was identified as magnetite black. It was assumed the Achaemenid black pigments are soot from the burning of organic materials. Indeed, carbon black was previously found at Pasargadae and Persepolis [52]. It is the first time that magnetite black has been reported in Achaemenid polychromy. It is impossible, however, to declare that magnetite black was a prevalent pigment as much as carbon-black during the time of the Achaemenids by finding a particle of magnetite. One should consider the possibility of hematite reduction to magnetite due to the weathering of the source rock (ore) [58]. This alteration is found in the natural deposits that high temperature and high pressure of hydrogen can accelerate its reduction reaction, although, the more stable phases of iron oxides are hematite and magnetite.

We do not want to exclude that some red and blue pigments identified on the paper squeeze of the stone axe or on the paper squeeze of the rosette could have originated from modern pen ink (Figure 11e). The ink may have been inserted either by Herzfeld and his team when they were marking the area of the molding or by archaeologists or curators who were studying and labeling the papers later.

Conclusions

Multianalytical investigations of four paper squeezes from previously unstudied stone reliefs at Pasargadae and Persepolis contribute to our existing and growing knowledge about evidence of ancient polychromy on these sites. There is evidence that an ear excavated in Palace P and a feather crown from Palace R, both at Pasargadae, have been painted. Previous examinations on the polychromy of other stone monuments close to the four architectural fragments and features introduced here provided evidence for the use of hematite as red pigment, goethite and cinnabar for red hues and carbon oxide to produce black pigment. Our study also suggests that the painters used lazurite blue and, probably, magnetite black. These findings are important in two respects. With ongoing studies on other monuments on the sites of Pasargadae and Persepolis, this investigation provides additional evidence that parts of the Achaemenid Persian stone facades were painted with blue materials probably made from lapis lazuli. The lazurite blue particles identified on the squeezes indicate the importance of the use of precious materials on the sites. Previously, only azurite and Egyptian blue were identified as the main blue pigments used for Achaemenid stone reliefs. These findings also prove that

indirect scientific investigation in combination with traditional methods of documentation provides an opportunity to discover new information on ancient polychromies.

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The incarnation of carnation: a reconstruction of late Gothic flesh tones using the example of a Mary (1510) by the workshop of Ivo Strigel

A encarnação da carnação: uma reconstrução dos tons de pele do Gótico Tardio usando como exemplo uma Virgem (1510) da oficina de Ivo Strigel

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Abstract

It has been suggested that the prestigious carnations adorning late Gothic sculptures were crafted by the workshops' masters themselves. In fact, they are a complex structure of skillfully constructed and aligned layers. The Bern University of the Arts (HKB) in Switzerland utilized the example of a Mary (1510, Centrepiece of the retable of Grono, Rhaetian Museum Chur) by the established workshop of Ivo Strigel (1486–1514) to elucidate the distinctive characteristics of a late gothic carnation. For the first time, the HKB not only displays various binding media and pigments found in each individual layer, but also illustrates the stratigraphy and binder systems that can vary depending on the facial area. To gain a full understanding of the analytical results, colour reconstructions were used to assess the effect of different concentrations of protein (egg yolk) dispersed in linseed oil on the properties of drying, flowability, and surface gloss of the respective colour media.

KEYWORDS
Experimental art technology
Tempera grassa
Stratigraphy carnation
Wooden sculpture
Drying oil
Egg yolk

Resumo

Tem sido sugerido que as prestigiadas carnações que adornam as esculturas do Gótico Tardio seriam elaboradas pelos próprios mestres das oficinas. De facto, trata-se de uma estrutura complexa de camadas habilmente construídas e alinhadas. A Universidade de Artes de Berna (HKB), na Suíça, utilizou como exemplo uma escultura da Virgem (1510, peça central do retábulo de Grono, Rhaetian Museum Chur), da reconhecida oficina de Ivo Strigel (1486–1514), para esclarecer as características distintivas dos tons de pele do Gótico Tardio. Pela primeira vez, a HKB apresenta os diferentes aglutinantes e pigmentos encontrados em cada camada individual, e também ilustra a estratigrafia e os sistemas de aglutinantes, que podem variar consoante a área do rosto. Para compreender plenamente os resultados analíticos realizaram-se reconstruções de cor, avaliando o efeito de diferentes concentrações de proteína (gema de ovo) dispersa em óleo de linhaça nas propriedades de secagem, fluidez e brilho superficial conferido pelos diferentes aglutinantes.

PALAVRAS-CHAVE
Tecnologia artística experimental
Tempera gorda
Estratigrafia carnação
Escultura em madeira
Óleo de secagem
Gema de ovo

Introduction

The protagonist of numerous late Gothic altar pieces is the holy Mary. One of her attributes is a porcelain like skin and rosy cheeks. The achievement of lifelike flesh tones has constituted a significant artistic challenge throughout the history of painting. Nevertheless, the late Gothic period witnessed a significant advancement in the portrayal of the skin's surface, characterised by an even greater degree of realism. The objective of this study is to ascertain the technological secrets of the workshops that came to establish Mary's carnation, a pivotal figure in many late Gothic retables. The execution of her highly symbolic skin was hardly left to chance. To what extent has research in art technology advanced our understanding of the materials and techniques employed in the creation of this distinctive polychrome attribute?

The execution of flesh tones is a subject dealt with extensively in numerous treatises on medieval panel painting and book illumination, such as *Schedula diversarum Artium* (12th century) by Theophilus Presbyter, *Il libro dell'Arte* (1329) by Cennino Cennini or the *Liber Illuministarum* (around 1500). However, regarding the application, a distinction can be made between the functional requirements of paint media used on panels and those employed on the three-dimensional surfaces of sculptures. Few documented sources provide deeper insights into the materials and techniques used for creating flesh tones in medieval sculpture. A significant source is the *Solothurn Codex*, a collection of recipes from the central library in Solothurn, which has not yet been fully transcribed and published. The codex was likely composed around 1500 in southern Germany. This work is of particular interest as it provides comprehensive details regarding the production of paint media and the techniques employed in their application [1]. In contemporary research Theiss [2] has dealt particularly intensively with the subject of understanding the properties of paint media used for medieval carnations. With his hypothetical reconstruction of Saint Barbara (Workshop of Michel Erhart, 1490) based on scientifically analysed material samples, he gathers important insights into the painting technique of late Gothic carnation. Krebs [3, p. 203] documents with her observations on the carnations of Hans Multscher workshop-internal polychrome peculiarities about colour-defining layers, located below the topmost flesh tone. Hahn [4] encounters in his research that the coloration of carnations can even vary within the workshop. This conclusion was also drawn from numerous master's theses at the HKB Bern, where the art technological laboratory, Karolina Soppa and students of the specialization of paintings and sculptures have been involved in the focused study of flesh tones from a wide variety of workshops [5-6].

However, in comparison to other areas of polychromy, the number of published analytical studies on medieval carnation is significantly lower than one might expect. One of the reasons for this may be that the step of taking a sample from this delicate area is often not considered justifiable. Another reason is the turbulent history of many sculptures. Layers of original paint have been removed or conversely overpainted and are now hidden. Beyond that, our research showed, flesh tones are often classified as a conglomerate of the entire polychromy or are believed to be a homogeneous paint media with limited possibility of variations in pigments and binders used. Therefore, they are rarely considered as a unique specimen and detailed examinations are exceptionally rare. Thus, there are still numerous uncertainties regarding the art-technological implementation of flesh tones and, in particular, the paint systems used for them. Those circumstances led to a careful examination of a Mary (1510) attributed to the workshop of Ivo Strigel. Macro- and microscopic observations, stratigraphic analyses, and chemical imaging on cross-sections were carried out. The distribution and concentration of binder components was investigated using Fourier transform infrared spectroscopy (FTIR) and Focal plane array (FPA) imaging in combination with the SF4 derivatization technique. Inorganic components were determined using a scanning electron microscope with backscattered electrons and energy-dispersive X-ray (SEM-BSE-EDX). To gain a more comprehensive insight into the physicochemical and material properties of a "modified oil paint", used for the carnation of the Mary by Ivo Strigel, experimental colour reconstructions

were carried out. The goal was to not only provide a visual depiction of the analytical results but also to use them to showcase the hypothetical properties of the analysed paint media, which include aspects such as drying, flowability, and surface aesthetics. Properties that were of particular interest regarding the impaired carnation of the examined sculpture. This study aimed to conduct a systematic test series with mixtures of sun-dried linseed oil and lead white, to which gradual amounts of egg yolk were added. By documenting the resulting characteristics, it was possible to identify the effects of varying protein concentrations on film formation, surface gloss, and viscosity of the films.

The stratigraphic examination of a late gothic carnation

Thanks to a collaboration with the Rhaetian Museum in Chur it was possible to study a late gothic altarpiece attributed to the workshop of Ivo Strigel, located in Memmingen, Southern Germany. In addition to domestic orders, lvo's workshop was geared towards exporting art [7, p. 123]. Strigel particularly supplied the diocese of Chur (in the fifteenth and sixteenth centuries, the present-day canton of Grisons, the Principality of Liechtenstein and South Tyrol were part of the diocese) with numerous altarpieces between 1486 and 1514. Nearly 30 completely preserved retables, altar fragments and individual figures can be linked to his workshop in this region [8, p. 10]. These circumstances made it possible to examine a flesh tone under workshop conditions and with an extended amount of time, a factor that often sets limits when examining sculptures in churches or exhibitions. The most significant sculpture in the shrine, Mary, was selected for this purpose. Her carnation was particularly suitable for this endeavour because it was affected by aging and previous interventions, as shown in Figure 1. These circumstances resulted in numerous areas exhibiting clearly visible stratigraphy, thus facilitating sampling.

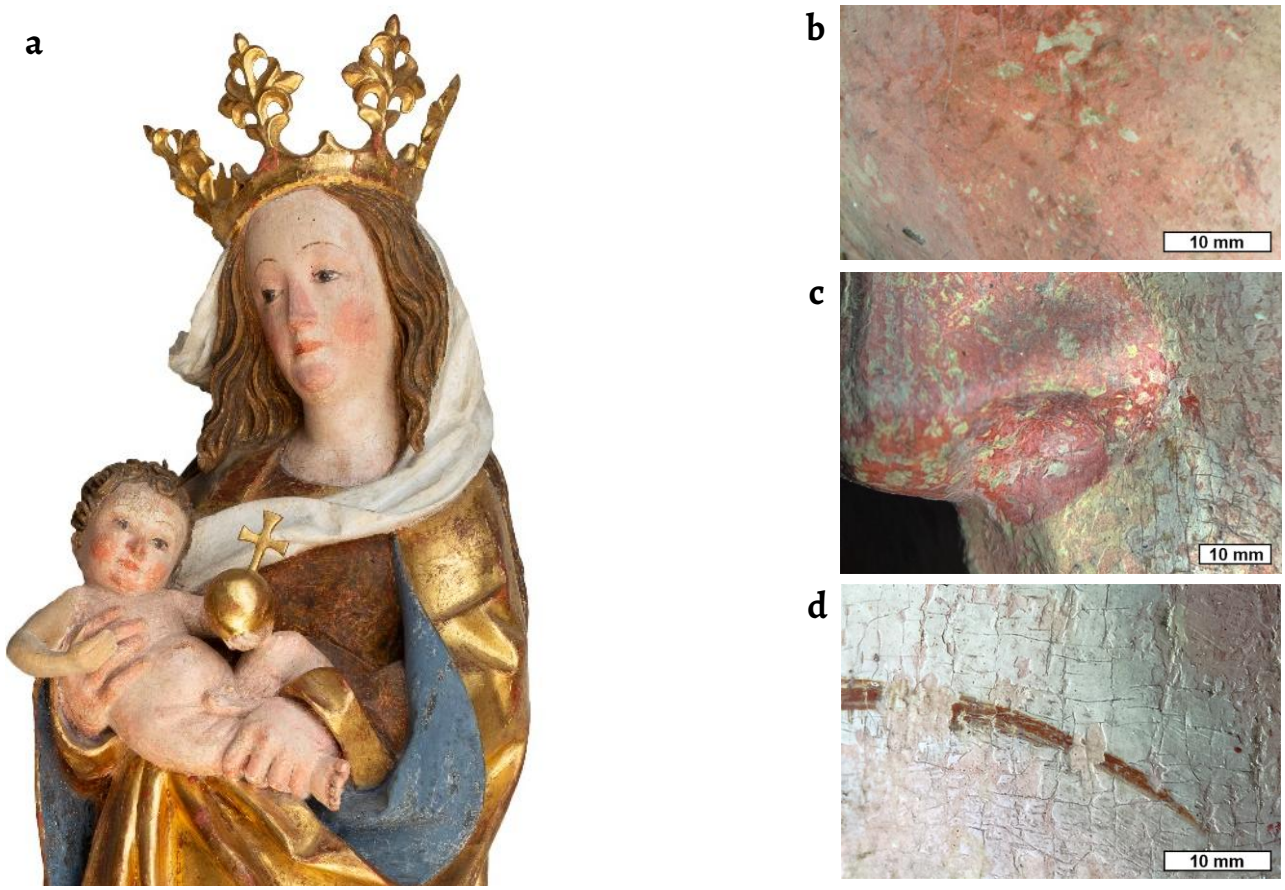

Figure 1. Mary with Child: *a)* general view; *b-d)* details of the carnation's present condition: cheek, nose, and eyebrow.

Method

A combined and complementary application of methods was target-aimed to create a maximum amount of information. Starting with aligned imaging methods, followed by a macro- and microscopic documentation of the painting technique, the examination was completed with spectroscopic analytics of selected samples. One challenge in spectroscopic analysis with FTIR is the spectra of oil-based colour samples. The presence of overlapping bands can make interpretation difficult. This applies especially to the prominent band of lead white which, due to signal interference can overlap the protein bands. In order to depict low-protein contents in oily binders, samples were derivatized with sulphur tetrafluoride. The derivatization method can eliminate the spectral band overlaps of carboxylates, as stated by Zumbühl et al. [9]. This improvement allows for the detection of low concentrations of proteins in oil-based systems [10]. However, it is still impossible to determine the specific type of protein present. Despite this, the concentration in micro samples can be estimated by analysing the relative signal intensities of the ester band (nC=O) in the oil and the amide I band of the protein. Since proteins are distributed heterogeneously, the concentration was also approximated by comparing FTIR-FPA images of reference samples with a defined protein concentration [10]. Inorganic components were determined using SEM-EDX.

Preliminary summary of the stratigraphy

The analysis of Maria's skin tone revealed the presence of a total of five different layers. However, the skin tone's stratigraphy is structured in four layers as shown in Table 1, Figure 2 and Figure 3. Layer three (not analysed) and four are applied exclusively to specific areas.

Table 1. Terminological classification of analysed binder systems and pigments in respective layers.

Description	Terminological classification		Binding media	Pigments
Light white-pink layer	5	Skin tone	Oil Protein 2-5 %	Lead white, cinnabar
Pure binder layer locally applied	4	Isolating layer	Protein based small oil content	none
Red shade locally applied	3	Accentuations	×	×
Pink layer with warm undertones	2	Colour defining preparatory layer	Protein 90 % Oil 10 %	Cinnabar, lead white, red lake pigment
Porous white layer	1	Primer	Protein 90 % Oil 10 %	Calcium carbonate

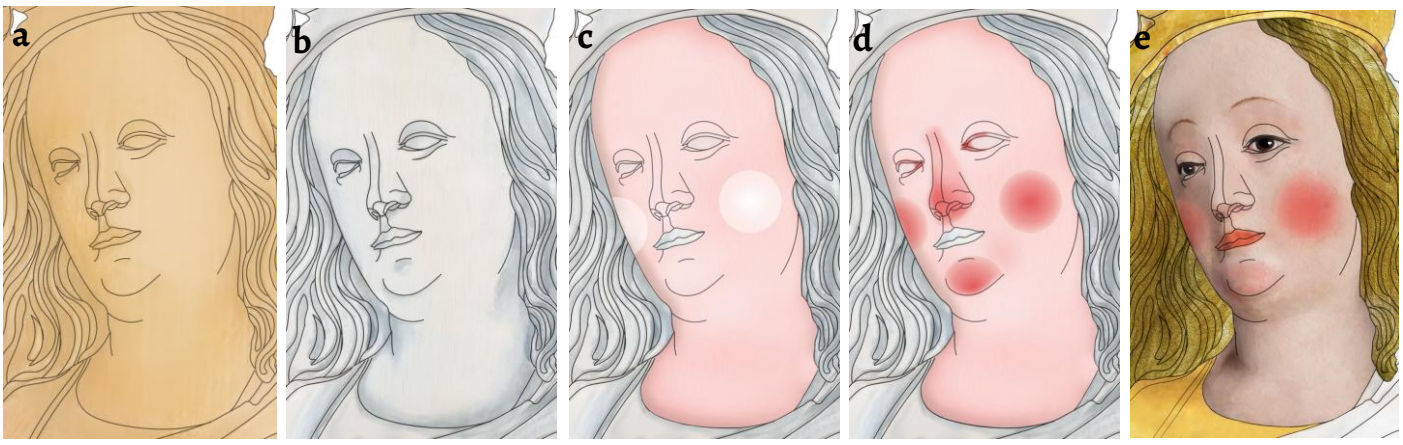

Figure 2. Stratigraphic implementation of the layers *a)* wooden support *b)* primer *c)* pink layer; *d)* locally applied red accentuations *e)* flesh tone.

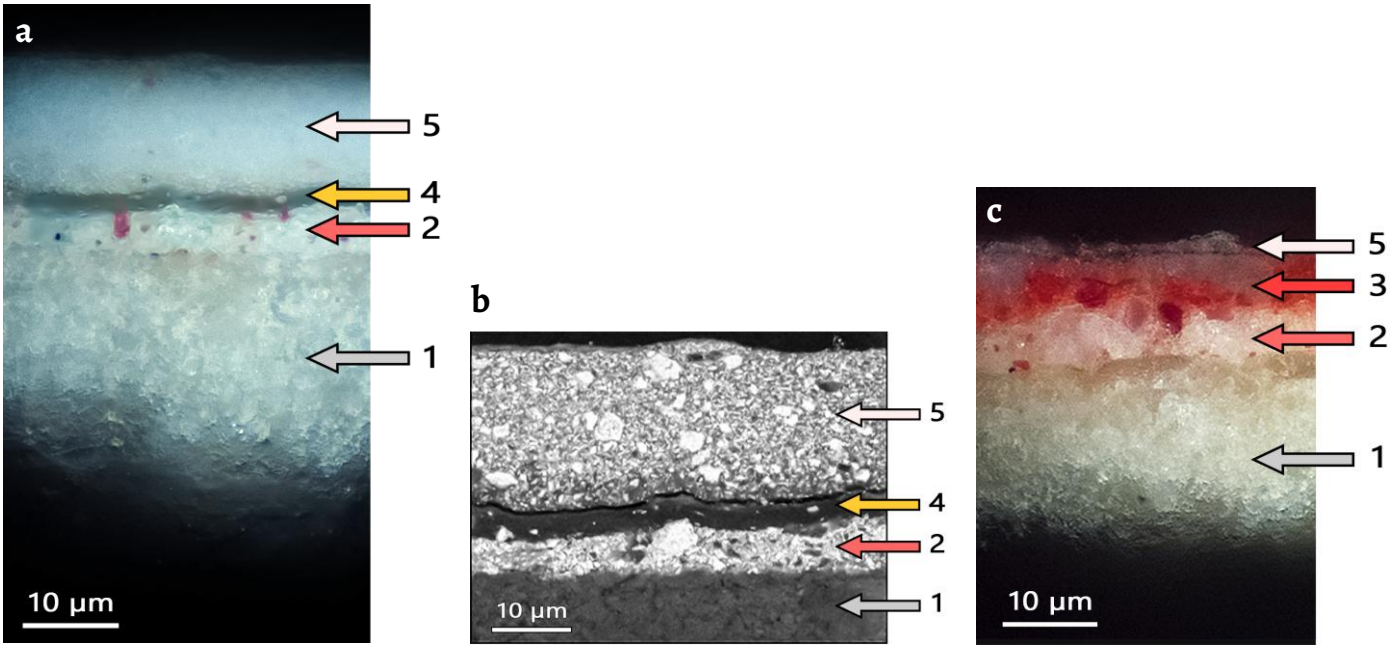

Figure 3. Cross-sections: *a)* forehead (VIS-BF xpol); *b)* forehead (SEM-BSE 2000× 20kV 100 pA 40); *c)* nose (VIS-BF xpol) with red accentuation and missing isolating layer.

Results of visual and analytical examination

The following descriptions illustrate the stratigraphy of Mary's carnation chronologically.

Wooden support and isolation layer

The wooden support was carved from lime wood, determined by a wood fibre analysis of a thin section sample. An isolation of the support could not be determined analytically but is visible with the stereo and digital microscope as a yellowish matrix lying over the wood fibres.

Primer

A single layer of primer, approximately 45 µm thick, was applied to the entire face of the sculpture (Figure 2b). The primer is noticeably thinner around the finely carved eyes and almost translucent on the lower eyelids. Since none of the cross-sections include the support, it cannot be ruled out that there are multiple layers of primer. The primer is composed of marine calcium carbonate with coccoliths and a binder that contains protein with a low amount of oil. Caused by a relatively low binder content, the primer exhibits weak binding. The FTIR measurement of the derivatized microsample indicates a ratio of approximately 90 % protein and 10 % oil. Adding an oil additive resulted in a more manageable, higher viscosity an extended drying period and furthermore reduces the absorbency of overlaying layers [11, p. 14].

Pink layer

The entire face, except for the lips and cheeks, has been coated with an opaque layer (9-10 µm) of a pink colour (Figure 2c). Raman spectroscopy and SEM identified that this shade is achieved by a mix of cinnabar and lead white with proportions of a red lake pigment, precipitated on the basis of calcium carbonate. The binder, identified by FTIR analysis, matches that of the primer.

Locally applied red shades

Red circles, defining the rosy cheeks, were applied using a vibrant red-orange paint media. Further, it was applied locally to the nose, chin, and eyes (Figure 2d). Although the paint media is thinly applied and highly saturated, it has a translucent character with high opacity. Analytical

data shows that this layer is also aqueous bound and that there is no mixing with the pink-coloured layer during application. Its morphological character indicates that it is likely a blend of cinnabar and red lake pigment, possibly with the inclusion of lead white. This indicates a potential correlation with the previously applied pink layer.

Layer of binding media

A protein layer with a low oil content was detected above the pink layer using FTIR-FPA. Although this layer cannot be identified microscopically, it is clearly visible in the UV-fluorescence image of the cross-sections as an area without inherent fluorescence. Additionally, in the SEM-BSE image, it is distinguishable as a black gap (Figure 3b). Even if it is not localized on the primer as is typical, the function of this layer can be classified as an isolation layer (glue size), with the task of preventing the oil-based binding media of the flesh tone from penetrating deeper layers, as documented in historical sources [12]. Besides its sealing effect, the binder also provides additional support for the subsequent oil-based layer. Interestingly, this layer was applied only to selected areas of the face, specifically the cheeks, forehead and neck, while it is missing on the nose.

Flesh tone

A shade of white with a warm undertone was applied in varying thicknesses between 2-25 µm. The mixture is composed of lead white and cinnabar and completes the composition of the carnation. The lead white component was identified as a basic lead carbonate (2 $PbCO_3$•b$(OH)_2$). Cinnabar (HgS) was identified through SEM element mapping. Bone black was identified in the sample due to its phosphorus content using SEM-EDS. The function of the black pigment remains unclear, but it is recognizable in practically all cross-sections. The binder used is an oil-based mixture with an approximate protein content of 2-5 %. As shown in

Figure 4, the uppermost layer revealed a heterogeneous distribution of a proteinaceous binder, which was made visible by derivatizing a cross-section and a subsequent FTIR-FPA examination. Although the low protein content limits definitive conclusions, it is evident that it is not evenly dispersed in the system. Furthermore, ketones, the primary oxidation products of resins, were detected. Although these can also be formed by oils, a resin component cannot be absolutely ruled out for this layer.

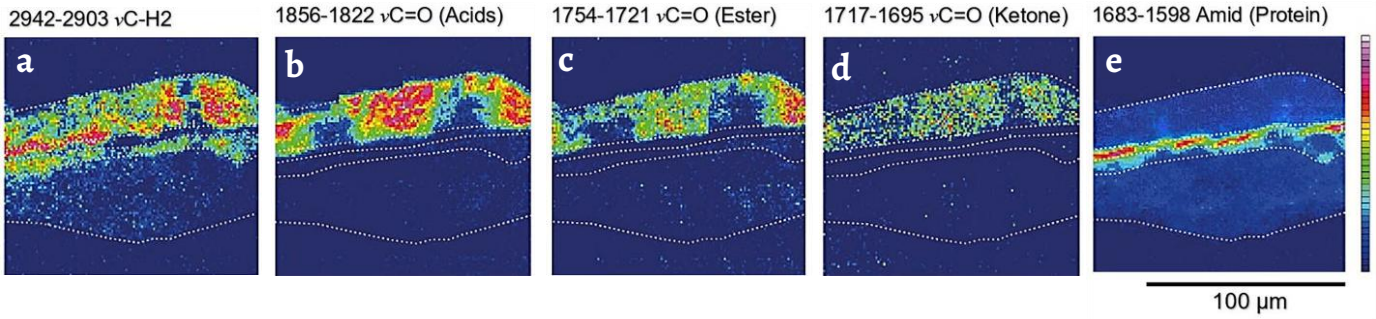

Figure 4. FTIR-FPA image of an SF4 derivatized cross-section. Showing a heterogeneous binder distribution of oil and protein in the topmost layer of the skin tone: *a)* 2942-2903 cm^{-1} $_{\upsilon}C–H_2$; *b)* 1856-1822 cm^{-1} $_{\upsilon}C=O$ (Acids); *c)* 1754-1721 cm^{-1} $_{\upsilon}C=O$ (Ester); *d)* 1717-1695 cm^{-1} $_{\upsilon}C=O$ (Ketone); *e)* 1683-1598 cm^{-1} Amid (protein).

Art technological observations

The technological observations allowed the classification of three different application methods, illustrated in Figure 5. The topmost skin tone is first applied to the peripheral areas of the face, forehead, and neck. This is done with a highly opaque and impasto application of colour. Areas previously highlighted in red, such as the cheeks, chin, and nose, as well as the eye sockets, are initially omitted. The heavily opaque paint application on the forehead becomes increasingly translucent, starting at the eyebrow level and fading toward the upper eyelid, with the pink layer becoming increasingly visible. The eye sockets and the areas around the nasal wings, highlighted in red, are only covered with a thin white glaze to model reddish skin tones. This fading opacity and glazing process can also be observed around the chin and the cheek circles previously highlighted in red. The upper segment of the cheek circle is covered with a delicate white glaze so they remain recognizable. The opacity of the paint application becomes weaker towards the centre of the circle until it finally disappears completely, and the red setup becomes visible. A technical variation was used for the nose. Since no blocking isolation layer was applied here, the binder of the very thinly applied skin tone is now partially absorbed by the pink layer, creating a white shimmer on the surface, which creates the common reddish nose tip of late Gothic carnation.

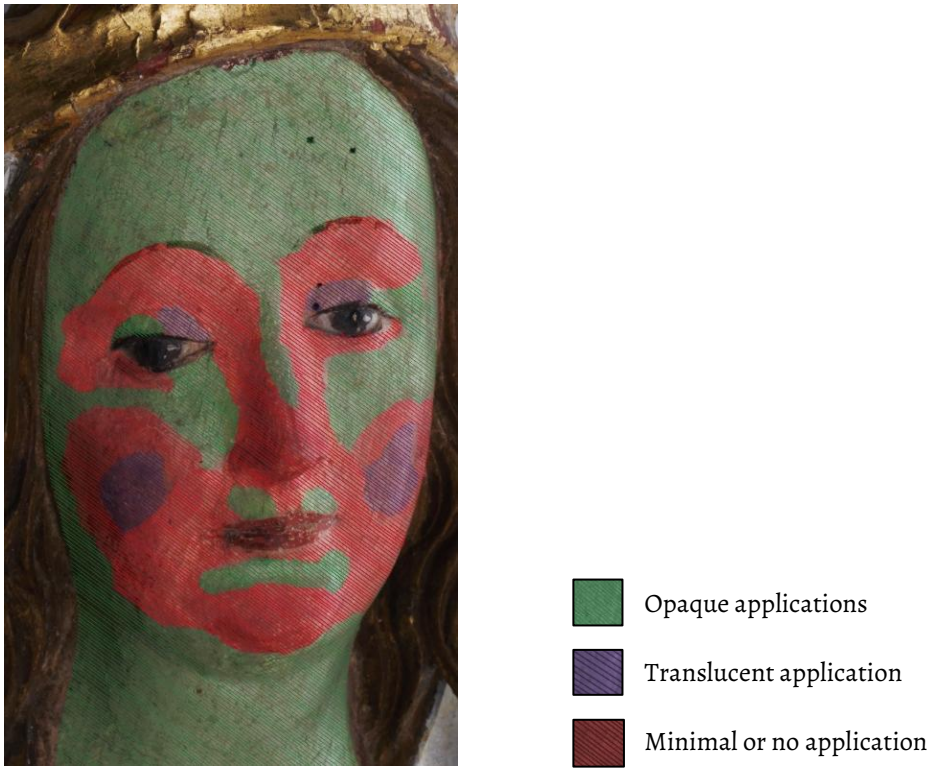

Figure 5. Mapping showing the different application techniques.

Reflections on the pink layer

One question regarding this stratigraphy is the technical function of the pink layer and the local accentuations. Do they influence the colour appearance of the overlying lead-white layer, or is its opacity such that it inhibits the visibility of the underlying pink layer? Moreover, if this is the case, what is their function? Due to the severely damaged paint layer, this question is challenging to answer visually.

When the function of the pink layer is placed in a technical context, the following conclusions can be drawn. If the construction of a skin tone begins with a reddish base or a coloured primer, the technical approach to the intended colour effect and modelling of the flesh tone is different than with methods using multiple colour systems. Reddish layers create a filter effect that lends

a warm depth of light to even opaque white paint applications [13, p. 203]. In terms of technique, it is therefore possible to achieve cool white skin tones with opaque colour applications and warmer flesh tones with glazing layers. This method was able to accelerate the completion of carnations [14, p. 303] and fits well with the rapid working methods of late Gothic workshops. In the case of carnations that are constructed without a coloured base, reddened segments of the face are achieved differently. Either by applying light, transparent red glazes on a dry base skin tone or with a wet-on-wet dispersion or dotted incorporation of a red paint media into the white base skin tone. However, the function of systems with coloured underpaintings remains an interpretation of current observations, and its complete understanding still needs to be discovered. Is the form of a two-staged underpainting an isolated phenomenon, or does it represent a conceptual aspect of Strigel's carnations? If this is indeed the case, can they be attributed solely to the workshop's final creative period (1506-1512), or is it even limited to the production of export goods? A comparison with other carnations of Ivo Strigel's workshop could prove highly beneficial in identifying patterns in the technique and thus gain insight into the purpose of coloured underpaintings.

Experimental practical studies

Scientific analysis of Mary's topmost skin tone allowed to identify two binder components, their percentages in the system and pigment additions of lead white and cinnabar. The result for the binder is a mixed system consisting of oil with a low protein content of approximately 2 to 5 %. Small amounts of protein added to oil-based paint media have not yet been conclusively clarified. In order to classify the analytical data, 20 German-language recipe books from the period 1400-1550 were consulted [12]. It has been speculated that proteins may have been used to grind the pigments [15]. This has not yet been proven as a common technique from the sources examined, nor has this hypothesis been confirmed analytically. Therefore, based on the distribution of the protein in the material structure, it is assumed to be an additive to the oil. The use of egg yolk is likely, since this protein-containing material can be mixed with oils due to its emulsifying properties. Upon consideration of the chemical composition the incorporation of protein into the binder is a crucial factor in determining the technical properties of the paint media. In order to further investigate this question, a systematic series of experiments was carried out. However, the aim is not to simulate a historical paint media, but rather to understand the possible effects of such mixed systems. It can be reasonably assumed that the protein had an impact on the texture of the paint media. The observations of Mary's carnations demonstrates that the paint media has a high degree of opacity and allowing both pastose and translucent applications. But what are the physical and optical qualities of such a paint media? These are questions that are of great interest for the present work, due to the damaged surface of Mary's carnation. The influence of the protein on the properties of an oil-based paint was simulated by varying the pigment, linseed oil and protein concentrations.

Questions

Prior to the test series, questions were defined for each analysed component in the system. In summary, these questions fall into three main categories as illustrated in Table 2.

Table 2. The three main research questions and their respective primary issues.

Drying	Viscosity	Surface appearance
Influence of protein on speed of drying	Amount of protein necessary to achieve change in viscosity	Effects of different protein concentrations on optical properties
Difference between film formation and chemical drying	Influence of viscosity on surface appearance and drying	Influence of protein on surface appearance
Drying time of a paint media matching the analysis (Protein 2-5 %)	Viscosity of a paint media matching the analysis (Protein 2-5 %)	Surface appearance of a paint media matching the analysis (Protein 2-5 %)

Materials

The components of the test series are based on the analytical results of the topmost skin colour of Mary, which were lead white and cinnabar in an oil-based binder with a protein content of approximately 2-5 %. Since cinnabar was only analysed in very small quantities and presumably has a primarily colour-influencing property on the binder, it was not included in the test series. Consequently, the test series were to be carried out with three components, namely lead white as a dry pigment, sundried linseed oil and an addition of protein. Since the specific protein type in the binder was not identified, examples from several studies in literature that examined protein additions in binders of carnations using GC-MS [2, p. 105; 16, p. 317ff] were consulted. Both analyses identified egg yolk as the protein component in the binder. Further egg yolk was chosen for its emulsifying properties and its protein content of 16 % [17, p. 282]. The protein content for the mixtures was therefore calculated based on this percentage. Accordingly, the stated protein content does not refer to the amount of egg yolk in a mixture, but to the proportion of protein it contains. Only organic eggs were used for the test series as the feeding of yolk-colouring pigments is prohibited [18, pp. 12-13]. Before processing, the vitelline membrane surrounding the yolk was removed and passed through a sieve to remove inclusions and blood clots. For the pigment a synthetically produced alkaline lead carbonate (2 $PbCO_3$•$Pb(OH)_2$) with a sieve residue < 44 µm was chosen (#46000 Cremnitz White by Kremer Pigments). The use of a pre-treated linseed oil appears likely, as the paint media would otherwise dry very slowly, which would significantly impede the efficiency of the work process. As early as Theophilus in the eleventh century [19, p. 60] and Cennini in the fourteenth century [20, p. 61] observed that placing linseed oil in the sun for a period of time would result in a more suitable consistency for painting. Therefore, a sun-thickened linseed oil, was used for the test series, which was produced by the slow absorption of oxygen in the sun (#73055, Linseed Oil, cold-pressed and sun thickened by Kremer Pigments).

Preparation

The lead white pigment first was submerged in sundried linseed oil. Then these mixtures were processed by grinding them on a glass plate for 15 minutes with a pestle until a homogeneous texture was achieved. Initial tests established the ideal ratio of lead white to linseed oil for creating a paint media that achieves uniform pigment saturation, ensuring good opacity and a consistency that is easy to distribute. The most effective results were obtained with a mix of 28 % linseed oil and 72 % lead white. Based on this ratio, ten different paint films were produced, each containing increasing protein content ranging from 0.15 to 5 %. Egg yolk was gradually added with a micrometric syringe (Pipet-Lite XLS), folded under with a spatula and again grinded for another 10 minutes. The paint media then was applied to a microscope slide with a film applicator (Type 284 Bird) in a layer thickness of 100 µm. Additionally, a brushstroke was drawn with a 1 cm hog hair paintbrush on a microscope slide, to evaluate if the paint media could be used in both opaque and transparent applications.

Method

The films were dried in light boxes and in daylight. The light box simulated an irradiation with mixed light with a light intensity of 5800 lm/m^2 and a UV component of 557 mW lm^{-1}. The temperature 10 cm above the samples varied between 45 °C and 15 °C, the relative humidity ranged between 32 to 45 %. The reference test series was dried indoors beside a window, with an exposure of 3.5 hours of direct sunlight per day. Temperatures ranged from 6 to 18 °C and a relative humidity between 45 to 56 %. Changes caused by drying were observed by monitoring the weight to assess the progress. This method is possible due to the technological uniqueness of linseed oil in its chemical drying. In this process, the binding agent solidifies through a chemical process known as auto-oxidation. Drying is initiated by a radical chain reaction, formed by atmospheric oxygen or UV-light, that can be defined by different reaction steps. These reactive particles accelerate the oxidation process which leads to a significant absorption of oxygen that increases

the size of the molecules [21, p. 6]. The paint films were weighed every 24 hours, selected films in more frequent intervals (1, 2, 3, 6, 12 and, 24 h) on a high precision scale. Changes in weight were documented gravimetrically to allow conclusions about the drying process of paint films with different protein concentrations. Film formation was evaluated haptically by touching the surface. Observations on the viscosity and surface appearance of the films were evaluated in terms of their utilization as a paint media based on the technical observations of Mary's carnation.

Results and discussion

Drying

The series of samples dried in the light box shows a steady increase in weight within the first three hours, reaching a maximum of 1.5 mg after 3 hours. After that a linear weight loss of about 0.25 mg per day occurs until the initial weight is reached after 5 days. The films dried in daylight however show a very heterogeneous drying process overall. In the first six hours, eight out of ten colour films show an increase in weight, but at different rates. After 24 hours, all samples show a steady but minimal loss of weight, which over the next eight days is characterized by a relatively flat curve with an average decrease of 0.05 mg per day.

The comparison to films without protein shows that egg yolk produces a more homogeneous drying with fewer fluctuations in weight increases and decreases. Nevertheless, the tests showed that the addition of protein does not have a significant effect on the speed of oxygen uptake. But if we evaluate the speed of film formation, however, there are clearer effects. Judged by haptic criteria, all films with a protein content of less than 1 % are touchable after 12 hours, above 2.5 % even within 1.5 hours without being tacky. This is around 5 times faster than the reference test series with the same lead white content but without egg yolk. It is important to differentiate between chemical drying and film formation. A comparison of film formation and changes in film weight has shown that there is no relationship between these two parameters. This means that the point at which a film is surface dry cannot be associated with a specific event such as weight loss. In particular, films with high protein contents show a drastically reduced drying time, which seems to be related to the higher water content of these films coming from the egg yolk. An explanation for these phenomena could be the partial transition from a purely chemical to a partially physical drying process defined by water loss in the initial phase.

Viscosity

Even the addition of minimal amounts of protein had an immediate effect on the viscosity of the mixtures (Figure 6). At 0.15 % protein in the binder, there is a slight reduction in flowability. At 0.35 %, flowability is significantly reduced. At a protein content of 0.75 % in the binder, the first thixotropic properties of the paint appear. This indicates that high viscosity can be temporarily reduced by shear forces, such as those generated during the application with a paintbrush. At a concentration of 1.65 % protein content, the fluidity of the mixtures is practically eliminated and the paint becomes highly viscous and honey-like. Even highly pastose brush applications retain their structure until drying. At concentrations above 3.5 % protein, thixotropic properties are no longer present and the mixtures becomes highly viscous and difficult to apply with a paintbrush.

Surface appearance

The addition of protein has a particular effect on the 100 µm films. These appear slightly glossier than films without egg yolk, but still fall into the semi-matte category. Pastose applications with a paintbrush have a porcelain-like gloss. The level of gloss increases continuously up to a protein concentration of 2 %, after which the effect is reversed, and all forms of application become increasingly matte as shown in Figure 7. Above 5 %, both film and brush applications appear very dull. All formulations are very yellowish due to the addition of egg yolk. However, this effect disappears within a few hours in the light box. Even when stored at the window, the yellow tint

disappears completely after a few days. Unlike the yellowing caused by linseed oil, this loss of colour is not reversible [22].

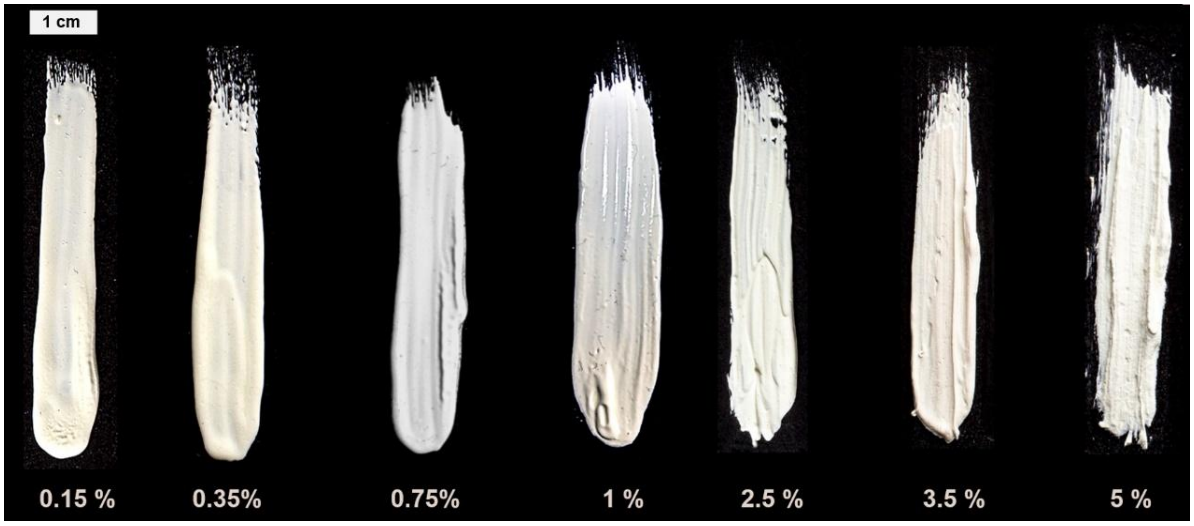

Figure 6. Changes in viscosity of mixtures with different protein concentrations (%): 0.15, 0.35, 0.75, 1, 2.5, 3.5, and 5.

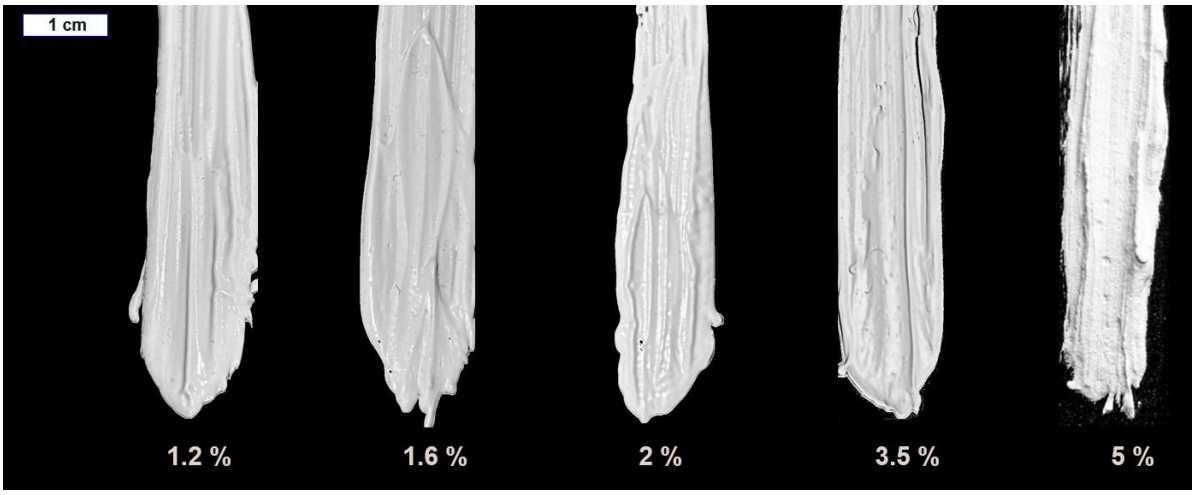

Figure 7. Changes in gloss level of paint media with different protein concentrations (%): 1.2, 1.6, 2, 3.5, and 5.

Hypothesis on the original surface aesthetics of Mary

The practical experiments have shown that the properties of oil colours can be modified in various ways by adding small amounts of protein. In view of the sophisticated painting technique observed on the sculptures by Ivo Strigel, it can be assumed that the workshops had specific requirements for their colours. By specifically modifying these properties, the artists were able to vary the workability and thus achieve different visual effects. If we were to hypothetically reconstruct the surface appearance of Mary's carnation, by concluding the gathered results it may have consisted of contrasting areas with different optical impressions. It would be possible to achieve smooth and glossy surfaces by finely dispersing thicker applications with a paintbrush. Conversely, it is conceivable that translucent white applications may result in a rather matte to satin-matte surface. This results in a juxtaposition of semi-gloss and glossy surfaces.

Conclusions

The combination of spectroscopic analysis and experimental art technology facilitated a significant reconstruction of the stratigraphic setup of Mary's carnation. The documentation revealed that a red underpainting was applied to the entire face, followed by two localized, protein-bound layers: the red accentuations and an isolation layer. This detail is particularly interesting from a technical perspective and enhances our understanding of the relationship between the final, predominantly oil-based layer and the two preceding preparatory layers, which serve as a foundation for achieving various skin tones. This reveals a sophisticated system for creating Mary's flesh tone, highlighting the artistic mastery of the workshop. Through the analytical examination of the samples, it was estimated that the protein content in the predominantly oil-based binder ranged from 2 to 5 %. This estimation facilitated the formulation of a test series derived from the analysed components of Mary's carnation. Consequently, it was possible to assess the drying times and film-forming properties while also documenting viscosity levels and rheological characteristics. This comprehensive analysis enhanced the understanding of the performance of the various mixtures as paint media. The observations from the test series indicated that protein concentrations between 1 and 3 % hypothetically are suitable as a paint media in terms of surface aesthetics, workability and viscosity, whereas the 5 % concentration proved inadequate without further modification. The study also highlighted the limitations of advanced analytical techniques, along with the time-consuming nature of developing a comprehensive understanding of the paint media used. While an approximation of the paint's characteristics can be achieved, a subsequent step remains necessary: the practical application of the paint on a three-dimensional surface. For this purpose, a wooden 3D model of Mary's face has been created. Initial tests indicate that this step presents its own challenges, such as visible brush marks on the surface and uneven distribution of the colorant over the topographical features. Theiss and Faldley [2, 23] have suggested initial solutions by using a fan brush dampened with water to help achieve a more uniform distribution of the colorant. However, many questions remain unanswered, and further research is needed to attain an even more precise approximation of late Gothic carnations.

Acknowledgements

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A hidden splendor: the color of medieval cloisters in the 12th and 13th century Catalonia

Um esplendor escondido: a cor dos claustros medievais na Catalunha dos séculos XII e XIII

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Abstract

The identification of polychromy in medieval imagery during restoration campaigns has significantly advanced the iconographic and formal interpretation of monumental sculpture. This integration of image and color provides a fresh perspective, offering deeper insights into how the Church explicitly conveyed its dogma. Consequently, the polychrome image emerges as a pivotal medium of expression for 12th and 13th century society. The limited availability of case studies on monumental sculptural color presents a major challenge in contemporary medieval art research. Within this context, Catalonia stands out as a remarkable example on the Iberian Peninsula, owing to the chromatic remnants preserved in various sculptural and architectural ecclesiastical elements. This study focuses on Catalan medieval cloisters, proposing novel approaches to understanding the role of polychromy in its environment, and the interplay between sculpture and liturgical practices. It proposes that color was not merely aesthetic but served a wide array of symbolic meanings and functional contexts.

KEYWORDS

Polychrome monumental sculpture
Polychrome Romanesque sculpture
Catalan Romanesque art
Romanesque cloister
Color techniques
Catalan Counties

Resumo

A observação de policromia na imaginária medieval durante as campanhas de restauro tem impulsionado a interpretação iconográfica e formal da escultura monumental. Esta combinação de imagem e cor oferece uma nova perspetiva, proporcionando uma visão mais profunda de como a Igreja transmitia o seu dogma. Consequentemente, a imaginária policromada surge como um veículo de expressão crucial para a sociedade dos séculos XII e XIII. A escassez de estudos de caso sobre a cor na escultura monumental representa um desafio na investigação da arte medieval contemporânea. A Catalunha destaca-se enquanto exemplo notável na Península Ibérica, devido aos vestígios de policromia preservados em diversos elementos escultóricos e arquitetónicos eclesiásticos. Este estudo centrado nos claustros medievais catalães pretende compreender o papel da policromia no seu ambiente, bem como a interacção entre a escultura e as práticas litúrgicas. Propõe-se que a cor não seria apenas estética, mas servia uma vasta gama de significados simbólicos e contextos funcionais.

PALAVRAS-CHAVE

Escultura monumental policromada
Escultura românica policromada
Arte românica catalã
Claustro românico
Técnicas de cor
Condados catalães

Introduction

The investigation of polychromy in Romanesque art represents a pivotal challenge within contemporary historiography [1-3]. Recent advancements in this domain have been catalyzed by findings from restoration projects and innovative analytical methodologies focused on medieval polychromy [3-8]. These developments compel a critical reassessment of established paradigms concerning the function of color, its interplay with monumental sculpture, and its reception by historical audiences. Central to this discourse are questions regarding the influence of polychromy on the iconographic and iconological configuration of these works, how it was perceived by contemporary viewers, and the extent to which it contributed to the articulation and dissemination of doctrinal messages.

While celebrated examples such as the Portico de la Gloria [9] have received considerable scholarly attention, it is imperative to extend the scope of inquiry to encompass other notable instances of monumental sculpture and their distinctive features across the diverse territories of the Hispanic Kingdoms. A systematic and comparative analysis of extant polychrome vestiges is indispensable for achieving a comprehensive understanding of the techniques employed in the application of color and its perceptual and symbolic dimensions within these artistic productions.

In this context, the Catalan counties serve as a paradigmatic example of the use of color in twelfth and thirteenth century sculpture and architecture [10]. The region's polychrome remnants constitute a unique case within the Iberian Peninsula, as it preserves a significant number of chromatic vestiges available for study. Currently, approximately 85 examples of medieval sculpture (such as portals, capitals of the cloisters, reliefs, and other sculptural decorations in church architecture) retaining their original polychromy have been identified across various territories that formed part of the Crown of Aragon during the Middle Ages [11].

Several factors influenced the development and preservation of polychromy in this region. Geography played a pivotal role, with the Pyrenees serving as a strategic source of specific minerals, such as aerinite, azurite, and malachite [12-13]. Additionally, the trans-Pyrenean exchange of pigments, facilitated by interactions with southern France, along with the itinerant nature of workshops, significantly contributed to the dissemination of polychromy [14, pp. 245-246]. Preservation of the polychrome remnants was further aided by their location. Notably, colors tend to be better conserved in the most sheltered areas of sculptures or in elements that have been less exposed to climatic conditions and the effects of time.

Within the context of Catalan monumental sculpture, two notable case studies stand out: the porticoes of Ripoll and Agramunt (Figure 1) [15]. These examples are exceptional both for the volume and for the quality and diversity of the preserved polychromy, prompting compelling questions regarding the reception and symbolic dimensions of color [16].

However, this study focuses on a different yet equally significant and underexplored aspect of polychromy in monumental sculpture, the medieval Catalan cloisters that retain polychrome remnants.

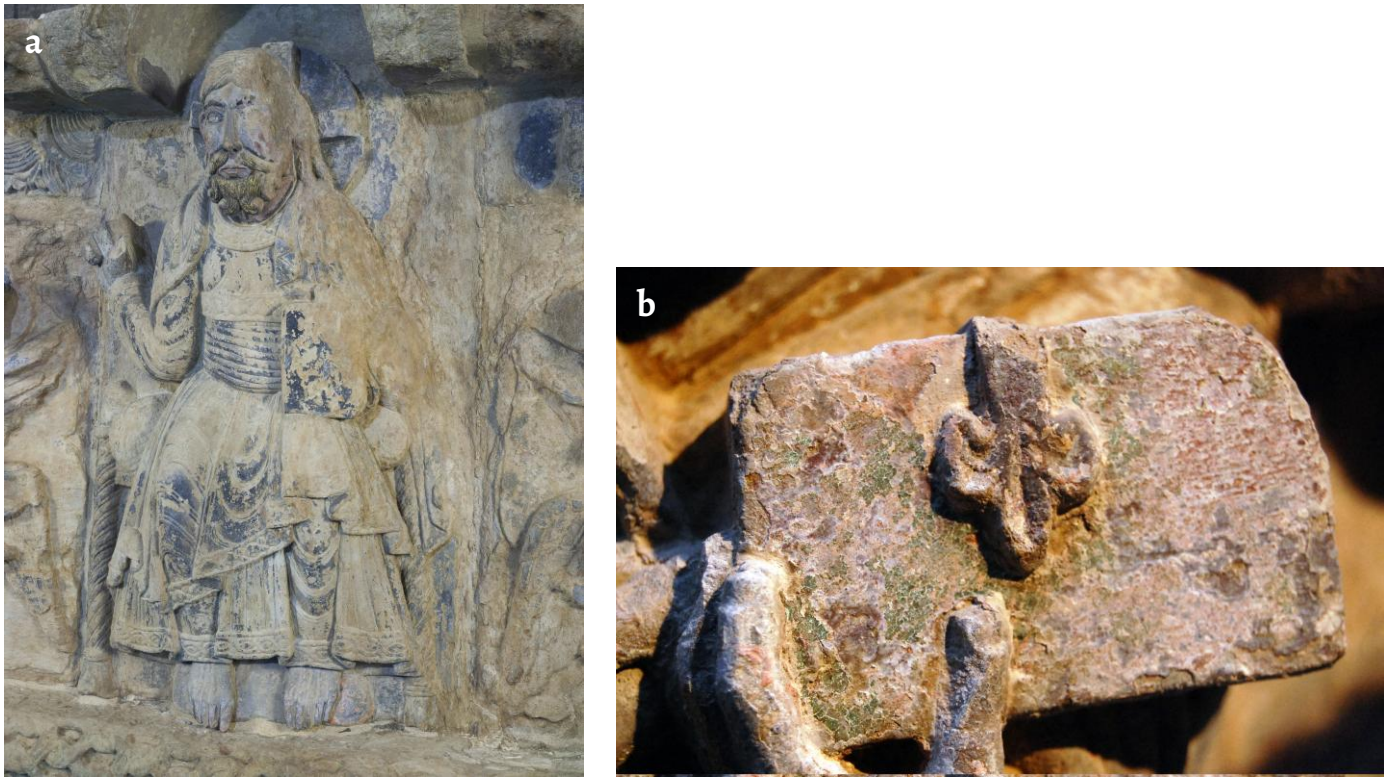

Figure 1. Portal case studies: *a)* Monastery of Santa Maria de Ripoll, Ripollès, Catalonia, c. 1140 (photograph: Centre de Restauració de Béns Mobles de Catalunya – CRBMC); *b)* church of Santa Maria d'Agramunt, Urgell, Catalonia, 1283 (photograph: Arcovaleno Restauro S.L.).

The color of the medieval Catalan cloisters: features and case studies

The current understanding of color in medieval Catalan cloisters is derived from the polychrome remnants that have survived to the present day. It is essential to acknowledge that the hypotheses and interpretations regarding this polychromy are shaped by the condition in which these colors have been preserved and the manner in which they are presented today. Such factors can skew our perception of the original appearance and the splendor these monumental ensembles would have conveyed in their historical context.

Additionally, this study was inherently constrained by the data obtainable through direct examination using digital microscopy and the information available from restoration reports. Chemical analyses are limited to elements that have undergone restoration, as exemplified by certain capitals in the cloister of Sant Cugat del Vallès (c.1190, Figure 2) [17]. This reliance on selective evidence underscores the challenges of reconstructing the original chromatic schemes of these medieval structures.

Despite these limitations, it is possible to identify recurring features in the polychrome capitals of cloisters within the Catalan counties. My research has identified a total of eight cloisters preserving polychrome vestiges on their capitals. In all cases, the study of color and its characteristics relied on direct observation and examination using a digital microscope. The only cloister for which detailed restoration information on the polychrome layers is available is Sant Cugat, which will be discussed in greater detail below.

Figure 2. The capital 129 polychromy (Museum of the Monastery of Sant Cugat del Vallès): *a)* original; *b)* reconstruction [17].

Based on visual observation, a predominant characteristic is the prevalence of red, ochre (mainly reddish, yellowish and brownish ochres), and black pigments. These colors might have been better preserved due to the chemical stability of their pigments, enabling them to withstand the effects of time more effectively. These colors are typically visible on the general surface of the capitals, whereas other hues, such as blues and greens, are often found in more protected areas. The latter have undergone changes in their shades as they are generally more prone to physicochemical processes. The predominance of red, ochre, and black, attributed to the chemical resilience of the pigments used, is not unique to polychrome sculpture but is also a notable feature in Catalan mural painting (especially *secco* techniques) [6, 18-19].

Unlike the application of polychromy in the large porticoes, where more saturated and bright pigments or imported from other territories were used and were observed by a wider public, which influenced their dogmatic and didactic function [6], in the Catalan polychrome cloisters mostly local or common pigments were used. For example, the color black vine used to be obtained by calcination of selected woods or fruits and seeds, known in Catalan as *negre vinya* and in medieval artistic manuals as *nigrum optimum*. This type of black could probably be the same as seen in various Catalan cloister assemblages such as Sant Cugat del Vallès (Figure 3) and perhaps also, although we do not yet analytical data, in Sant Pere de Galligants (c. 1170-1185) and Sant Joan de les Abadesses (twelfth century).

Figure 3. Color black found at *E* Romanesque gallery, cloister of the Monastery of Sant Cugat del Vallès, Vallès Occidental, Catalonia, c. 1190.

Figure 4. Color red, like cinnabar and clays present in: a) E Romanesque gallery, cloister of the Monastery of Sant Cugat del Vallès, Vallès Occidental, Catalonia, c. 1190; b) W-S Romanesque gallery, cloister of the Cathedral of Santa Maria de Girona, Gironès, Catalonia, second half of the 12th century; c) N Romanesque gallery, cloister of the Monastery of Santa Maria de Lluçà, Lluçanès, Catalonia, c. 1172–1206; d) Capital from the old romanesque cloister of the Monastery of Sant Pere de Camprodon, Ripollès, Catalonia, 1150–1200 (photograph: Museu d'Art de Girona, núm. reg. MDG0034. Fons del Bisbat de Girona. Rafel Bosch).

For red, cinnabar (or vermilion), clays, and minium were commonly employed in portals, cloisters and other sculptoric reliefs. It should be noted that cinnabar and clays seem to be the pigments that predominate in the preparation layers, as can be seen – through optical microscopy – in the examples of Sant Cugat (Figure 4a), Santa Maria de Girona (second half of the twelfth century, Figure 4b), Santa Maria de Lluçà (c. 1172-1206, Figure 4c) and a capital of the disappeared cloister of the Monastery of Sant Pere de Camprodon (twelfth century, now exhibit in the Museu d'Art de Girona, Figure 4d).

Figure 5. Red color in the carnations and drapery at S Romanesque gallery, cloister of the Monastery of Sant Cugat del Vallès, Vallès Occidental, Catalonia, c. 1190.

The widespread application of red in the carnations and drapery (Figure 5) suggests that the remnants of red may have served as a preliminary base for the subsequent application of rich tonal nuances and additional pictorial layers [6]. It seems unlikely that the red in this instance corresponds to traces of red bole (commonly used in the preparation and application of gold and other metal leaves), as it is distributed extensively across the entirety of the figure [20, book I, rec. I-XIII, XIV]. Nevertheless, we cannot exclude the possibility that gold or other metal leaves were applied to certain areas of the figures, although no such traces have been preserved.

These procedures highlight the technical complexity involved in the application of color and the expertise required by the polychrome craftsmen of monumental sculpture. One could conceive of their mastery as a process of gradual learning, akin to the process described by Cennino Cennini in his treatise *Il Libro dell'Arte*.:

> *Capitolo CIII – Come dal muro pervieni a colorire in tavola: […] E tieni bene a mente, che chi imparasse a lavorare prima in muro e poi in tavola, non viene così perfetto maestro nell'arte, come perviene a imparare prima in tavola e poi in muro.* [21, cap. CIII]
>
> *Capitolo CIV – In che modo dèi pervenire a stare all'arte del lavorare in tavola: Sappi che non vorrebbe essere men tempo a imparare: come, prima studiare da piccino un anno a usare il disegno della tavoletta; poi stare con maestro a bottega, che sapesse lavorare di tutti i membri che appartiene di nostra arte; e stare e incominciare a triare de' colori; e imparare a cuocere delle colle, e triar de' gessi; e pigliare la pratica dell'ingessare le ancone, e rilevarle, e raderle; mettere d'oro; granare bene; per tempo di sei anni. E poi, in praticare a colorire, ad ornare di mordenti, far drappi d'oro, usare di lavorare di muro, per altri sei anni, sempre disegnando, non abbandonando mai nè in dì di festa, nè in dì di lavorare. E così la natura per grande uso si convertisce in buona pratica. Altrimenti, pigliando altri ordini, non sperare mai che vegnino a buona perfezione […].* [21, cap. CIV]

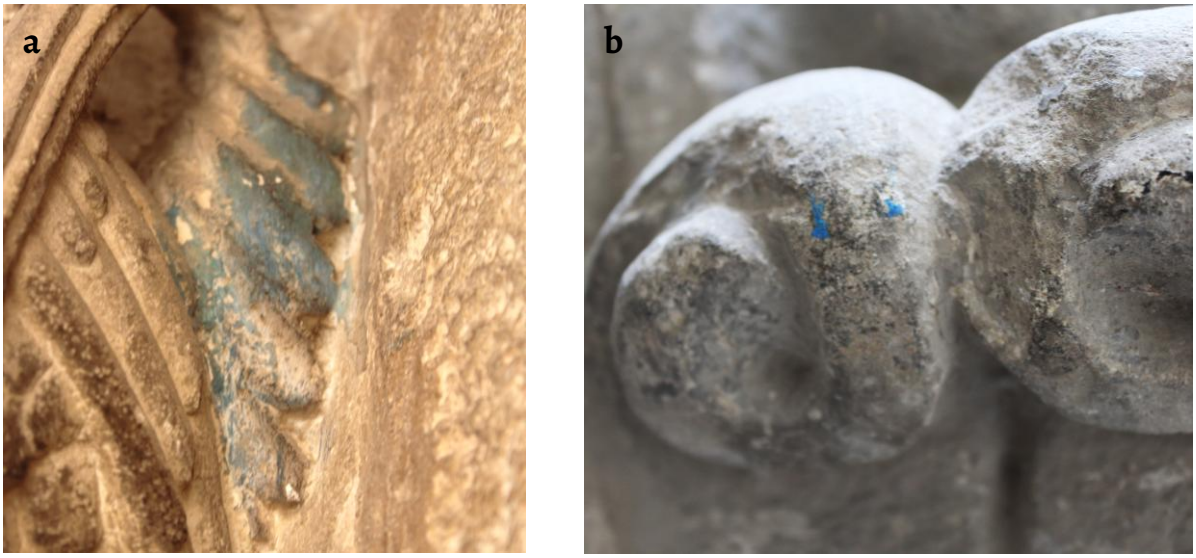

Figure 6. Blue color present in: a) S Romanesque gallery, cloister of the Monastery of Sant Cugat del Vallès, Vallès Occidental, Catalonia, c. 1190; b) Capital from the Romanesque gallery, cloister of the Cathedral of Santa Maria de la Seu d'Urgell, Alt Urgell, Catalonia, end of the 12th century / beginning of the 13th century.

Continuing the investigation into the colors and materials employed in polychromy, particular attention should be given to two notable capitals that have retained a blue color. One is located in the cloister of the Monastery of Sant Cugat del Vallès (Figure 6a), and the other in the cloister of the Cathedral of La Seu d'Urgell (late twelfth century to early thirteenth century, Figure 6b). Although chemical analyses are not available for the latter, capital 129 from Sant Cugat has undergone restoration, yielding valuable samples that reveal a complex composition [17, pp. 198-199].

Analysis of samples taken from the garments indicates the presence of a white base (preparation layer) of lead white and calcium carbonate in a proteinaceous binding medium, over which a bluish top layer was applied. This blue hue was achieved with either lime blue (the origin of the term *lime blue* probably lies with the production of the synthetic copper carbonate hydroxide pigment known as blue verditer. In addition, lime blue was a then-current term for a "variety of ultramarine") or verdigris [22, pp. 245-246]. The purpose behind this bluish color is particularly noteworthy; restorers have suggested that it may have been intended to emulate the ultramarine blue derived from lapis lazuli [17, pp. 198-199].

Additionally, other blue particles have been identified in samples from the eyebrows and pupils, accompanied by black vine and calcium carbonate. These elements form a *ueneda*, a term referenced in treatises such as those by Theophilus and Cennini, which describes a preparation layer used both as a base for applying blue pigments and for detailing features such as pupils and eyebrows [20, book I, rec. VI, XIII, XV; 23, pp. xxxvi, xxviii].

Moreover, the discovery of *tapaporos* (porosity sealer, previous to preparation layers) on several capitals of Sant Cugat provides further insight into the methods employed in the preservation of polychromy. These *tapaporos*, composed of calcium carbonate and iron ochre with added lead white, underscore the meticulous efforts to ensure the long-term durability of the painted surfaces. The primary function of these *tapaporos* was to create an initial priming layer for the stone, effectively sealing it to minimize the impact of moisture on the overlying pictorial layers.

This discovery highlights the dual significance of polychromy in medieval monumental sculpture. On a technical level, the careful preservation of color was essential to maintaining the visual integrity of the artwork over time, ensuring that its intended appearance would endure despite environmental challenges. However, this technical aspect was inseparable from the symbolic and communicative function of polychromy.

The vibrancy and clarity of color were integral to the sculpture's role as a didactic and spiritual medium, conveying theological messages and reinforcing Church dogmas. By safeguarding the pigments and their brilliance, craftsmen ensured that the artwork's communicative power remained intact, enabling it to effectively engage and educate its audience across generations. However, we must exercise caution when interpreting these colors today, as the oxidation process of most pigments (primarily those of a green hue) can result in a perception that differs from the original intention.

So far, we've only mentioned the black, red, and blue colors. However, we must assume that the original polychromy of the medieval Catalan cloisters would have encompassed the entire range of primary colors, including those that we have not yet mentioned (the range of primary colours it can also be observed in Catalan Romanesque panel painting, which shares many technical and material similarities with sculptural polychromy) [24-25].

A particularly noteworthy case is the use of white, which did not primarily function as an independent color but served as a preparatory base to enhance the saturation and brilliance of other pigments. As such, white is commonly observed in the preparatory layers of stratigraphy, often in combination with red layer. The most frequently employed materials for this purpose included lead white, as well as, to a lesser extent, lime, calcium carbonate, and gypsum [12, 18, 24-25].

Similarly, the analysis of yellow and green pigments in cloister ensembles offers intriguing insights, as these colors are notably scarce or almost absent from the chromatic palette applied.

In the case of yellow, current evidence does not indicate the presence of orpiment or gold leaf on the sculptural surfaces of any cloisters within the Catalan counties. While the original material used for yellow remains uncertain, the color is most likely derived from ochres. These natural pigments provided a wide tonal range, from yellows to oranges and reds, and were both highly versatile and readily available in the region. This accessibility suggests that ochres were the primary material used for yellow hues in the cloisters under study.

The analysis of green pigments, the least prevalent color in preserved polychrome cloisters, reveals their scarcity probably as a consequence of the chemical instability associated with green pigments, particularly those containing copper [6, pp. 173-175]. While the green color was often produced with likely synthetic copper greens, such as verdigris, more stable alternatives, like green earth pigments (e.g., celadonite and glauconite), were also utilized.

Among the cloisters examined, only those of Girona Cathedral and Sant Cugat del Vallès exhibit evidence of greenish patinas. However, in the case of Girona Cathedral, the observed green coloration does not appear to be directly related to the original polychromy. Instead, it seems to result from environmental factors, such as humidity, which promote the growth of mold or fungi. A definitive determination of its origin would require further analysis.

Conversely, in the cloister of Sant Cugat, the use of green pigments has been confirmed in specific overpainted areas on capitals 129 (representation of a dance, Figure 2) and 139 (Annunciation, Figure 3) [17, p. 195]. These pigments comprise ochres and green earth, the latter being mentioned in medieval art treatises by authors such as Theophilus and Cennini, who describe it as an ideal pigment for depicting human faces – a practice also observed in Byzantine traditions [26-27]. Known as *prasinus* in medieval treatises, green earth was frequently mixed with white to produce lighter tones. This technique is evident in the present study [17, p. 195], where the pigment was combined with a calcium carbonate layer and, in another instance, with white lead [20, book I, rec. II; 23, p. xxxvi].

It is important to point out certain differences in terms of the material and technique used in the polychromy of Catalan medieval monumental sculpture, especially between

the large porticoes and the cloisters. These examples illustrate how the application of sculptural polychromy was influenced by the function and use of these spaces [6].

It is widely recognized that the Gregorian Reformation (c. 1050-1125) found in monumental sculpture and its polychromy a means of spreading the dogmatic principles of the Church [28]. The sculpted porticoes became a *mise-en-scène* of liturgical life carried out within the sacred space. The Romanesque portals, therefore, became a speaking face [29-33; 34, p. 29], a resource through which the Church established a connection with the viewer, capturing their attention through the abundance of richly painted images. Consequently, the porticoes required a bright and saturated polychromy, intended to attract the attention of the faithful, and consequently higher quality pigments and materials were used [6].

On the other hand, I think that the cloisters, spaces characterized by their more reserved character and intended for the privacy of the religious community, were only accessible to those who resided in the monastic complexes. Therefore, it was not imperative to use luxury or high-quality pigments, but rather those that were readily available in the region or cheaper to acquire. Likewise, we must also consider the option that monastic complexes would use expensive pigments in the production or decoration of other arts, such as in the production of books and illuminations. These dissimilarities were reflected in the use of colors such as yellow, blue and green: in the cloisters, ochre, black vine or lime blue were used, as well as green earths; while, for example, in the portico of Agramunt (1283), the same colors were applied with higher quality pigments, such as orpiment, indigo blue and malachite (Figure 1b) [35-36]. These distinctions in the application of polychromy and its materials in monumental sculpture not only reflect the symbology of color, but also act as an indicator of the uniqueness of these spaces and the disparities in their functions and uses.

Color parallels: the polychrome work in its environment and other cross-border examples

The study of sculptural polychromy not only gives us the opportunity to analyze the techniques employed by the artificers, but also to identify color-related and material similarities with other artistic ensembles both inside and outside the territory, allowing us to make meaningful comparisons.

These comparisons can be made in artistic ensembles from different places, but from the same territory, or in different works that are part of a single building. For example, in the Monastery of Santa Maria de Ripoll, we find several relevant examples of sculptural polychromy [37]. This complex houses its paradigmatic Romanesque portico (c. 1140, Figure 1a), polychrome and repainted [38-40]; the Romanesque north-western wing (c. 1160-1170, Figure 7a) and the Gothic south-western wing (c. 1390-1400, Figure 7b) of the cloister with traces of color in several of its capitals [41]; the polychrome image of the *Maiestas Mariae* (mid thirteenth century, Figure 7c) in the southern wing of the cloister [42]; and the bases of the old stone canopy (c. 1150), now exhibited in the Museu Nacional d'Art de Catalunya (MNAC), which underwent a restoration treatment during which the original colors were studied [43]. All of them create a polychrome program for the monumental sculpture of the monastery, presumably with the aim of creating a sense of aesthetic unity and evoking the colorful Heavenly Jerusalem [44]. In addition, there is a coherence in the use of materials, particularly in the use of red obtained from clays and iron oxides, present in the polychromy of all these works of the monastic complex, as well as in the Romanesque mural painting of the eleventh century that is hidden behind the stone portico of the twelfth century [40, p. 178; 45-46].

Figure 7. Examples of sculptural polychromy from Monastery of Santa Maria of Ripoll: *a) N-O* Romanesque gallery of the cloister, c. 1160 – 1170; *b) S-W* gothic gallery of the cloister, c. 1390 – 1400; *c)* image of the Maiestas Mariae in the cloister, mid-13th century.

Another type of comparison that can be examined through the use of color and its materials in nearby territories is through the material craftsmanship of the works. For example, the similarity in the use of the color red (referring to the use of the same pigment or very similar and the use related to specific areas and figures) in the capitals of Ripoll, Sant Joan de les Abadesses and Lluçà suggests a possible connection with the so-called *Ripoll Sculptural Workshop* [47-49], which is believed to have been not only the material architect of the capitals of these cloistered complexes, but also that of the portal of the Monastery in the same town of Ripoll.

We also have another relevant case such as that of the figure of Arnau Cadell [50], architect and sculptor who left a record of his self-portrait and signature in his sculptural work in the cloister of Sant Cugat del Vallès. This monastery shares a marked similarity in iconography and in the application of polychromy with another cloister designed by the same architect, that of the Cathedral of Girona. It can be observed, for example, in the same generalized application of red in the figures of the capitals as a possible preparation layer.

It is plausible to consider that, similarly to the existence of workshops or masters in charge of sculpture in a territory, there were also artisans specialized in the polychromy of these sculptures. It is likely that both professionals formed a collaborative binomial that allowed them to work together to enrich the artistic expression of the ensembles, both in their formal and chromatic aspects, while maintaining their role and professional status independently. A fact that in Gothic monumental sculpture is evidenced by clearly documented examples, such as the famous *Well of Moses* (1395-1404) in the Carthusian monastery of Champmol in Dijon, a collaborative commission between the sculptor Claus Sluter and his nephew Claus de Werve with the painter Jean Malouel, who was the best-paid painter of the Burgundian court at the time [51-52].

The parallels in the use of color, particularly red, transcend contemporary territorial boundaries, illustrating a shared artistic practice within the former domains of the Crown of Aragon. These similarities are not only evident in the visual effects of the color but also in the application techniques and the choice of pigments, which appear to be strikingly similar due to their chemical and physical properties. The red hues applied in these sculptural ensembles exhibit common features in both technique and composition, suggesting that the same or closely related pigments were used across various regions. Notably, this phenomenon is observed in the cloister of the Monastery of San Juan de la Peña (second half of the twelfth century, Figure 8), the Collegiate Church of Santa María de Alquézar (c. 1150), and the Monastery of San Pedro el Viejo in Huesca (thirteenth century) [53].

Figure 8. *S-W* Romanesque gallery, cloister of the Monastery of San Juan de la Peña, Botaya, Aragón, Spain, second half of the 12th century.

The application of red in these areas follows a consistent pattern, with the pigment being applied in similar layers and techniques, such as in underpainting or as a foundational base, to achieve specific tonal effects. This is also reflected in the specific red pigments used, which likely include cinnabar or vermilion, common in this period due to their stability and vivid hue. Such uniformity in the pigment composition and application is evident across different regions once under the Crown of Aragon, highlighting the interconnectedness of these areas in both artistic and technical practices.

A comparable pattern can be seen in southern France, which was also part of the Crown of Aragon, where the use of red in polychromy appears to follow similar principles. This is observable in the capitals of the Cathedral of Elna (end of the twelfth century, Figure 9), the Monastery of Sant Martí del Canigó (late twelfth to early thirteenth century), and the Priorat of Serrabona (mid- twelfth century) [53].

These cross-border similarities, particularly in the application and material composition of red pigments, underscore a cultural and stylistic connection within the Crown of Aragon. The movement of workshops and the exchange of technical knowledge, materials, and methods, likely facilitated by pilgrimage and trade routes, played a crucial role in the preservation and continuity of polychrome techniques across these territories, ensuring a cohesive artistic identity throughout the region [6].

Figure 9. Details from S Romanesque gallery, cloister of the Cathédrale d'Elne, Pyrénées-Orientales, Occitanie, France, end of the 12th century: *a)* figure from the scene of the Conversion of Paul, carved on the southeast pillar; *b)* pair of capitals from the south gallery featuring four lions and a central motif with a four human faces.

Topography of polychromy in a cloister: Santa Maria de Lluçà and Sant Cugat del Vallès

I would like to conclude this analysis of the chromatic splendor of the medieval cloisters of the Catalan counties, with a special mention of the cloisters of Sant Cugat del Vallès and Santa Maria de Lluçà, previously mentioned. These two cloisters not only show a similar appearance characterized by the widespread presence of red on the surface of the capitals, but also share similarities in terms of the distribution of polychromy in their cloistered wings and their visible wear on different capitals. I will refer to it as the "topography of polychromy" in the cloister (Figure 10).

On the one hand, it can be seen how, in both cases, the north wing (N) is the one that retains the least polychromy in its capitals, unlike the eastern (E) and southern (S) wings that house more polychrome capitals. On the other hand, it is striking that also, in both cases, there is a more noticeable wear of the polychromy in the capitals located in front of the door that connects the church with the cloister. This phenomenon could be linked to the performance of specific liturgical rites and blessings, such as those performed on Palm Sunday. The act of sprinkling holy water, which often contained salts, may have accelerated the process of degradation of the capitals and, therefore, of their polychromy [53].

In addition, in the case of Sant Cugat, his Costume and Cartulary [54] details the use of torches to illuminate the entire cloister, a fact that may also have influenced the wear and tear of certain capitals and the deterioration of their polychromy, mainly in those closest to the corners of the cloistered wings.

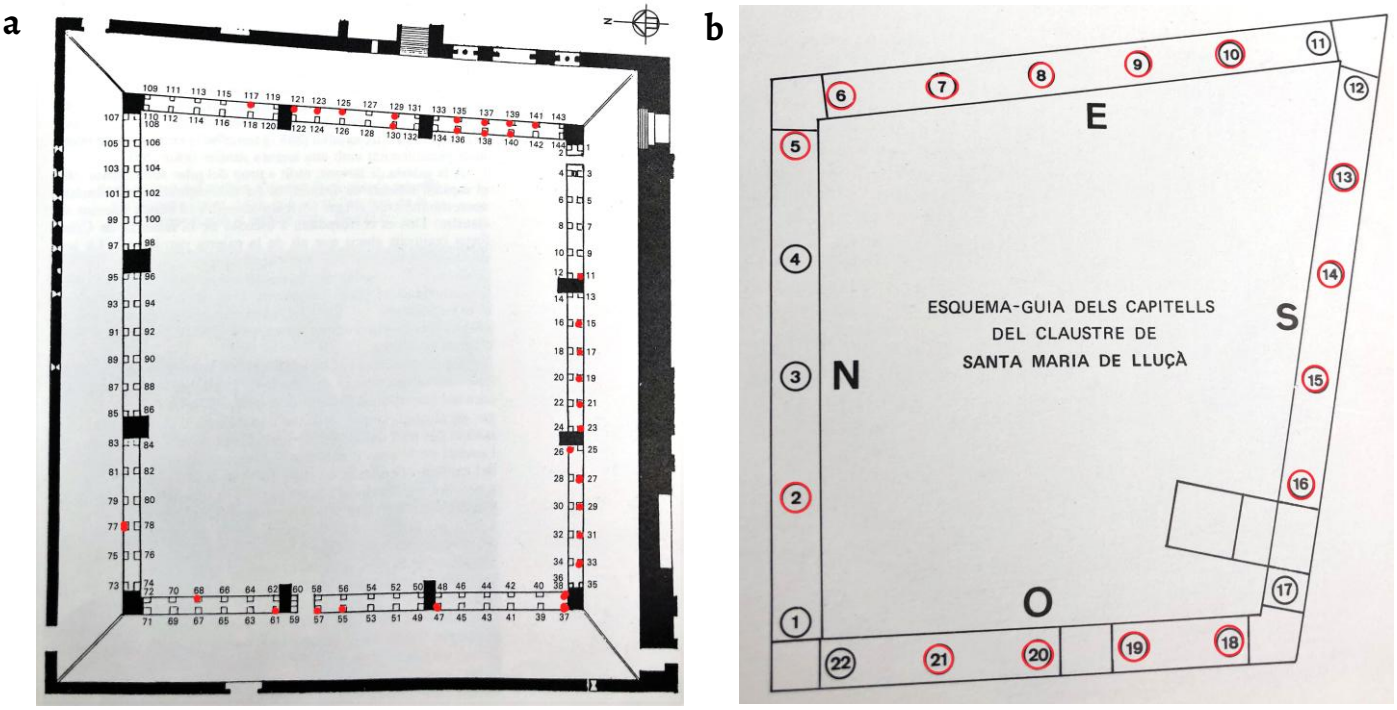

Figure 10. Map of the Monastery cloisters showing the topography of polychromy: *a)* Sant Cugat del Vallès, Vallès Occidental, Catalonia, c.1190; *b)* Santa Maria de Lluçà, Lluçanès, Catalonia, c. 1172–1206.

Localized degradation in certain capitals of the cloisters is a factor that should be taken into greater consideration, as it is a key factor in understanding the use and functions of these spaces and the relationship of polychromy with its immediate surroundings.

Conclusions

Based on the collected testimonies, it can be asserted that polychromy in medieval sculpture extends beyond its mere technical execution and practical application. The polychromy of these cloisters should be understood in relation to both their environment and the iconography of their figures. The application of color not only contributed to the stylistic richness of the sculptures but also enhanced their visual impact, making their meanings more accessible and comprehensible.

This phenomenon calls for interdisciplinary research that investigates the interconnections between color and various fields of study. From a symbolic perspective, color served as an intermediary, representing concepts such as the distinction between good and evil or the power of specific figures. From a liturgical standpoint, it is crucial to understand the role of these spaces in daily rituals and how their use may have influenced the preservation of the polychromatic surfaces. Additionally, the role of the painter – how they worked within a cloistered setting and collaborated with sculptors – deserves closer examination. Finally, the "polychrome cross-border parallels" highlight the significance of color in monumental sculpture across regions, underscoring the role of itinerant workshops and the cross-border trade of pigments and materials.

The chemical analysis of materials, study of pictorial stratigraphy, and investigation of possible repaintings would further illuminate and enrich these ideas, which can already be partially discerned through the surviving pictorial remnants.

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