Chapter Seven

Students’ Assignments

Carmen Joubert: THC 801

Carmen Joubert, for her first assignment on a biographical object, meant to introduce the students to each other, wrote about her great-grandmother’s suitcase that she has used constantly during her life. She was part of the 2021 intake of students.

My suitcase

Figure 1: A vintage Basset travel trunk from the 1930s. It is an Air Force blue rectangular suitcase, roughly 0,8 m x 0,5 m in size. The suitcase itself is made out of hardboard. It has a unique locking mechanism made of metal, with a wooden handle. It belonged to my maternal great-grandmother.

‘Our battered suitcases were piled on the sidewalk again; we had longer ways to go. But no matter, the road is life.’—Jack Kerouac, *On the Road.*

I chose my suitcase as my autobiographical object. A dusty blue case that has become one of the most significant objects in my life as the child of a diplomat. Not only has it been one of the few constants throughout my travels, but it has also become a symbol of the values I have gained. I have used it over the years to carry my personal possessions from place to place, no matter the distance.

My suitcase connects me to the past, present, and future. My ancestors, French Huguenots, sailed to South Africa between 1688 and 1691, mainly to flee from religious persecution. During this time, suitcases stood as a symbol of change and travelling towards the unknown—something I have had my fair share of throughout my life. With the unpredictability and turmoil of modern society, a suitcase is something that cannot be replaced by technology. This is perhaps one of the most comforting aspects of the suitcase—being an element that ties me to the past and simultaneously transcends time simply because its form directly follows its function. It is my totem, an anchor tying me to reality.

Even though I do not have a strong connection to my ancestors, I know that settling somewhere new can be difficult. As the daughter of a diplomat, I have lived in five countries—most recently India, where I completed my honours degree and my younger sister ended her high school career. From a young age, I've had to learn to look forward to big changes and adapt to create positive and valuable experiences. This mostly led to my sister and I building a lot of moving-box forts, an essential step in the unpacking process. But it also gave us perspective on what we carry when we move.

'Though we travel the world over to find the beautiful, we must carry it with us, or we find it not.'—Ralph Waldo Emerson, *Emerson's Essays.* What fits into a small suitcase? What's important to you? Sometimes, it becomes too heavy and so we have to repack our belongings so they fit, discarding what is no longer needed and finding new ways to arrange what matters. In the same way, we make and remake the luggage we carry to fit our new, built world. I've found that this doesn't only apply to what we pack—what I carry inside my suitcase—but also to identity. Marcel Proust writes in the fifth volume of *In Search of Lost Time*: 'The real voyage of discovery consists not in seeking new landscapes, but in having new eyes.' Travel has allowed me to gain new insight into so many different cultures. It has gifted me with new ways of seeing and experiencing without preconceived ideas and judgements. But these new eyes and cherished fragments of the world I carry with me in my suitcase, a special form of uncertainty in who I am, were brought along with them. When I was younger, I thought I was Peruvian, and when we came back to South Africa from our posting in Uruguay, I couldn't identify with anyone in my primary school. My life has been a process of constant cultural recalibration, something that might create what seems to be a confused suitcase to the normal tourist—a jumbled mix of untidy memories. The niche and mysterious samples of an obscure collector.

Evolving suitcase contents mirror evolving identities because with adaptation comes a change in what version of me I attach myself to. I can see many of my own qualities in my suitcase—a hardened exterior that can withstand many climates and tumbles, even falls. Sometimes the contents stay protected, and other times they become damaged by the rain or lost and forgotten. My suitcase has some enviable qualities too; it shows every mark and scratch, every etched memory exposed and remembered exactly, every stain from a once-resting Chai cup on a train from Delhi that was delayed by hours, every scuff from a clumsy traveller on a packed bus in Italy in the hot summer.

Every imperfect memory carved into it creates an irreplaceable object woven with countless moments that give it a sense of place. It belongs somewhere, to someone who very often feels misplaced.

'Wherever you go becomes a part of you somehow.'—Anita Desai. Only my suitcase can carry what is most important to me. My little suitcase has become a symbol of the valuable experiences and lessons I have picked up from my travels. It is the most significant part of every trip. In the same way, one of my favourite films, *The Darjeeling Limited,* directed by Wes Anderson, depicts suitcases as a symbol of the characters' journey. Three brothers reunite for a quest on the Darjeeling Express to find their estranged mother after their father passes away. With their father's passing, great emphasis is put on his physical belongings such as his glasses, which the older brother insists on wearing even though they give him a headache. As well as the glasses, the suitcases that once belonged to him also accompany them on the trip. They are authentic calf-leather, 'classical style' 60s suitcases decorated with his initials, J.L.W., and a series of tropical motifs: giraffe, rhinoceros, antelope and palm trees. One of the brothers, Francis, says towards the end of their journey, when they have come to realise that the trip wasn't really about finding their mother at all but rather to gain self-awareness and self-acceptance: 'Dad's bags aren't gonna make it.' They don't, and only the essentials remain. Before the event where they leave their father's suitcases behind, their train gets lost and one of the brothers asks how far off course they are. One of them replies: 'Who knows? We haven't located us yet.' Maybe I haven't located myself yet either, but I can trust my suitcase to keep track, and that has a lot of value. Once the luggage in *The Darjeeling Limited* sheds its meaning as a metaphor for the brothers' emotional baggage, these suitcases become a clear and significant symbol of what they gained on their journeys.

'The journey itself is my home.'—Matsuo Basho. I can build a home out of my suitcase. My suitcase is my comfort, my constant through all these years of travel. I can't imagine not travelling, not having to settle somewhere new, not having to fight to fit in and make connections and then say goodbye just as things felt 'complete'. Because in those areas of insecurity and discomfort and change, that's where my suitcase lives. My suitcase can be picked up in the hazy realm at any time, ready for a new expedition. In the past, present and future, my suitcase makes a home for me.

Salomé Le Roux: THC 801

Salomé le Roux was one of the first three students to register for the THC programme. She completed her degree in 2020 and is continuously studying South African artists' materials. She was also appointed assistant lecturer on a yearly contract.

Introduction

The Kingdom of Benin and its people have an emotional, spiritual and contextualising relationship with their art objects. This essay attempts to demonstrate that the art objects, such as the Benin bronzes, have a long existence in the history of the Kingdom of Benin and are an intrinsic part of its social and political structures, as well as its cultural and spiritual practices.[1] First, the context is set. A brief history of the Kingdom of Benin is discussed, in order to situate the production and use of the Benin bronzes. Thereafter, the concept of Benin art is elaborated on, as it sprang from the brief history discussion. Once the context has been set, a discussion of the British punitive expedition of 1897 and how the Benin bronzes came to be in museums around the world is established. At the end, before concluding the argument, I make my case for the restitution of the Benin bronzes. The argument is based on the intangible aspects of tangible cultural heritage and their importance in the formation of identity and legitimacy of the Benin people. Even though it is not within the scope of this essay to provide possible restitution solutions, the conclusion touches on various possibilities for the restitution of cultural property and heritage.

Context

A short history of the Kingdom of Benin

Benin is a kingdom in Edo State, Southern Nigeria, West Africa. Its capital is called Benin City, and even though the kingdom, the capital and the art are known as 'Benin', the people call themselves, their kingdom, their language and their city 'Edo' (Ben-Amos 2003).

1 For the purpose of the essay, I refer to the Benin plaques as either the Benin bronzes or plaques. The plaques are known as the Benin bronzes, even though they are in fact brass objects.

Figure 1: Representation of the territory of the Kingdom of Benin
at the height of its power (Blier 1998:44)

In the fifteenth century, when Portuguese explorers, on their quest to find a route to India, came into contact with the Kingdom of Benin, they found a powerful and prosperous civilisation (Ben-Amos 2003). Little is known about the history of the Kingdom before contact with the Portuguese, but oral histories and traditions of the area suggest that the dynasty was initiated in or before the fourteenth century (Ben-Amos 2003).[2] From the mid-fifteenth to the end of the sixteenth century, the Kingdom of Benin, under the rule of five consecutive warrior kings, or obas—Ewuare, Ozolua, Esigie, Orhogbua and Ehengbuda—became a force to be reckoned with.[3] According to Paula Ben Amos (2003), this was the period

2 According to Werner Gillon (1984: 248), oral histories and traditions refer to 'an old "dynasty", that of the Ogiso . . . whose rule over the city of Benin is said . . . to have begun about A.D. 900'. However, according to these oral histories and traditions, in the twelfth century, a rebellion ended the Ogiso, and a new king from Ife, Oranmiyan, was sent to Benin at the request of the city elders (Gillon 1984: 248).

3 The Kingdom of Benin, after contact with the Portuguese and at the height of its power, covered an estimated 10 400 km2. Figure 1 represents an idea of the reach and size of the Kingdom of Benin in the late sixteenth century.

in which the obas 'extended the boundaries of the kingdom and established the core institutions, rituals and art forms that were to characterise the kingdom through the remaining centuries of its independence.'

The oba inherits spiritual powers from his predecessors as well as his royal possessions, such as the royal relics, regalia, insignia and paraphernalia (Ben-Amos 2003). [4] The first of the warrior obas, Ewuare, is credited for the creation of the layout of Benin City, the organisation of the chiefly associations, the centralisation of politics and administration, and the artistic organisation in the Kingdom of Benin (Ben-Amos 2003). Regarding the first attribution, Benin City was divided into two parts, the oba's area, called Ogbe, and the town at large, Ore n'Okhua, with the oba's palace, Eguae-oba, at the centre of Ogbe and Benin City (Ben-Amos 2003).

From traveller's reports, writings and recollections, the Eguae-oba of the oba was the 'hub of the nation', with many visitors, dignitaries and travellers describing it as being 'a vast complex covering several hectares, containing not only the residential quarters of the king and his numerous wives and offspring but shrine rooms, council chambers, work spaces for guild members, and extensive storage areas for the ritual paraphernalia, tribute and other property of the king' (Ben-Amos 2003).

The Eguae-oba was intricately decorated with depictions of his exploits and feats—his status imagery. According to two accounts—one from 1686 by Dapper, a seventeenth-century traveller, and the other by British forces in the nineteenth century—the Eguae-oba was described as having 'beautiful long galleries with pillars covered with cast copper, on which are engraved the pictures of their war exploits and battles . . . [and] lintels and rafters of the council chambers and residential areas were lined with sheets of brass covered with geometric repoussé designs' (Ben-Amos 2003, Blier 1998: 60). Cyril Punch, a British trader and traveller to Benin in 1889, described what he saw at the palace of the oba: 'mostly statuettes and plaques in deep relief, portraying scenes in the history of Benin and commemorative tablets of dead kings' (Ben-Amos 2003).

This period of expansion and cultural, social and political development is especially depicted on the 'low-relief plaques that apparently once adorned the palace walls' (Ben-Amos 2003). This brings the discussion to the third

4 The oba was considered a divine king—he was simultaneously human and god and stood in a special and direct relationship with the ancestors and other Benin deities (Ben-Amos 2003).

creation attributed to Oba Ewuare, the artistic organisation. Oba Ewuare and his successors were patrons and promoters of the arts by initiating and sustaining policies and procedures of its development and promotion. After contact with the Portuguese, and the subsequent importing of coral beads, red cloth, headgear, and brass bars, the artistic practices of Benin guilds and crafters expanded (Ben-Amos 2003).

After trade with the Portuguese faded, the Kingdom of Benin continued trade and commerce with other Europeans, especially the Dutch, French and English. Prosperity continued until about the late seventeenth century, when an oba died without an heir, and nine subsequent claimants and kings could not establish their legitimacy. The first to do so, at the beginning of the eighteenth century, was Oba Ewuakpe, and later Oba Akenzua I, by establishing a legitimate line and introducing primogeniture to the royal house (Ben-Amos 2003). Again, through political, economic and artistic means, the obas of the eighteenth century brought about authority, peace and trade. The arts, especially, flourished and were used to depict the recovery of the royal house and its divine connection and dependence on spiritual powers of validity. Ben-Amos (2003) describes various examples, such as

> elaborately carved ivory tusks set on brass memorial heads on the royal ancestral altars and altarpieces; a rectangular tableau depicting the king in his most elaborate attire at the main divine kingship rituals, a clear reflection of the concerns of the time. A number of singular objects were also created: a magnificent cast-brass stool decorated with motifs signifying mystical power and alluding to the great 16th-century king, Esigie; a series of brass masks (examples, London, BM) used in a ceremony honouring Ododua, the founder of the royal dynasty; a sceptre (New York, Met.) depicting the monarch who overthrew the most powerful rebel chief; and a brass head (London, BM) depicting birds surmounting a human head, recalling the mystical powers of the forest that support the kingship.

By the end of the nineteenth century, the Kingdom of Benin's territory was threatened from the north, the east and the coast. The Kingdom was an obstacle to the British expansion into the interior of Western Africa, and after the ambush and murder of a British envoy on their way to the oba, the British launched the punitive expedition of 1897 (Ben-Amos 2003). The Kingdom of Benin lost its independence, and the oba was exiled. However, when Oba Eweka II attained the title and status of oba in 1914, Benin was reinstated as a centre of art production (Ben-Amos 2003).

Benin art

Figure 2: The Benin plaques displayed in The British Museum, London (Bailey 2018)

Throughout the various rulers' reigns, the oba was the primary patron of the arts. He commissioned art objects of brass, ivory, iron and wood for his Eguae-oba and shrines and ceremonial dress and objects of coral beads, cloth, metal and leather for use in the annual cycle of royal rituals.[5] According to Ben-Amos (2003), the estimated 1 000 brass plaques that adorned the Eguae-oba's walls 'portray a variety of court figures – warrior chiefs, priests, musicians, kings, officials and servants – as well as such animals as leopards, snakes and crocodiles, symbols of the oba's ferocious power.' Figure 2 shows the various imagery on the plaques, which are displayed in the British Museum. The most prestigious craftsmen in the Kingdom of Benin were the brass casters. In the lost-wax technique, the commissions included 'commemorative heads, elaborate tableaux and figures

5 Chiefs and priests were permitted by the oba to acquire and own similar dress and objects, but of inferior quality and intricacy (Ben-Amos 2003).

of horsemen and messengers for the royal ancestral altars and plaques depicting court life and royal triumphs for the palace walls' (Ben-Amos 2003).[6]

There is no doubt that the creation of the brass plaques required a high level of skill and artistic ability. The significance of the brass material in the plaques is important. The brass is considered enduring, permanent and powerful, and it is associated with inherent power that can ward off evil and bad luck. It is thus well-suited to preserving, protecting and treasuring the accomplishments of obas, the politically and culturally significant events and moments, and to enforcing their permanence as a people (Ben-Amos 2003). The prevailing iconography on the Benin plaques makes specific references to the social and political power and status of the Kingdom and obas to those who would view them on the Eguae-oba walls (Layton 1991: 75).[7] Figure 3 is a representation of an oba flanked by his aids and servants. The diminished sizes in relation to the oba are reflective of their social status and rank. The title of the plaque, as given on The British Museum website, is indicative that the plaques lack their history, understanding and significance.

For the people of Benin, Benin art is intricately intertwined with their history. The art objects created are a means to preserve, protect and treasure their past. This relationship between Benin art and Benin history is most prominent in the brass plaques (Ben-Amos 2003).[8] During the latter part of the twentieth century, the plaques are interpreted as depicting events, scenes and moments from their past. The plaques are used to reconstruct the history of Benin as captured in the collective memory of these objects (Gillon 1984: 259). As observed by Dapper and Punch (referred to earlier), the link between art and history in Benin was a well-established tradition in their culture. However, it is understood that the extent to which the plaques represent specific, named individuals, as opposed to general types, is unclear, and the portrayal of specified individuals and general types may have fluctuated (Ben-Amos 2003).

6 The lost-wax technique is described as follows: 'a molten metal is poured into a mould that has been created by means of a wax model. Once the mold is made, the wax model is melted and drained away. A hollow core can be affected by the introduction of a heat-proof core that prevents the molten metal from totally filling the mold' (The Editors of Encyclopaedia Britannica 2018).

7 For example, the leopard was the king of the jungle, and in order to show the oba's strength and divinity, he is the only figure depicted overpowering a leopard (Layton 1991: 78).

8 Interestingly, according to Ben-Amos (2003), the phrase '"to cast a plaque" can be used metaphorically for the creation and establishment of a tradition and monument.'

According to Gus Casely-Hayford (2012), the plaques are historical documents that depict 'everyday and mythological scenes, images of great political, military and ceremonial importance.' They are also 'symbolic of the enduring continuity of historical narrative' (Casely-Hayford 2012: 211).

How Benin was looted

According to William Fagg (1978: 10), in 1892, the British demanded that the Kingdom of Benin should terminate the practice of human sacrifice and allow mutual trade. However, by 1896, when it was evident that Oba Ovonramwen would not consent, Consul Phillips led an envoy to Benin City, despite being warned that the oba could not receive them due to the celebration of an annual festival.[9] On 4 January 1897, led by diehard war chiefs, not under the command of the oba, the envoy was ambushed, killing all but two individuals (Fagg 1978: 10, Casely-Hayford 2012: 234). Thus, in 1897, a decisive moment in the history of British colonialism, the British embarked on a military campaign in the Kingdom of Benin (Casely-Hayford 2012: 208). By 18 February 1897, 1 200 soldiers from Britain and Simonstown in South Africa captured the Kingdom of Benin with force and violence (Fagg 1978: 10). Casely-Hayford (2012: 208) states that '[t]he invasion led to the annihilation of the Benin monarchy and its court, the trial of the Oba – the head of state – the removal and execution of senior court dignitaries, the razing to the ground of the royal compound and the torching of a number of principal towns.' An estimated 2 000 objects were looted, sold and distributed to Western museums (Casely-Hayford 2012: 234).

Figure 3: Made by Edo, Benin Plaques, to century. Brass, 510 x 380 x 110 mm. The British Museum, London (Benin Plaques sa)

An estimated 900 plaques were seized and looted by the British in 1897 (Casely-Hayford 2012: 210). The so-called 'European discovery' of the intricate,

9 Fagg (1978:10) states that the festival was a celebration in memory of the oba's father and ancestors.

complex and mysterious Benin art objects amazed and confused Europeans (Casely-Hayford 2012: 208). European views of Africans in general did not permit reasoning that a 'primitive' culture could create these objects. It is evident that the removal and subsequent looting of the Benin plaques have robbed them of the understated meanings they once expressed. The establishment of the chronology, use, function and significance of many Benin bronzes is debated and questioned as they were not excavated under controlled conditions (Gillon 1984: 270). The objects were robbed of their history, cultural utilisation, and symbolism of status, wealth and power.

The case for restitution

An information kit created by UNESCO titled 'Promote: The Return or the Restitution of Cultural Property: Committee – Fund – UNESCO Conventions' (2001: sa) observes that plundering and pillaging another country is a long-accepted tradition. It states that during colonial times, 'the practice of theft of cultural property became even more widespread, and practically systematic, no longer necessarily linked to war or military occupation' (Promote... 2001: sa). By doing this, cultural property and heritage became scattered across the globe, to the sole benefit of Western collections.

Why, then, with the above paragraph in mind, the understanding of the (albeit short) history of the Kingdom of Benin, and the awareness that the people of Benin had a special and specific relationship with their art objects, do members of the international museum community, through statements such as the 'Declaration on the Importance and Value of Universal Museums'[10] contest the restitution of the Benin bronzes? It is evident that these leading museums are trying to evade their responsibility of returning cultural property and heritage, as well as protecting the prestige and status of their collections. The declaration states that restitution of cultural property and heritage disregards the importance and respect granted to history and the object (Schuster 2004: 4). However, with special regard to the Benin bronzes, the object's importance and significance is

10 In 2002, the Declaration on the Importance and Value of Universal Museums was signed by the leading museums in Europe and North America. In it, they claim that they are universal museums that cherish, safeguard and promote the cultural property and heritage of all peoples of the world (Schuster 2004: 4). The document stressed the very important roles of representation, comprehension and knowledge formation that museums claim they play.

undeniably altered by not being a part of the Benin culture. Another point the declaration makes, which is echoed by Peter-Klaus Schuster (2004: 4), is that cultural property and heritage often obtained their infamy by being displayed in so-called 'universal museums'. However, this argument is flawed, because the world has become globalised and the Kingdom of Benin would not have existed in a vacuum with the world forever oblivious to the existence of their artworks.

In addition, these leading museums advocate for globalisation and that, due to globalisation, individuals from Benin are able to visit the museums and 'visit' their own culture. This is an essentially Eurocentric point of view and one that appears to be oblivious to economic situations in developing countries. UNESCO observes that cultural property and heritage are 'irreplaceable testimony to the culture and identity of a people' (Promote... 2001: sa). Thus, the signatories of the declaration are indirectly stating that, as long as the Benin bronzes remain in the 'universal museums', the people of Benin can visit the museums, at great expense, to experience the testimony to their unique culture and identity as a people.

The next important point to be made is that the looted Benin bronzes fall under the category of war booty seized on behalf of Britain and subsequently sold and distributed across the world. Claims for restitution based on this premise are governed by the Geneva Convention and national and international property law (Schuster 2004: 5). However, as the history of the punitive expedition of 1897 is well-known, I find it confusing that the negotiations and bilateral discussions on the restitution of the art objects are taking so long.[11] It is evident that the fact that the objects are claimed for restitution based on the tangible objects' intangible emotional and spiritual significance to *a group* outweighs the 'universal museums' prerogative to retain the objects.[12]

Closely related to this point is one of the fundamental problems with the

11 When stakeholder parties (in this case, the Western museums and the Kingdom of Benin) are unable to come to an agreement on the obligation and moral responsibility to return cultural property and heritage, the international community has proposed solutions. The international community, with the aid of UNESCO, created a legal framework and highlighted the importance of cooperation during the process of restitution (Promote... 2001: sa).

12 When stakeholder parties (in this case, the Western museums and the Kingdom of Benin) are unable to come to an agreement on the obligation and moral responsibility to return cultural property and heritage, the international community has proposed solutions. The international community, with the aid of UNESCO, created a legal framework and highlighted the importance of cooperation during the process of restitution (Promote... 2001: sa).

restitution of the Benin bronzes: 'Universal museums' and the justification and ethics for conservation are based on Western attributions of qualities and purpose (Vogel 2003: 653). In other words, Western interpretive lenses and meanings are ascribed to art objects that do not fundamentally adhere to the same concepts, conventions and understandings. The museum and conservation individuals become too locked into the perspectives of their own culture. In line with Stuart Hall (in Klopper 1996: 34), if the Benin bronzes were to be returned to their country of origin, the people of Benin would have 'the means to speak for themselves for the first time' since the brute destruction of their culture. They would speak for themselves and their cultural property and heritage in their own language and voice.

The restitution of the Benin plaques is firmly rooted in identity politics (Wood 2012: 122). In an everyday setting, identity is the way in which individuals 'make sense of themselves, of their activities, of what they share with, and how they differ from others' (Brubaker and Cooper 2000: 4). 'Identity' is to conceptualise 'all affinities and affiliations, all forms of belonging, all experiences of commonality, connectedness, and cohesion, all self-understandings and self-identifications' (Brubaker and Cooper 2000: 2). Hypothetically, a child on a field trip to a 'universal museum' can achieve the type of identity formation and identification of oneself to others through exploring different exhibitions. A child on a field trip to a current Nigerian or Benin museum in Nigeria would not be able to achieve the same sense of self, identity and belonging. According to Paul Wood (2012: 122), 'this identification overrides all other arguments and counterarguments, and has the further effect of rendering counter arguments hollow, even before they are articulated.'

Conclusion

After establishing a short history of the Kingdom of Benin and the people of Benin's relation to their art objects, especially the Benin plaques, it is plain to see that the interaction with and display of the plaques have political, social, spiritual and contextualising values and significances. The plaques were removed by force and brute strength by the British during the punitive expedition of 1897, without any regard to their artistic, cultural and historic importance. Based on the notions that the plaques are functional and legitimising entities for Benin culture and spirituality, there can be no doubt that the Benin bronzes should be returned. However, the process cannot be as simple as that. The counter-argument for restitution is fundamentally based on their safe-keeping, knowledge-granting capabilities and accessibility. If the Benin plaques were to return to the full ownership of the oba and the Benin monarchy, the plaques would probably very seldom be seen, and they would not be available for further study and research. In my humble opinion, the Benin plaques would have to be returned to a Nigerian museum or institution, whether it is in Lagos or Benin City.[13] The plaques could also then become part of a travelling exhibition, because museum conservators have the knowledge and means to keep them safe. The most important characteristic of the restitution of the Benin bronzes is open, multilateral dialogue without egoistic arrogance and attitudes of compromise on the sides of all stakeholders. However, the outcome will far outweigh the difficulties in this process.

13 A lot of preparation still needs to be done for such a return of objects, which does not necessarily have to include all Benin plaques. Nigerian institutions would need support and assistance with multiple aspects.

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Laura Esser: THC 801

Laura Esser, who started the programme in 2020, graduated in 2021. She is a German national who has completed all her studies in South Africa. She is a prospective paper conservator. This assignment was a summary of the agents of deterioration of museum and cultural heritage objects.

Introduction

The agents of deterioration are a list of threats that cause change to cultural heritage objects. The assignment's aim is to create cheat sheets with the necessary information contained on a single page. The agents of deterioration are: physical force; fire; water; pests; pollutants and contaminants; radiation; incorrect temperature; incorrect relative humidity; dissociation; thieves, vandals and displacers; and inherent vice.

Physical force

Physical force directly impacts an object. It can be caused by an object colliding or knocking an object, which results in impact or shock, depending on the severity. This can happen because of incorrect handling, transport (cumulative cause), excavations, earthquakes (catastrophic cause), traffic or overload of shelving units. Vibration also falls under this agent of deterioration and can also be caused by earth-quakes or traffic near the building (ICCROM 2016:28 Marcon 2018).

All materials are affected.

Collapse, deformation, breakage, abrasion, wear, tearing, wind erosion, distortion, punctures, dents, scratches (I-Saad n.d.:5)

Avoid

- Avoid transport of fragile objects
- Avoid untrained transport agencies
- Avoid vibration during transport cushioning and crating plan
- transport/movement of objects and assess obstacles
- Avoid inadequate shelving units
- Avoid crowded shelves to ease access (Marcon, 2018)

Block

- Vibration during transport crating
- Forces ensure adequate packaging in storage, on display, during transport
- Earthquake resistant buildings
- Primary packaging isolate fragile objects
- Train staff in handlingand storage techniques (Marcon 2018)
- Display artefacts behind barriers/ in cases or cabinets (Postaluseum n.d.)
- Put padding underneath storage furniture to absorb vibration

Detect

- Crowded storage areas give each object adequate space
- Tipping indicators, shock detectors
- Document any damage but also every movement of an object (Marcon 2018)

Respond

- Install adequate shelving
- Do not place objects too close together
- Keep unstable objects isolated
- Redesign packaging (Marcon 2018)
- Introduce/enforce handling procedures for objects (Roper 1989

Recover

- Depends on the severity of the impact/
- shock that the object received

Fire

For a fire to start, there needs to be an ignition source, a fuel source, and oxygen. Fire in a museum can be caused by lightning, forest fires, gas leaks, fireworks, faulty electrical wiring/equipment, candles, arson, construction works, open fire places or incense burning. It can destroy a museum's whole collection, melt materials, lead to collapse, and soot deposition. All materials are affected by fire (Steward 2018).

Avoid

- Avoid using multiple adaptors/extension cords
- Avoid open flames (Steward 2018)
- Avoid space heaters
- Avoid faulty/open wiring should be in conduits
- Avoid having trees, bushes, shrubs close to your building
- wildfires will not be able to reach the building (Watkins 2013)
- Avoid shelving units/display cases are easily set alight use
- chemically inert (non-reactive), fireproof shelving (Roper 1989)

Block

- Portable fires in every room (exhibition, storage, etc)
- Fire protection equipment sprinklers, fire extinguishers, automatic gaseous suppression systems no water damage (inspect & update)
- Have a fire prevention committee risk assessments/ inspection
- Implement fire safety policies and procedures (e.g., no smoking, no open flames) (Steward 2018)
- Use enclosures provide some protection, fire retardants (Roper 1989)

Detect

- Smoke detectors
- Heat detectors (Steward, 2018)
- Know and minimise possible sources of fire ignition (Pioneer Air Museum 2014)
- Detect any faulty wiring have it checked out by an electrician
- Detect any flammable liquids in the building/conservation lab/storage store appropriately
- Identify hazardous objects (cellulose nitrate films) and store safely, away from other objects (Steward 2018)

Respond

- Call the fire department familiarise them with the museum before a case of fire (Steward 2018
- Train your staff on how to respond to a fire emergency
- Human life takes priority over objects (Watkins 2013)

Recover

- Fire causes irreversible chemical reactions (I-Saad n.d.:9)
- The longer soot is on an object, the harder it becomes to remove

Water

Water damage can be caused by tsunamis, flooded rivers, rain, ground water, water pipes, cleaning firefighting
It causes objects to weaken, stain, deform, dissolve, corrode and weather. It can also cause salt efflorescence and biological growth (lichens, mould), and tide marks (Tremain 2018 Museum of Ontario Archaeology 2014)

Recover

- Pests and mould prefer warm damp environment ventilation is key
- Building and objects are in danger
- Wooden storage units might collapse
- Pigments and adhesives may dissolve
- Ceramics and papers may be unstable (Tremain 2018)

Avoid

- Avoid buildings too close to bodies of water
- Avoid buildings with a history of flooding
- Avoid fountains water features in and around museum
- spaces (Tremain 2018)

Respond

- Have an emergency response policy in place
- Staff safety comes first safety wear: Tyvek coveralls, respirators,
- gloves, rubber boots, hard hats
- Identify source of waterblock it/revert it
- Ventilate buildings to prevent mould
- Dehumidifiers (Tremain 2018)

Detect

- Have a risk assessment (in and outside of buildings)
- Install water detectors
- Inspect the building for previous water damage/flood lines (water stains)
- Differentiate between immediate action risks (leak) and that do not need immediate
- action (Tremain 2018)
- Detect any burst/leaking pipes or plumbing (Museum of Ontario Archaeology 2014)
- Inspect and remove dirt from gutter sit can store humidity/water

Block

- Monitor weather forecast
- Elevate objects off the floor
- Emergency kit: sandbags, window/door seal (polyethylene sheeting), pumping equipment
- Have an emergency evacuation procedure
- Train your staff assign positions (Tremain 2018)

Pests

Pests that usually cause damage in museum spaces include insects, especially termites, rodents, birds and bats. They are attracted by food sources, which not only include restaurants on the museum's premises but also textiles, wooden objects and pollutants or dust brought into the museum. Pest damage usually includes staining, perforation, weakening, loss of parts discoloration foxing (Strang Kigawa 2018).

Pests can be divided into different groups: fabric pests (carpet beetles, clothes moth), wood pests (wood boring beetles, termites), stored product pests (biscuit beetles, cigarette beetle), moisture pests (moulds) and general pests (cockroaches, crickets, silverfish) (I-Saad n.d.:28 Trematerra 2018:242)

Avoid

- Avoid objects in the open
- Avoid unsealed containers
- Avoid cluttered/organised storage
- Avoid water features in museum vicinity uncontrolled rH
- Avoid dust build-up
- Avoid food/food waste thrown out near the museum/ storage
- Avoid use of non-treated wooden shelves inorganic materials
- (polyethylene sheets, Mylar) (Strang Kigawa 2018)

Block

- Pollen has appropriate HVAC system filters
- Repair cracks in building to prevent pests from coming in
- Seal chimneys
- Quarantine new collections (Strang Kigawa 2018)
- Do regular housekeeping

Detect

- Install mouse and fly traps, sticky traps, light traps inspect regularly
- Regular pest inspections look for faecal deposits, chewing, nests
- Inspect organic objects textiles, wooden objects, books and papers
- Train staff
- Integrated pest management helps to prevent and resolve pest problems pesticide last resort (I-Saad n.d.:30f.)
- Keep all spaces sanitary (Canada CA)

Respond

- Remove infested objects
- Isolate infested objects carry in sealed plastic bags
- Freeze objects to disinfect (fragile objects should not be frozen)
- Heating kills insects more rapidly than freezing but is more
- likely to damage objects
- Identify the pest document the findings
- Remove pest as soon as possible
- Anoxia removes oxygen out of air in airtight chamber (Strang
- Kigawa 2018, I-Saad n.d.:30f.)

Recover

- Not all damage can be repaired
- Clean objects remove dead pests/ eggs/waste/larvae/nests (Canada CA)
- Stains n textiles/leathers can decrease their strength
- Fungi can produce acids corrosion and etching (Strang Kigawa 2018)

- Remove dust particles, efflorescence or erosion compounds as carefully as possible
- Stains cannot be easily removed from fragile/porous objects (Tétreault 2018)

- Limit source of pollution from inside the building
- Avoid setting up a museum space in areas with heavy air pollution
- (highways, inner city centre, industrial areas)
- Avoid use of adhesives, rubber bands
- Avoid using storage shelves/display cases they gas-off pollutants
- (Tétreault 2018)
- Avoid skin contact with the objects' oils can cause damage (nitrile gloves)
- Avoid storing different materials next to each other wood and plastics
- off-gas chemicals (Roper 1989)

Recover

Avoid

Pests

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Respond

Block

- Discover source of pollutants (Canada CA)
- Keep storage, shelves, display cases, exhibition spaces clean
- Install seals around doors and windows weather strips
- Use cabinets or containers to store/ exhibit objects
- Cover stored objects with dust covers
- Store objects emitting gaseous pollutants separately
- Install pollution filters in your HVAC system (I-Saad n.d.:27)

Detect

- Inspect objects regularly for dust
- Discoloration powdering are indicators pollutants
- Pest activity may be a sign of dust accumulation
- Install gas particle, water vapour and oxygen absorbents
- Inspect and replace HVAC filters

- Pollutants by installing appropriate filters in HVAC system exchange regularly
- Do not place objects directly in front of HVAC exhaust
- Have airtight display cases
- Do not use untreated wood for storage or display have a protective barrier
- Chemical storage units, cooking facilities should have a local exhaust
- Some museum objects may emit pollutants themselves store in sealed boxes (old plastics emitting phthalates and acids, cellulose nitrates (films) and residual fumigants I-Saad n.d.:25)
- Know what is in your collection
- Block visitors from touching objects
- Block dust from coming with visitors by installing dust trap mats (Tétreault 2018)

Radiation

Radiation is a form of energy that helps us to see things. Its energy can be measured by measuring the wavelengths of radiation. Ultraviolet radiation has short wavelengths and therefore high energy (300499nm). Infrared radiation has long wavelengths (769nm). We can feel IR as heat. They fall on each side of the radiation spectrum. Visible light falls between 400 and 760nm (l-Saad n.d.:21). Even extended exposure to low levels of light will cause damage (Roper 1989).

Radiation accelerates the deterioration of most organic materials. It causes colour fading, yellowing, weakening, disintegration and embrittlement. Textiles and paintings are affected the most (l-Saad n.d.:5; Roper 1989).

Recover

- Light damage cannot be recovered unless new materials is used
- Light damage is cumulative (l-Saad n.d.:21)

Avoid

- Avoid direct sunlight
- Avoid having the lights on at all times as all lamps emit UV radiation (l-Saad n.d.:21)

Respond

- Objects should be removed
- Light source should be detected and removed switch light bulbs to low UV light bulbs
- Adapt your strategies/ policies
- Cases, boxes and folders help to protect objects from light (l-Saad n.d.:21)
- Rotate objects on display with similar objects (Pioneer Air Museum 2014)

Block

- Use UV resistant window films
- Screens, curtains, blinds
- Replace lamps with low UV lamps
- Protect outside objects with shading
- Limit exposure time (l-Saad n.d.:21

Detect

- Inspect objects for radiation damage
- Install visible light and UV meter measure illuminance on objects (the strength of
- visible light, measured in lux) (l-Saad n.d.:21)
- Install thermometers to detect infrared radiation
- Install cloth samples (Blue Wool) and inspect them for fading (l-Saad n.d.:22)

Light standards:

- 50 lux for light sensitive objects: dyed organic materials, textiles, watercolours, photographs, tapestries, prints/ drawings, manuscripts, leather, wallpapers, biological specimen, fur, feathers
- 200 lux for less light sensitive objects: undyed organic materials, oil/tempera paintings, wood
- 300 lux for non-light sensitive surfaces: metals, stone, ceramics, glass (l-Saad n.d.:22)

Incorrect Temperature

Temperature measures the speed of molecules in material. With a temperature increase, molecules move faster, causing the material to expand. When temperature decreases, molecules move slower, causing a material to contract (l-Saad n.d.:10).Incorrect temperatures caused by climate, direct sunlight, lamps and heaters. Warmer temperatures cause quicker chemical reactions, which can lead to faster deterioration of objects.

The damage incorrect temperature causes includes deformation, dehydration, embrittlement softening. Organic and fragile objects are particularly affected by this agent. Pests are attracted to warmer climates.

Incorrect temperature and incorrect relative humidity are directly linked (Michalski 2018)

Recover

- Fissure and cracks can be repaired (but they are not reversible)
- Chemical aging is not reversible (Michalski 2018)

Avoid

- Avoid placing organic or fragile objects in direct sunlight (temperature fluctuations)
- Avoid poorly insulated buildings (Michalski 2018)
- Avoid too high temperatures increased chemical reactions
- Avoid temperature fluctuations over +-5°C (Gilroy Godfrey 2017

Respond

- Install heaters or HVAC systems to respond to temperature changes
- Adjust heaters/HVAC systems
- Keep temperatures as low as possible to prevent unstable objects from deteriorating too fast
- Store unstable objects separate in a temperature-controlled microenvironment (Michalski 2018)
- Not all objects can be stored under the same temperature conditions known components of your objects (Pioneer Air Museum 2014)
- Use crates/boxes/display cases as buffers to insulate objects (Gilroy Godfrey 2017)

Detect

- Install thermometers in all rooms
- Inspect collections regularly cracks in furniture, paintings or building could be an indicator of temperature fluctuations (Michalski 2018)

Block

- Sunlight (blinds, curtains, window filters)
- Provide shaded areas for outside objects
- Do not place objects against exterior walls
- Insulate objects for transport (Michalski 2018)

Incorrect relative humidity (RH)

Humidity measures the amount of water in the air at a given temperature. Relative humidity measures the percentage of water the air is able to hold at a given temperature. The warmer the air, the more moisture it can hold (l-Saad n.d.:11). The reason for incorrect relative humidity include climate, ground water, inadequate air ventilation and micro-climates, human respiration and perspiration (Michalski 2018a).

It causes deformation, cracking, flaking, weakening, corrosion, mould growth or staining (l-Saad n.d.:6). Organic materials are especially affected because they absorb and give off water.

Avoid

- Avoid water features, dripping water, any sources of external water (Michalski 2018a)
- Avoid fluctuations above 5% (l-Saad n.d.:13)
- Avoid RH below 30%objects may become brittle
- Avoid RH above 65%mould growth (l-Saad n.d.:13)
- Avoid too many people in a room (l-Saad n.d.:17)
- Avoid sensitive objects exposed to spotlight, sunlight, air vents, exterior walls, doorways (l-Saad n.d.:17)

Block

- Seal cracks and holes to prevent moisture from coming in
- Moisture from entering packaging use polyethylene sheeting to block it
- Block rainwater and groundwater from entering your building or gathering close to it (Michalski 2018a)

Detect

- Install humidity detectors psychrometers detect RH (l-Saad n.d.:14)
- Install hygrometers (for RH and temperature) inside of display cases and cabinets
- Gather your data and interpret
- Inspect collections (e.g., swelling in ceramics if humidity is too high, cracking if humidity fluctuates) (Michalski 2018a)

Respond

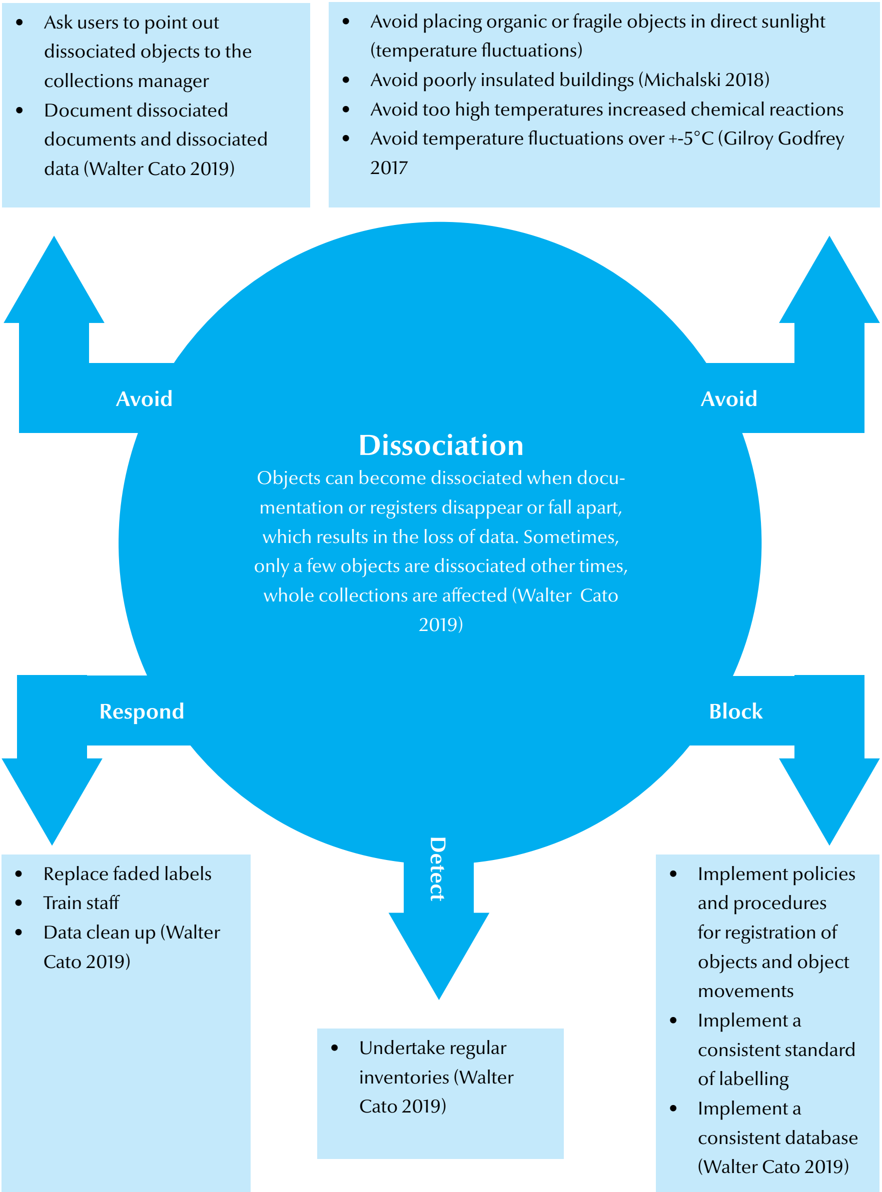
- Install humidifiers or dehumidifiers (installed or portable)
- If problem persists, consult engineering consultant about building-wide systems
- Passive control silica gel (for high humidity problems) (Michalski 2018a)
- When setting up a standard for RH and temperature, take into consideration your local climate and condition and nature of your collection (l-Saad n.d.:16)

Recover

- Mould damage cannot be recovered it eats away the material
- Corrosion removes the original surface material (Michalski 2018a)
- Glass is extremely sensitive to humidity can get glass disease

Examples:

- (too high too low)
- Metal corrosion
- Dyes fading
- Swelling/warping of wood and ivory
- Paper can cockle or buckle
- Canvases may slack
- Above RH of 65%mould growth, insect activity
- Shrinkage, warping, cracking of wood and ivory
- Shrinkage, stiffening, cracking, flaking of photographs and leather
- Desiccation of paper and adhesives and basketry fibres (l-Saad n.d.:12).



- Ask users to point out dissociated objects to the collections manager
- Document dissociated documents and dissociated data (Walter Cato 2019)
- Avoid placing organic or fragile objects in direct sunlight (temperature fluctuations)
- Avoid poorly insulated buildings (Michalski 2018)
- Avoid too high temperatures increased chemical reactions
- Avoid temperature fluctuations over +-5°C (Gilroy Godfrey 2017
Avoid
Avoid
Dissociation
Objects can become dissociated when documentation or registers disappear or fall apart, which results in the loss of data. Sometimes, only a few objects are dissociated other times, whole collections are affected (Walter Cato 2019)
Respond
Block
Detect
- Replace faded labels
- Train staff
- Data clean up (Walter Cato 2019)
- Undertake regular inventories (Walter Cato 2019)
- Implement policies and procedures for registration of objects and object movements
- Implement a consistent standard of labelling
- Implement a consistent database (Walter Cato 2019)

Thieves, vandals, displacers

A theft is described as someone deliberately taking objects from a space. For museums, this can include documents, money, or objects (Roper 1989). Most theft cases involve someone working at the museum who has insider knowledge (Pioneer Air Museum 2014). The motivations of thieves can be political, ideological or economic (But 2018). Vandalism occurs when someone deliberately tries to destroy or in any way alter an object or building. Damages include tearing, cutting, writing, marking, and even arson (Roper 1989). Two of the most common acts of vandalism are graffiti and leaving chewing gum on/under furniture (Pioneer Air Museum 2014). Displacers are usually museum staff who either accidentally or purpose misplace objects (Science Museum of Minnesota 2020)

Avoid

- Avoid cover for thieves around your buildings (hedges, bushes, trees too close to the building)
- Avoid dark areas around your buildings have a well-lit space, especially doors, have vandal proof lights
- Avoid opportunities to get to higherup windows/entrances from outside the building
- Avoid easy access into the buildings through air vents, HVAC systems reinforce them
- Avoid leaving doors/windows open after hours (Tremain 2020)

Block

- Undertake security screens before hiring new personnel (Pioneer Air Museum 2014)
- Thieves or vandals from entering your building key card access, PIN code access
- Close cabinets with locks (Spacesaver n.d.:5)
- Insure your building and objects (Pioneer Air Museum 2014)
- Install burglar bars on windows, reinforce doors
- Remove overhanging branches from trees or ladders
- Provide additional security during renovations
- Secure displays and objects with proxy alarms, passive infrared motion detectors
- Have shatter-proof display cases (Tremain 2020)
- Secure loose papers from theft/displacers by binding them into volumes (Roper 1989)

Detect

- Keep track of who is accessing objects/collections (Spacesaver n.d.:5)
- Install security cameras (CCTV), alarms
- Employ security personnel (Pioneer Air Museum 2014)
- ny damage to the building and repair it
- install glass-break detectors
- ire security guards for all rooms and areas in the museum (visitor entrance, exhibition spaces, staff entrance, loading bay, study rooms, office areas, maintenance rooms) (Tremain 2020)

Respond

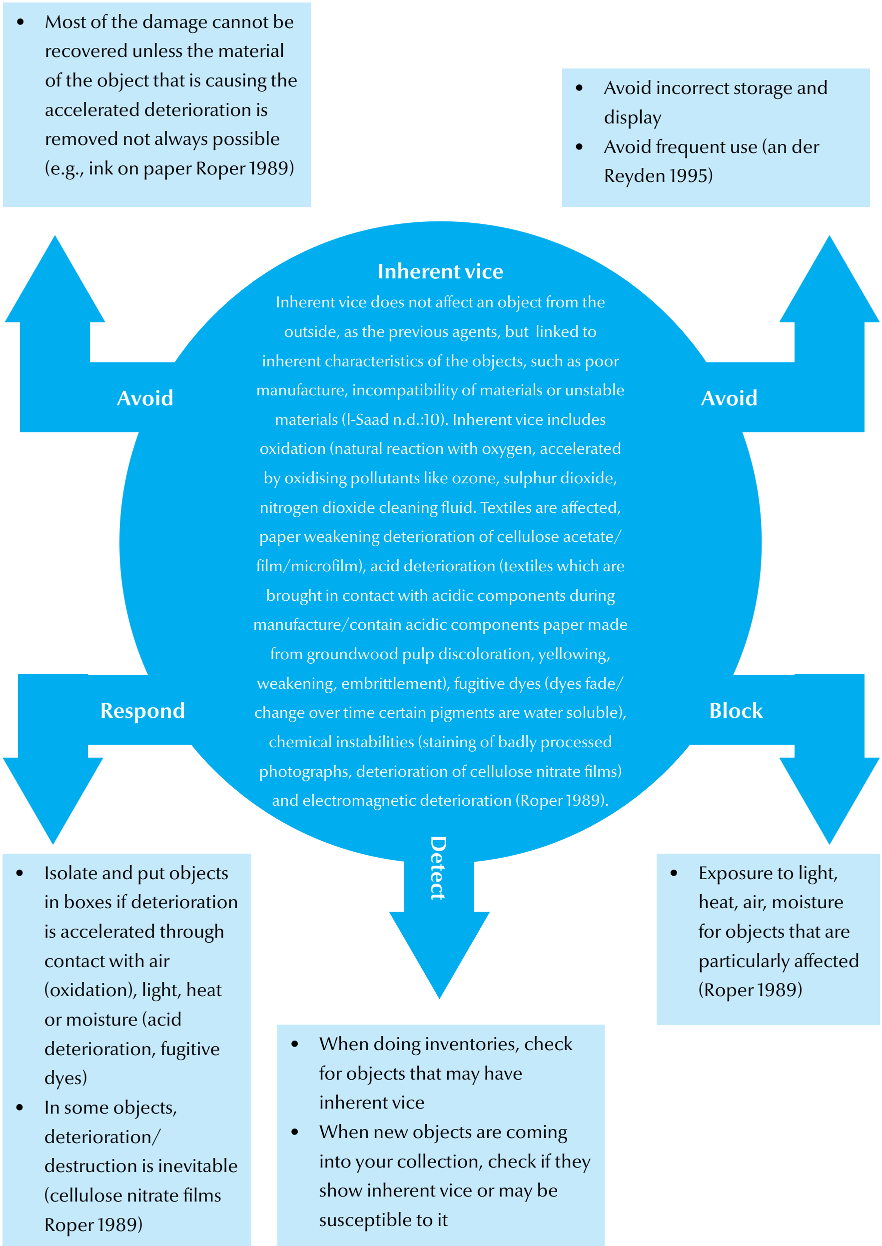
- Once an event is noticed, notify the responsible people/organisations security control room
- If event is unauthorised, intervene prioritise own safety (memorise perpetrator/vandal)
- Train security staff on how to intervene, know the law
- Call the police secure and restrict access to the area (Tremain 2020)

Recover

- Report stolen objects to the police
- Report vandalised objects/collections to the police
- Give description and documentation to the police
- Stolen objects are not likely to be recovered
- Review museum's security/security policies
- Vandalised objects can be restored, depending on the severity of the damage (Tremain 2020)

Security policy

- Access control/key control
- Building security
- Security guard duties
- Security screening
- Emergency preparedness & response
- Camera policy
- Extra-curricular activities


Most of the damage cannot be recovered unless the material of the object that is causing the accelerated deterioration is removed not always possible (e.g., ink on paper Roper 1989)
Avoid incorrect storage and display
Avoid frequent use (an der Reyden 1995)
Inherent vice
Inherent vice does not affect an object from the outside, as the previous agents, but linked to inherent characteristics of the objects, such as poor manufacture, incompatibility of materials or unstable materials (I-Saad n.d.:10). Inherent vice includes oxidation (natural reaction with oxygen, accelerated by oxidising pollutants like ozone, sulphur dioxide, nitrogen dioxide cleaning fluid. Textiles are affected, paper weakening deterioration of cellulose acetate/ film/microfilm), acid deterioration (textiles which are brought in contact with acidic components during manufacture/contain acidic components paper made from groundwood pulp discoloration, yellowing, weakening, embrittlement), fugitive dyes (dyes fade/ change over time certain pigments are water soluble), chemical instabilities (staining of badly processed photographs, deterioration of cellulose nitrate films) and electromagnetic deterioration (Roper 1989).
Avoid
Avoid
Respond
Block
Detect
Isolate and put objects in boxes if deterioration is accelerated through contact with air (oxidation), light, heat or moisture (acid deterioration, fugitive dyes)
In some objects, deterioration/ destruction is inevitable (cellulose nitrate films Roper 1989)
When doing inventories, check for objects that may have inherent vice
When new objects are coming into your collection, check if they show inherent vice or may be susceptible to it
Exposure to light, heat, air, moisture for objects that are particularly affected (Roper 1989)

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Henry Nakale: THC 802

Henry Nakale was the first male student the programme welcomed in 2020. He is from Namibia and works at Windhoek Museum.

Introduction

Physical deterioration of paper has been an issue for many museums, libraries, archives and private collections around the world, although there are other challenges that these institutions are faced with as far as the preservation and conservation of paper is concerned. This review is centred around tear-mending, looking at the principles of mending structural damage to paper and providing a summary of current practices which include options for recipes. Several tear-mending options are available, a few of which are briefly described in this assignment. Valuable documents and books were examined individually, and the best conservation treatments were chosen based on their use, state and worth. New techniques of tear-mending have been developed over the years and have been adapted to successfully repair different tears in different types of paper and books. This review also unpacked different necessities required in paper treatment: these include a lack of information on several adhesives used in mending tears, which affects the process of decision-making; impacts of tears are also not addressed.

Chemistry of paper

Papers are made using hands (handmade) and modern machines. Most papers today are made from indigenous plant material. Fibres and leaves are extracted for paper manufacturing. Some chemicals are added for texture, depending on the type of paper to be produced.

General principles of tear mending

Paper is the most common medium for recording information, and it is very resistant to ageing if it is well-manufactured. But due to its characteristics and manufacturing components, some paper grades are very likely to deteriorate, especially the acidic papers manufactured between the mid-nineteenth and twentieth centuries (Zervos and Alexopoulou 2015).

Many papers, archives and paintings face very harsh conditions, which can lead to their deterioration, and most of them end up fragile and unusable. There are several factors that accelerate the pace at which these materials deteriorate, such as pH, raw materials and how they were manufactured. External factors like the climatic conditions, pollution and biological activities also play a significant role in controlling the rate of deterioration. Deterioration causes tears in many papers and loss of valuable information (Lee et al. 2010, Zyska 1996). One thing that we conservators need to bear in mind is that the way paper tears is directly related to how it is manufactured. And as mentioned above, paper is made from wood fibres, where wood chips are mixed with water and chemicals. Wood fibres are then separated, and a soupy mash called pulp is made. The water is squeezed out, so when the pulp moves on the conveyor belt, the wood fibres line up in the same direction that the belt is moving, which aligns the fibres and gives the paper a grain. The grain is what causes the paper to tear straight in one direction. Paper gets ripped with grain tears in the direction of its fibres.

The general standards for repairing tears in paper, particularly using

Japanese pulp, are stated by Zerovos and Alexopoulou (2015: 81) and are used by most conservators these days. Let us look at how the Japanese papers are manufactured. Japanese papers are produced using long, solid fibres removed from the inner bark of different indigenous Japanese plants. Their properties (mechanical quality, weight, pH, shading, fibre length, dimensional security and protection from maturing) are perfect for paper repairing. Another option for Japanese paper is the Chinese manufactured paper, Xuan, which is produced using bast fibres.

For paper-mending, glue is used, including methylcellulose, carboxymethylcellulose, starch glue, unsupported Archibond and hydroxypropyl cellulose. Methylcellulose may have a lower holding quality; however, it is favoured because of its better protection from both biodegradation and synthetic corruption. The mash utilised for fixes can be like cotton material (unbleached, without any added substances). Many conservation laboratories utilise faded synthetic pulp, which is widely accessible. A few conservators and researchers, like Vodopivec (1997), prescribe the addition of up to 30 to 40% unbleached fibre to the leaf-casting mash, with respect to its use of coloured pulp since they contain metal particles, for example, Fe and Cu (Zervos and Alexopoulou 2015: 81). A vacuum (suction) table is regularly used in paper preservation; the vacuum is used mainly for local treatments and for filling losses of paper. Another machine used in paper treatment is the leaf-casting machine. As pointed out by Zervos and Alexopoulou (2015: 82), leaf-casting is used for filling losses of paper with paper pulp. Leaf-casting is certainly not a mass-production technique; however, for artefacts that can withstand water, it tends to be a lot quicker than the manual strategies and elicits better outcomes.

Tear-mending or paper repair

Mending is joining splits or tears or reinforcing cracks in a paper support using an adhesive material. The main purpose of mending is to restore the aesthetic of paper and preserve its physical integrity. In paper conservation, mending of structural damage can be accomplished with either Japanese paper or pulp but it mostly depends on the nature of the damage and type of paper. Zervos and Alexopoulou (2015: 80) discussed the Japanese paper method in detail; according to them, the Japanese papers are thin, handmade papers extracted from various indigenous Japanese plants, and their properties (weight, colour, pH, and stability) make them ideal for mending tears and losses. For example, Tenguijo, which is a thin specialist Japanese paper made from kozo, alkaline water and neri, is mostly transparent and is widely used in archival conservation and lighting designing. It is very light and weighs about 7 to 11 g/m^2.

When filling lacunas, as described by Zervos and Alexopoulou (2015: 80), the original damaged paper is placed on a light table with a polyester sheet over it, and on top of it, a sheet of Japanese paper is placed. Both the Japanese and original paper should be placed parallel and in one direction. Use a refillable pen, filled with a mixture of alcohol and water. When the contour becomes wet and soft, remove the patch by pulling and glue the original on with paste, methylcellulose or a mixture of the two. They further discussed paper pulp, which is prepared from the Japanese paper, linen and cotton textile, and they recommended adding 30 to 40% unbleached fibres to the leaf-casting pulp. This can then be added to the lacunae with a leaf-casting machine.

A case study of mending sprung tears

Bernier (2004) discussed treatment tips for mending sprung tears in her study of gelatine silver prints. She argued that long tears in gelatine silver prints—

especially the ones running in the grain direction—fail to realign and mend successfully, but a new technique was developed to overcome such challenges. A concave support board is the solution to this problem, whereby the convex surface can be employed to apply mending tissues to the back of the tears. This procedure is most successfully used to mend oversized maps (Bernier 2004). In her study, Bernier (2004) used aerial photographs that were treated in 2002 at the document conservation lab. The double-weight gelatine silver prints measured 24 x 36 in and larger and had sprung long tears measuring four inches and more. Several alignment techniques were employed to align the tears but only the concave support board yielded satisfactory results.

The concave support board was made from corrugated plastic boards and draped with polyester webbing. According to Bernier (2004), the tears were aligned from the front using pressure to adjust the degree of the curve. They tacked the tears in place using a warm gelatine solution and wheat starch for strength. The aligned tears were mended on the verso using the Japanese tissues and wheat starch paste. The old-style alignment techniques did not work in aligning the sprung tears in this study, as stated by Bernier (2004). The tears were successfully aligned and mended using the new concave support procedure. After consolidating the prints with the gelatine solution, the tears were no longer noticeable and there were no local distortions as the tears were reunited.

Tear-mending recipes

The Northeast Document Conservation Centre (NEDCC) conservation leaflet (1999) also outlined some tear-mending procedures for books. According to this leaflet, tears in the leaves must first be carefully aligned and then repaired with the Japanese paper and a starch paste, the same as with normal paper-mending, as stated by different authors above. The holes and losses in books are filled with inlays of Japanese paper pulp. However, the NEDCC conservation leaflet (1999) proposed another option for filling holes in books, which is inlaying with a paper which is similar in weight, texture and colour to the book being treated. Choose two layers of Japanese tissue that are similar to the repaired page and cover up the hole— always remember to protect the text block with paper on both sides of the damaged page. Paste up the first piece of the Japanese tissue, ensure that it is well-positioned, and put the edges into place. Then, paste up the second piece and lay it in place, working the edges down. Cover the treated part with non-stick material and dry it under a weight. Once it is dry, twist the paper around the hole to ensure that the edges are adhered. This procedure can be time-consuming, and it is only recommended for valuable books.

Mohie and Korany (2005) also did a study on the conservation of oil paintings, and they discussed a recipe for mending tears in oil paintings, stating that it is a process that requires accuracy and extensive knowledge of many sciences. An assessment of the preservation status should be conducted first, and the integrity of the materials should be analysed by examining and describing the changes in the physical and chemical properties.

In their study, they used two miniature paintings from the Museum of Helwan University, which are both supported on paperboard and both fixed to a thick secondary paper support. UV radiation was used to detect deterioration, tears and past restoration areas, while IR radiation was used to examine the artistic characteristics of the paintings. Mohie and Korany (2005: 111) stated that these paintings were exposed to harsh environments and had been neglected, which led to several deterioration phenomena such as tears, cracks, scratches, lacunas and dirty appearances. The treatment steps used in this study are as follows: they first had to separate the paintings from their frames, clean the dirt using ethyl alcohol, reinforce the paint layers and provide protection for the layer during the treatment process. A 5% and 10% solution of Beva 371 in white spirit and pieces of Japanese paper and gauze were applied.

The lacunas were restored by inserting pieces of special acid-free board in the lacunas and then fixed by what is known as the window method. The acid-free board used was of the same thickness as the paper board. The paperboard was then de-acidified by brushing it with 2.5% magnesium carbonate and distilled water. The tears in the board were mended by brushing them with 10% water solution of rabbit-skin glue, and the edges were repaired using a cauter. Then, they consolidated the board with a 5% solution of Plextol B500 (Mohie and Korany 2005: 112).

They also discussed the mounting process, whereby the first painting support was solidified by spreading a layer of Plextol B500 on the verso of the artwork, then Japanese paper of a similar board size was stuck on the rear of the composition board using 5% Plextol B500. Some Japanese paper strips were additionally stuck on the edges of the board; a corrosive-free board was then used to mount the first board using Plextol B500 (Mohie and Korany 2005: 111).

The paintings were then modified, re-varnished and encircled. And to protect the paperboard from the high relative humidity, wacker BS 1001—a dissolvable-free silane/siloxane emulsion—was used (Mohie and Korany 2005: 112).

Conclusion

In summary, paper and books experience a wide range of damage, including broken joints, harmed sheets, split endpapers, and tears. Most of the time, it is possible to complete minor fixes or store deteriorated books in corrosive-free areas. However, mass tear-mending is advancing, and there are a few affordable methods these days. The examination and treatment of paper-mending is noteworthy, and new strategies have arisen. A lot has been written on paper conservation. In the relevant literature, many authors discussed mending techniques and procedures, definitions and principles. It is, however, surprising that not much has been documented on the impacts of improper structural mending or just lack of mending at all. Therefore, there is a need to cover some of the impacts of tear-mending blanks, and there is still a lack of information on several adhesives used in mending tears, which affects the process of decision-making.

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Marinda Van Der Nest: THC 803

Marinda Van Der Nest, a student who was part of the THC programme intake of 2021 and will have submitted her thesis in 2022, wrote the assignment below on analytical techniques for THC 803.

Introduction

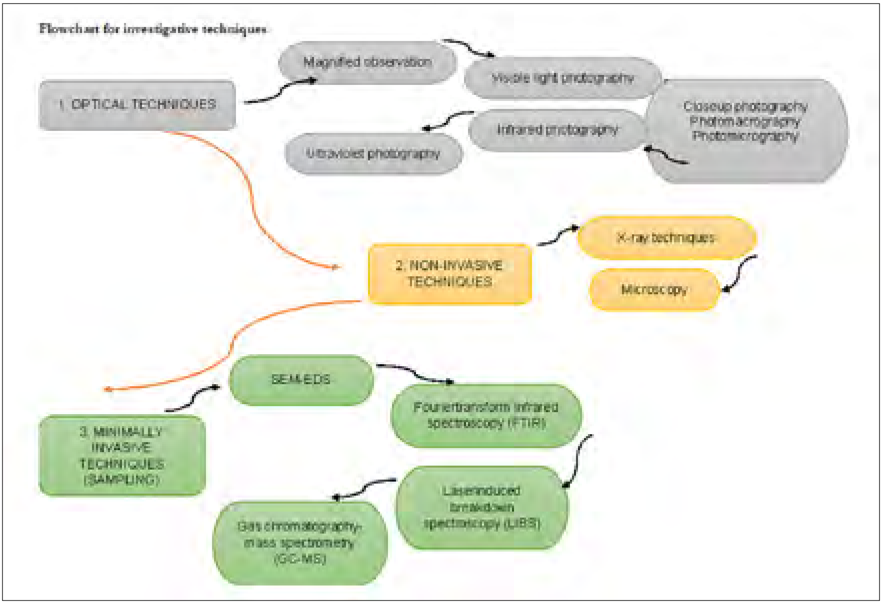
The conservator needs reliable and accurate methods to analyse objects to understand what materials are original, what deteriorated and what was altered or repaired and then determine what treatment to use (Bezur 2021: 5, Vallance 1997: 75). The conservator needs to do research by examining the object to answer questions and increase knowledge on the object for conservation. There should also be communication and teamwork between curators, restorers, art historians, conservation scientists and scientists from outside fields (Whitmore 2005: 2). This will provide the necessary information to design a conservation/ restoration treatment plan. It will enable the conservator to understand what analytical methods and techniques to use to come to an educated and informed conclusion about the conservation/restoration treatment (Vallance 1997: 75).

With this assignment, all possible investigative imaging, as well as analytical techniques will be discussed. Information discussed will be whether the techniques are invasive or non-invasive, the basic information on the technique, the uses for conservators, the benefits and the limitations. A flowchart will suggest the procedure of investigation.

Visual examination is the first step of investigation. It is non-invasive, low-cost and examines the surface and underlying layers of an object. Direct observation can be used or magnified observation using a variety of illumination techniques. Visual examination detects the history of an object by examining its physical condition; it detects modifications and any conditions of components that may have an influence on the conservation and treatment of the object (Wasiutynski 2020: 1).

The next step in investigation is instrumental analysis. The conservator can operate most of the analytical equipment, but other instruments require conservation scientists to do analytical testing. The conservator, however, should understand the working of the instruments and what tests should be done, as well as how to evaluate the results (Rizzutto et al. 2015: 3, Wasiutynski 2020: 26).

The last step is sampling where the conservator should select a technique where the smallest of samples will give the maximum information needed (Vallance 1997: 80).



Different techniques
Optical techniques

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Magnified observation Single-lens magnifiers	Hand-held magnifier	For initial examination of the surface of objects.	Inexpensive, compact, portable, simple to use, wide field of view.	Short depth of field, fixed magnification, no built-in light source.
Illuminated magnifiers	Hand-held flashlight magnifier	For initial examination of the surface of objects.	Inexpensive, easy to use, portable, compact, large view-field. Models with stands leave both hands free for work.	Resolving power is limited because of the small opening for magnification.

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
• Visible light photography. • Normal illumination	It is used to view the object under standard illumination conditions. The light beams are of equal intensity and distance at a 45° angle to the object to give an even illumination.	It will reveal the following of the object: design, the colouration of the medium used, the structure, any deformations, damages, stains or repairs.	The illumination is as even as possible to give a more satisfactory viewing as with normal daylight viewing.	Illumination can be harmful to works of art or photography (Wasiutynski 2020: 15).
• Raking illumination	The light source is projected across the surface of the object at a low angle, to the one side.	The light source coming from the top or one side will reveal the following: topography of the surface, watermarks, mould, print techniques, rubbing marks, flaking and repairs.	Detailed irregularities can be revealed.	Illumination can be harmful to works of art or photography (Wasiutynski 2020: 15).
• Specular illumination (two techniques)	Axial technique. The camera is positioned parallel to the object's surface, and the lamps are placed adjacent to the camera. Oblique technique. The viewer and the light source are placed on opposite sides of the object at the same angle as the camera.	Reveal surface topography, disparities in surface sheen, any coatings.	Can sometimes be more informative on surface irregularities than raking illumination.	Depth or height of surface irregularities will not be so specifically indicated as raking illumination. Incandescent light can be harmful to the object because of the heat (Warda 2017: 118).

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
• Transmitted illumination	The object is lit from the side, opposite the viewing position. Light that is able to penetrate the object is recorded, usually by using a fibre-optic light.	Reveal differences in density, thickness, gaps, separations, paper structure, watermarks, repairs, tears, scratches, cracks in canvas paintings. In objects, it can reveal separations, cracks or losses.	More detailed information can be revealed.	Watermarks or paper structure cannot be examined when overlying support is severely strained (Warda 2017: 121, Wasiutynski 2020: 16).
• Darkfield and edge illumination	It is mostly used to record cracks in glass and image transfer onto glass. The object is placed on a dark background and illuminated from one or both sides at a low angle.	Framed photographs, drawings, prints or paintings adhered to glass are illuminated to record points of attachment. It is also used to record the loosening of sealed paint in glass paintings or the loosening of photographs adhered to acrylic sheeting.	Impurities and deterioration can be revealed.	No natural light source is used, so colour or grayscale targets cannot be used (Warda 2017: 123).
• Reflectance transformation imaging (RTI)	Previously referred to as polynomial texture mapping (PTM), it consists of a dome with many light sources that is positioned at different angles. For each different illumination direction, images are recorded. The surface normal is then calculated based on the images (Bezur 2021: 10).	The technique creates texture maps of objects from multiple digital images with different illumination directions. This reveals the surface texture (Payne 2021: 18). JPEG files are created to be processed by the RTIBuilder software (Warda 2017: 126).	Complete surface information is gathered. Detailed images can be monitored. It can be easily repeated to compare sets of images effectively (Payne 2021: 21).	The images are virtual, and it is important that other inspection techniques are also used when unusual information is seen before conclusions are made (Warda 2017: 127).

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Close-up photography, photomacrog-raphy, photomi-crography	With this technique, small objects and detail of larger objects, like fibres or their micro-structure, are captured. Photos are taken with a camera and/or a microscope. Close-up photography can take up to 1X mag-nification, photomac-rography up to 50X and photomicrography up to 1500X.	It is practical to reference specific working setups. The proper terminology describing the specific tech-nique is very important.	It is crucial to calculate exposed modifications in depth of field. Nearly all digital cameras can be mounted on a microscope. Diffuse illu-mination can be created by using a small circle of paper large enough for the focus area.	Close-up photography can often result in blurry images. Depth of field can be very limited and lens changes can result in loss of sharpness. Any movement of the micro-scope will result in blurry images (Warda 2017: 129).
Infrared photog-raphy Reflected infra-red photography	Digital cameras are used where the infrared filter is removed to take near-infrared photos without the filter. Incandescent lamps should be used for the illumination as they emit enough infrared that the filters can absorb these longer wavelengths. The light should be uniform and glare-free. All of these techniques require photoshop software to finalise the images taken.	It is used to detect changes, examine underdrawings, faded inscriptions or any other obscured detail.	This technique is used to reveal images and texts that are not visible with the naked eye or general photography. Photographs are in grayscale and are in a mo-saic form (lots of images).	The infrared flare can create a hot spot in the centre of the photograph.

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Transmitted infrared photography	Digital cameras are used with infrared filters removed. The light source should emit infrared light, and the ambient illumination that will fall on the object should be minimised.	It reveals inscriptions, obscured designs (obscured by linings or mounts), watermarks or underdrawings, especially lead white.	It gives a deeper layer of visibility to works of art.	Accurate focus can sometimes be a problem (Warda 2017: 140).
False-colour infrared digital photography (FCIR)	An infrared and visible light image of the same area is taken, and because of both filtrations, a false-colour image is created.	It is used to differentiate and characterise materials to examine inks, dyes and pigments.	Colourants similar in appearance can be differentiated and characterised.	The camera should not be moved between taking images. Specific software should be used to develop the images (Warda 2017: 143).
Visible-induced infrared luminescence	Luminescent infrared wavelengths are produced by exciting material with a blue/green light. This is then recorded by a camera with an IR-pass filter.	It is used to examine documents to specify inks and pigments.	Greater intensity of images and larger subject matter can be examined.	Installing filters to eliminate all infrared output can be especially difficult (Warda 2017: 146).

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TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Ultraviolet photography Ultraviolet-induced visible fluorescence photography	Digital cameras may require no filtration for this imaging. The room should be very dark. Lamps should be positioned with edges parallel to the object so that their beams can fall as directly as possible on the object.	To document faded materials and repairs.	With digital cameras, you have greater control over colour accuracy.	Can be harmful to humans, but the necessary awareness should be adhered to (Warda 2017: 147).
Reflected ultraviolet photography	This technique records the reflection or transmission and the absorption of the ultraviolet radiation.	To examine surfaces and for the characterisation and differentiation of materials. Surface brush strokes, flaws, variations or scratches can be documented.	Enhances the visibility of gums, resins, varnishes, paint residues on paper, textiles, wood and other porous substrates. Residues on metal and stone are also visible. Pigments, textile fibres, dyes, iron, glass and glazes will be visible.	The radiation does not penetrate surfaces deeply, so no deeper visibility is available (Warda 2017: 160).
False-colour reflected ultraviolet (FCUV)	It is similar to false-colour infrared imaging where a non-visible radiation image is combined with two visible light sources.	It is an additional tool to characterise and differentiate materials.	Colourants similar in appearance can be differentiated and characterised.	Specific software like Adobe Photoshop must be used to develop the images (Warda 2017: 163).

Non-invasive techniques

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Microscopy Stereo microscopy	It has low magnification and must typically be used with a light reflecting the surface of the object.	Study external features and objects that cannot be mounted flat. Study details of damage, former repairs, details of technique.	Two separate eyepieces. Mostly used for three-dimensional objects.	Low magnification range, between 10X and 40X (Wasiutynski 2020: 17).
X-ray techniques CT scanning	A rotating X-ray source and detector takes a series of virtual 2D cross-sections of the object. These images are combined to form a black and white 3D image.	It produces 3D images of the interior structure and surfaces of objects.	High-resolution images of very small objects can be taken.	Sometimes the 3D imaging data has a loss of surface detail (Payne 2021: 22).
X-ray fluorescence (XRF)	High-energy X-ray photons are emitted and strike the sample to knock electrons out of the innermost orbital. These atoms become unstable ions. An electron from an outer orbital will fill the vacant space in the inner orbital. These electrons have more energy that needs to be released as they drop. This energy is given off as a photon, which is then detected by the XRF (Loubser 2021: 16–19).	It detects the chemical elements in a sample as well as the concentration thereof.	It is very stable. Predictable and matrix effects can be corrected. It is used for solids, powders and liquids. It is precise and accurate. Elemental compositions from Mg to U can be determined. Concentrations as low as 5 PPM up to 100% can be identified. Up to 25 elements can be measured. It is portable.	The phase and oxidation state of the analyte cannot be detected. There is no differentiation between analytes with the same elemental composition. It cannot detect individual minerals in a sample. There is no low atomic number analysis and limited penetration depth in the sample (Loubser 2021: 7–13).

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Raman spectroscopy	This technique identifies molecules of organic and inorganic compounds. The sample is irradiated with a focused laser beam. The difference in frequency of the scattered molecules is detected by the Raman and compared to a library of Raman spectra from known materials.	To identify crystalline materials (precious, semi-precious stones and minerals). Identify pigments, identify corrosion products on metals and alloys. Characterise mineral phases. Identify plastics.	Non-destructive and can be non-invasive. Analyse samples of powders, liquids and cross-sections. Can be used for chemical mapping. Relatively fast technique.	If laser power is too high, compounds can be destroyed. Dark materials like black pigments are difficult to analyse. Very small particles are difficult to analyse. Because of non-detection, it can give a false-negative result. It can be costly, and operation and interpretation of results can be difficult (Bezur and Sperber 2021: 3).
X-ray diffraction	The inter-planar spacings in the geometry of crystal are measured by X-ray diffraction. It is then compared to the database of collected powder patterns of almost all known organic and inorganic crystalline compounds.	It is used to examine and characterise pottery shards, metal corrosion, metal structures, pigments, cosmetics, ancient hair, salts and clays.	It is non-destructive and portable. The micro-structure of very old/ corroded coins, pottery shards and rock art can be examined. Each crystalline phase has a unique powder diffraction pattern.	If the crystallites in a sample are very large, the distribution will not be smooth, and the measurement will not agree with the database. Interpretation of data requires experience (Loubser 2021: 67–78).

Minimally invasive techniques (sampling)

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Scanning electron microscopy-energy dispersive X-ray spectroscopy analysis (SEM-EDS)	Samples are viewed at high magnifications (SEM) with the ability of mapping fixed elemental analysis (EDS). A focused electron beam is moved across the surface of a sample in a raster pattern. The backscattered electrons are captured and a grayscale image displays the intensity of the electrons. Sample atoms can also give off characteristic X-rays, similar to how XRF and EDS detectors show the elements present in the area.	It detects tool marks, hair/fur, alterations and deterioration of the surface area. It detects layer structures or exposed edges of metals, alloys, textile with metals, glass and glazed ceramics. It detects paint layers (in polished cross-section samples) as well as pigment elements.	High magnification helps to see features not visible with optical microscopy. Light elements and pigments can be more accurately identified than with XRF. Individual pigments and small particles can be identified more easily. It is more sensitive.	Mostly requires a sample. Inference from elemental data limits the identification of compounds. Operation and data interpretation requires extensive training. Maintenance is costly. It is not portable (Bezur and Sperber 2021: 4).

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Fourier-transform infrared spectroscopy (FTIR)	Just as Raman spectroscopy, this technique also identifies molecules of organic and inorganic compounds. The sample is irradiated with an infrared beam. The molecules absorb the infrared wavelengths, and their vibrational motions are detected by the FTIR and compared to a library of FTIR spectra from known materials. This can be regarded as molecular fingerprints.	It categorises organic material (oils, resins, proteins, waxes) and identifies inorganic material (plastics, varnishes, acrylic paints). Fibres can be identified. Degradation products can be identified.	It can identify a wide range of organic and inorganic compounds. Samples are small and can be reused with other analytical techniques. It can be used in situ on relatively flat surfaces. It is widely available.	It requires sample removal. Operation and data interpretation requires experience and understanding of molecular structures. Custom spectral libraries must often be developed (Bezur and Sperber 2021: 5).
Laser-induced breakdown spectroscopy (LIBS)	This technique also identifies molecules. A short-pulse laser beam ablates (removes) a small volume of the sample. This interacts with a portion of the laser pulse to form a plasma that contains free electrons, excited atoms and ions. The plasma then cools, and during this process, the electrons fall down into natural ground states, causing the plasma to give off light with distinct spectral peaks, that is compared to a library of unique LIBS spectral peaks (Loubser 2021: 64).	It identifies chemical compositions.	Broad elemental coverage (H, Be, Li, C, N, O, Na, and Mg). Each element in the periodic table has a unique LIBS spectral peak. This identification enhances the determination of the chemical composition of samples.	It requires sample removal. Custom spectral peaks libraries must be developed (Loubser 2021: 61–64).

TECHNIQUE	BASIC CONCEPT	USES FOR CONSERVATORS	ADVANTAGES	LIMITATIONS
Gas chromatography-mass spectrometry (GC-MS)	It is used to detect and identify the molecular components of organic material (Bezur and Sperber 2021: 6) It uses a carrier gas, usually helium (mobile phase), to carry sample components through capillary columns containing the stationary phase. Low-molecular-weight compounds travel faster through the columns than high-molecular-weight compounds. When they exit, the molecules are ionised and fragmented and determined by the mass spectrometer using electrical or magnetic fields to determine ions based on their mass.	It identifies components of adhesives, coatings, plant resins, waxes, oils, synthetic organic pigments, some protein sources, plant gums and residues in vessels and containers like ointments, food or perfume.	It has a high level of specificity. It can deal with complex molecule mixtures. It is flexible and can use gasses, liquids and solids as samples.	Sampling is required, and the sample is then destroyed. It is highly sensitive, and contamination of samples can interfere with correct data interpretation. Interpretation of data is complex and needs trained and experienced analysers. Samples are prepared in a lab, and the analysing is also done in a lab (Bezur and Sperber 2021: 6).

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San-Mari van der Merwe: THC 803

San-Mari van der Merwe was a first-year master's student in 2021. For her analytical techniques' module assignment, she created a website that can be used when deciding on an appropriate technique for a conservator's research.

Behind all them unturned stones: A look at investigative techniques in heritage conservation

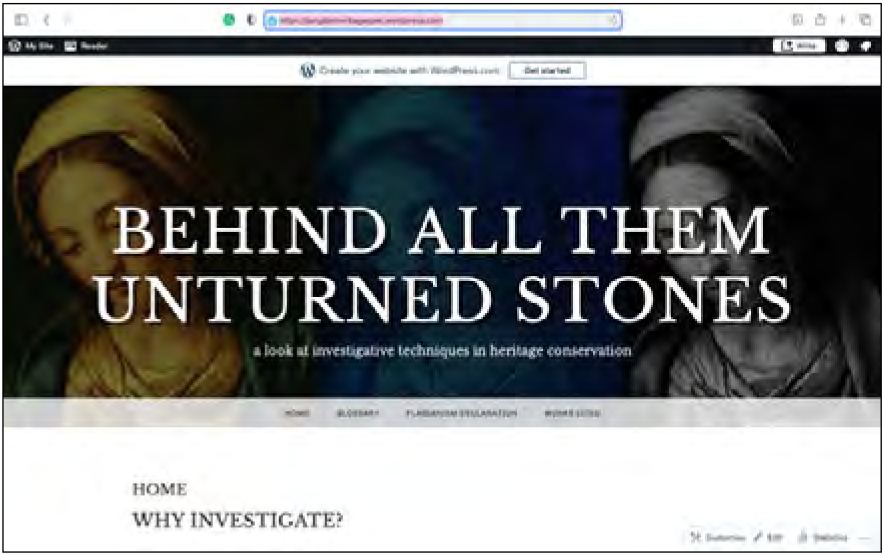
> *How are these imaging technologies currently employed for cultural heritage applications?*
> *What are the advantages, disadvantages and risks of these technologies?*
> *What are the implications of these technologies for preservation of accessibility to objects?*

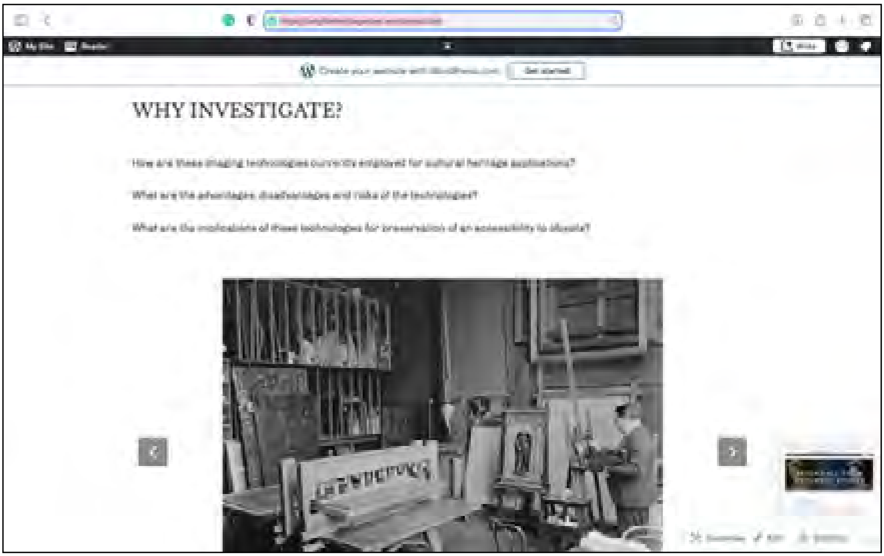
Analysis is needed to answer many questions we may feel the need to ask. It is there to determine the original materials of the object, as well as the characteristics and history of both the materials and the object. It is also there to determine the presence of components or conditions that may influence conservation treatment and to aid in the evaluation of ongoing treatment.

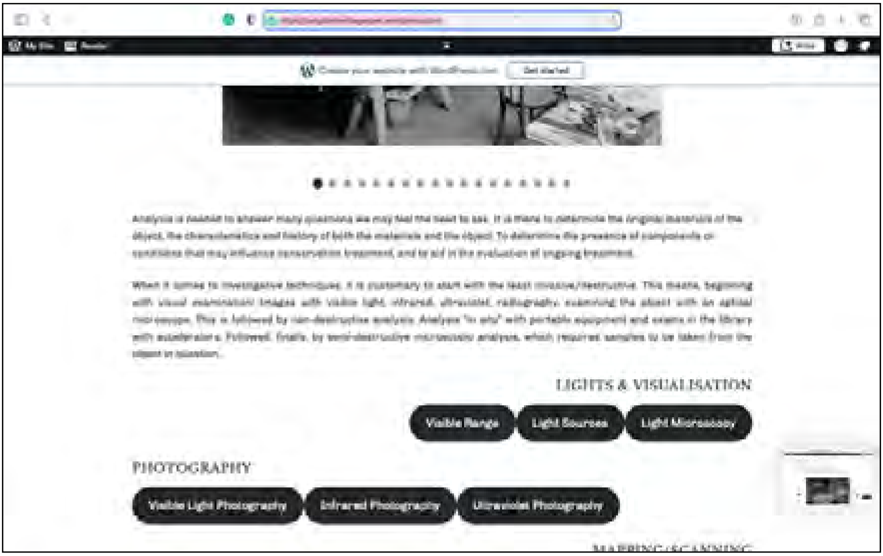
When it comes to investigative techniques, it is customary to start with the least invasive/destructive. This means beginning with visual examination: Images can be examined using visible light, infrared, ultraviolet, radiography or by examining the object with an optical microscope. This is followed by non-destructive analysis—analysis in situ with portable equipment and exams in the library with accelerators. Finally, semi-destructive microscopic analysis can be done, which requires samples to be taken from the object in question.

Please use the link to view the website: https://tangibleheritagespec.wordpress.com

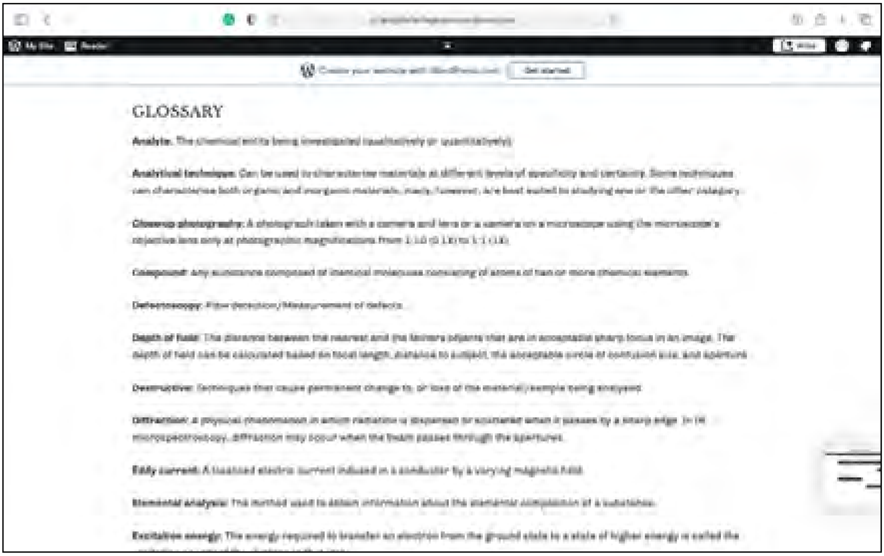
Herewith are attached screenshots in case of technical difficulties:






LIGHTS & VISUALISATION
Visible Range
Light Sources
Light Microscopy
PHOTOGRAPHY
Visible Light Photography
Infrared Photography
Ultraviolet Photography


Visible Light Photography
Infrared Photography
Ultraviolet Photography
MAPPING/SCANNING
Maps and Scans
Handheld XRF
THE "OGRAPHIES"
Chromatography
Thermography
SPECTROSCOPY
SEM-EDS
Raman
LIBS
FTIR
FORS



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GLOSSARY

Analyte: The chemical entity being investigated (qualitatively or quantitatively).

Analytical technique: Can be used to characterize materials at different levels of specificity and certainty. Some techniques can characterize both organic and inorganic materials; many, however, are best suited to studying one or the other category.

Closeup photography: A photograph taken with a camera and lens or a camera on a microscope using the microscope's objective lens only at photographic magnifications from 1:10 (0.1X) to 1:1 (1X).

Compound: Any substance composed of identical molecules consisting of atoms of two or more chemical elements.

Defectoscopy: Flaw detection/Measurement of defects.

Depth of field: The distance between the nearest and the farthest objects that are in acceptably sharp focus in an image. The depth of field can be calculated based on focal length, distance to subject, the acceptable circle of confusion size, and aperture.

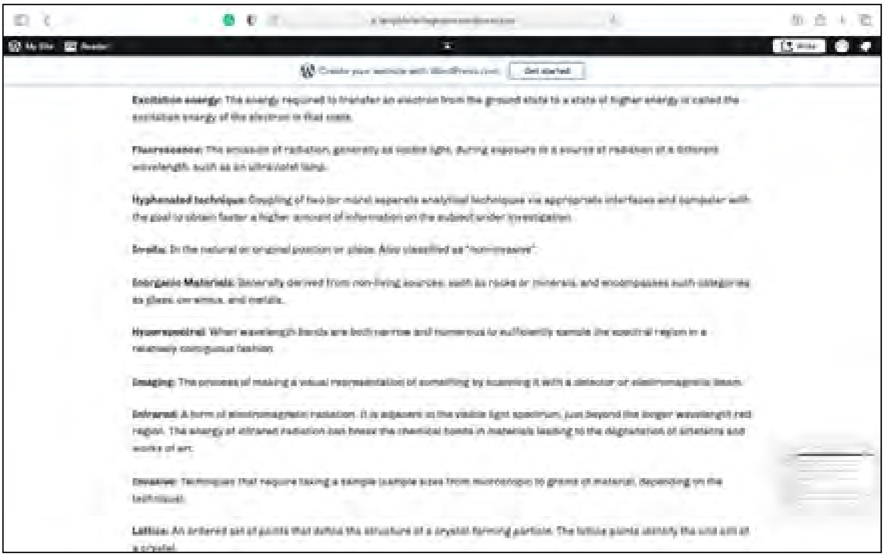
Destructive: Techniques that cause permanent change to, or loss of the material/sample being analysed.

Diffraction: A physical phenomenon in which radiation is dispersed or scattered when it passes by a sharp edge. In IR microspectroscopy, diffraction may occur when the beam passes through the apertures.

Eddy current: A localized electric current induced in a conductor by a varying magnetic field.

Elemental analysis: The method used to obtain information about the elemental composition of a substance.

Excitation energy: The energy required to transfer an electron from the ground state to a state of higher energy is called the



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Excitation energy: The energy required to transfer an electron from the ground state to a state of higher energy is called the excitation energy of the electron in that state.

Fluorescence: The emission of radiation, generally as visible light, during exposure to a source of radiation of a different wavelength, such as an ultraviolet lamp.

Hyphenated technique: Coupling of two (or more) separate analytical techniques via appropriate interfaces and computer with the goal to obtain faster a higher amount of information on the subject under investigation.

In-situ: In the natural or original position or place. Also classified as "non-invasive".

Inorganic Materials: Generally derived from non-living sources, such as rocks or minerals, and encompasses such categories as glass, ceramics, and metals.

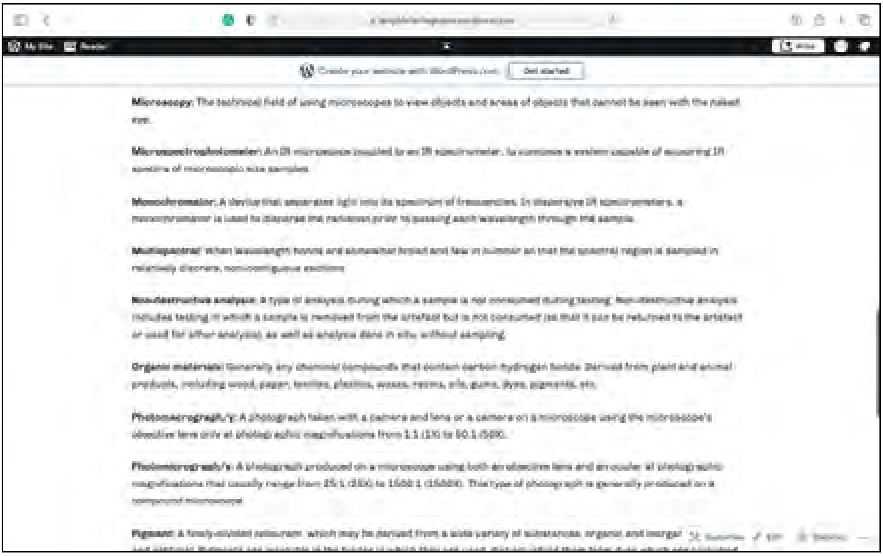
Hyperspectral: When wavelength bands are both narrow and numerous to sufficiently sample the spectral region in a relatively contiguous fashion.

Imaging: The process of making a visual representation of something by scanning it with a detector or electromagnetic beam.

Infrared: A form of electromagnetic radiation. It is adjacent to the visible light spectrum, just beyond the longer wavelength red region. The energy of infrared radiation can break the chemical bonds in materials leading to the degradation of artefacts and works of art.

Invasive: Techniques that require taking a sample (sample sizes from microscopic to grams of material, depending on the technique).

Lattice: An ordered set of points that define the structure of a crystal forming particle. The lattice points identify the unit cell of a crystal.



My Site Reader

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Microscopy: The technical field of using microscopes to view objects and areas of objects that cannot be seen with the naked eye.

Microspectrophotometer: An IR microscope coupled to an IR spectrometer, to combine a system capable of acquiring IR spectra of microscopic size samples.

Monochromator: A device that separates light into its spectrum of frequencies. In dispersive IR spectrometers, a monochromator is used to disperse the radiation prior to passing each wavelength through the sample.

Multispectral: When wavelength bands are somewhat broad and few in number so that the spectral region is sampled in relatively discrete, non-contiguous sections.

Non-destructive analysis: A type of analysis during which a sample is not consumed during testing. Non-destructive analysis includes testing in which a sample is removed from the artefact but is not consumed (so that it can be returned to the artefact or used for other analysis), as well as analysis done in situ without sampling.

Organic materials: Generally any chemical compounds that contain carbon-hydrogen bonds. Derived from plant and animal products, including wood, paper, textiles, plastics, waxes, resins, oils, gums, dyes, pigments, etc.

Photomacrography: A photograph taken with a camera and lens or a camera on a microscope using the microscope's objective lens only at photographic magnifications from 1:1 (1X) to 50:1 (50X).

Photomicrography: A photograph produced on a microscope using both an objective lens and an ocular at photographic magnifications that usually range from 25:1 (25X) to 1500:1 (1500X). This type of photograph is generally produced on a compound microscope.

Pigment: A finely-divided colourant, which may be derived from a wide variety of substances, organic and inorgar

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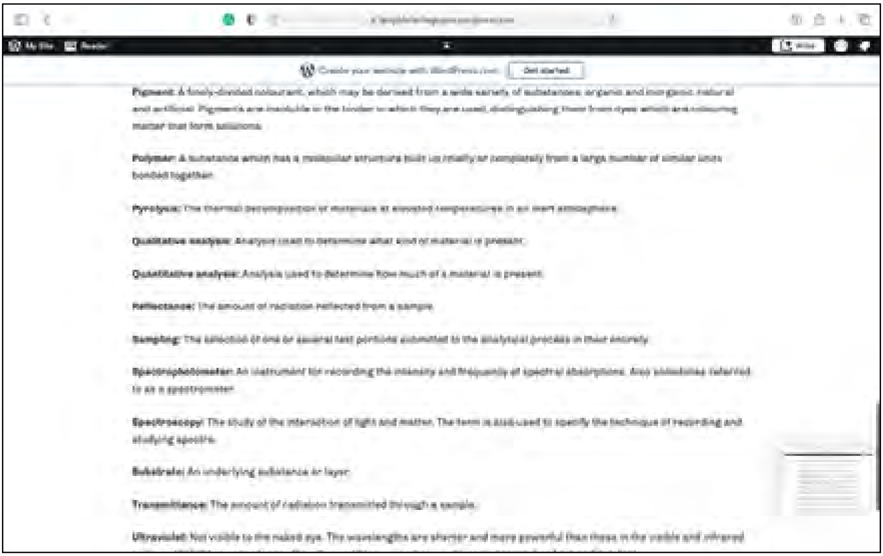

My Site Reader

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Pigment: A finely-divided colourant, which may be derived from a wide variety of substances, organic and inorganic, natural and artificial. Pigments are insoluble in the binder in which they are used, distinguishing them from dyes which are colouring matter that form solutions.

Polymer: A substance which has a molecular structure built up chiefly or completely from a large number of similar units bonded together.

Pyrolysis: The thermal decomposition of materials at elevated temperatures in an inert atmosphere.

Qualitative analysis: Analysis used to determine what kind of material is present.

Quantitative analysis: Analysis used to determine how much of a material is present.

Reflectance: The amount of radiation reflected from a sample.

Sampling: The selection of one or several test portions submitted to the analytical process in their entirety.

Spectrophotometer: An instrument for recording the intensity and frequency of spectral absorptions. Also sometimes referred to as a spectrometer.

Spectroscopy: The study of the interaction of light and matter. The term is also used to specify the technique of recording and studying spectra.

Substrate: An underlying substance or layer.

Transmittance: The amount of radiation transmitted through a sample.

Ultraviolet: Not visible to the naked eye. The wavelengths are shorter and more powerful than those in the visible and infrared


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Get started
Reflectance: The amount of radiation reflected from a sample.
Sampling: The selection of one or several test portions submitted to the analytical process in their entirety.
Spectrophotometer: An instrument for recording the intensity and frequency of spectral absorptions. Also sometimes referred to as a spectrometer.
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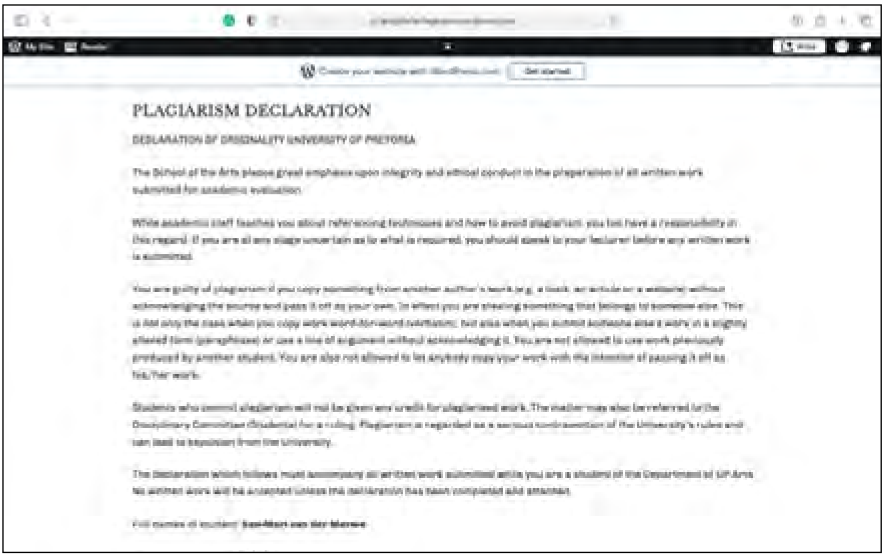
Substrate: An underlying substance or layer.
Transmittance: The amount of radiation transmitted through a sample.
Ultraviolet: Not visible to the naked eye. The wavelengths are shorter and more powerful than those in the visible and infrared regions. UV light rays are longer than X rays. UV rays can be very damaging to works of art and artefacts.
Wavelength: The distance between two successive crests or troughs of a wave – i.e., the length of one wave.

180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PLAGIARISM DECLARATION
DECLARATION OF ORIGINALITY UNIVERSITY OF PRETORIA
The School of the Arts places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.


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Full names of student: SanMari van der Merwe
Topic of work: THO000 Module Assessment
Declaration
1. I understand what plagiarism is and am aware of the University's policy in this regard.
SIGNATURE: SanMari van der Merwe

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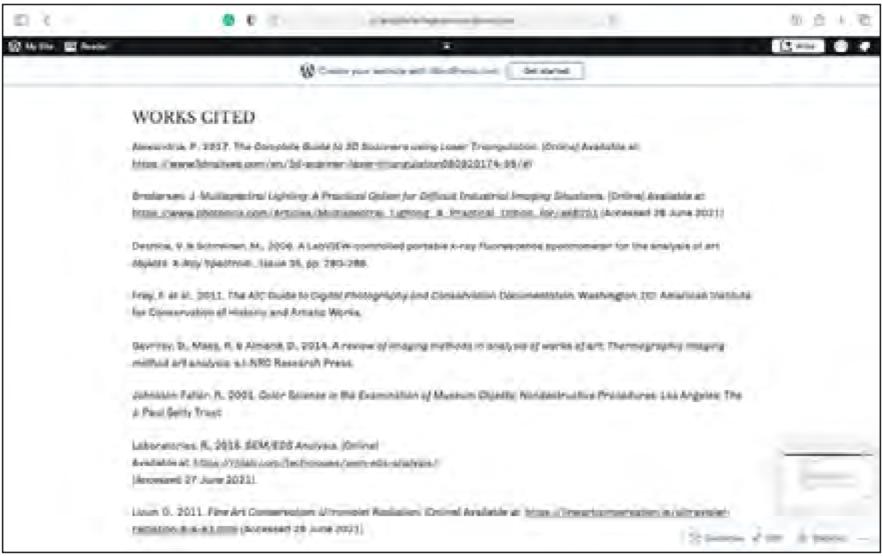
Get started
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(Accessed 27 June 2021).

VISIBLE RANGE

The Eye as Tool/Direct Observation

Encompasses direct visual examination of support and media using visible light (400-700nm), i.e., the range of electromagnetic radiation to which the human eye responds and which gives us sensations of colour, texture, transparency, etc.

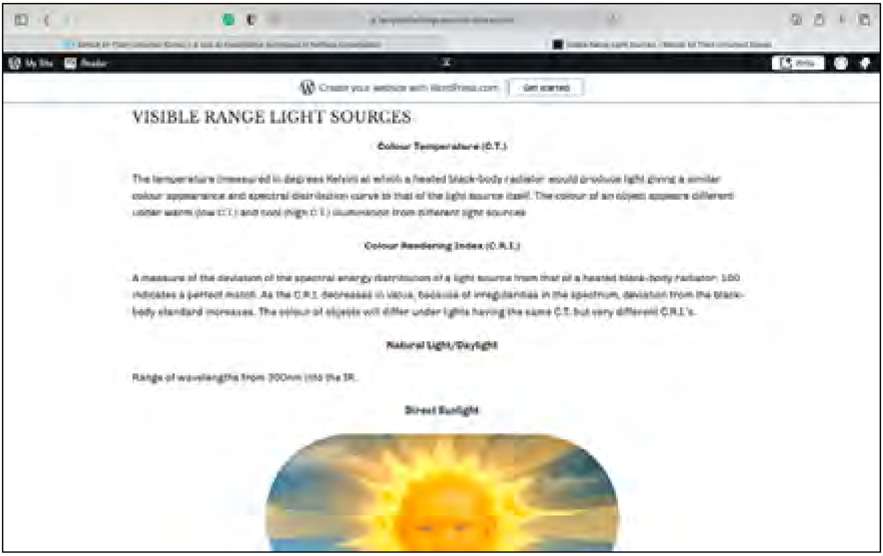
During this visual examination, the object must be seen in as much detail as possible – strong illumination is needed. The human eye is very adaptable and interprets colour and brightness relatively, rather than according to absolute standards. Thus, it is important to know the effects of different illumination types. The object may be illuminated from several angles, information may be recorded photographically.

Magnifiers

Hand-held magnifiers consist of a single lens or lens combination. Placed between object and eye, a convex lens restores image sharpness, increasing apparent object size. Magnification is usually in the range 1.5 to 20 times. Field of view (area of object seen) is directly related to the diameter of the lens. With or without built-in light source.

Multiple lens magnifiers are more complex, consist of double or triple combination lenses designed to eliminate certain optical errors. Upper magnification limit is about x20, usual values are x8 to x10.

Illuminated magnifiers provide both magnification and illumination and are available in single and multiple lens systems.



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VISIBLE RANGE LIGHT SOURCES

Colour Temperature (C.T.)

The temperature (measured in degrees Kelvin) at which a heated black-body radiator would produce light giving a similar colour appearance and spectral distribution curve to that of the light source itself. The colour of an object appears different under warm (low C.T.) and cool (high C.T.) illumination from different light sources.

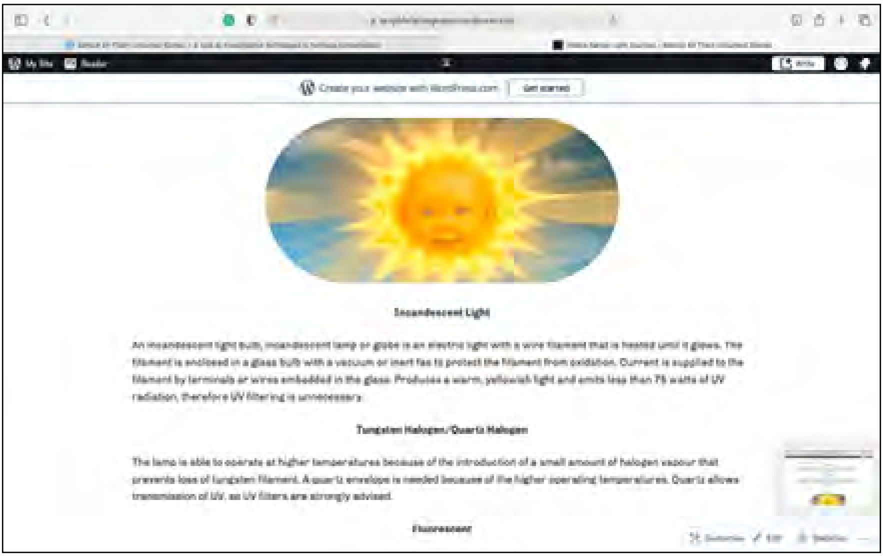
Colour Rendering Index (C.R.I.)

A measure of the deviation of the spectral energy distribution of a light source from that of a heated black-body radiator. 100 indicates a perfect match. As the C.R.I. decreases in value, because of irregularities in the spectrum, deviation from the black-body standard increases. The colour of objects will differ under lights having the same C.T. but very different C.R.I.'s.

Natural Light/Daylight

Range of wavelengths from 300nm into the IR.

Direct Sunlight



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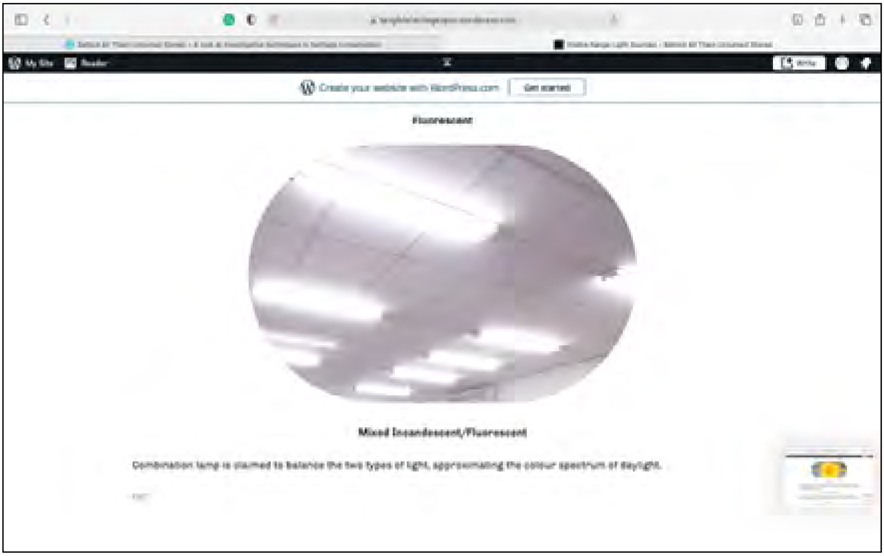
Incandescent Light

An incandescent light bulb, incandescent lamp or globe is an electric light with a wire filament that is heated until it glows. The filament is enclosed in a glass bulb with a vacuum or inert fas to protect the filament from oxidation. Current is supplied to the filament by terminals or wires embedded in the glass. Produces a warm, yellowish light and emits less than 75 watts of UV radiation, therefore UV filtering is unnecessary.

Tungsten Halogen/Quartz Halogen

The lamp is able to operate at higher temperatures because of the introduction of a small amount of halogen vapour that prevents loss of tungsten filament. A quartz envelope is needed because of the higher operating temperatures. Quartz allows transmission of UV, so UV filters are strongly advised.

Fluorescent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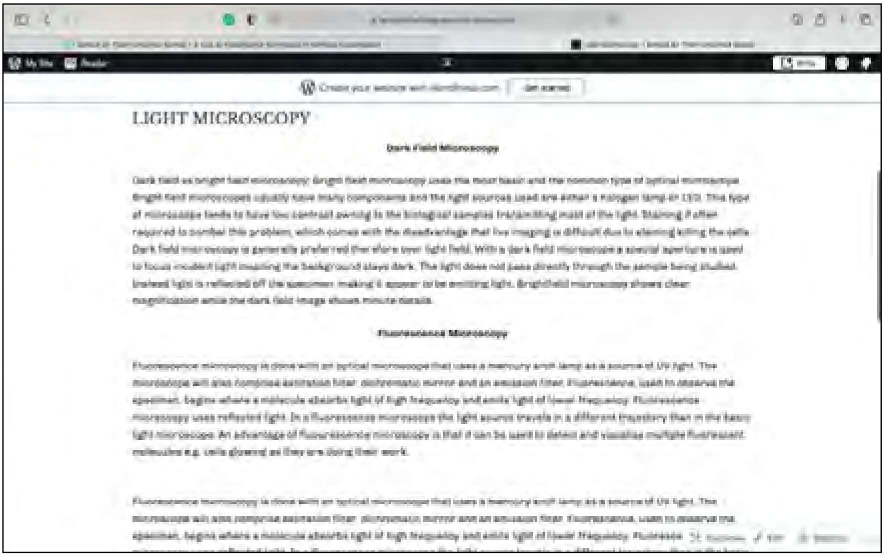
Fluorescent
Mixed Incandescent/Fluorescent
Combination lamp is claimed to balance the two types of light, approximating the colour spectrum of daylight.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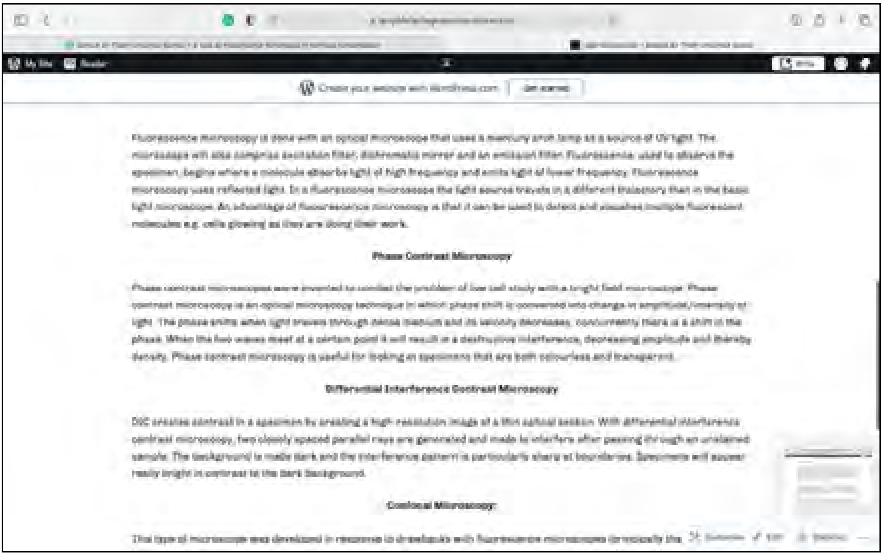
LIGHT MICROSCOPY
Dark Field Microscopy
Dark field vs bright field microscopy: Bright field microscopy uses the most basic and the common type of optical microscope. Bright field microscopes usually have many components and the light sources used are either a halogen lamp or LED. This type of microscope tends to have low contrast owing to the biological samples transmitting most of the light. Staining if often required to combat this problem, which comes with the disadvantage that live imaging is difficult due to staining killing the cells. Dark field microscopy is generally preferred therefore over light field. With a dark field microscope a special aperture is used to focus incident light meaning the background stays dark. The light does not pass directly through the sample being studied. Instead light is reflected off the specimen making it appear to be emitting light. Brightfield microscopy shows clear magnification while the dark field image shows minute details.
Fluorescence Microscopy
Fluorescence microscopy is done with an optical microscope that uses a mercury arc lamp as a source of UV light. The microscope will also comprise excitation filter, dichromatic mirror and an emission filter. Fluorescence, used to observe the specimen, begins where a molecule absorbs light of high frequency and emits light of lower frequency. Fluorescence microscopy uses reflected light. In a fluorescence microscope the light source travels in a different trajectory than in the basic light microscope. An advantage of fluorescence microscopy is that it can be used to detect and visualise multiple fluorescent molecules e.g. cells glowing as they are doing their work.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Phase Contrast Microscopy

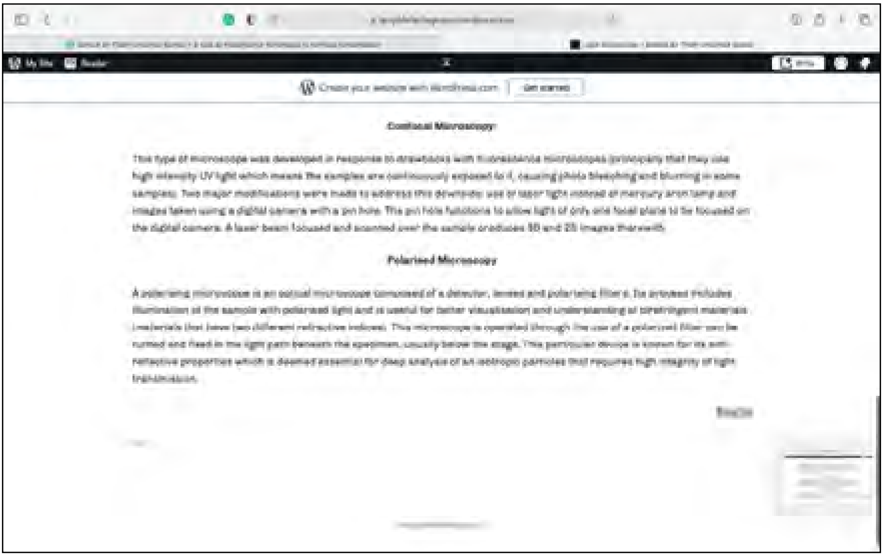
Phase contrast microscopes were invented to combat the problem of low cell study with a bright field microscope. Phase contrast microscopy is an optical microscopy technique in which phase shift is converted into change in amplitude/intensity of light. The phase shifts when light travels through dense medium and its velocity decreases, concurrently there is a shift in the phase. When the two waves meet at a certain point it will result in a destructive interference, decreasing amplitude and thereby density. Phase contrast microscopy is useful for looking at specimens that are both colourless and transparent.

Differential Interference Contrast Microscopy

DIC creates contrast in a specimen by creating a high-resolution image of a thin optical section. With differential interference contrast microscopy, two closely spaced parallel rays are generated and made to interfere after passing through an unstained sample. The background is made dark and the interference pattern is particularly sharp at boundaries. Specimens will appear really bright in contrast to the dark background.

Confocal Microscopy

This type of microscope was developed in response to drawbacks with fluorescence microscopes (principally the [illegible]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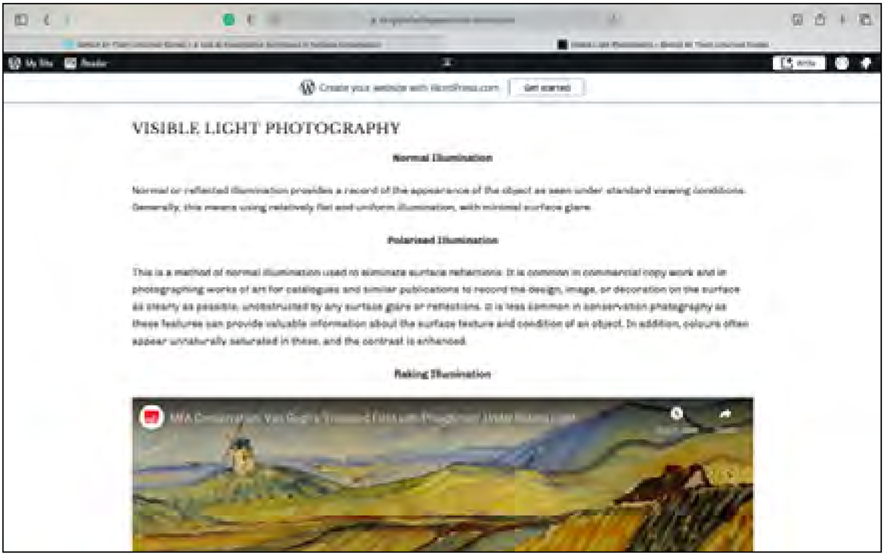
Confocal Microscopy

This type of microscope was developed in response to drawbacks with fluorescence microscopes (principally that they use high intensity UV light which means the samples are continuously exposed to it, causing photo bleaching and blurring in some samples). Two major modifications were made to address this downside: use of laser light instead of mercury arch lamp and images taken using a digital camera with a pin hole. The pin hole functions to allow light of only one focal plane to be focused on the digital camera. A laser beam focused and scanned over the sample produces 3D and 2D images therewith.

Polarised Microscopy

A polarising microscope is an optical microscope composed of a detector, lenses and polarising filters. Its process includes illumination of the sample with polarised light and is useful for better visualisation and understanding of birefringent materials (materials that have two different refractive indices). This microscope is operated through the use of a polarised filter can be turned and fixed in the light path beneath the specimen, usually below the stage. This particular device is known for its anti-reflective properties which is deemed essential for deep analysis of anisotropic particles that requires high integrity of light transmission.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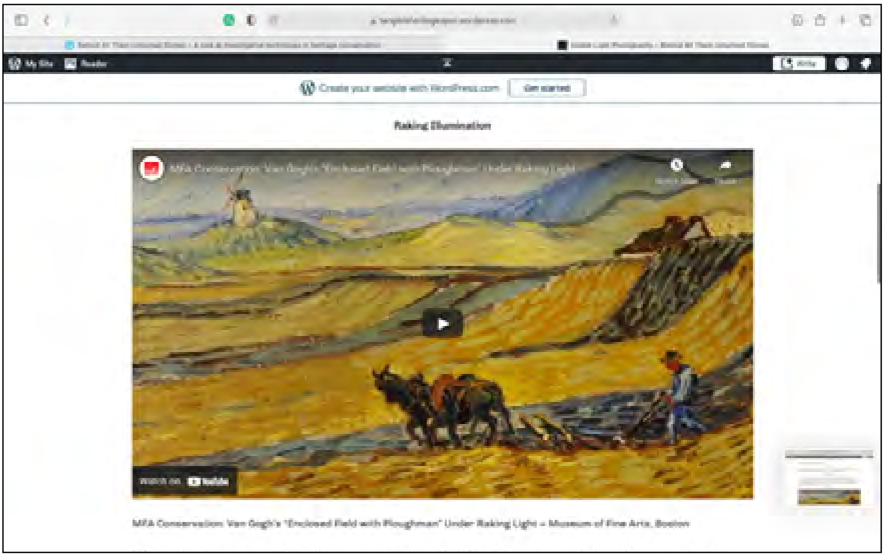
Get started
VISIBLE LIGHT PHOTOGRAPHY
Normal Illumination
Normal or reflected illumination provides a record of the appearance of the object as seen under standard viewing conditions. Generally, this means using relatively flat and uniform illumination, with minimal surface glare.
Polarised Illumination
This is a method of normal illumination used to eliminate surface reflections. It is common in commercial copy work and in photographing works of art for catalogues and similar publications to record the design, image, or decoration on the surface as clearly as possible, unobstructed by any surface glare or reflections. It is less common in conservation photography as these features can provide valuable information about the surface texture and condition of an object. In addition, colours often appear unnaturally saturated in these, and the contrast is enhanced.
Raking Illumination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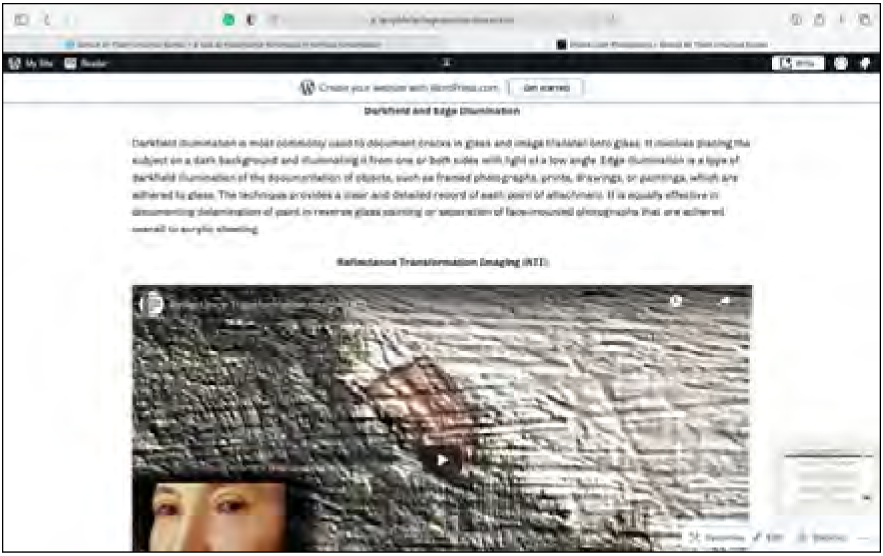
Raking Illumination
MFA Conservation: Van Gogh's "Enclosed Field with Ploughman" Under Raking Light
Watch on YouTube
MFA Conservation: Van Gogh's "Enclosed Field with Ploughman" Under Raking Light – Museum of Fine Arts, Boston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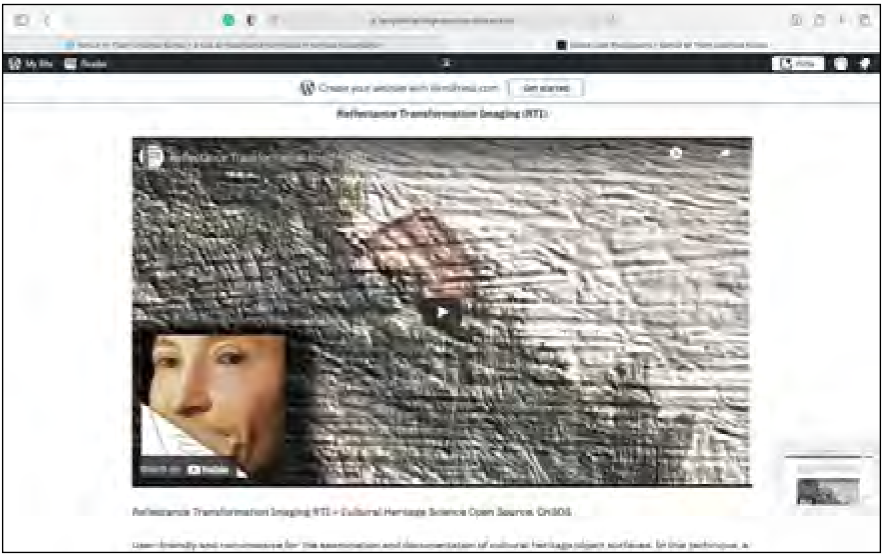
Get started
Darkfield and Edge Illumination
Reflectance Transformation Imaging (RTI)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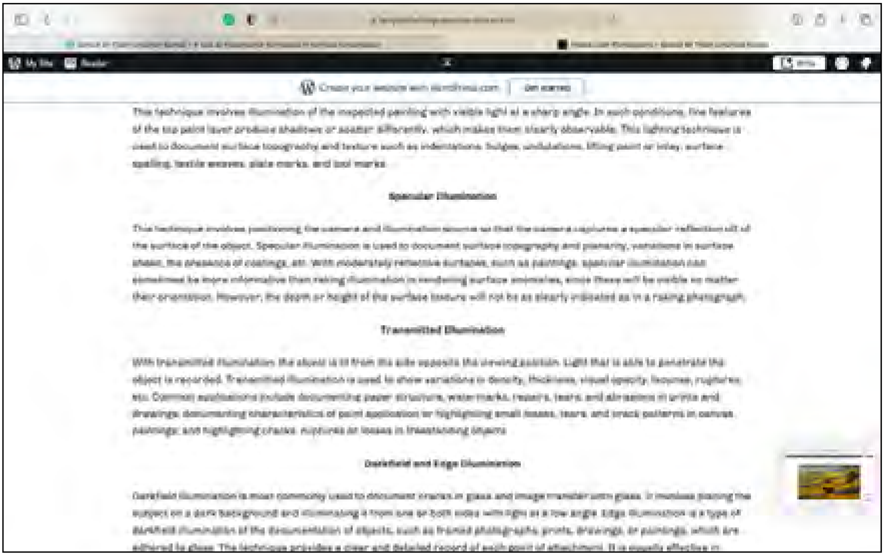
Reflectance Transformation Imaging (RTI)
Reflectance Transformation Imaging RTI – Cultural Heritage Science Open Source, CHSOS



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This technique involves illumination of the inspected painting with visible light at a sharp angle. In such conditions, fine features of the top paint layer produce shadows or scatter differently, which makes them clearly observable. This lighting technique is used to document surface topography and texture such as indentations, bulges, undulations, lifting paint or inlay, surface spalling, textile weaves, plate marks, and tool marks.

Specular Illumination

This technique involves positioning the camera and illumination source so that the camera captures a specular reflection off of the surface of the object. Specular illumination is used to document surface topography and planarity, variations in surface sheen, the presence of coatings, etc. With moderately reflective surfaces, such as paintings, specular illumination can sometimes be more informative than raking illumination in rendering surface anomalies, since these will be visible no matter their orientation. However, the depth or height of the surface texture will not be as clearly indicated as in a raking photograph.

Transmitted Illumination

With transmitted illumination, the object is lit from the side opposite the viewing position. Light that is able to penetrate the object is recorded. Transmitted illumination is used to show variations in density, thickness, visual opacity, lacunae, ruptures, etc. Common applications include documenting paper structure, watermarks, repairs, tears, and abrasions in prints and drawings; documenting characteristics of paint application or highlighting small losses, tears, and crack patterns in canvas paintings; and highlighting cracks, ruptures or losses in freestanding objects.

Darkfield and Edge Illumination

Darkfield illumination is most commonly used to document cracks in glass and image transfer onto glass. It involves placing the subject on a dark background and illuminating it from one or both sides with light at a low angle. Edge illumination is a type of darkfield illumination of the documentation of objects, such as framed photographs, prints, drawings, or paintings, which are adhered to glass. The technique provides a clear and detailed record of each point of attachment. It is equally effective in

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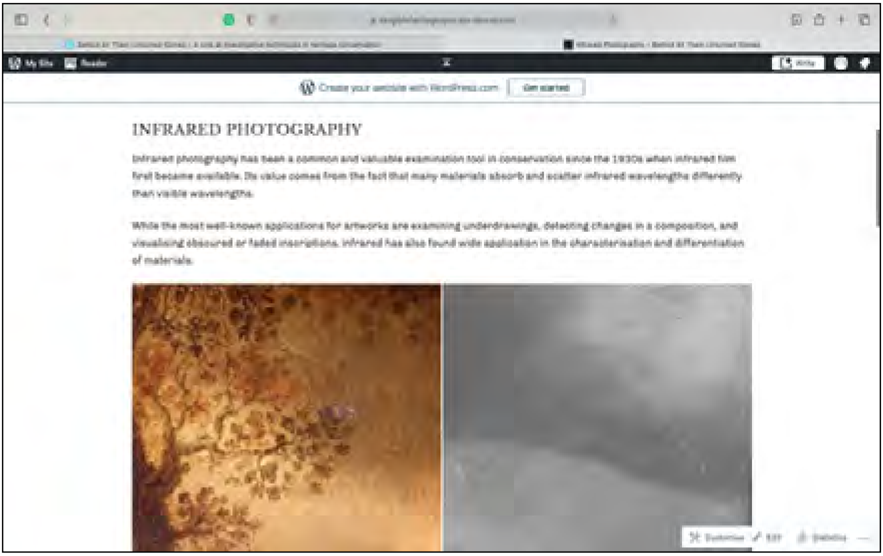
Reflectance Transformation Imaging RTI – Cultural Heritage Science Open Source, CHSOS

User-friendly and non-invasive for the examination and documentation of cultural heritage object surfaces. In this technique, a source image set is processed into an interactive file. It allows the viewer to examine the visual appearance of an object in various lighting conditions with a range of computational enhancements, highlighting and revealing characteristics of the imaged objects. RTI can be used for a variety of activities including documentation, condition monitoring, intervention conservation treatment, interactive museum displays and research. RTI is a Computational Photography assisted technique which uses multi-lighting conditions to capture a set of images from a fixed camera position.

The distinctive feature of this method is the ability to virtually 'relight' the imaged surface from any angle in a viewer. A processed source image set is therefore often referred to as a relightable file or image. Key to this imaging method is the acquisition of the source image set; a series of images are captured with the object and camera static relative to each other, while knowing or recording the spatial location of the light sources.

(If you want to see more of this, click here to view the Cooper Hewitt webpage where you are able to adjust the light source by moving your mouse over the images)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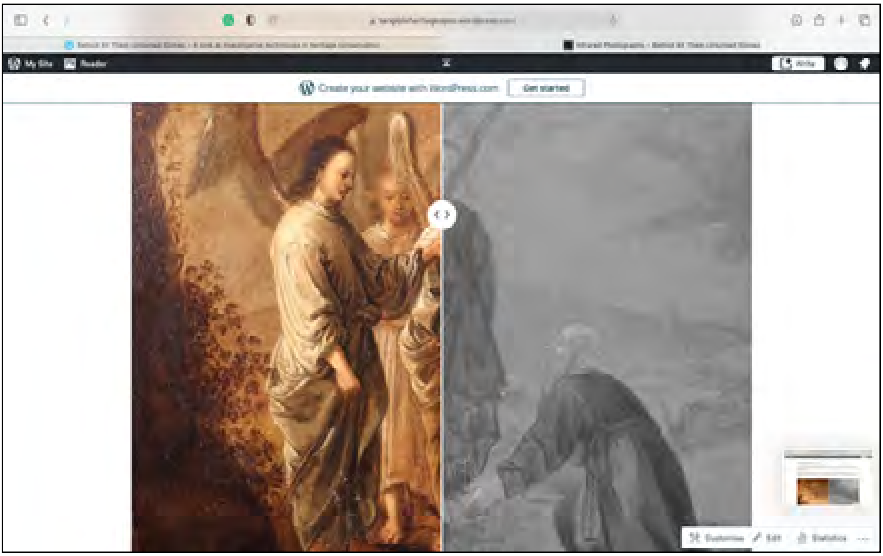
INFRARED PHOTOGRAPHY
Infrared photography has been a common and valuable examination tool in conservation since the 1930s when infrared film first became available. Its value comes from the fact that many materials absorb and scatter infrared wavelengths differently than visible wavelengths.
While the most well-known applications for artworks are examining underdrawings, detecting changes in a composition, and visualising obscured or faded inscriptions, infrared has also found wide application in the characterisation and differentiation of materials.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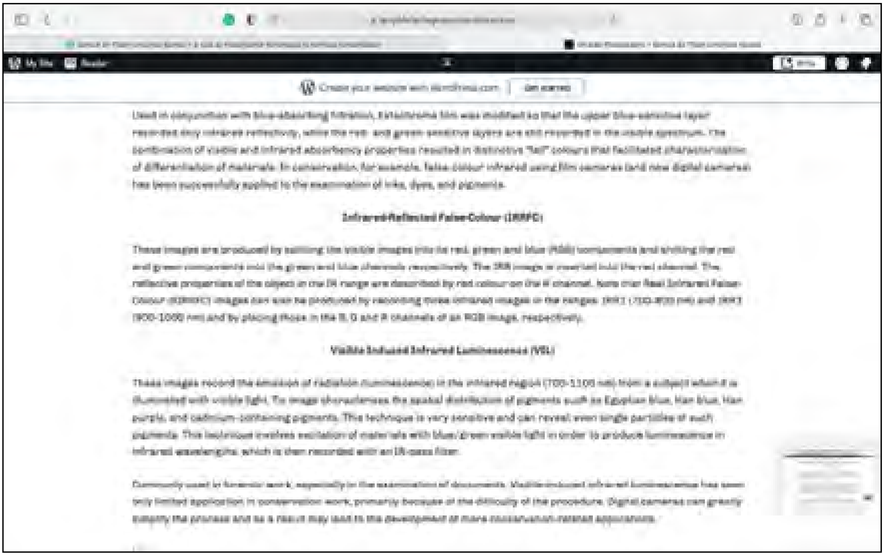

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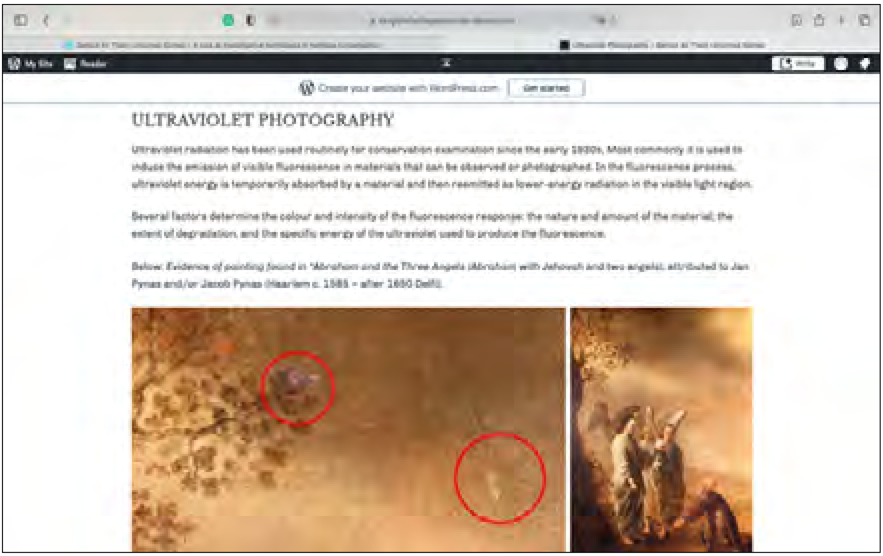
Get started
Infrared-Reflected False-Colour (IRRFC)
Visible Induced Infrared Luminescence (VIL)



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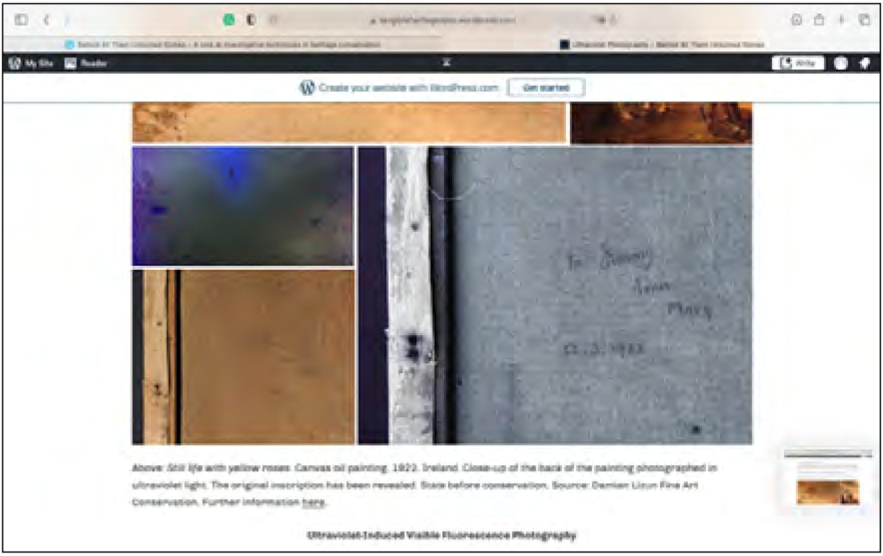
ULTRAVIOLET PHOTOGRAPHY
Ultraviolet radiation has been used routinely for conservation examination since the early 1930s. Most commonly it is used to induce the emission of visible fluorescence in materials that can be observed or photographed. In the fluorescence process, ultraviolet energy is temporarily absorbed by a material and then reemitted as lower-energy radiation in the visible light region.
Several factors determine the colour and intensity of the fluorescence response: the nature and amount of the material, the extent of degradation, and the specific energy of the ultraviolet used to produce the fluorescence.



Above: *Still life with yellow roses*. Canvas oil painting, 1922, Ireland. Close-up of the back of the painting photographed in ultraviolet light. The original inscription has been revealed. State before conservation. Source: Damian Lizun Fine Art Conservation. Further information here.

Ultraviolet-Induced Visible Fluorescence Photography

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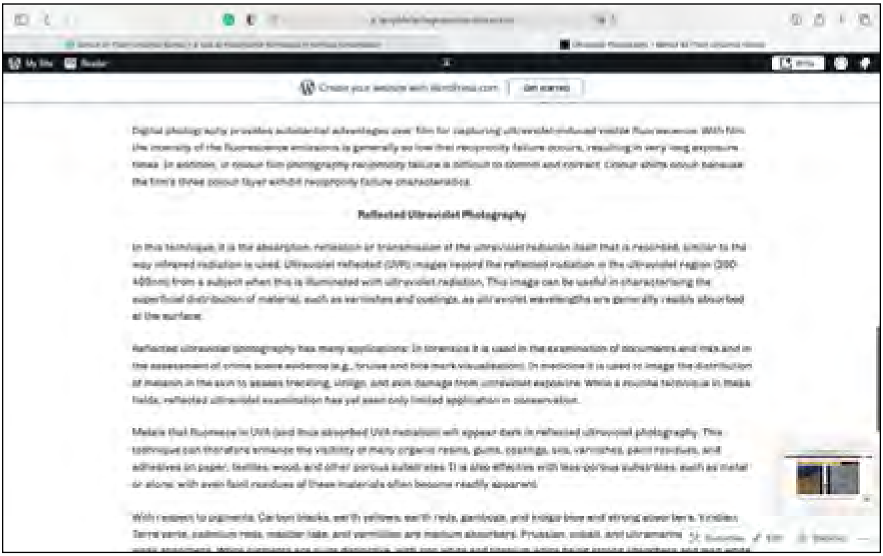

Digital photography provides substantial advantages over film for capturing ultraviolet-induced visible fluorescence. With film the intensity of the fluorescence emissions is generally so low that reciprocity failure occurs, resulting in very long exposure times. In addition, in colour film photography reciprocity failure is difficult to control and correct. Colour shifts occur because the film's three colour layers exhibit reciprocity failure characteristics.

Reflected Ultraviolet Photography

In this technique, it is the absorption, reflection or transmission of the ultraviolet radiation itself that is recorded, similar to the way infrared radiation is used. Ultraviolet reflected (UVR) images record the reflected radiation in the ultraviolet region (200-400nm) from a subject when this is illuminated with ultraviolet radiation. This image can be useful in characterising the superficial distribution of material, such as varnishes and coatings, as ultraviolet wavelengths are generally readily absorbed at the surface.

Reflected ultraviolet photography has many applications: In forensics it is used in the examination of documents and inks and in the assessment of crime scene evidence (e.g., bruise and bite mark visualisation). In medicine it is used to image the distribution of melanin in the skin to assess freckling, vitiligo, and skin damage from ultraviolet exposure. While a routine technique in these fields, reflected ultraviolet examination has yet seen only limited application in conservation.

Materials that fluoresce in UVA (and thus absorbed UVA radiation) will appear dark in reflected ultraviolet photography. This technique can therefore enhance the visibility of many organic resins, gums, coatings, oils, varnishes, paint residues, and adhesives on paper, textiles, wood, and other porous substrates. It is also effective with less-porous substrates, such as metal or stone, with even faint residues of these materials often become readily apparent.

With respect to pigments: Carbon blacks, earth yellows, earth reds, gamboge, and indigo blue are strong absorbers. Viridian, Terre verte, cadmium reds, madder lake, and vermilion are medium absorbers. Prussian, cobalt, and ultramarine [illegible]


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False-Colour Reflected Ultraviolet (FCUV)
Ultraviolet-Reflected False-Colour (UVRFC)
Ultraviolet-Induced Luminescence (UVL)

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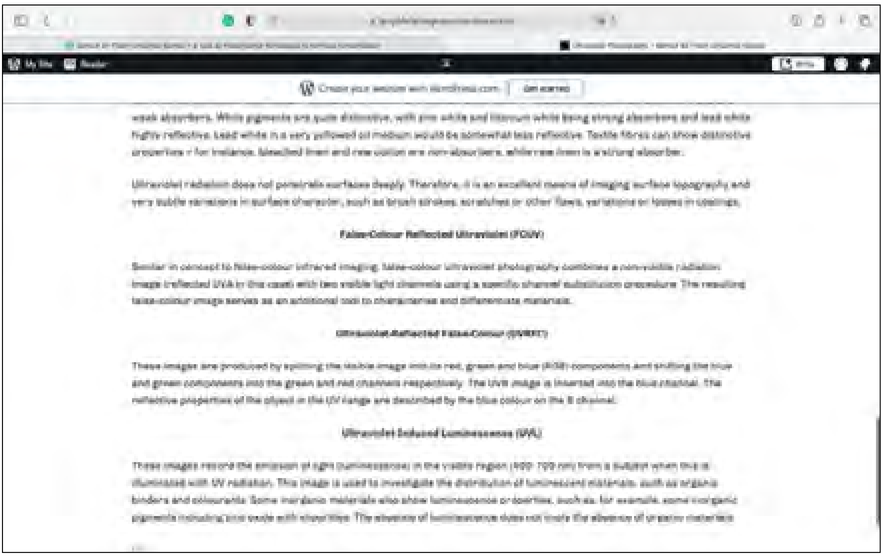
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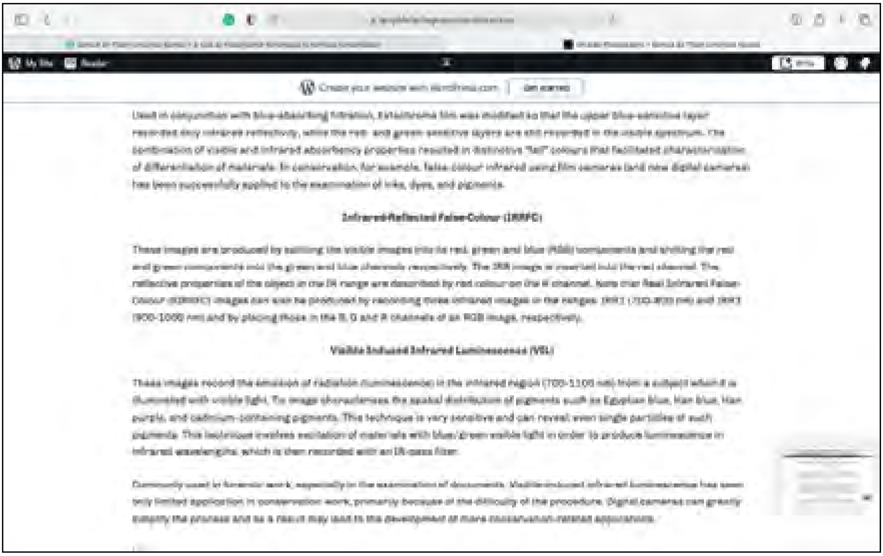

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Used in conjunction with blue-absorbing filtration, Ektachrome film was modified so that the upper blue-sensitive layer recorded only infrared reflectivity, while the red- and green-sensitive layers are still recorded in the visible spectrum. The combination of visible and infrared absorbency properties resulted in distinctive "fall" colours that facilitated characterisation or differentiation of materials. In conservation, for example, false-colour infrared using film cameras (and now digital cameras) has been successfully applied to the examination of inks, dyes, and pigments.

Infrared-Reflected False-Colour (IRRFC)

These images are produced by splitting the visible images into its red, green and blue (RGB) components and shifting the red and green components into the green and blue channels respectively. The IRR image is inserted into the red channel. The reflective properties of the object in the IR range are described by red colour on the R channel. Note that Real Infrared False-Colour (RIRFC) images can also be produced by recording three infrared images in the ranges: IRR1 (700-800 nm) and IRR3 (900-1000 nm) and by placing those in the B, G and R channels of an RGB image, respectively.

Visible Induced Infrared Luminescence (VIL)

These images record the emission of radiation (luminescence) in the infrared region (700-1100 nm) from a subject which it is illuminated with visible light. To image characterises the spatial distribution of pigments such as Egyptian blue, Han blue, Han purple, and cadmium-containing pigments. This technique is very sensitive and can reveal even single particles of such pigments. This technique involves excitation of materials with blue/green visible light in order to produce luminescence in infrared wavelengths, which is then recorded with an IR-pass filter.

Commonly used in forensic work, especially in the examination of documents, Visible-induced infrared luminescence has seen only limited application in conservation work, primarily because of the difficulty of the procedure. Digital cameras can greatly simplify the process and as a result may lead to the development of more conservation-related applications.

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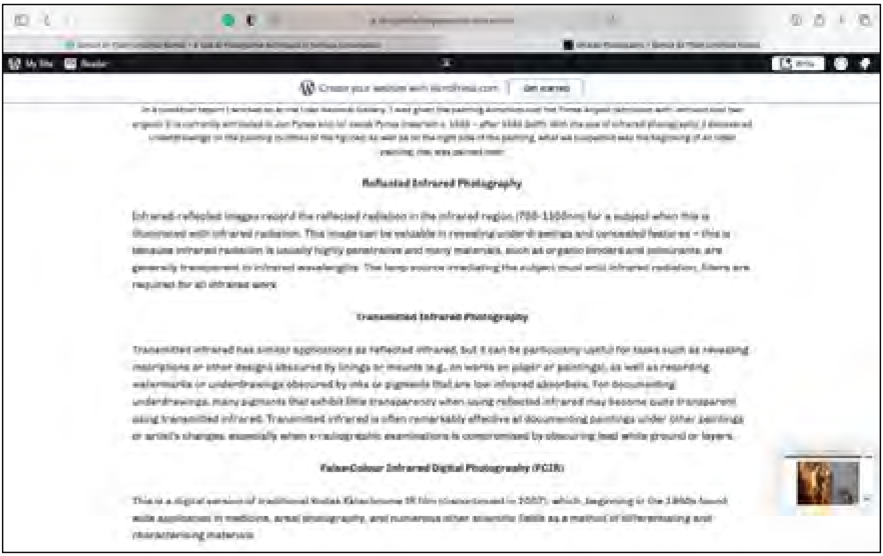

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[illegible]

Reflected Infrared Photography

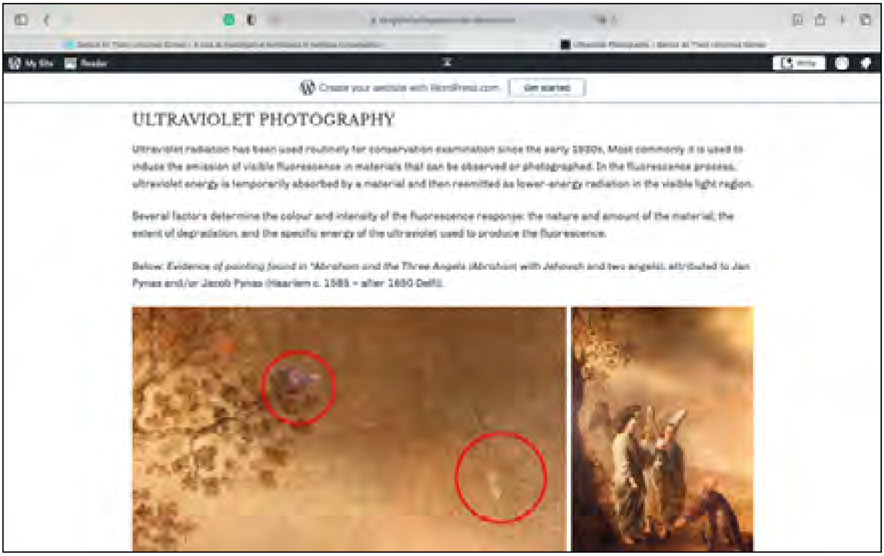
Infrared-reflected images record the reflected radiation in the infrared region (750-1100nm) for a subject when this is illuminated with infrared radiation. This image can be valuable in revealing underdrawings and concealed features – this is because infrared radiation is usually highly penetrative and many materials, such as organic binders and colourants, are generally transparent in infrared wavelengths. The lamp source irradiating the subject must emit infrared radiation, filters are required for all infrared work.

Transmitted Infrared Photography

Transmitted infrared has similar applications as reflected infrared, but it can be particularly useful for tasks such as revealing inscriptions or other designs obscured by linings or mounts (e.g., on works on paper or paintings), as well as recording watermarks or underdrawings obscured by inks or pigments that are low infrared absorbers. For documenting underdrawings, many pigments that exhibit little transparency when using reflected infrared may become quite transparent using transmitted infrared. Transmitted infrared is often remarkably effective at documenting paintings under other paintings or artist's changes, especially when x-radiographic examination is compromised by obscuring lead white ground or layers.

False-Colour Infrared Digital Photography (FCIR)

This is a digital version of traditional Kodak Ektachrome IR film (discontinued in 2007), which, beginning in the 1960s found wide application in medicine, aerial photography, and numerous other scientific fields as a method of differentiating and characterising materials.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ULTRAVIOLET PHOTOGRAPHY
Ultraviolet radiation has been used routinely for conservation examination since the early 1930s. Most commonly it is used to induce the emission of visible fluorescence in materials that can be observed or photographed. In the fluorescence process, ultraviolet energy is temporarily absorbed by a material and then reemitted as lower-energy radiation in the visible light region.
Several factors determine the colour and intensity of the fluorescence response: the nature and amount of the material, the extent of degradation, and the specific energy of the ultraviolet used to produce the fluorescence.
Below: Evidence of painting found in 'Abraham and the Three Angels (Abraham with Jehovah and two angels), attributed to Jan Pynas and/or Jacob Pynas (Haarlem c. 1585 – after 1650 Delft).

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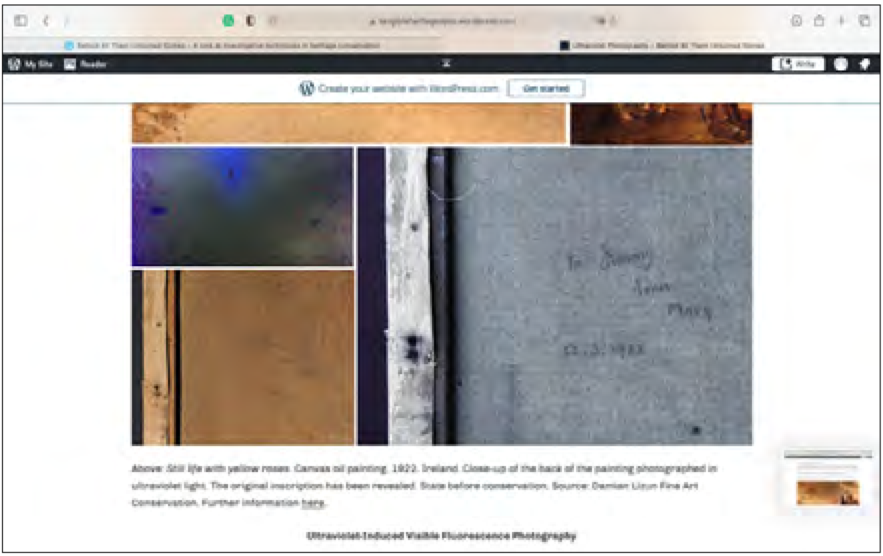
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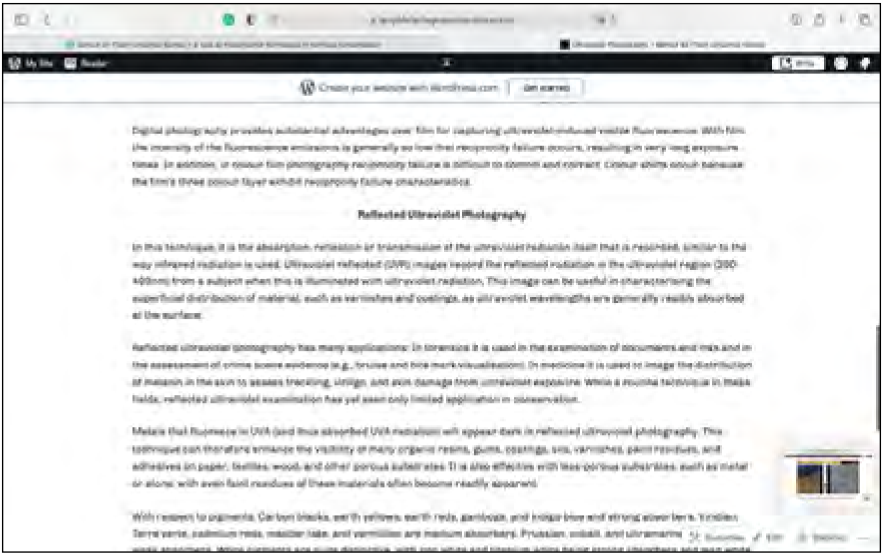
Above: Still life with yellow roses. Canvas oil painting. 1922. Ireland. Close-up of the back of the painting photographed in ultraviolet light. The original inscription has been revealed. State before conservation. Source: Damian Lizun Fine Art Conservation. Further information here.
Ultraviolet-Induced Visible Fluorescence Photography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In this technique, it is the absorption, reflection or transmission of the ultraviolet radiation itself that is recorded, similar to the way infrared radiation is used. Ultraviolet reflected (UVR) images record the reflected radiation in the ultraviolet region (300-400nm) from a subject when this is illuminated with ultraviolet radiation. This image can be useful in characterising the superficial distribution of material, such as varnishes and coatings, as ultraviolet wavelengths are generally readily absorbed at the surface.

Reflected ultraviolet photography has many applications: In forensics it is used in the examination of documents and inks and in the assessment of crime scene evidence (e.g., bruise and bite mark visualisation). In medicine it is used to image the distribution of melanin in the skin to assess freckling, vitiligo, and skin damage from ultraviolet exposure. While a routine technique in these fields, reflected ultraviolet examination has yet seen only limited application in conservation.

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With respect to pigments: Carbon blacks, earth yellows, earth reds, gamboge, and indigo blue are strong absorbers. Viridian, Terre verte, cadmium reds, madder lake, and vermilion are medium absorbers. Prussian, cobalt, and ultramarine


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With respect to pigments: Carbon blacks, earth yellows, earth reds, gamboge, and indigo blue are strong absorbers. Viridian, Terre verte, cadmium reds, madder lake, and vermilion are medium absorbers. Prussian, cobalt, and ultramarine blues are weak absorbers. White pigments are quite distinctive, with zinc white and titanium white being strong absorbers and lead white highly reflective. Lead white in a very yellowed oil medium would be somewhat less reflective. Textile fibres can show distinctive properties – for instance, bleached linen and raw cotton are non-absorbers, while raw linen is a strong absorber.

Ultraviolet radiation does not penetrate surfaces deeply. Therefore, it is an excellent means of imaging surface topography and very subtle variations in surface character, such as brush strokes, scratches or other flaws, variations or losses in coatings.

False Colour Reflected Ultraviolet (FCUV)

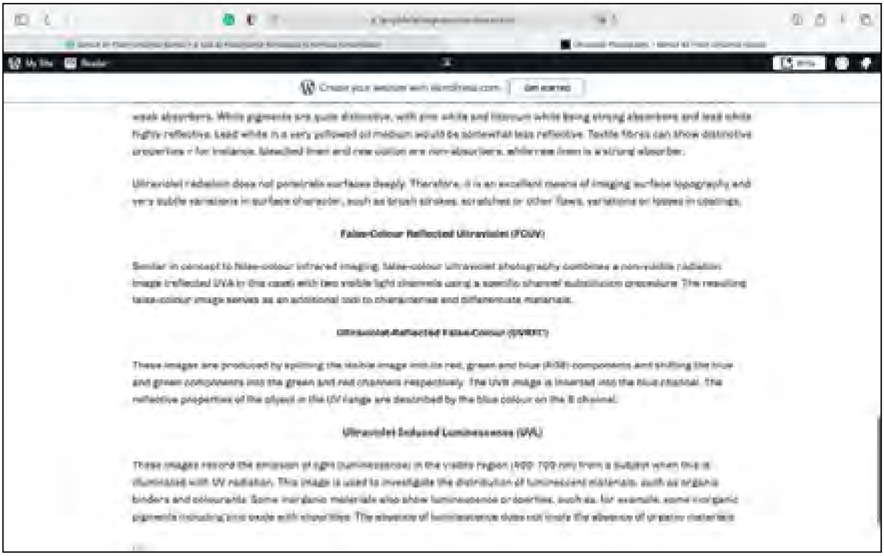
Similar in concept to false-colour infrared imaging, false-colour ultraviolet photography combines a non-visible radiation image (reflected UVA in this case) with two visible light channels using a specific channel substitution procedure. The resulting false-colour image serves as an additional tool to characterise and differentiate materials.

Ultraviolet Reflected False-Colour (UVRFC)

These images are produced by splitting the visible image into its red, green and blue (RGB) components and shifting the blue and green components into the green and red channels respectively. The UVR image is inserted into the blue channel. The reflective properties of the object in the UV range are described by the blue colour on the B channel.

Ultraviolet-Induced Luminescence (UVL)

These images record the emission of light (luminescence) in the visible region (400-700 nm) from a subject when this is illuminated with UV radiation. This image is used to investigate the distribution of luminescent materials, such as organic binders and colourants. Some inorganic materials also show luminescence properties, such as, for example, some inorganic


False-Colour Reflected Ultraviolet (FCUV)
Ultraviolet Induced Luminescence (UVL)


SCANNING & MAPPING
3D Laser Scanning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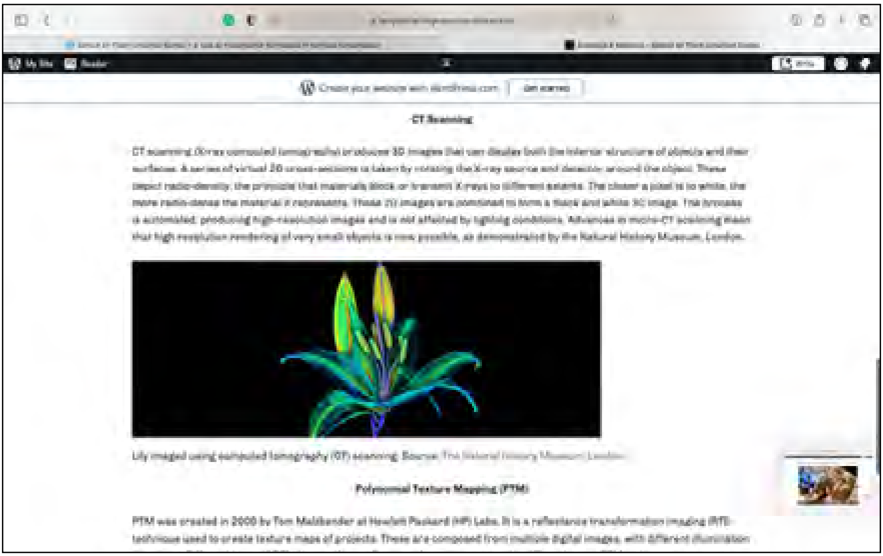
Additionally, 3D printing can be used to create replicas of missing pieces of an artefact. While clearly not authentic, aids in allowing patrons to envisage the wholeness of the object they are observing. Source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CT Scanning
CT scanning (X-ray computed tomography) produces 3D images that can display both the interior structure of objects and their surfaces. A series of virtual 2D cross-sections is taken by rotating the X-ray source and detector around the object. These depict radio-density, the principle that materials block or transmit X-rays to different extents. The closer a pixel is to white, the more radio-dense the material it represents. These 2D images are combined to form a black and white 3D image. The process is automated, producing high-resolution images and is not affected by lighting conditions. Advances in micro-CT scanning mean that high resolution rendering of very small objects is now possible, as demonstrated by the Natural History Museum, London.
Lily imaged using computed tomography (CT) scanning. Source: The Natural History Museum, London
Polynomial Texture Mapping (PTM)
PTM was created in 2000 by Tom Malzbender at Hewlett Packard (HP) Labs. It is a reflectance transformation imaging (RTI) technique used to create texture maps of objects. These are composed from multiple digital images, with different illumination


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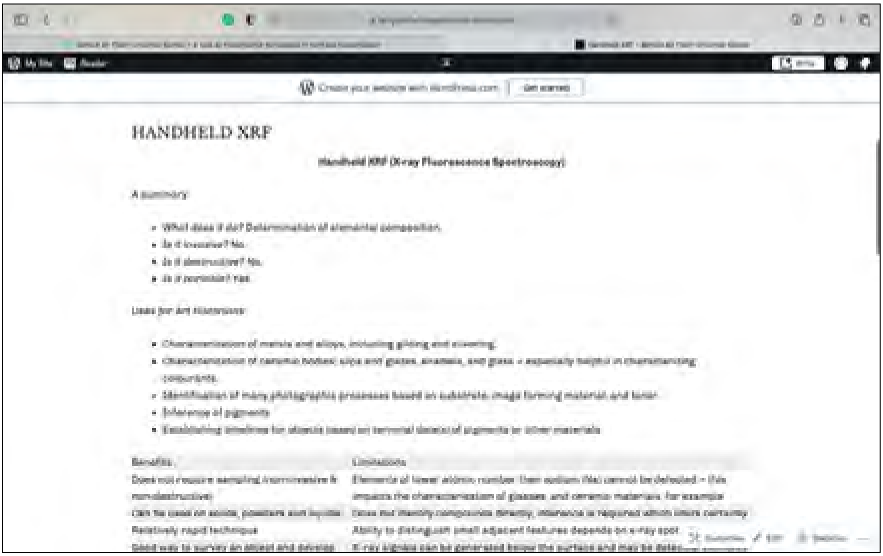
Lily imaged using computed tomography (CT) scanning. Source: The Natural History Museum, London
Polynomial Texture Mapping (PTM)
PTM was created in 2000 by Tom Malzbender at Hewlett Packard (HP) Labs. It is a reflectance transformation imaging (RTI) technique used to create texture maps of objects. These are composed from multiple digital images, with different illumination directions. Different types of RTI store surface reflection information per pixel in different ways. PTM is the most common type of RTI used within cultural heritage. Each pixel in the PTM stores both colour information and 'normal' values. Normals are vectors perpendicular to the object surface. They represent surface shape and enable calculation of light reflection, allowing the object image to be artificially relit from different directions to reveal surface texture. Therefore, PTMs are interactive 2D images that appear 3D.
To create a PTM, illumination direction must be either known in the source images or determinable from them. The analytical capabilities of these technologies combined with their non-contact nature mean that they are potentially very useful for investigating objects. The detailed images produced can be beneficial from a functional conservation perspective to monitor and record condition, can be used within exhibitions and online to enhance object exploration and reach a broader audience. This suggests that wider introduction of the techniques would be beneficial for conservation and display.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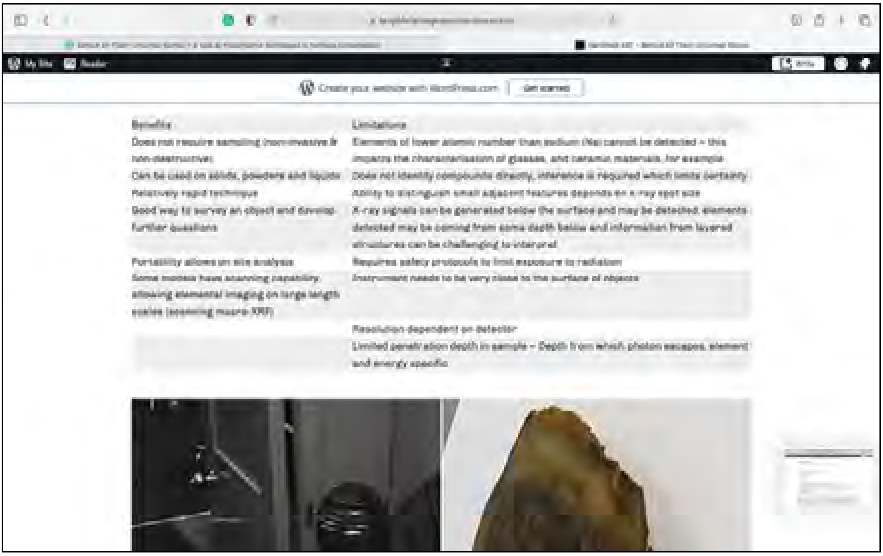
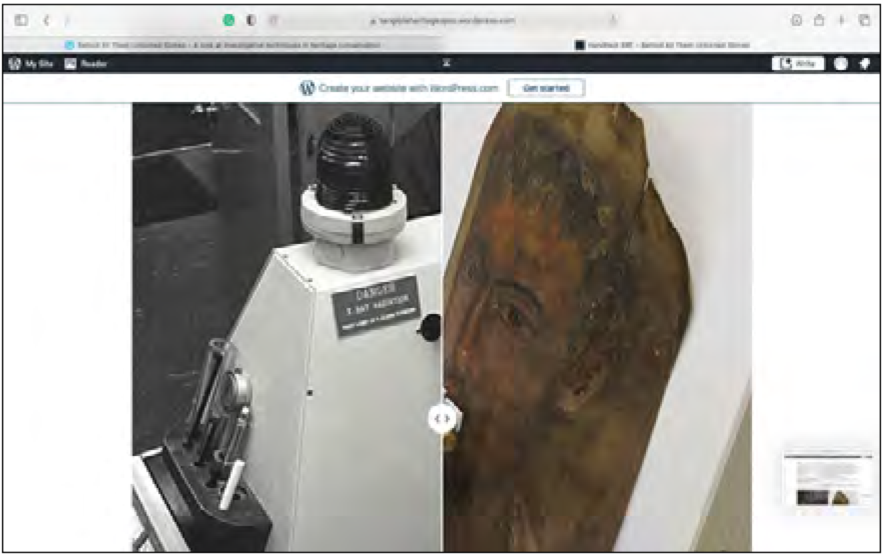
HANDHELD XRF
Handheld XRF (X-ray Fluorescence Spectroscopy)
A summary
What does it do? Determination of elemental composition.
Is it invasive? No.
Is it destructive? No.
Is it portable? Yes.
Uses for Art Historians
Characterisation of metals and alloys, including gilding and silvering
Characterisation of ceramic bodies, slips and glazes, enamels, and glass – especially helpful in characterising colourants.
Identification of many photographic processes based on substrate, image forming material and toner
Inference of pigments
Establishing timelines for objects based on terminal dates of pigments or other materials
Benefits
Limitations
Does not require sampling (non-invasive & non-destructive)
Elements of lower atomic number than sodium (Na) cannot be detected – this impacts the characterisation of glasses and ceramic materials, for example
Can be used on solids, powders and liquids
Does not identify compounds directly; inference is required which limits certainty
Relatively rapid technique
Ability to distinguish small adjacent features depends on x-ray spot
Good way to survey an object and develop
X-ray signals can be generated below the surface and may be detec…



Benefits	Limitations
Does not require sampling (non-invasive & non-destructive)	Elements of lower atomic number than sodium (Na) cannot be detected – this impacts the characterisation of glasses, and ceramic materials, for example
Can be used on solids, powders and liquids	Does not identify compounds directly, inference is required which limits certainty
Relatively rapid technique	Ability to distinguish small adjacent features depends on x-ray spot size
Good way to survey an object and develop further questions	X-ray signals can be generated below the surface and may be detected; elements detected may be coming from some depth below and information from layered structures can be challenging to interpret
Portability allows on site analysis	Requires safety protocols to limit exposure to radiation
Some models have scanning capability allowing elemental imaging on large length scales (scanning macro-XRF)	Instrument needs to be very close to the surface of objects
	Resolution dependent on detector
	Limited penetration depth in sample – Depth from which photon escapes, element and energy specific



XRF in 1976 compared to XRF in the 21st Century

The widespread use and number of different instruments that have been developed and employed for the application of x-ray fluorescence (XRF) analysis illustrates well the value, advantages and usefulness of this analytical method in the field of art and archaeology. The development of portable XRF instrumentation extends the range of use of this technique to an even wider area, by allowing in situ measurements on objects regardless of their shape, size or place where they are stored and/or displayed.

The most frequent use of this technique is in the characterization of materials, i.e., the determination of their elemental composition. As a truly non-destructive method it is often used for investigations on artistic, historical and/or archaeological samples/objects.

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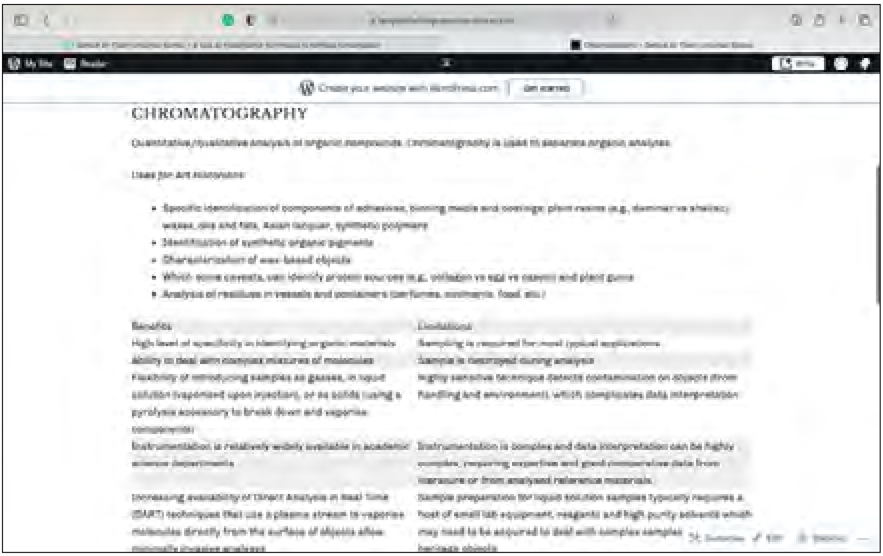


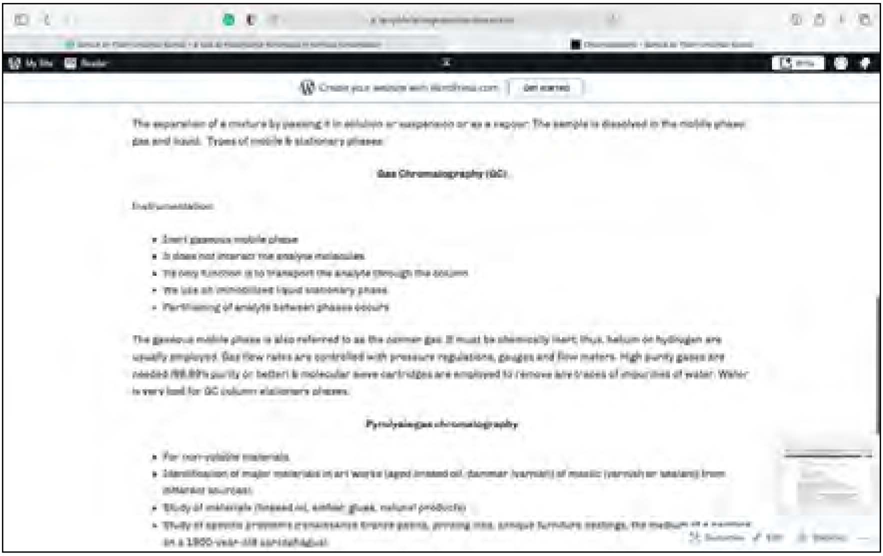
CHROMATOGRAPHY

Quantitative/qualitative analysis of organic compounds. Chromatography is used to separate organic analytes.

Uses for Art Historians:

- Specific identification of components of adhesives, binding media and coatings: plant resins (e.g. dammar vs shellac), waxes, oils and fats, Asian lacquer, synthetic polymers
- Identification of synthetic organic pigments
- Characterization of wax-based objects
- With some caveats, can identify protein sources (e.g. collagen vs egg vs casein) and plant gums
- Analysis of residues in vessels and containers (perfumes, ointments, food, etc.)

Benefits	Limitations
High level of specificity in identifying organic materials	Sampling is required for most typical applications
Ability to deal with complex mixtures of molecules	Sample is destroyed during analysis
Flexibility of introducing samples as gases, in liquid solution (vaporized upon injection), or as solids (using a pyrolysis accessory to break down and vaporize components)	Highly sensitive technique detects contamination on objects (from handling and environment), which complicates data interpretation
Instrumentation is relatively widely available in academic science departments	Instrumentation is complex and data interpretation can be highly complex, requiring expertise and good comparative data from literature or from analysed reference materials
Increasing availability of Direct Analysis in Real Time (DART) techniques that use a plasma stream to vaporize molecules directly from the surface of objects allow minimally invasive analyses	Sample preparation for liquid solution samples typically requires a host of small lab equipment, reagents and high purity solvents which may need to be adjusted to deal with complex samples heritage objects



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The separation of a mixture by passing it in solution or suspension or as a vapour. The sample is dissolved in the mobile phase: gas and liquid. Types of mobile & stationary phases

Gas Chromatography (GC)

Instrumentation

- Inert gaseous mobile phase
- It does not interact the analyte molecules
- Its only function is to transport the analyte through the column
- We use an immobilized liquid stationary phase
- Partitioning of analyte between phases occurs

The gaseous mobile phase is also referred to as the carrier gas. It must be chemically inert; thus, helium or hydrogen are usually employed. Gas flow rates are controlled with pressure regulations, gauges and flow meters. High purity gases are needed (99.99% purity or better) & molecular sieve cartridges are employed to remove any traces of impurities of water. Water is very bad for GC column stationary phases.

Pyrolysis-gas chromatography

- For non-volatile materials
- Identification of major materials in art works (aged linseed oil, dammar (varnish) of mastic (varnish or sealant) from different sources)
- Study of materials (linseed oil, animal glues, natural products)
- Study of specific problems (renaissance bronze patina, printing inks, antique furniture coatings, the medium of a painting on a 1800-year-old sarcophagus)

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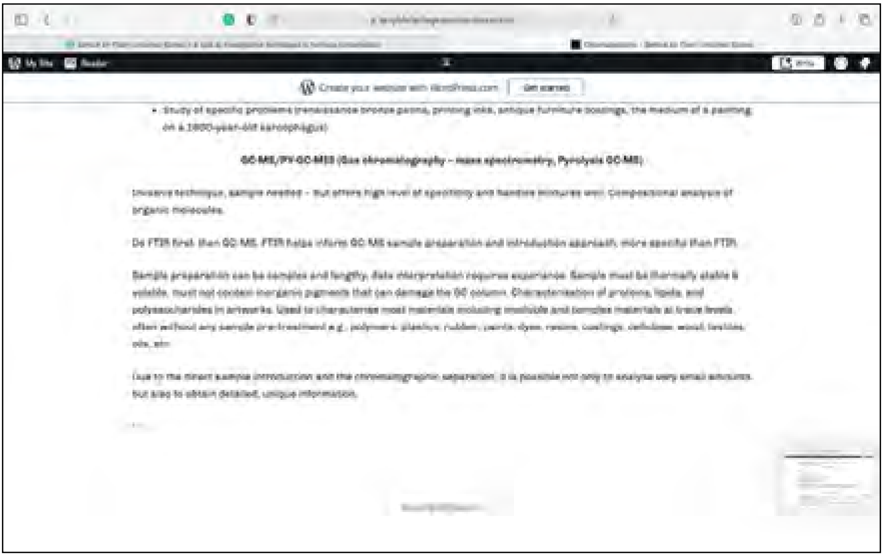

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- Study of specific problems (renaissance bronze patina, printing inks, antique furniture coatings, the medium of a painting on a 1800-year-old sarcophagus)

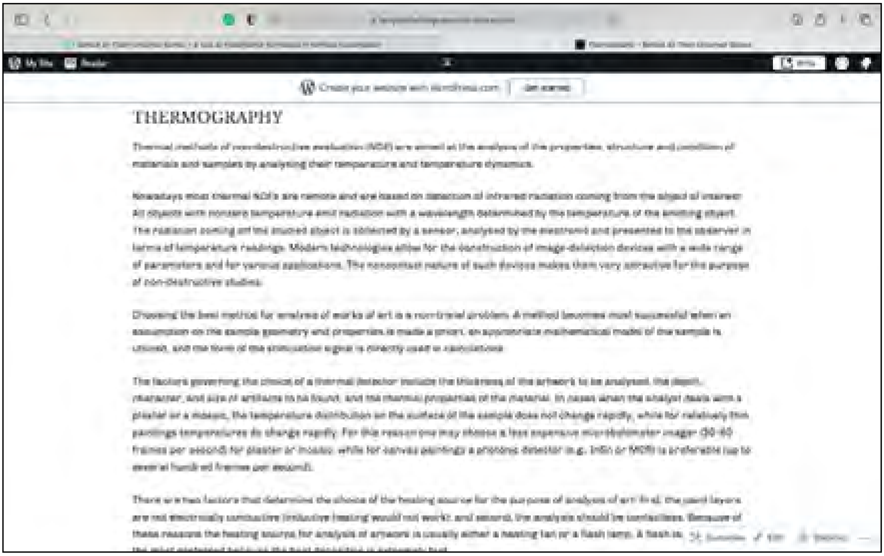
GC-MS/PY-GC-MS (Gas chromatography – mass spectrometry, Pyrolysis GC-MS)

Invasive technique, sample needed – but offers high level of specificity and handles mixtures well. Compositional analysis of organic molecules.

Do FTIR first, then GC-MS. FTIR helps inform GC-MS sample preparation and introduction approach, more specific than FTIR.

Sample preparation can be complex and lengthy, data interpretation requires experience. Sample must be thermally stable & volatile, must not contain inorganic pigments that can damage the GC column. Characterisation of proteins, lipids, and polysaccharides in artworks. Used to characterise most materials including insoluble and complex materials at trace levels often without any sample pre-treatment e.g. polymers: plastics, rubber, paints, dyes, resins, coatings, cellulose, wood, textiles, oils, etc.

Due to the direct sample introduction and the chromatographic separation, it is possible not only to analyse very small amounts but also to obtain detailed, unique information.



THERMOGRAPHY

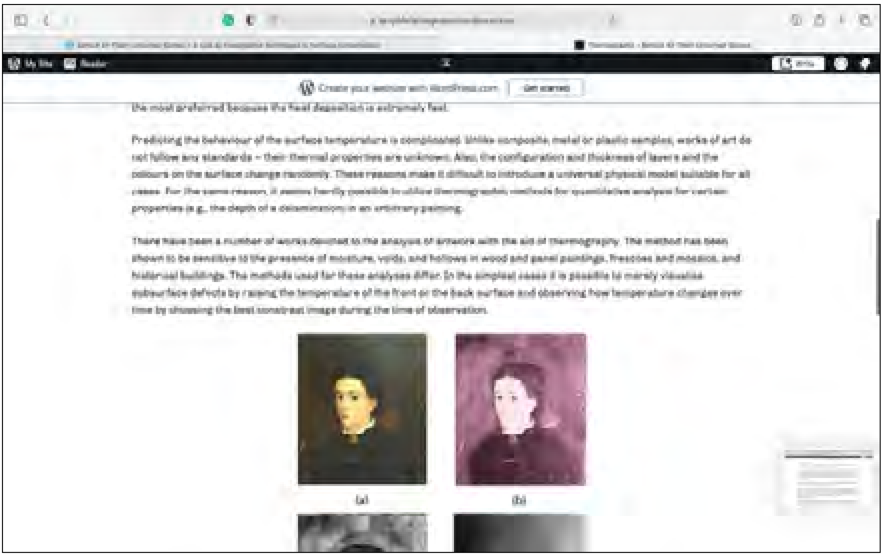
Thermal methods of non-destructive evaluation (NDE) are aimed at the analysis of the properties, structure and condition of materials and samples by analysing their temperature and temperature dynamics.

Nowadays most thermal NDEs are remote and are based on detection of infrared radiation coming from the object of interest. All objects with nonzero temperature emit radiation with a wavelength determined by the temperature of the emitting object. The radiation coming off the studied object is collected by a sensor, analysed by the electronic and presented to the observer in terms of temperature readings. Modern technologies allow for the construction of image-detection devices with a wide range of parameters and for various applications. The noncontact nature of such devices makes them very attractive for the purpose of non-destructive studies.

Choosing the best method for analysis of works of art is a non-trivial problem. A method becomes most successful when an assumption on the sample geometry and properties is made a priori, an approximate mathematical model of the sample is chosen, and the form of the stimulation signal is directly used in calculations.

The factors governing the choice of a thermal detector include the thickness of the artwork to be analysed, the depth, character, and size of artifacts to be found, and the thermal properties of the material. In cases when the analyst deals with a plaster or a mosaic, the temperature distribution on the surface of the sample does not change rapidly, while for relatively thin paintings temperatures do change rapidly. For this reason one may choose a less expensive microbolometer imager (30-60 frames per second) for plaster or mosaic while for canvas paintings a photonic detector (e.g. InSb or MCT) is preferable (up to several hundred frames per second).

There are two factors that determine the choice of the heating source for the purpose of analysis of art: first, the paint layers are not electrically conductive (inductive heating would not work), and second, the analysis should be contactless. Because of these reasons the heating source for analysis of artwork is usually either a heating fan or a flash lamp. A flash is the most preferred because the heat deposition is extremely fast.

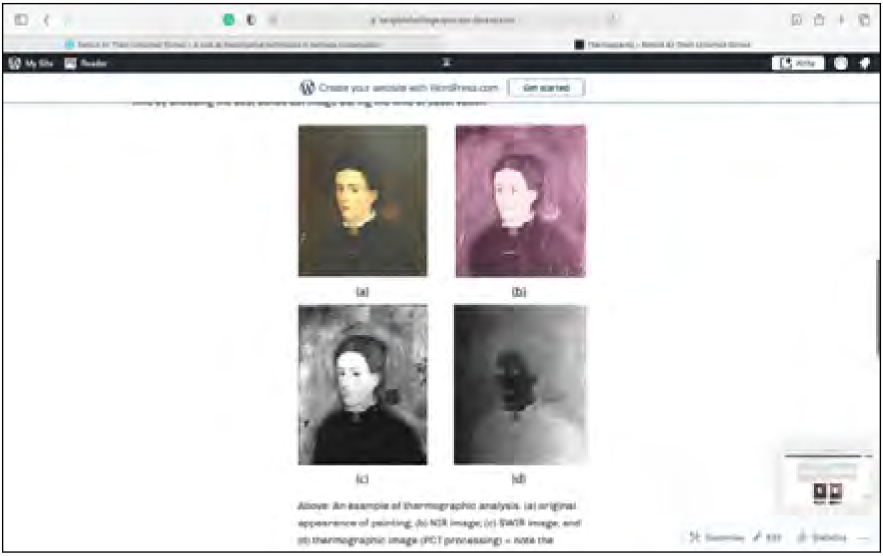


the most preferred because the heat deposition is extremely fast.

Predicting the behaviour of the surface temperature is complicated. Unlike composite, metal or plastic samples, works of art do not follow any standards – their thermal properties are unknown. Also, the configuration and thickness of layers and the colours on the surface change randomly. These reasons make it difficult to introduce a universal physical model suitable for all cases. For the same reason, it seems hardly possible to utilise thermographic methods for quantitative analysis for certain properties (e.g., the depth of a delamination) in an arbitrary painting.

There have been a number of works devoted to the analysis of artwork with the aid of thermography. The method has been shown to be sensitive to the presence of moisture, voids, and hollows in wood and panel paintings, frescoes and mosaics, and historical buildings. The methods used for these analyses differ. In the simplest cases it is possible to merely visualise subsurface defects by raising the temperature of the front or the back surface and observing how temperature changes over time by choosing the best contrast image during the time of observation.

(a) (b)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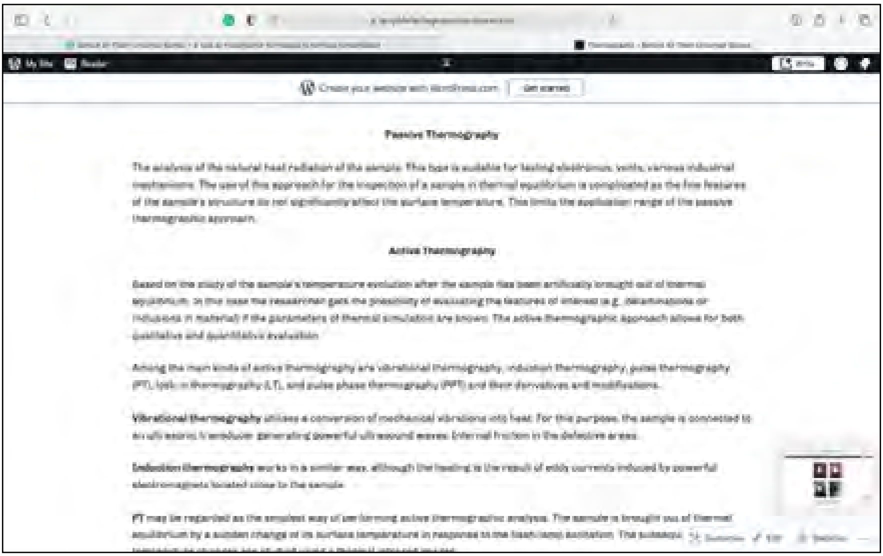
(a)
(b)
(c)
(d)
Above: An example of thermographic analysis. (a) original appearance of painting; (b) NIR image; (c) SWIR image; and (d) thermographic image (PCT processing) – Note the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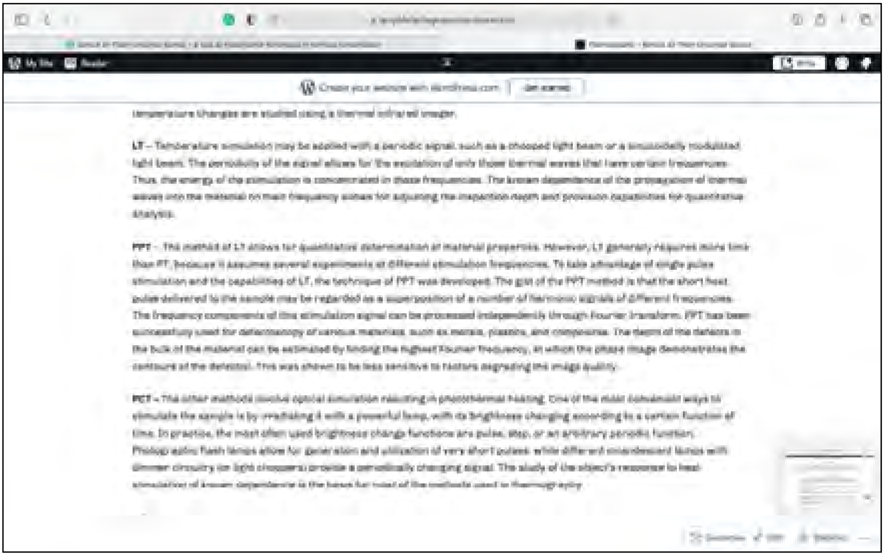
Passive Thermography
Active Thermography
Vibrational thermography
Induction thermography



temperature changes are studied using a thermal infrared imager.

LT – Temperature stimulation may be applied with a periodic signal, such as a chopped light beam or a sinusoidally modulated light beam. The periodicity of the signal allows for the excitation of only those thermal waves that have certain frequencies. Thus, the energy of the stimulation is concentrated in those frequencies. The known dependence of the propagation of thermal waves into the material on their frequency allows for adjusting the inspection depth and provides capabilities for quantitative analysis.

PPT – The method of LT allows for quantitative determination of material properties. However, LT generally requires more time than PT, because it assumes several experiments at different stimulation frequencies. To take advantage of single pulse stimulation and the capabilities of LT, the technique of PPT was developed. The gist of the PPT method is that the short heat pulse delivered to the sample may be regarded as a superposition of a number of harmonic signals of different frequencies. The frequency components of this stimulation signal can be processed independently through Fourier transform. PPT has been successfully used for defectoscopy of various materials, such as metals, plastics, and composites. The depth of the defects in the bulk of the material can be estimated by finding the highest Fourier frequency, at which the phase image demonstrates the contours of the defect(s). This was shown to be less sensitive to factors degrading the image quality.

PCT – The other methods involve optical stimulation resulting in photothermal heating. One of the most convenient ways to stimulate the sample is by irradiating it with a powerful lamp, with its brightness changing according to a certain function of time. In practice, the most often used brightness change functions are pulse, step, or an arbitrary periodic function. Photographic flash lamps allow for generation and utilization of very short pulses, while different incandescent lamps with dimmer circuitry (or light choppers) provide a periodically changing signal. The study of the object's response to heat stimulation of known dependence is the basis for most of the methods used in thermography.

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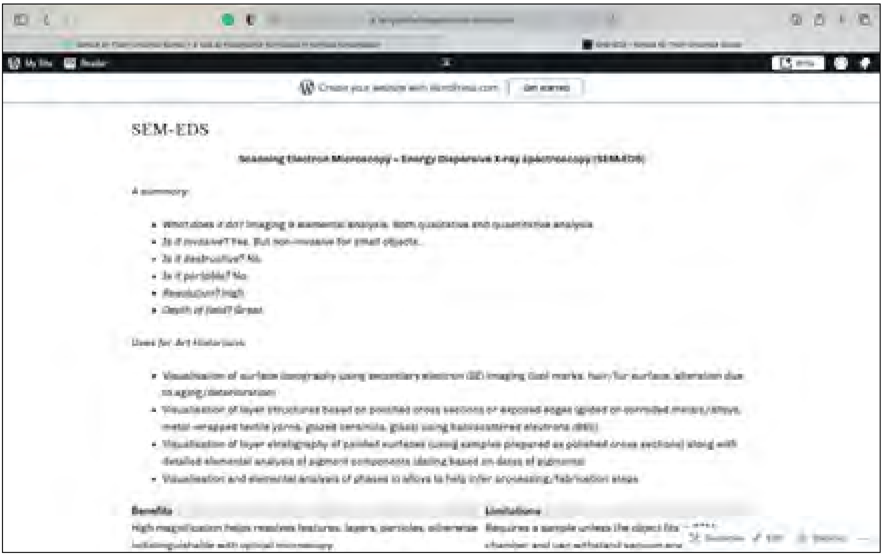


SEM-EDS

Scanning Electron Microscopy – Energy Dispersive X-ray Spectroscopy (SEM-EDS)

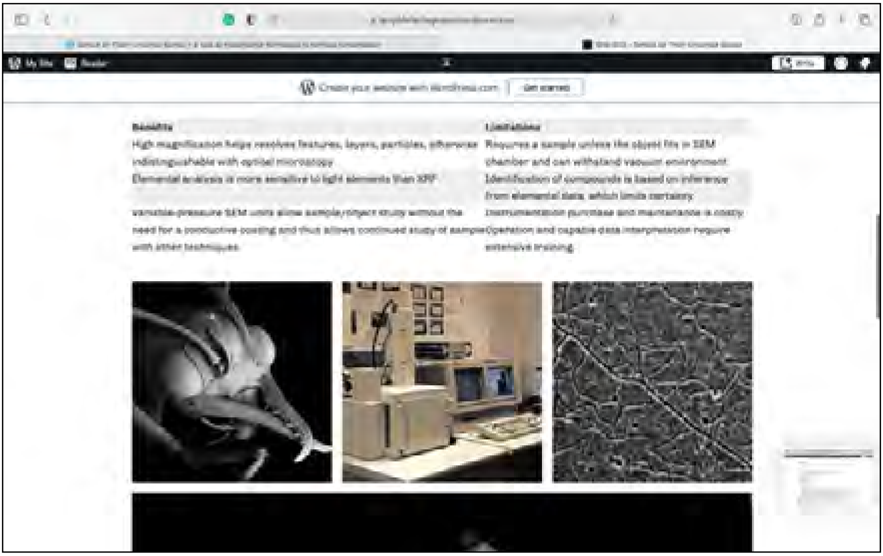
A summary:

- *What does it do?* Imaging & elemental analysis. Both qualitative and quantitative analysis
- *Is it invasive?* Yes. But non-invasive for small objects.
- *Is it destructive?* No.
- *Is it portable?* No.
- *Resolution?* High
- *Depth of field?* Great

Uses for Art Historians:

- Visualisation of surface topography using secondary electron (SE) imaging (tool marks, hair/fur surface, alteration due to aging/deterioration)
- Visualisation of layer structures based on polished cross sections or exposed edges (gilded or corroded metals/alloys, metal-wrapped textile yarns, glazed ceramics, glass) using backscattered electrons (BSE)
- Visualisation of layer stratigraphy of painted surfaces (using samples prepared as polished cross sections) along with detailed elemental analysis of pigment components (dating based on dates of pigments)
- Visualisation and elemental analysis of phases in alloys to help infer processing/fabrication steps

Benefits	Limitations
High magnification helps resolves features, layers, particles, otherwise indistinguishable with optical microscopy	Requires a sample unless the object fits … chamber and can withstand vacuum and …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Benefits
High magnification helps resolves features, layers, particles, otherwise indistinguishable with optical microscopy
Elemental analysis is more sensitive to light elements than XRF
Variable-pressure SEM units allow sample/object study without the need for a conductive coating and thus allows continued study of sample with other techniques
Limitations
Requires a sample unless the object fits in SEM chamber and can withstand vacuum environment
Identification of compounds is based on inference from elemental data, which limits certainty
Instrumentation purchase and maintenance is costly
Operation and capable data interpretation require extensive training

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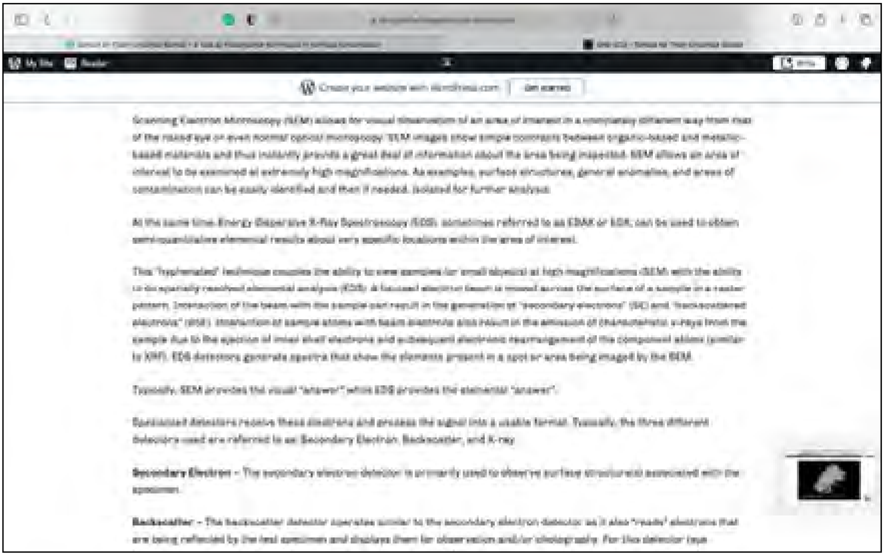
Acc.V Spot Magn Det WD 500 µm
15.0 kV 6.0 100x BSE 13.5
Compilation of SEM photographs taken by The Australian Museum. Top left is an ant, top middle is the SEM, top right is a microstructure example. The bottom and largest image is an SEM paint sample.



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Scanning Electron Microscopy (SEM) allows for visual observation of an area of interest in a completely different way from that of the naked eye or even normal optical microscopy. SEM images show simple contrasts between organic-based and metallic-based materials and thus instantly provide a great deal of information about the area being inspected. SEM allows an area of interest to be examined at extremely high magnifications. As examples, surface structures, general anomalies, and areas of contamination can be easily identified and then if needed, isolated for further analysis.

At the same time Energy Dispersive X-Ray Spectroscopy (EDS), sometimes referred to as EDAX or EDX, can be used to obtain semi-quantitative elemental results about very specific locations within the area of interest.

This "hyphenated" technique couples the ability to view samples (or small objects) at high magnifications (SEM) with the ability to do spatially resolved elemental analysis (EDS). A focused electron beam is moved across the surface of a sample in a raster pattern. Interaction of the beam with the sample can result in the generation of "secondary electrons" (SE) and "backscattered electrons" (BSE). Interaction of sample atoms with beam electrons also result in the emission of characteristic x-rays from the sample due to the ejection of inner shell electrons and subsequent electronic rearrangement of the component atoms (similar to XRF). EDS detectors generate spectra that show the elements present in a spot or area being imaged by the SEM.

Typically, SEM provides the visual "answer" while EDS provides the elemental "answer".

Specialized detectors receive these electrons and process the signal into a usable format. Typically, the three different detectors used are referred to as: Secondary Electron, Backscatter, and X-ray.

Secondary Electron – The secondary electron detector is primarily used to observe surface structure(s) associated with the specimen.

Backscatter – The backscatter detector operates similar to the secondary electron detector as it also "reads" electrons that are being reflected by the test specimen and displays them for observation and/or photography. For this detector type

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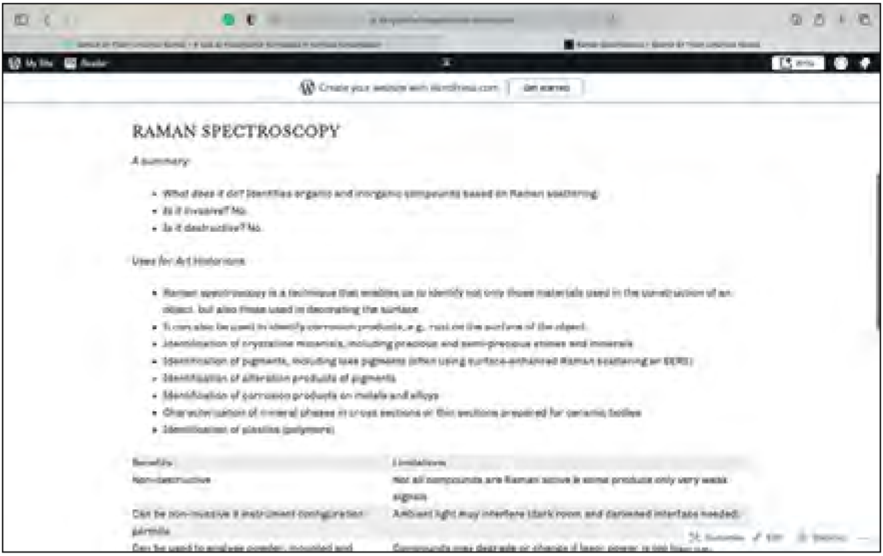
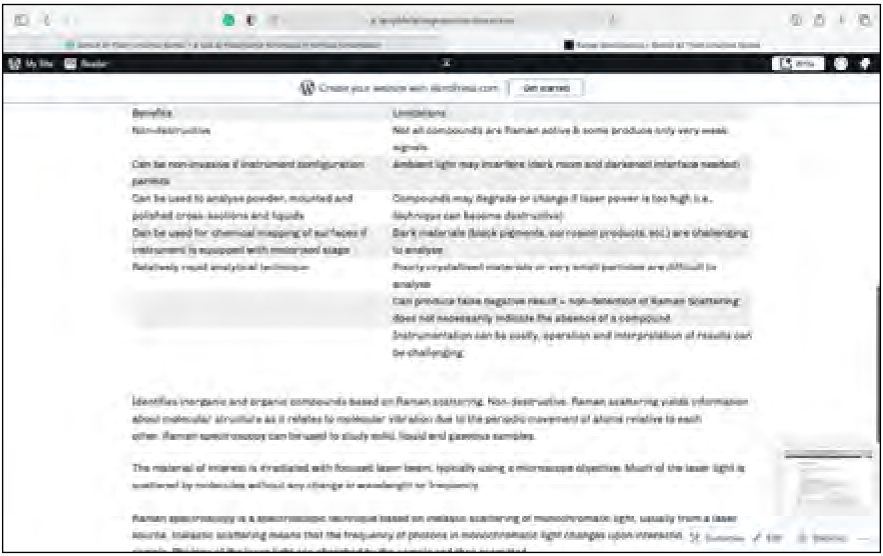
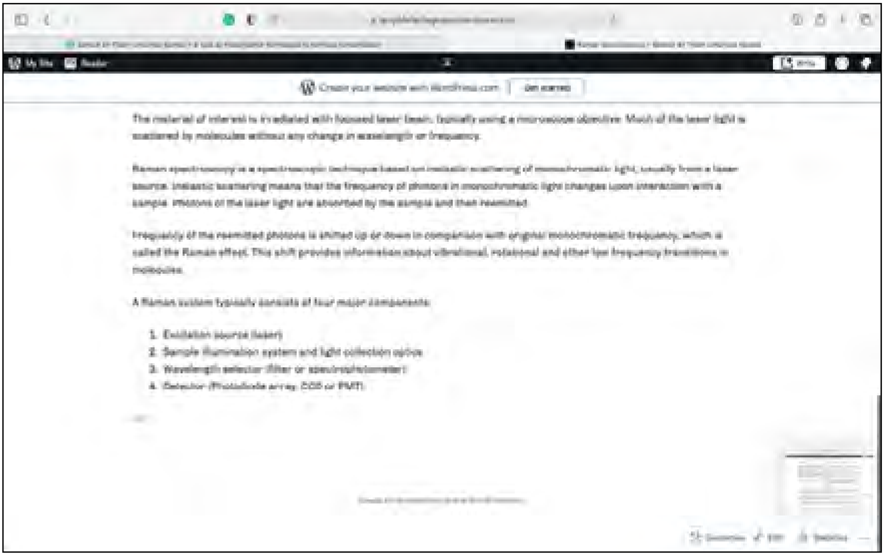
Secondary Electron – The secondary electron detector is primarily used to observe surface structure(s) associated with the specimen.

Backscatter – The backscatter detector operates similar to the secondary electron detector as it also "reads" electrons that are being reflected by the test specimen and displays them for observation and/or photography. For this detector type however, the grayscale observed in the images is a direct result of the element(s) present in the area being observed.

X-Ray – The term X-ray detector is a general term for the type of detector used to perform Energy Dispersive X-Ray Spectroscopy (EDS). The X-ray detector, or more specifically, the EDS technique is used to qualitatively and (most of the time "semi-quantitatively") determine the elemental composition on an area of interest which was visually identified and observed using the secondary electron and backscatter detectors mentioned above.


RAMAN SPECTROSCOPY
A summary
Uses for Art Historians
Benefits
Limitations
Non-destructive


Get started
Benefits
Limitations
Non-destructive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The material of interest is irradiated with focused laser beam, typically using a microscope objective. Much of the laser light is scattered by molecules without any change in wavelength or frequency.
Raman spectroscopy is a spectroscopic technique based on inelastic scattering of monochromatic light, usually from a laser source. Inelastic scattering means that the frequency of photons in monochromatic light changes upon interaction with a sample. Photons of the laser light are absorbed by the sample and then reemitted.
Frequency of the reemitted photons is shifted up or down in comparison with original monochromatic frequency, which is called the Raman effect. This shift provides information about vibrational, rotational and other low frequency transitions in molecules.
A Raman system typically consists of four major components:
1. Excitation source (laser)
2. Sample illumination system and light collection optics
3. Wavelength selector (filter or spectrophotometer)
4. Detector (Photodiode array, CCD or PMT)

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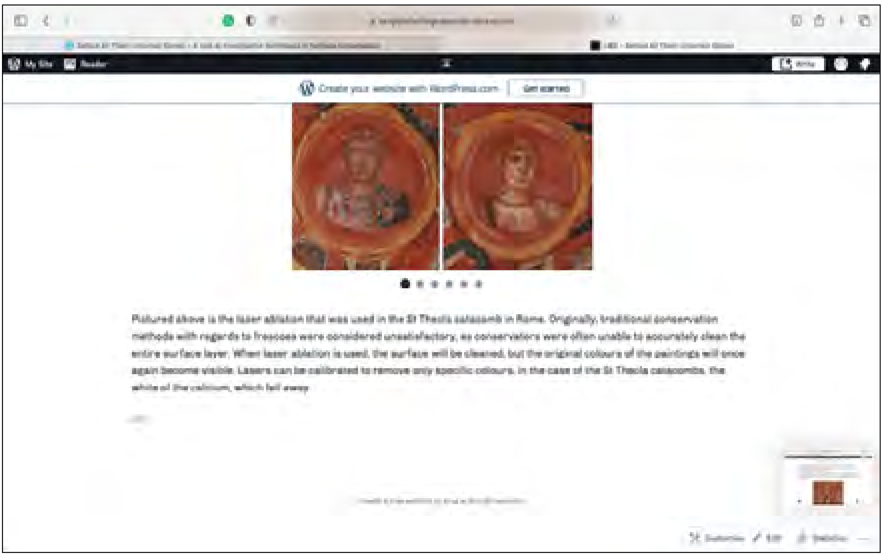
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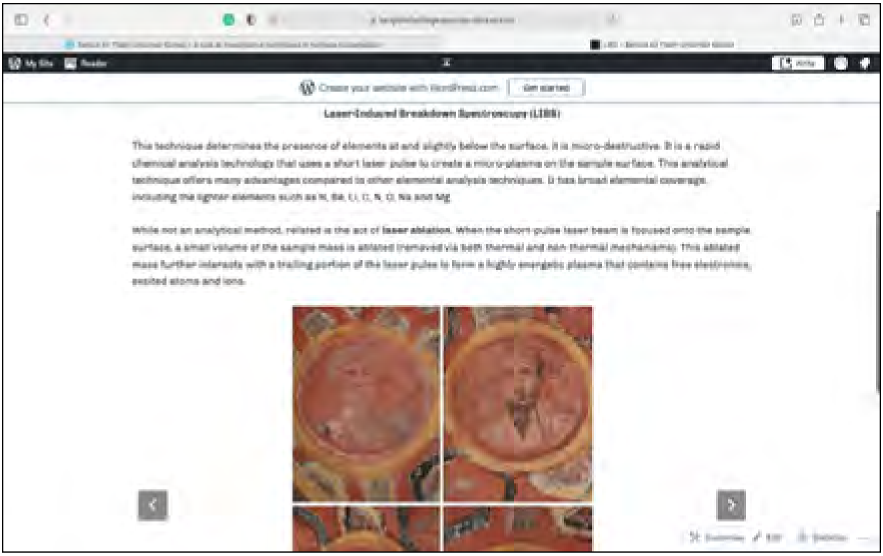
Pictured above is the laser ablation that was used in the St Thecla catacomb in Rome. Originally, traditional conservation methods with regards to frescoes were considered unsatisfactory, as conservators were often unable to accurately clean the entire surface layer. When laser ablation is used, the surface will be cleaned, but the original colours of the paintings will once again become visible. Lasers can be calibrated to remove only specific colours, in the case of the St Thecla catacombs, the white of the calcium, which fell away.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Laser-Induced Breakdown Spectroscopy (LIBS)
This technique determines the presence of elements at and slightly below the surface. It is micro-destructive. It is a rapid chemical analysis technology that uses a short laser pulse to create a micro-plasma on the sample surface. This analytical technique offers many advantages compared to other elemental analysis techniques. It has broad elemental coverage, including the lighter elements such as H, Be, Li, C, N, O, Na and Mg.
While not an analytical method, related is the act of laser ablation. When the short-pulse laser beam is focused onto the sample surface, a small volume of the sample mass is ablated (removed via both thermal and non-thermal mechanisms). This ablated mass further interacts with a trailing portion of the laser pulse to form a highly energetic plasma that contains free electrons, excited atoms and ions.

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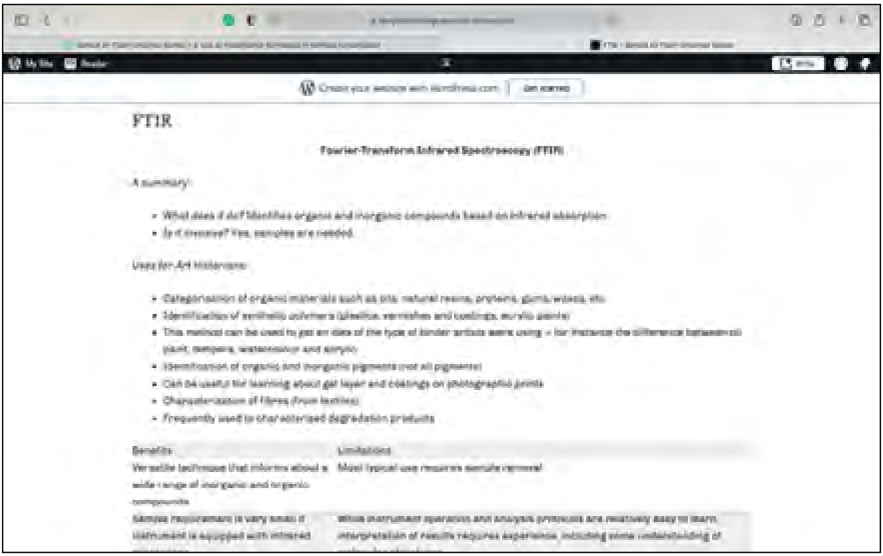
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FTIR
Fourier-Transform Infrared Spectroscopy (FTIR)
A summary:
What does it do? Identifies organic and inorganic compounds based on infrared absorption
Is it invasive? Yes, samples are needed.
Uses for Art Historians:
Categorisation of organic materials such as oils, natural resins, proteins, gums, waxes, etc
Identification of synthetic polymers (plastics, varnishes and coatings, acrylic paints)
This method can be used to get an idea of the type of binder artists were using – for instance the difference between oil paint, tempera, watercolour and acrylic
Identification of organic and inorganic pigments (not all pigments)
Can be useful for learning about gel layer and coatings on photographic prints
Characterisation of fibres (from textiles)
Frequently used to characterised degradation products
Benefits
Limitations
Versatile technique that informs about a wide range of inorganic and organic compounds
Most typical use requires sample removal
Sample requirement is very small if instrument is equipped with infrared
While instrument operation and analysis protocols are relatively easy to learn, interpretation of results requires experience, including some understanding of

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compounds	
Sample requirement is very small if instrument is equipped with infrared microscope	While instrument operation and analysis protocols are relatively easy to learn interpretation of results requires experience, including some understanding of molecular structures
Samples can frequently be reused and analysed with another analytical technique	If a mixture of compound is present, spectra contains peaks relating to the components, thus complicating interpretation of data
Analysis can be conducted in-situ on relatively flat surfaces	While collection of spectra in reflectance mode can be done non-invasively interpretation of results often requires development of custom spectral libraries
Portable instruments may allow non-invasive, in-situ analysis with some limitations	
Widely available	

Basic Concept

This is a molecular spectroscopy technique capable of characterising and identifying inorganic and organic compounds. It is complimentary to Raman spectroscopy. The material/sample of interest is irradiated with an infrared (IR) beam containing 2500-25000 nm wavelength range. Molecules absorb IR wavelengths with frequencies corresponding to certain vibrational motions within the molecule (such as stretching of specific bonds). Infrared spectrometers detect with specific frequencies are absorbed and to what degree and display spectra that can be regarded as molecular fingerprints for compounds. Compounds are typically identified by comparing results to libraries of infrared spectra from known compounds/materials.

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Mampopi Namane: THC 804

Mampopi Namane, from the Lesotho State Library, submitted this THC 804 assignment for the section on ceramics, in which she proposes a treatment for a Ruan Hoffmann plate. She graduated in April 2022.

Introduction

Ceramics are materials that have been altered by heat at different temperatures (Logan and Grant 2018). They are often thought of as inert; however, the stability of their fabric is affected by use, environmental conditions and manufacturing defects (Canadian Conservation Institute n.d Logan and Grant 2018). The more a ceramic is fired at a high temperature, the more water-resistant it becomes, but it is still brittle (Logan and Grant 2018). Their manufacturing defects, like poorly formulated body and inappropriate firing, make them more prone to agents of deterioration (Logan and Grant 2018). Before cleaning an object, it is always important to identify the type of ceramic composition and the nature of the dirt (Abd-Allah, al-Muheisen and al-Howadi 2010: 106). Not all ceramics are glazed (Logan and Grant 2018), but this paper focuses on a ceramic with a fragile gilt and lustre surfaces. When cleaning an object, not only is the effectiveness of cleaning considered but also the potential damage as a result of cleaning (Abd-Allah, al-Muheisen and al-Howadi 2010: 97) Cleaning is the removal of dirt from an object to a desired state without disrupting the original material or archaeological features (Abd-Allah, al-Muheisen and al-Howadi 2010: 106).

Removing dust

Dust is made up of loose foreign material that attaches itself to the surface of an object (Conservation Unit Museums & Galleries Commission 1992: 14). It is often made of textile fibres, human skin and soot, among other things (Conservation Unit Museums & Galleries Commission 1992: 14). Within this, there are micro-organisms that feed on organic material such as human skin and will secrete waste after feeding (Conservation Unit Museums & Galleries Commission 1992: 14). If left untreated, this further soils the surface until a hard grit is formed, which is hard to remove (Conservation Unit Museums & Galleries Commission 1992: 14). Dust is easier to remove because it does not chemically bond with the object

(Conservation Unit Museums & Galleries Commission 1992: 28).

Why brushes?

Brushes are best used when there is dust/loose dirt and where the surface of an object has either crevices or undercuts because they get in between the cracks (Lavelle and Miller 2017: 7). Brushes ensure that there is little to no fiction while in use (Lavelle and Miller 2017: 7). They also allow for flexibility and gentleness of hand during cleaning (Lavelle and Miller 2017: 7). However, brushes must be matched to the surface to be worked—for example, avoid using hard-bristled brushes on gilded surfaces; this is damaging (Lavelle and Miller 2017: 7).

Dusters

- Use a lint-free duster (microfibre cloth) so no fibres attach to the surface of the object during cleaning.
- Avoid damaged or fragile (gilded) surfaces of the object while dusting.
- While cleaning, always fold the duster towards the clean area.
- Wash dusters after object treatment in mild, non-ionic detergent and rinse well (Canadian Conservation Institute n.d., Lavelle ad Miller 2017: 8).

Why dusters?

Dusters make it easy to remove dust from smooth surfaces (Lavelle and Miller 2017: 8). There is no solvent added, so hygroscopic objects will be safe (Conservation Unit Museums & Galleries Commission 1992: 27). There is also no interaction of toxic chemicals with objects (Conservation Unit Museums & Galleries Commission 1992: 28).

Vacuum cleaner

- Turn the vacuum cleaner to a low-suction setting.
- With a brush, sweep dust towards the mouth of the vacuum while also minding the grain, if any.
- Ensure that the vacuum is a few centimetres away from the surface of the object as you sweep and suction, as ceramics are prone to damage from

knocks and other physical forces (Conservation Unit Museums & Galleries Commission 1992: 28).

Why vacuum?

Dust is not chemically bonded with an object; rather, it is adhered to the surface of an object by electrostatic attraction (Conservation Unit Museums & Galleries Commission 1992: 16 & 28). Therefore, only dusting or using brushes may not be enough; because as dust is swept away, there is further charging of particles and surface (Conservation Unit Museums & Galleries Commission 1992: 28). Dust removed with brushes and dusters floats in the atmosphere then attaches to the newly charged surface, but with vacuum-cleaning, everything is removed (Conservation Unit Museums & Galleries Commission 1992: 28, Lavelle and Miller 2017: 7). Due to the attached Perspex stand and the folds in the ceramic body, there are recesses that make access and removal of dust by brushing inaccessible and complicated. No chemicals are used.

Removing the perspex stand

Because of the thickness of the silicone, it was feasible to attempt to cut through it to liberate the Perspex stand.

Sharp object/scalpel

- With a scalpel, pick and cut the silicone between the stand and the ceramic carefully, especially where it is in contact with the guiding.
- Movements must be cautious while cutting to avoid scraping part of the object.
- On the caulk below the date, carefully cut but not all the way through, then use solvents to soften.
- The caulk may also be cut completely to separate the stand and the object (Buys and Oakley 1993: 78).

Why scalpel?

Because of its location, thickness and size, the caulk will be easily removed when cut and scraped thinly before chemical cleaning (Buys and Oakley 1993: 78). Silicone softens, and chemical cleaning introduces the risk that the surface of the object will be damaged, depending on its porosity (Buys and Oakley 1993: 78).

Removing the stand chemically

Seeing as the caulk just below the date is as the base, in contact with the gilding, and given the fact that the stand is a bit raised, there may be a need for both mechanical and chemical cleaning.

- Cut or poke the silicone just enough for the chemicals to be introduced.
- Roll cotton onto the swab stick and moisten in the solution.
- Roll the swab stick in between the holes made in the silicone, leaving the cotton sandwiched in the caulk.
- After some time, attend to the object and carefully cut the now-softened caulk (Buys and Oakley 1993: 77 & 78).

Why chemically?

Since the silicone caulk is just under the date on the object, it is a bit hard to reach. Introducing a certain amount of solution will help soften it (Buys and Oakley 1993: 77). This will make it easier to remove because the long chains of silicone caulk will be broken (Deziel 2019).

Removing silicone

Silicone consists of polymers made of siloxane (chain of alternating silicon atoms and oxygen atoms) (Deziel 2019, Jenkins n.d.). Silicon, used to make Silicone, is an element found abundantly in sand (silicon), and it is mixed with hydrogen and carbon (Deziel 2019, Jenkins n.d.). It is elastic, non-reactive and resistant to extreme environmental conditions. For this reason, it does not dissolve when solvents are introduced; rather, it softens (Deziel 2019, Jenkins n.d.).

Removing silicone with a scalpel

- Scrape the silicone that has been softened by chemicals further with a

sharp blade/scalpel.
- Smooth the remaining residue with a scalpel.

Why with a scalpel?

Cutting through the silicone makes work faster because there are no preliminary tests needed to evaluate damage that may occur (Buys and Oakley 1993: 78). Using a scalpel also ensures that an object will be spared some of the chemical cleaning it might have to undergo (Buys and Oakley 1993: 78). If an object was porous, it would not have had contact with liquids, which could potentially cause staining, drive dirt below the surface or leave potentially damaging residues in the substrate (Buys and Oakley 1993: 78).

Removing silicone with chemicals

Solvent must always be appropriate for the intended adhesive while also gentle on the substrate (Buys and Oakley 1993: 78). If unsure of the properties of the solvent, take a sample for testing.

Dodecylbenzenesulfonic acid, dichloromethane toluene and xylene solution

- Prepare a solution of dodecylbenzenesulfonic acid, dichloromethane toluene and xylene and moisten cotton wool, then apply to the affected area (poultice).
- Softening may be done in vapour form by placing an object and solution together in an airtight container or a few fume cupboards.
- Rinse with carbon-based solvents to avoid ionisation of acid content left during cleaning (Buys & Oakley 1993:79 & 80).

Why acidic solutions?

Silicone is acidic; therefore, using acidic solvents will shorten the long bonds of silicone making it softer to work on (Deziel 2019). Other chemicals may be used, like dodecylbenzenesulfonic acid, dichloromethane toluene and xylene solution, following the same procedure:

- White spirit/white vinegar
- Isopropyl alcohol
- Denatured alcohol

Conclusion

Museum objects do not necessarily have to be perfectly clean—rather, clean enough that there is no material falling if one touches an object. Methods of cleaning and the level of cleaning must be considered thoughtfully because some interventions are damaging to objects. In this particular case, silicone could have ingressed into the porous ceramic causing some measure of staining, which could be irreversible as the required solvents may not be able to draw out the silicone and may in fact damage the ceramic body. However, as the silicone is on the reverse of the object, chemical cleaning was not necessary, and the potential damage is too high a risk for very little benefit as a thin residual layer of silicon is neither damaging nor visually distracting. Conservation always balances the needs of the object and those of the custodian and aims for a mutually beneficial compromise. Cleaning is one of those routine treatments that needs to be carefully considered because it is irreversible.

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Jabu Ntuli: THC 804

Jabulile Ntuli is a dedicated and successful student from the 2021 intake. She was also part of the Holocaust Centre digitisation and Jagger Reading Room fire at the UCT Library salvage projects. She will complete her degree at the end of 2022.

Introduction

Ultraviolet (UV) light is a form of electromagnetic radiation invisible to the naked eye. However, certain materials absorb this light and reflect it back as longer-wavelength radiation, which is then visible to the naked eye as UV-induced visible fluorescence (Measday et al. 2017).

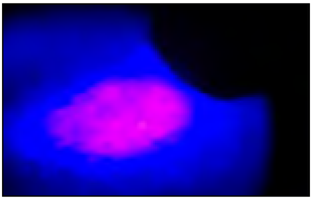
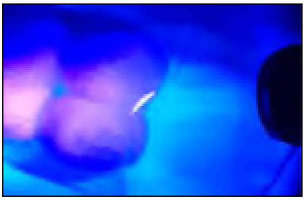
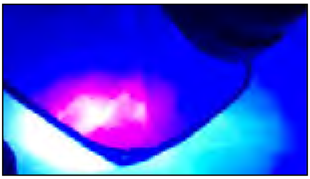
As this fluorescence is particular to certain materials, it can be used by conservators as a non-destructive analytical technique in the examination of cultural materials to aid in the identification of previous restorations to help identify what an object is made of. The colours of the fluorescence depend on the wavelength used and the type of material examined. For example, many adhesives used in repairs fluoresce under long-wave UV but not under short-wave.

Long-wave UV, also referred to as UV-A, is between 320 and 400 nm; UV-B, also known as medium-wave UV, is between 280 and 320 nm; and short-wave UV, or UV-C, is between 180 and 280 nm (Simpson-Grant 2000a: 1).

Although UV examination can assist in identifying some materials, it is not always conclusive. Colour evaluation can easily be misinterpreted, and results can also sometimes be misleading due to changes occurring as the materials age or with the presence of obscuring surface dirt.

The objective of this assignment is to place the various organic materials in the discovery kit under the UV light provided (long-wave) and note observations in a table.

Results

Material	UV colour	Protein type in material
Wool sample swatch	Spritz purple 	Keratin
Cotton sample swatch	Light spritz purple 	No protein, cotton is cellulose-based
Silk sample swatch	Light spritz purple 	Fibrion
Ivory sample item	Whitish blue 	Collagen

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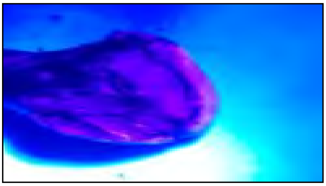
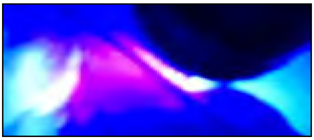
Shell/horn sample item	Dark Purple 	Keratin
Bone sample item	Dark purple 	Collagen
Feather sample	Spritz purple 	Keratin

Conclusion

I felt that the test was inconclusive as it was difficult to see any of the colours reported in Measday's article and even harder to photograph the differences. The only difference was the intensity of the fluorescence, for example, the bone and ivory, which are similar materials and noted in Simpson-Grant (2000b:2) as both fluorescing with a bright whitish colour when new, appeared dark purple and whitish-blue in my test. In fact, most of the colours observed tended to be blue or purple. Perhaps there was a problem with the way the samples were illuminated.

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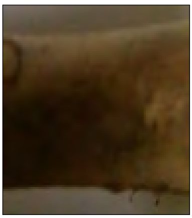
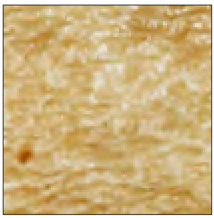
Mabokang Mokotjo: THC 804

Mabokang Mokotjo is from Lesotho where she works for the Department of Culture. She completed her degree with a distinction. In this assignment, she discussed the degradation of buried bones as part of THC 804.

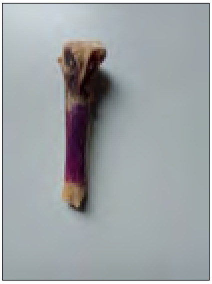
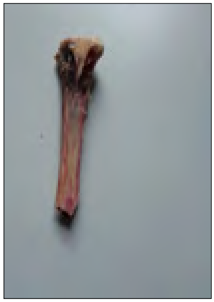
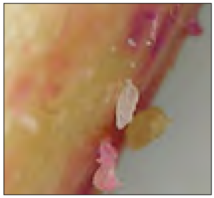
Bone inspection

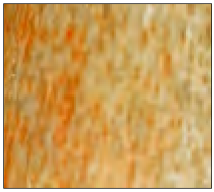
PLACE TO EXAMINE	NORMAL PICTURE	PICTURE NORMAL + MICROSCOPE	DESCRIPTION
END OF THE BONE			The end of the bone (epiphysis) under the microscope shows different tissues ranging from brown to light brown and white, and the gaps or breakages are also visible on the black spots. In the normal photo, tissues are not clear and the breakages on the epiphysis are not visible. The epiphysis consists of a cancellous bone protected by a thin layer of compact bone (Editors of the Encyclopaedia Britannica 2018).
MID PART OF THE BONE			The mid part of the chicken leg bone (diaphysis) looks cream-white to light brown and smooth to the naked eye. Under the microscope, the bone appears to have ridges of what looks like a boiling paste forming thick little bubbles. Diaphysis is composed of compact bone surrounding the medullary cavity (Brick 2018: 1).

CROSS-SECTION OF THE BONE			The cross-section of the chicken leg bone has two parts visible under the microscope, the hard outer layer and the inner spongy part. According to Rice University (2020: 4), the outer layer is called compact bone and contains four important cells, namely osteoblasts, osteocytes, osteogenic cells, and osteoclasts. It is also the denser, stronger of the two types of bone tissue (Rice University 2020: 4). The inner spongy tissue of the bone is called cancellous, and it contains osteocytes and red marrow protected by the trabeculae (Rice University 2020: 4).

226 It is obvious that normal photos cannot provide enough information about objects. Photos taken with a microscope are detailed and consist of all information that is needed about the object. This observation brings me to the conclusion that for museum documentation, normal photography is not enough and can also be deceptive when it comes to the object condition assessment. It needs to be coupled with microscope photos for adequate documentation.

PERIOD	PHOTO OF BONE MARKED WITH FELT-TIP PEN	DESCRIPTION OF THE BONE MARKED WITH A FELT-TIP PEN	REMOVE PEN MARK	DESCRIPTION OF THE BONE AFTER RE-MOVING THE PEN MARK
DAY ONE		A greyish-brown, 35 mm-thick and 67 mm-long chicken thigh bone with little rem-nants of meat marked with pink felt-tip pen. A week old.		I used erasers and sponges but they could not remove the pe mark. I used a wool swab dipped in distilled warm water and rubbed it against the bone surface. A lot of the ink was removed but the bone had absorbed some of it so I waited for 15 minutes for the bone to dry off. While I was rubbing it with the cotton swabs, some dry remnants of meat came off the bone.

<table>
<tr>
<td>ONE MONTH</td>
<td></td>
<td>A 16 mm-long grey and brown bone with tiny, shiny remnants of dried meat and a broken epiphysis on the other side. The epiphysis has become light brown to lighter grey and shiny. On the other side of the bone, a purple ink mark is applied. The bone is harder than before. When applying ink on the bone, it seemed to be absorbed quickly. The applied ink dried and was absorbed by the bone.</td>
<td>
Cleaned bone under magnification.

The purple ink is visible under magnification.</td>
<td>To clean the ink, I started with all the dry methods in my kit, Staedtler eraser, crepe eraser, wishabs, vulcanised rubber sponge and polyurethane sponges. Only the Staedtler eraser removed some green colour of the ink, although it did not come off. I then used acetone, rubbing it on the ink mark with the cotton swabs, which removed a bit of ink—a green colour. So I made a poultice of rubbing alcohol and acetone, which did not remove the ink altogether.</td>
</tr>
</table>

THREE MONTHS		A dried grey bone 18 mm long and 13 mm wide with dry, brown meat remnants. On one side of the epiphysis, across the body of the bone, a pink ink mark is applied.	 The cleaned bone under magnification. 	An 18 mm-long, 13 mm-wide bone with visible wet remnants of meat due to warm wash. Across the middle of the bone, towards the epiphysis, there is slight evidence of the orange ink mark applied three months prior to removal. All dry methods I used failed to remove the ink. I also used acetone and rubbing alcohol, then an alcohol poultice, but neither removed the ink completely. Although the cotton swabs removed some ink, there was a lot of ink left on the bone. Then, I used saliva, then warm water with soap with a brush, and a lot of ink came off, but I could not remove it all.

Through this exercise, I realised that bones are absorbent, and if ink is applied to them, it is difficult to remove because it is absorbed.

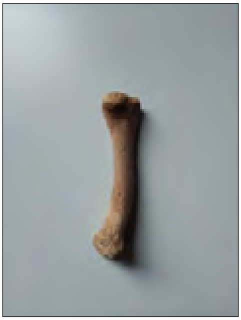
Buried bones before burial

BONES BEFORE BURIAL	PHOTO	DESCRIPTION
A BONE COVERED WITH A CLOTH		A 60 mm-long, brown and grey chicken thigh bone with 51 mm-thick, chipped epiphysis and 40 mm un-chipped epiphysis and a small amount of meat remnants.
UNCOVERED BONE		A 70 mm-long, 34 mm-thick chicken thigh bone with 51 mm and 58 mm epiphyses and a few meat remnants.

Buried bones after a few months

BONES BEFORE BURIAL	PHOTO	DESCRIPTION
A BONE BURIED COVERED	 Bone after cleaning	A 60 mm-long, 51 mm-thick bone with 40 mm epiphyses, slightly greenish, rustic, wet with a toxic muddy smell. It has a very fragile and flaking epiphysis, which is easily dented and flaked by a short thumbnail. The bone also has tiny worms. It is also mouldy, and its exterior particles are flaking onto the cloth, changing its colour to those of the bone. There is a white, powdery substance on the bigger epiphysis. Dark spots are also evident. The covered bone after cleaning After cleaning, the bone looks dark grey and dark brown with large and small black patches all over the surface. It is fragile; the epiphysis comes off in a form of powder when rubbed off or against the finger.

BURIED BONES	PHOTO	DESCRIPTION
UNCOVERED BONE	 Bone under magnification  Above is the bone buried covered with cloth under magnification. Dark patches, visible to the naked eye, look green under the microscope. The green patch seems to be embedded in the bone like it has always been part of it. I suspect the black patches and spots are due to mould.  The epiphysis of the bone is buried, covered with a cloth, showing a long string within the epiphysis.	

BURIED BONES	PHOTO	DESCRIPTION
A BONE BURIED UNCOVERED	 Uncovered bone after cleaning  The bone under magnification  The epiphysis of the bone buried uncovered under magnification  The bone buried uncovered does not show large black patches like the bone buried covered with a cloth.	A 70 mm-long, 34 mm-thick rustic bone with 58mm epiphyses, embedded with soil and with a muddy smell. The bone has slightly greenish dots due to mould, and its body is fragile to the extent that it is dented with a short thumbnail. Its epiphyses are more fragile; they are flaked when rubbed with fingertips. Uncovered bone after cleaning: The bone looks dark brown with small black patches scattered along the bone. The epiphysis comes off in a powder form when rubbed against any hard surface.

Challenges

Two weeks after I had buried the bones, I went to check on them but I found them exposed. Fortunately, I had buried them under a garden chair so they were not exposed to the sun. I had to change the cloth and extend the time before digging them up by a week.

Conclusion

Buried bone degradation is determined by many factors, and it does not follow simple, predictable pathways (Nicholson 1996: 529). These factors include the history of the bone before burial, the soil pH, microorganisms, and the overall environment (Karr and Outram 2015: 207). Nord, Kars, Ullen, Tronner and Kars (2005: 78) argue that bones buried in soil with a high organic content deteriorate slowly while those buried in soil with acidifying pollutants deteriorate faster. Buried bones lose their strength and rigidity due to acidic conditions (Tiley-Sian and Antonites 2015: 07). Also, bacteria and fungi cause degradation of bone material (Nord et al. 2005: 77). Bones that were previously frozen have been proven to deteriorate slowly (Karr and Outram 2015: 207). It is obvious that if these bones were to remain buried for a longer time they would have deteriorated more. Therefore, bone objects need extra care—especially archaeological bone objects as they have been under different environmental conditions that render them extremely fragile.

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Mariet Conradie: THC 804

This assignment was written by Mariet Conradie, an education officer from the Ditsong Museums of South Africa: Kruger Museum in Pretoria. She is a museum professional with more than 20 years' experience in the sector. She will submit her thesis in 2023.

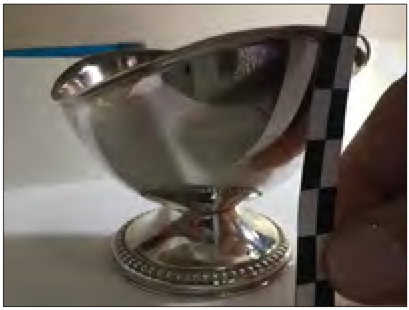
Introduction: Silver (Ag) silver bowl

Silver tarnishes on exposure to pollutants, particularly sulphur in the environment, and this dark layer can obscure details on the surface of artefacts (Selwyn 2004). As such, cleaning historic silver to remove the tarnish is a common practice in period house museums. This can be carried out by the use of polishes, polishing cloths, chemical dips or electrochemical reduction, and the method chosen depends on the object (Selwyn 2007). The objective of this assignment was to observe what happens when cleaning a silver (Ag) object. Please see photos taken with an iPhone on pages 5, 6 and 7. I first have to document 'before' and 'after' overall images and then show the different sides with scale.

Next, I have to document 'before' and 'after' at 100x and 10x magnification with your USB microscope. The USB microscope is set at 1600x. That is the setting that I can use, I cannot change this setting—it is what it is. (I have since discovered how to scale an object photo taken with a USB microscope. Please see p. 8.)

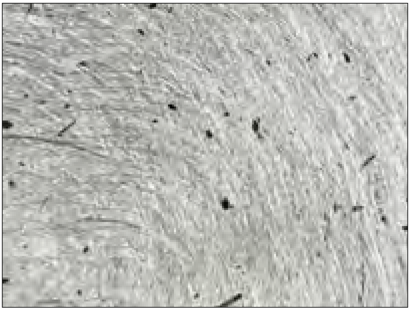
I will now, as instructed, mix 50% H2O (water) + 25% CaCO3 (chalk) + 25% C2H6O (ethyl alcohol) and apply this paste to the bottom of the silver object to see what the outcome is. I will turn the object upside-down and apply the paste right at the bottom.

	
This is a photo, taken with my iPhone, from one of the long sides. (So here are two recto sides.)	This is a photo, taken with my iPhone, from the other, shorter side of the same silver object. (So here are two recto sides)

	
This is a photo, taken with my iPhone. With this asymmetrical object, you cannot say which side is recto and which is verso.	This is a photo, taken with my iPhone. With this asymmetrical object, you cannot say which side is recto and which is verso

	
This is the inside of the silver bowl, taken with my iPhone.	This is the bottom of the silver bowl, taken with my iPhone.

	
The silver bowl, lying on its side, taken with my iPhone	The pattern of the silver dish, taken with the USB microscope at 1600x magnification

	
Photos taken with the USB microscope before applying paste 1 that I made to the bottom of the silver object	Photos taken with the USB microscope after applying paste 1 that I made to the bottom of the silver object

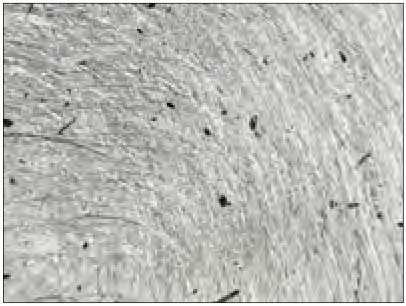
Paste 1:

When making the first paste that we were instructed to make, mixing 50% H_2O (water) + 25% $CaCO_3$ (chalk) + 25% C_2H_6O (ethyl alcohol), I observed, as shown in the pictures above, that the consistency of the paste remained more constant. There was less evaporation taking place, compared to the second paste. Thus, the abrasive properties of the paste remained more constant over a short period of time, which made the paste dry and more abrasive, and when I applied it to the bottom of the bowl, it was so abrasive that it immediately caused the instant damage as described below in the conclusion.

Paste 2:

The second paste that I made consisted of 50% $CaCO_3$ (chalk) and 50% C_2H_6O (ethyl alcohol) only. In the above paste, the $CaCO_3$ (chalk) + C_2H_6O (ethyl alcohol) evaporated very quickly, and then the chalk became dry very quickly. Please see the conclusion.

I have discovered how to enlarge a USB microscope photo to 10x, as well as to 100x.

	
Before applying the second paste to the right side (underneath) of the silver bowl, enlarging USB microscope photo 10x	Before applying the second paste to the right side (underneath) of the silver bowl, enlarging USB microscope photo 100x
	
After applying the first paste to the right side (underneath) of the silver bowl, enlarging USB microscope photo 10x	After applying the first paste to the right side (underneath) of the silver bowl, enlarging USB microscope photo 100x

Conclusion

On page 7, the pictures on the versa side show the object before I applied the first paste, and the pictures on the recto side show so much damage to the silver object that I will immediately stop applying this paste to this object.

This paste, which I made by mixing 50% H_2O (water) + 25% $CaCO_3$ (chalk) + 25% C_2H_6O (ethyl alcohol) until the chalk was ground into a paste that could mix with the water and alcohol, rubbed away the thin layer of plating. This will now expose the object to corrosion. This object is an 1840 electroplated silver dish, and the bronze alloy underneath the layer of plating, which I have now removed, is showing in the pictures on the right side (you see a yellowish metal).

The abrasive nature of the chalk, albeit used in a very fine powder form, has also scratched the surface of the object; it can be clearly seen on the USB microscope photo on the side of pages 7 and 8, where it is enlarged 10x and 100x. So, while the chalk paste was effective at removing the tarnish from the surface of the historic silver object, the polishing action required is in itself causing damage. As Selwyn notes, 'The resulting finish, or scratch pattern, is often influenced more by the polisher than by the polish. The polisher must take care to minimise damage from abrasive polishing.' This suggests that, perhaps, routine polishing of the silverware in period house museums should be minimised in order to extend the life of the objects.

Secondly, mixing the solution oneself allows for complete control over both the abrasive particles (the chalk) and how fast the paste dries, which in turn minimises the potential for metal oxidation, thereby minimising damage and deterioration from the materials themselves. In contrast, the recipe and ingredients of commercial polishes and chemicals are not controlled, can change without warning, can contain harmful chemicals and are generally more abrasive (Selwyn 1991).

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Laura Esser: THC 804

Laura Esser, one of the five students from the 2020 intake, wrote the assignment titled: Adhesives and their solvents in ceramic objects.

Introduction

Conservators deal with a variety of art and museum objects made of different kinds of material. Generally, these materials can be grouped into inorganics and organics. Inorganic material is made out of plants and minerals, while organic objects are made of plants and animal parts or extracts. This essay focuses on inorganic materials. Inorganic materials include stone, metals, ceramics and glass (Wilks 1992a: 16). Since covering adhesives and adhesive solvents for all of these materials goes beyond the scope of this paper, the focus is on ceramics. Ceramics form an important part of museum collections because they have been used for storage, transport and cooking and have served as pieces of art since prehistoric times. There is a variety of different ceramics available, but this is not the focus of this essay (Met Museum 2020).

This essay focuses on the adhesives that have been used for ceramics over time. In particular, the composition, properties and ageing of each adhesive are discussed. Then, solvents which have been used for the particular adhesive are explained, with a particular focus on the Teas solubility chart. At first, a few historic adhesives are discussed, but special attention is given to shellac, which is still found as an adhesive in many museum collections. The next adhesive is cellulose nitrate, which was commonly found in the nineteenth and early twentieth century in museums (Neiro 2003: 237). Lastly, acrylic adhesives are discussed, with special attention given to Paraloid B-72. To get a better picture of the usage and ageing of these adhesives, different case studies are consulted and their findings compared.

Solvents and solubility

A solvent dissolves a solute in a solution. Solutions are usually homogenous mixtures of more than one substance. Usually, solutes are solids, but they can also be gaseous or liquids. Conservation practice mostly deals with solid solutes (Helmenstine 2019, Brown, LeMay, Busten, Murphy and Woodward 2019a).

Solubility describes the maximum amount of a solute that can possibly be dissolved in a given amount of solvent, at a constant temperature and pressure. In conservation, however, solvents are mostly used to soften adhesives on objects; they are not present in excess in solutions, as may be the case in a chemistry laboratory (Conservation Science Tutorials n.d.) To know which solvents dissolve which solute, it is important to know about the intermolecular interactions in the substrates, in particular focusing on London dispersion forces, dipole-dipole interactions and hydrogen bonding (Brown, LeMay, Busten, Murphy and Woodward 2019b). As a general rule, 'like dissolves like', meaning that substrates whose molecules are similar in structure and therefore exhibit similar intermolecular forces tend to be soluble in each other (Vitz, Moore, Shorb, Prat-Resina, Wendorff and Hahn 2019a). According to Stravroudis and Blank (1989: 1f.), the 'likeness' of substrates can also be compared with their polarity.[1] Substances with similar polarities are usually miscible. However, in some cases, a non-polar solvent will mix with a polar solvent if one of them is present in excess (Conservation Science Tutorials n.d.). Most organic materials appear to be polar, such as proteins and minerals, animal and plant derivatives, as well as waxes (intermediate polarity). Another important factor when considering solubility is the cohesive energy density, which is the attractive force that holds molecules of a solute to a liquid, the solvent. In order to dissolve a solute in a solvent, their cohesive energy density must be relatively equal. If the solute's molecules prefer to stick to each other instead of the solvent, a solution does not form (Stravroudis and Blank 1989: 4).

There are many ways to measure and categorise the solubility of adhesives and adhesive solvents, such as Hansen's solubility parameter and the Teas solubility chart diagram. The Teas diagram was inspired by Hansen's solubility parameter but incorporated its three dimensions into a two-dimensional triangle. It represents the effects of London dispersion forces (f_d), dipole forces, also called polar attractions (f_p), and hydrogen bonding forces (f_h) combined, each on one side of the triangle. The sum of these forces always adds up to the value of 100. For most solvents used in conservation, the fractional solubility parameters have already been published. They were determined by trial-and-error experiments

1 Polarity describes the electrical charges in an atom. When atoms do not have the same charge bond, a partial charge is created, which signifies that a polar bond has been formed (Editors of Encyclopaedia Britannica 2019).

and therefore are not possible to measure by oneself. Solvents that are located in roughly the same area on the triangle can form solutions (Stravroudis and Blank 1989: 5, Conservation Science Tutorials n.d.). Even though this chart has been used extensively over the years by conservators, some, including Stravroudis and Blank (1989: 5), criticise its accuracy. They argue that Teas himself admitted that the diagram does not work for a number of solvents, especially the aromatic and aliphatic hydrocarbons, because some relations between solvents are lost due to their triangular shape.

Ceramics and their composition

There are four types of ceramic objects: earthenware (which is low-fired pottery), stoneware (which is high-fired pottery), soft-paste 'imitation' porcelain, and hard-paste 'true' porcelain (Icon 2006: 2). The bodies of ceramic objects are made from clay minerals and filling materials, also called temper, which prevents the body from shrinking when fired, as well as impurities. Ceramic objects also often have a glazed surface, which makes the object waterproof, but also serves for decoration purposes. The glaze is made of glass, which contains silica and fluxes, such as sodium, potassium, calcium and lead, as well as colourants. When ceramics are fired at high temperatures, the glaze is usually hard and glassy. If a ceramic is fired at low temperatures, the glaze can become brittle and flaky. Low or unevenly fired ceramics tend to be porous and more prone to breakage and flaking (Newton and Logan 2007).

Adhesives

Historic adhesives

Ceramics have been repaired since ancient times, but adhesives and solvents have changed over time. To discuss each adhesive would be outside the scope of this essay; therefore, a short historic summary of adhesives made from animal glue and plants is given. Then, more recent adhesives are discussed. Several case

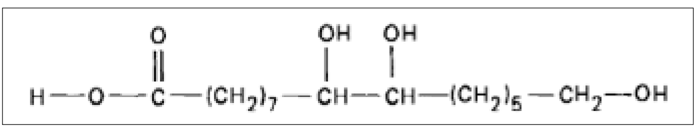

Figure 1: Chemical structure of shellac (Horie 1987:149)

studies are consulted to indicate what museums use for their own collections.

In a study about adhesives used on ceramic, glass and stone done at the Arizona State Museum (ASM) collections in the United States of America, it was found that pine resins and creosote lac resins were among the oldest adhesives found in their collection. Pine resins were used as adhesives, as well as to waterproof objects. This resin continues to be used by some Native American potters. Creosote Lac is produced by the insect *Tachardiella larreae* on the leaves of the creosote bush. It is a relatively strong adhesive used by Native Americans in the southwestern USA. The earliest example of an object with this adhesive in the ASM collection was from around 1440 until 1460. Creosote lac also continues to be used by Native American potters today (White and Odegaard 2008: 180f.).

Hide or animal glues were commonly used in conservation laboratories before the introduction of cellulose nitrate around 1915. Unfortunately, the study at the Arizona State Museum showed that 5% of objects repaired with animal glues have failed, and another 19% are labelled as unstable (White and Odegaard 2008: 180f.). A study done at the Greek Ceramics collection of the National Museum of Antiquities in Leiden, Netherlands, states that animal glues were relatively easy to remove from ceramics. The objects were submersed in deionised water to soften the animal glue. Then, using cotton swabs with acetone or industrial methylated spirit, the glue swelled enough that it could be removed mechanically using a scalpel or soft brushes (Dooijes 2007: 106).

Since the early twentieth century, cellulose nitrate became widely used in conservation, which also shows in the ASM collection, because it is the adhesive that was most commonly found in repaired objects. However, the study found that the adhesive does not age well; it becomes brittle and its strength decreases with age. Fifteen percent of repairs done with cellulose nitrate had failed, while four percent were considered to be unstable. Cellulose nitrate is discussed below.

Another historic adhesive is shellac. Shellac is made from the secretions of the lac beetle, which is native to southwest Asia. It was introduced to Europe as early as the 1300s. This secretion is washed and purified and becomes a resin when dissolved in ethyl alcohol (Bjorneberg 2019). However, shellac does not age well. It becomes brittle and discoloured. This can leave stains on the ceramic object. The shellac is also likely to seep into the body of the ceramic. Any solvent could cause the resin to soak even deeper into the material (Dooijes 2007: 108). Removing this resin can be difficult because of its complicated chemical

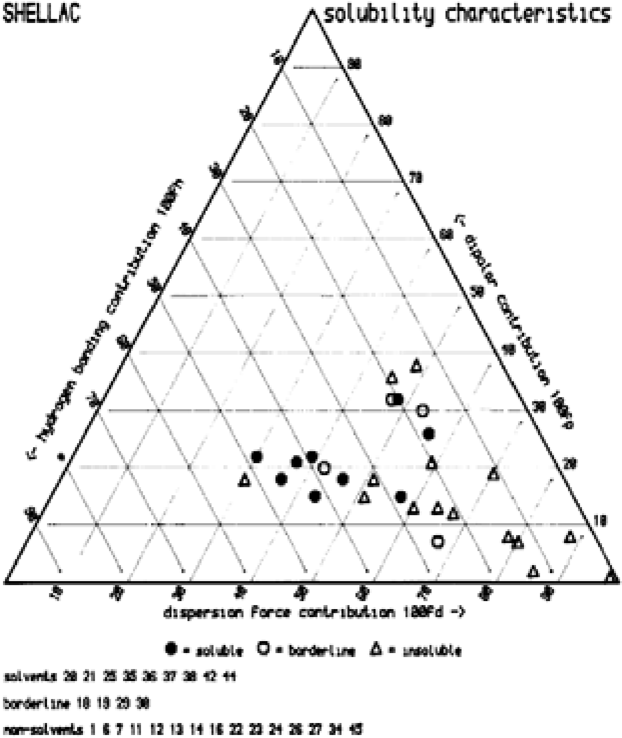

Figure 1: Chemical structure of shellac (Horie 1987:149)

structure. Since the resin comes from a beetle, the chemical structure can change depending on the environmental conditions the insect was exposed to. One of its major elements is aleuritic acid,[2] which esterifies into a polyester (see figure 1, Horie 1987: 149) According to a study done in 2017 (Tamburini, Dyer and Bonaduce 2017: 1), shellac consists predominantly of soft and hard resin, with the soft resin taking up 30% and the hard resin taking up 70%. These fractions can further be divided into mixtures of mono- and polyesters of hydroxy aliphatic acids, sesquiterpenoid acids and lactic acids. These mixtures are complex.

When ageing, the shellac undergoes crosslinking,[3] intermolecular

2 9, 10, 16-trihydroxyhexacanoic acid

3 Cross-linking occurs when covalent bonds form that hold polymer chains together. The result is a three-dimensional, random network of polymer chains. Cross-linking makes a substance more rigid and harder (Vitz et al. 2019b).

esterification, as well as the formation of unsaturated compounds, which makes it more difficult to identify in FTIR or fluorescence spectroscopies. While this study does not mention any solvents for shellac, it refers to another study done on the molecular changes during biopolymer ageing, which had shellac as a case study. They used methanol as a solvent for their shellac samples (Coelho, Nanabala, Menager, Commereuc and Verney 2012: 937). When Koob (1979: 134) discussed the removal of aged shellac in 1979, he considered the pyridine (C_5H_5N), a solvent with slight to moderate chemical toxicity, as most appropriate for the removal of shellac from ceramics. However, Koob states that 2-methoxy ethanol and a 50:50 mixture of ethyl alcohol and acetone are also effective. The latter two solvents only swell the resin enough so that it can be brushed or scraped away mechanically. The Victoria and Albert Museum suggested in 1971 that shellac should be removed with a 50:50 mixture of ammonia and industrial methylated spirits or Nitromors, which is a paint stripper containing predominantly methylene chloride (Larney 1971: 70). This shows how the approach to dissolving adhesives has changed over time.

According to the Teas solubility chart, shellac is soluble in methyl Cellosolve (2-methoxyethanol), butyl Cellosolve (2-butoxyethanol), isopropyl acetate, methanol, ethanol, isopropyl alcohol (propan-2-ol), butanol, n-methyl-2-pyrrolidone and pyridine (Horie 1987: 190). Koob (1979: 134) also used pyridine, which matches Horie's findings.

Cellulose nitrate

An adhesive that is still found in abundance in many museum collections is cellulose nitrate. In the Arizona State Museum, cellulose nitrate is the most widely used adhesive material in repaired ceramic vessels. It is a derivative of cellulose and made by adding nitric acid (HNO_3) to cellulose (($C_6H_{10}O_5$)

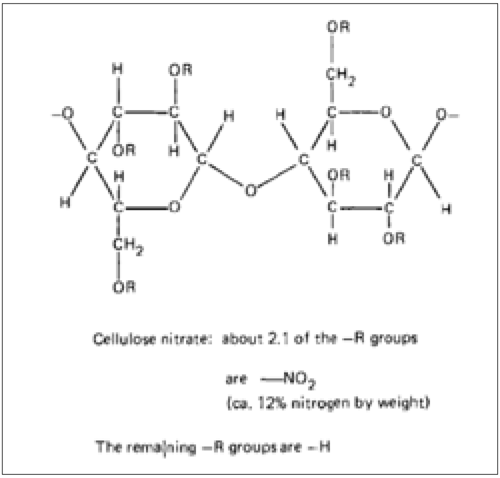

Figure 3: Chemical structure of cellulose nitrate (Horie 1987:131)

$_n$) (Encyclopedia.com n.d., National Centre for Biotechnology Information n.d.). At first, cellulose nitrate was a popular adhesive among conservators and is still being used today, not only for ceramics but also for iron and glass. Cellulose nitrate was considered useful because the solvents rapidly evaporated, leaving a strong, dry film of adhesive. However, it is extremely unstable (Horie 1987: 132). The lifetime of cellulose nitrate as an adhesive is only estimated to be around 100 years, after which degradation has made the product completely unstable (Ziegler, Kuhn-Wawrzinek, Eska and Eggert 2014: 1). Horie (1987: 133) also mentions that, as early as the 1920s, conservators expressed concerns about cellulose nitrate's stability as an adhesive, as well as its effects on objects. The study done at the Arizona State Museum noted that cellulose nitrate becomes problematic with age because it becomes increasingly brittle. About 15% of all ceramics repaired with cellulose nitrate failed and another 4% were considered unstable (White and Odegaard 2008: 180).

There are a number of different cellulose nitrate adhesives available on the market. The most popular ones are Archäocoll 2000, Frigilene, HMG and Mecosan L-TR (Ziegler et al. 2014: 2).

Archäocoll 2000 was developed in Germany in 1997 as an adhesive for archaeological ceramics. It contains no plasticiser[4] and is therefore relatively rigid and brittle. Its glass transition temperature (T_g)[5] is between 80 and

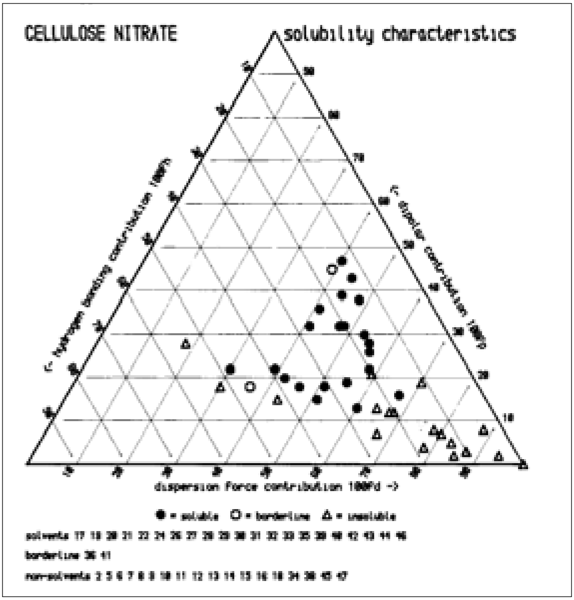

Figure 4: Teas chart for cellulose nitrate (Horie 1987:214)

4 Plasticisers are often added to adhesives to increase their flexibility and workability. They lower the adhesive's glass transition temperature (see below) and elastic modulus (Chemceed 2017).

5 The glass transition temperature (Tg) is the temperature at which the thermal energy of a material/chemical is smaller than the forces that hold the molecules in the chemical together. At that temperature, the substrate moves from a hard, glassy consistency to a soft consistency. Below its Tg, an amorphous (not exhibiting crystalline structure) polymer is (Vincotte et al. 2019: 2).

90°C. Archäocoll can be didsolved in a mix of ethylacetate (35–40%), acetone (35–40%) and *i*-propanol (10–25%). Unfortunately, Archäocoll degrades faster than plasticised cellulose nitrate adhesives. Frigilene is a cellulose nitrate lacquer. It contains alkyd resin and phthalates (possibly dibutyl phthalate) as plasticisers. It is not often used in conservation. Frigilene best dissolves in a mix of butyl acetate (30–60%), xylene (30–60%) and butanol (10–30%). HMG is a cellulose nitrate adhesive that contains 2.5–10% di-iso-nonyl phthalate as a plasticiser. Its solvent is acetone, or a mixture of 50–100% acetone, 10–25% butyl acetate, 2.5–10% *i*-propanol, 2.5–10% *i*-butanol, as well as 2.5–10% 2-methoxy-1-methylethyl acetate. Mecosan L-TR is plasticised with camphor and small amounts of diphenylkresyl-phosphate. This adhesive can be dissolved in 100% methyl acetate or a mixture of 50–100% methyl acetate, 10–12.5% ethanol, 5–10% naphtha, 5–10% *i*-propanol and less than 1.5% hexane (Ziegler et al. 2014: 2). The adhesives that have additional plasticisers have a T_g around 70°C. Most studies, however, state that cellulose nitrate is readily soluble in acetone (Neiro 2003: 238, Larney 1971: 70). Whether or not these adhesives are soluble in acetone or a mixture alcohol and ether also depend on the amount of nitrogen that is contained in the cellulose nitrate. Manufacturers may have different formulas (Encyclopedia.com n.d.).

The study also conducted tests for each of the above-listed cellulose nitrate adhesives to show how they age. The results showed that the plasticisers had a negative impact on the adhesives' degradation process. For example, Mecosan L-TR showed yellowing and shrinkage when heat-aged (Ziegler et al. 2014: 6f.). Cellulose nitrate also shows discolouration and becomes brittle. Light and heat can accelerate its deterioration severely (Neiro 2003: 238). The study proposed polyvinyl butyral 30 (PVB 30), and Paraloid B-72 as alternatives to cellulose nitrate adhesives (Ziegler et al. 2014: 3). Another disadvantage of cellulose nitrate is that its degradation is autocatalytic; the chemicals created during initial

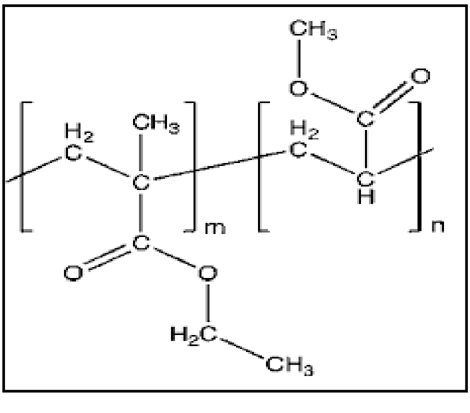

Figure 5: Chemical structure of Paraloid B-72 (Baglioni 2014)

degradation increase the speed of cellulose nitrate breakdown. Furthermore, one of the chemicals created during the degradation process is nitrous oxide (NO_2), an oxidising agent which is highly toxic (Shashoua, Bradley and Daniels 1992: 114).

There only appears to be a Teas solubility chart for pure cellulose nitrate. It is soluble in tetrahydrofuran, Cellosolve (2-ethoxyethanol), methyl Cellosolve (2-methoxyethanol), butyl Cellosolve (2-butoxyethanol), Cellosolve acetate (2-ethoxyethyl acetate), ethyl acetate, *n*-butyl acetate, propylene carbonate (propane-1,2-diol carbonate), 4-butanolide (butyrolactone), acetone, ethyl methyl ketone (MEK or butan-2-one), cyclohexanone, isobutyl methyl ketone (4-methyl pentan-2-one), di-isobutyl ketone (2,6-dimethylheptan-4-one), methanol, *n*-butyl alcohol (butanol), nitroethane, n-methyl-2-pyrrolidone, dimethyl methanamide (*N, N-dimethylformamide*), pyridine and dimethyl sulphoxide (Horie 1987: 188–190). None of these solvents appears in the above-mentioned studies.

Acrylic adhesives

Acrylic polymers as adhesives began to appear on the market in the 1950s (Samson Kamnik, 2013). They were developed by the company Rohm and Haas and were originally used as surface coating (Cameo, 2019). They are now the most widely used in conservation laboratories. The most frequently used acrylic adhesive is Paraloid B-72, which is a copolymer of 70% ethyl methacrylate (EMA) and 30% methyl acrylate (MA, see figure 5). Butyl methacrylate (BMA) may make up 2% of Paraloid B-72. This adhesive is often preferred over cellulose nitrate because of its relative stability, its transparency and mechanical resistance, but most importantly, its reversibility (Vincotte, Beauvolt, Boyard and Guilminot 2019: 1).

There are many different acrylic adhesives on the market, including Paraloid B-44, B-66, B-72 and B-82. However, not all chemical compositions of these resins are as clearly specified as that of Paraloid B-72. Paraloid B-44, for example, has a higher T_g than Paraloid B-72—above 60°C (Vincotte et al. 2019: 1f). Since Paraloid B-72 is the most widely used in conservation, it is what this essay focuses on.

Paraloid B-72 is relatively resistant to oxidation, light and hydrolysis.[6] Its moderate hardness is beneficial since adhesives that are too hard are prone to cracking at the joins because they are less flexible (Koob 1986: 7f.). Paraloid B-72 can be used for many materials, including metals, stone, wood, glass and ceramics.

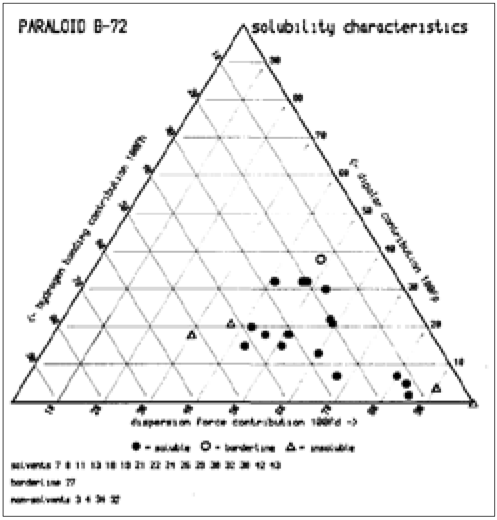

Figure 5: Chemical structure of Paraloid B-72 (Baglioni 2014)

In the Arizona State Museum's collection, acrylic polymers, especially Paraloid B-72 and B67, began to appear around 1984. These adhesives largely replaced cellulose nitrate adhesives. As of 2008, there was a failure rate of below 1% for objects treated with Paraloid (White and Odegaard 2008: 180). However, other studies claim that Paraloid B-72 proved to be unstable in large ceramic objects, which is attributed to its glass transition temperature of only 40°C (Shashoua et al. 1992: 113).

The Kaman-Kalehözük Museum in Kaman, Turkey, for example, found Paraloid B-72 to collapse in ceramic vessels repaired with the resin. Since Turkey has extremely hot summers but also cold winters, this study questioned the effectiveness of Paraloid B-72 in extreme climates. Therefore, the study suggests conservators in warmer climates use Paraloid B-48N, which has a T_g of 50°C (Pohoriljakova and Moy 2013: 83). However, the study also showed that Paraloid B-48N lost its flexibility and became brittle after three years and lost its solubility over the years as well. Paraloid B-72, however, retained the best solubility when compared to Paraloid B-48N. None of the Paraloid adhesives showed any yellowing or discolouration as they aged (Pohoriljakova and Moy 2013: 89, 92).

As an adhesive for ceramics, Paraloid B-72 is often dissolved in a 70:30 ratio of acetone and Paraloid B-72. Other solvents include ethanol, toluene, xylene

6 Hydrolysis is a chemical reaction in which a water molecule is added to a substance. This often breaks down the substance (The Editors of Encyclopaedia Britannica 2016).

and ethyl acetate (Vincotte et al. 2019: 1). Acetone is the most commonly used solvent for Paraloid B-72 because it is the least toxic. However, it evaporates relatively quickly. Therefore, ethanol is used in combination with acetone to create a slower setting time. In hotter climates, solvent mixtures containing up to 40% ethanol are often used to dissolve Paraloid B-72, which prevents the acetone from dissolving too quickly (Koob 1986: 9, Neiro 2003: 239f.).

Vincotte et al. (2019: 2, 7) divide the solvents of Paraloid B-72 into two groups. The first group consists of more volatile solvents, including ethanol, acetone and ethyl acetate. The second group contains heavier solvents—toluene, butyl acetate and ethyl lactate. Increasing the quantity of solvent with a set amount of Paraloid B-72 will decrease its T_g. Acetone, for example, can decrease the T_g of Paraloid B-72 by several degrees Celsius, and toluene can lead to as much as a 15°C reduction. This can be problematic since Paraloid B-72 only has a T_g of 40°C but often softens at 30 to 35°C.

According to the Teas solubility chart, Paraloid B-72 is soluble in toluene, xylene, methylene chloride (dichloromethane), carbon tetrachloride (tetrachloromethane), dioxane (1,4-dioxacyclohexane), Cellosolve (2-ethoxyethanol), butyl Cellosolve (2-butoxyethanol), Cellosolve acetate (2-ethoxyethyl acetate), ethyl acetate, *n*-butyl acetate, acetone, ethyl methyl ketone (MEK, butan-2-one), isobutyl methyl ketone (4-methyl pentan-2-one), *n*-butyl alcohol (butanol), *n-methyl-2-pyrrolidone*, dimethyl methanamide (*n*, *n-dimethylformamide*) (Horie 1987: 186–190). Some of these adhesive solvents correlate with previously discussed literature, but most of the solvents found on the Teas solubility chart for Paraloid B-72 are not mentioned in literature.

Conclusion

This essay only covered a small section of the adhesives and their solvents used in the conservation of ceramic objects. Among the adhesives not discussed are polystyrene (PS) and polyvinyl acetate (PVAC) (Nel, Noake, Jones-Amin and McKenna 2024: 1, 4, White and Odegaard 2008: 180), as well as epoxy adhesives such as Araldite and adhesives designed to make archaeological excavations easier, such as Aquazol (Ortlik, Bussienne and Maynes 2011, Muros 2012). While these adhesives play an important role in conservation and are still used, the most relevant adhesive used in the twentieth century, according to literature coverage, seemed to be cellulose nitrate, while Paraloid B-72 was most commonly found in literature for the twenty-first century.

Finding solvents for adhesives has been a practice ever since the invention of adhesives, which was long before academics gained the chemical knowledge about molecular structures and chemical reactions in adhesives that we have today. Therefore, many of the solvents used are a result of trial-and-error experiments (Stravroudis and Blank 1989: 5). What also has to be taken into consideration is that different manufacturers may have differing recipes for their adhesives, which may also have changed over the years, as was the case with the amount of nitrogen in cellulose nitrate (Encyclopedia.com n.d.). This might explain why there are so many solvents on the Teas solubility chart for the respective adhesives discussed that are not mentioned in literature at all. While the Teas solubility chart is a scientific measurement to identify possible adhesive solvents according to their properties (London dispersion forces, attraction forces and hydrogen bonds), these may not always be the most useful solvents in practice because of differing recipes for adhesives.

This highlights the importance of staying updated with current literature on adhesives and their solvents and learning from other conservators who work with similar objects. When doing so, the difference in location has to be taken into consideration. Seeing as adhesives have varying glass transition temperatures, conservators working in hotter climates, such as those in the Kaman-Kalehözük Museum in Kaman, Turkey, may have different experiences than the Arizona State Museum in the United States of America (Pohoriljakova and Moy 2013: 83).

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Hannes Elsenbroek: THC 807

Hannes Elsenbroek, an artist and student from the 2021 intake, aims to become a paintings conservator. He submitted this condition report and documentation of an easel painting during the THC 807 speciality module.

Introduction

This condition report formed part of the core grading components of the elective module THC 807: Conservation: Polychrome Surfaces. While serving as an exercise for identifying and documenting the damage and deterioration processes inherent in easel paintings, this project further provided an opportunity to apply newly learnt concepts, such as the anatomy of easel paintings, as well as several methods of observational analysis such as microscopy, normal and raking-light photography, and ultraviolet and infrared imaging. This exercise also enabled an opportunity to undertake and experience a project at a professional level since the client is Melrose House Museum Collection. This condition report marks the beginning of the conservation treatment of an undated O.T. Clark painting titled River Scene as requested by the client. This painting is in poor overall condition, displaying multiple areas of material loss, extensive tears, planar distortion, cracks, varnish discolouration, as well as previous areas of repair that have become undesirable. Paintings in such an unstable condition are generally at risk of being deaccessioned if not restored, and so the objective is to use this artwork as a teaching tool in live demonstrations or practical sessions and ultimately restore the painting.

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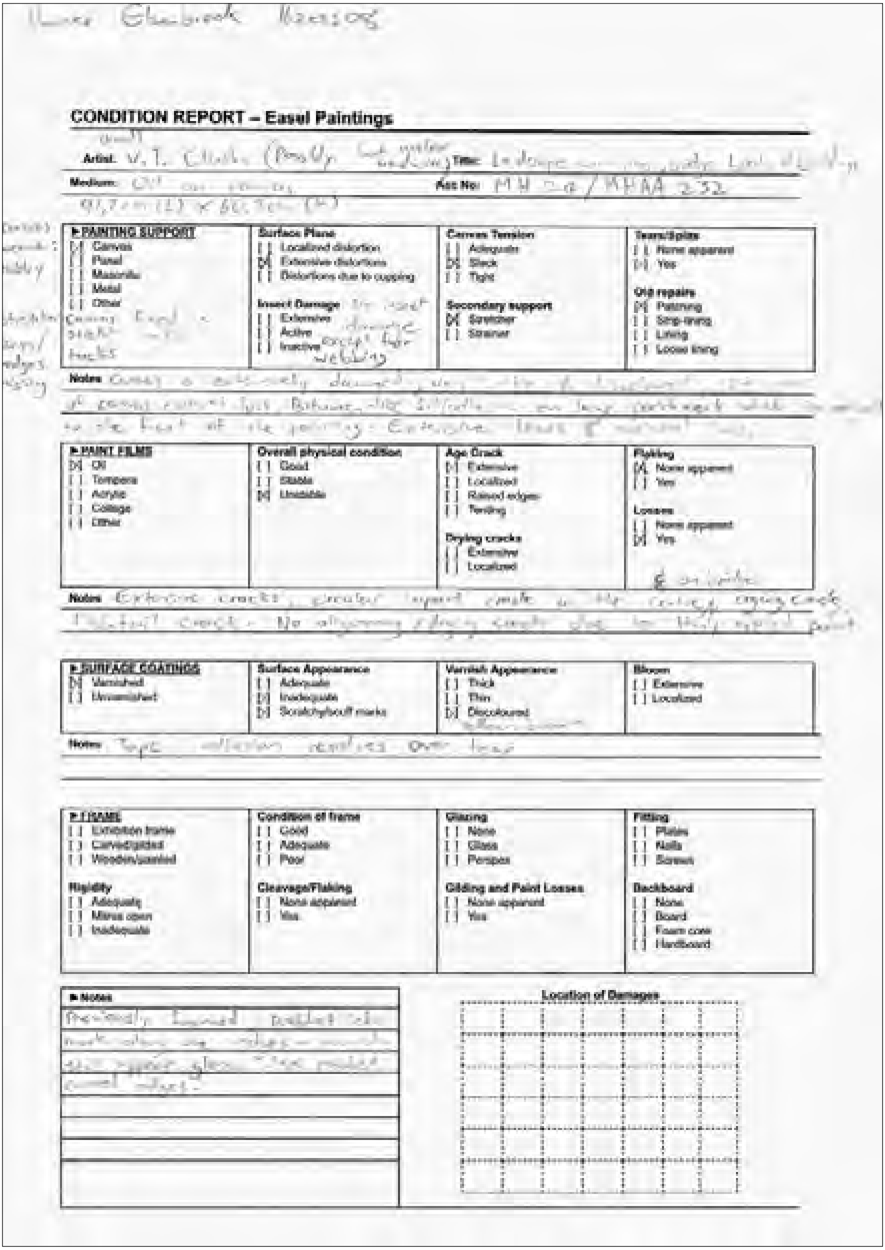


CONDITION REPORT – Easel Paintings

Artist: V. T. Clark Title:

Medium: Oil on canvas Acc No: MH 2a / MHAA 232

91,7 cm (L) x 60,5 cm (H)

▶ PAINTING SUPPORT	Surface Plane	Canvas Tension	Tears/Splits
[x] Canvas [ ] Panel [ ] Masonite [ ] Metal [ ] Other	[ ] Localized distortion [x] Extensive distortions [ ] Distortions due to cupping **Insect Damage** [ ] Extensive [ ] Active [ ] Inactive	[ ] Adequate [x] Slack [ ] Tight **Secondary support** [x] Stretcher [ ] Strainer	[ ] None apparent [x] Yes **Old repairs** [x] Patching [ ] Strip-lining [ ] Lining [ ] Loose lining

Notes:

▶ PAINT FILMS	Overall physical condition	Age Crack	Flaking
[x] Oil [ ] Tempera [ ] Acrylic [ ] Collage [ ] Other	[ ] Good [ ] Stable [x] Unstable	[x] Extensive [ ] Localized [ ] Raised edges [ ] Tenting **Drying cracks** [ ] Extensive [ ] Localized	[x] None apparent [ ] Yes **Losses** [ ] None apparent [x] Yes

Notes:

▶ SURFACE COATINGS	Surface Appearance	Varnish Appearance	Bloom
[x] Varnished [ ] Unvarnished	[ ] Adequate [x] Inadequate [x] Scratchy/scuff marks	[ ] Thick [ ] Thin [x] Discoloured	[ ] Extensive [ ] Localized

Notes:

▶ FRAME	Condition of frame	Glazing	Fitting
[ ] Exhibition frame [ ] Carved/gilded [ ] Wooden/painted **Rigidity** [ ] Adequate [ ] Mitres open [ ] Inadequate	[ ] Good [ ] Adequate [ ] Poor **Cleavage/Flaking** [ ] None apparent [ ] Yes	[ ] None [ ] Glass [ ] Perspex **Gilding and Paint Losses** [ ] None apparent [ ] Yes	[ ] Plates [ ] Nails [ ] Screws **Backboard** [ ] None [ ] Board [ ] Foam core [ ] Hardboard

▶ Notes

Location of Damages

Identification details

Artist: Clark, Octavius Thomas (1850–1921)
Signature: Signed bottom left corner in brown (figure 1)
Title: *River Scene*
Date: Undated
Medium: Oil on canvas
Dimensions: 607 x 912 mm
Collection: Melrose House Museum, Pretoria, South Africa

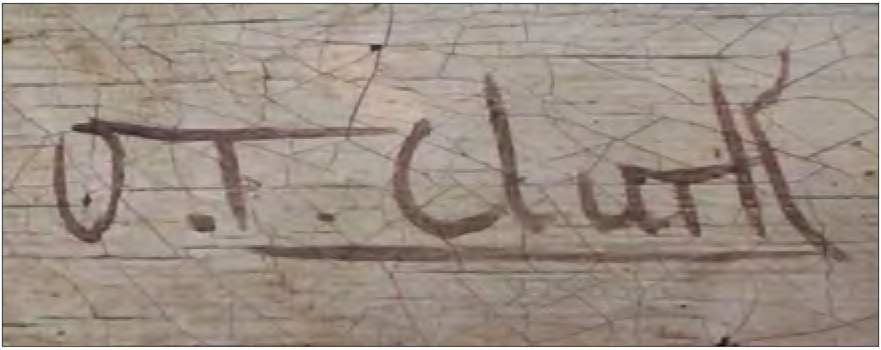


Figure 1: Signature *O.T. Clark* located in the bottom left corner of the picture plane in brown (photograph by Hannes Elsenbroek)

Artist biography

Octavius Thomas Clark was a British painter born on 21 December 1850 in Hoxton New Town, England (Robinson 1973: 70). Octavius was born into a family of artists with both his father and three older brothers practising as painters (Sulis Fine Art 2022). Robinson (1973: 70), however, notes that in 1874, when Octavius Clark married at the age of 23, he noted his profession as 'clerk', suggesting that at that point at least he had not entered the art profession. He did so later as, for the 1881 census, Octavius Clark's profession is noted as 'artist' (The Clark Family of Artists Sa). In addition, during the early 1900s, he did stage appearances as a 'lightning artist': 'Professor OT Clark, the celebrated lightning artist, who will produce on canvas 30in. by 20in. a beautiful oil painting in 10 to 15 minutes' (The Clark Family of Artists Sa).

Octavius Clark primarily painted bucolic landscape scenes imbued with the serenity of the countryside—as seen in the example of this particular case study. His technique involved painting on-site, where he worked swiftly to record the prevailing light and weather conditions of the area with great skill (Antiques Atlas 2022). He became the most prolific painter of the Clark family due to his practice of painting his landscapes in sets of six at a time, which appeared nearly identical (Sulis Fine Art 2022). His work was never exhibited but rather directly sold to art dealers who sold much of it in America (Sulis Fine Art 2022). In America, several of his paintings were reproduced in lithographs, making his work more accessible and affordable to the settlers for whom it functioned as a means of remembering their home country (Antiques Atlas 2022). These lithographs were screen-printed on canvas in colour, and then a coat of clear glaze was brushed on by hand to make the lithograph appear more like an original hand-painted oil painting (Jody 2022).

Octavius produced most of his paintings in oils on canvas. He also occasionally worked with watercolours and sometimes produced paintings under the name of Louis Edgar (Leland Little Sa). Octavius continuously produced paintings until his death on 7 February 1921 at the age of 70 (Robinson 1973: 72).

Provenance

As a result of dissociation, the provenance of this painting is no longer known. Dissociation is regarded as one of those factors which can cause deterioration or loss to artefacts and is defined by the Canadian Conservation Institute as 'the tendency for order systems to fall apart of time . . . this results in the loss of objects, object-related data or the ability to retrieve or associate objects and data.' In this case, the records associated with the painting's provenance and history of ownership are no longer available. It currently belongs to the Melrose House Museum Collection and was loaned to the Ditsong National Museum of Cultural Heritage in 1990. In 2020, it was returned to Melrose House and subsequently loaned to the University of Pretoria's Tangible Heritage Conservation programme with the hope of getting the painting restored.

In light of the fact that Octavius Clark often painted the same subject in batches of six at a time, a painting (represented in figure 2) has been found that appears very similar to the one on which this condition report is based (represented in figure 3). This painting (figure 2) appears on the Invaluable Auction House website as part of an auctioning event hosted by Gildings Auctioneers in January 2018 at Market Harborough in the United Kingdom (Invaluable 2022).

Figure 2: Octavius Thomas Clark, *River Scene*, undated. Oil on canvas, 490 x 740 mm, Private Collection. (Invaluable 2022).

Figure 3: Octavius Thomas Clark, *Landscape river scene with bridge and settlements* (provisionally titled), undated. Oil on canvas, 607 x 912 mm, Melrose House Museum Collection (photograph by Salomé Le Roux)

These paintings display the exact same arch bridge at the right foreground of the picture plane, leading the viewer's gaze over the river into the middle ground. Here, one sees the square tower of a fortress emerging out of a forest of tall trees to the right. Towards the centre of the middle-ground, a dirt path, occupied by people, leads towards a group of cottages that recede into the vanishing point of the background. The path also leads towards the riverbank, at the left side of the picture plane, where small river boats are docked. Behind the bank where the boats are docked, there is a white picket fence that surrounds a building with two chimneys. The entrance to this building is marked with an arched sign that reads 'White Hart' as seen in the detailed image of the painting (figure 4).

This building is most probably an inn since many inns adopted the name The White Hart as a way of pledging allegiance to the king, whose personal badge was a white stag (Holt 2020). Royal names for pubs had always been popular, but in 1393, when King Richard II passed a law that made it compulsory for all inns to display an identifying sign, many of them chose the name The White Hart (Holt 2020).

Figure 4: Detail of the painting showing White Hart sign (photograph by Hannes Elsenbroek)

There is an instance in 1907, when Octavius Clark was 56, where he requested, through a letter, a loan of 10 shillings from Mr Sewell—the owner of the White Hart in Green Street, Forest Gate (Robinson 1973: 70). Could this perhaps be the same White Hart as portrayed in the painting(s)? If so, then the area which appears in the painting can be ascertained to be Forest Gate. It is also, however, entirely possible that the White Hart in the painting may be in another area since this name for taverns and hotels was, and still is, rather widespread.

Useful information that will prove vital to the restoration attempt of the battered Melrose House painting (figure 3) can be obtained by comparing it with its sibling painting (figure 2), which appears to be in pristine condition. This information includes the overall fresh appearance of the colours in the picture, unaffected by surface dirt and varnish discolouration. The wholeness of the picture plane in figure 2 will also aid in the interpretation and reconstruction of areas of loss that are so prevalent in the Melrose House painting (figure 3). However, before a treatment decision-making discussion can take place, it is first necessary to document and identify the damage present in the painting, which can be found in the following condition report.

Condition report

Figure 5: Recto view of painting (with scale bar) upon its arrival at the Van Wouw House. Due to its poor condition, it was difficult to take a proper photo without risking further damage. When positioned upright, the extensive tears (along with gravity) cause certain areas to flap and fold (as indicated by the red stippled lines), thus further weakening the brittle canvas support and risking an extension of the tears, which could cause further material loss (photograph by Hannes Elsenbroek)

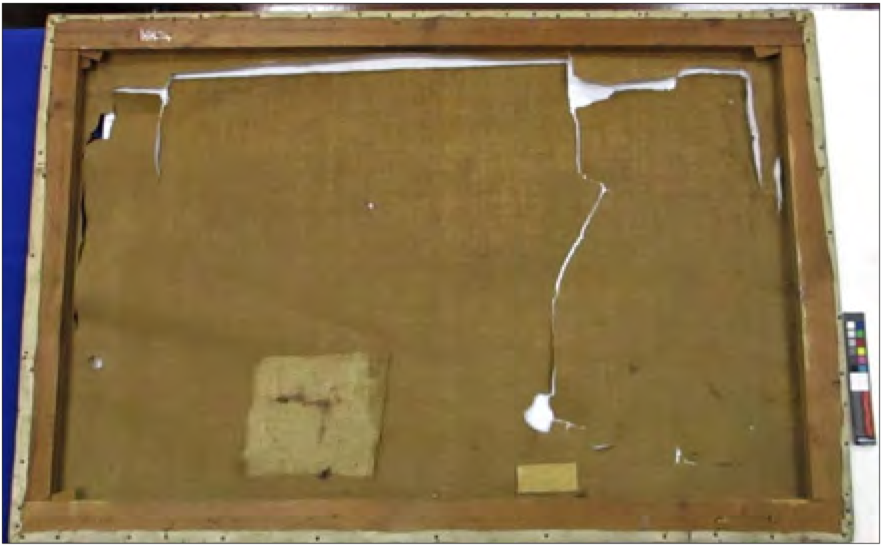


Figure 6: Verso view of painting (with scale bar) (photograph by Hannes Elsenbroek)

266 **Secondary support:**

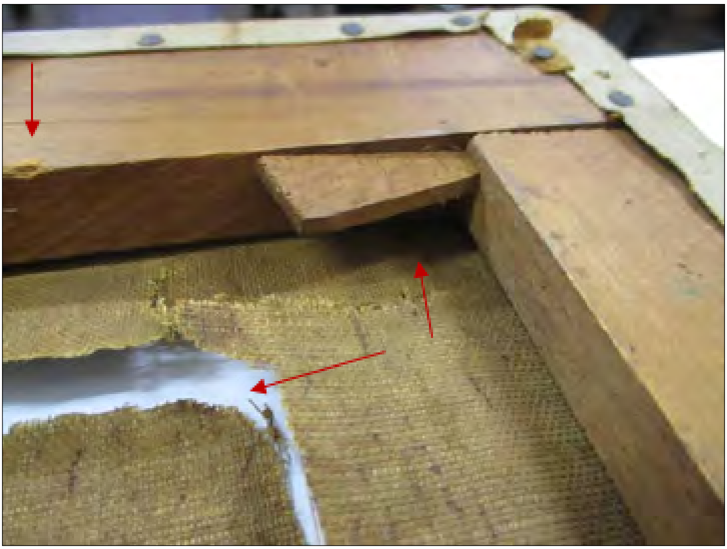


Figure 7: Back of top left corner showing missing stretcher key, extensive tears on canvas, chips along edges and tacks that attach the canvas to the wooden stretcher (photograph by Hannes Elsenbroek)

- Wooden stretcher, fair condition
- 4 members (width: 45 mm x thickness: 15 mm)
- Mortise and tenon joint, top right keys intact, one key missing from top left and bottom right and both keys missing at bottom left (figure 6)
- Arched warping of the left vertical member (causing distortions) (figure 9)
- Accession number MH 24 in white ink and consolidant at top right (figure 10) and accession number MHAA 232 in pencil at bottom left (figure 8)
- Previous tacks and canvas remnants as well as tack holes: This could indicate that the painting was re-stretched or that the canvas was stretched on an already-used frame (figure 8).
- Visible cracks on stretcher members along the grain of the wood (figures 8, 10 and 11)
- Chips and scuff marks on edges of wooden stretcher
- No insect damage present except for webbing on the lateral bottom member (figure 12)
- White stains that remain to be identified visible on the left vertical stretcher member (figure 13)
- Dust visible

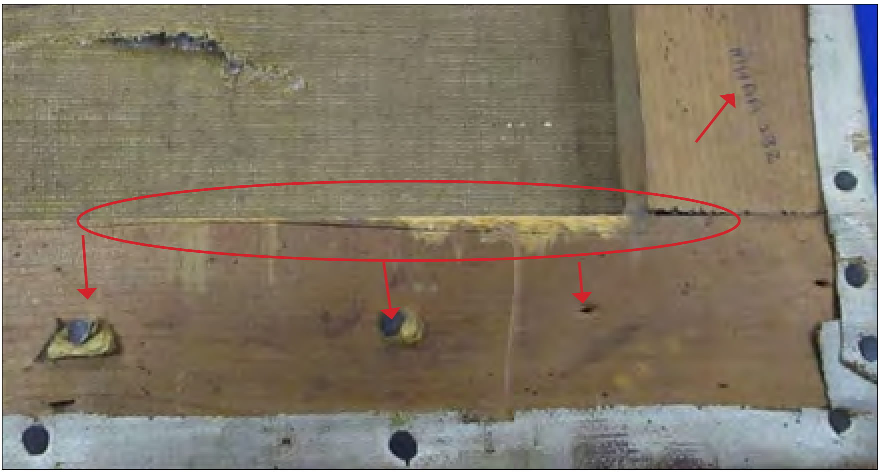


Figure 8: Back view of bottom left corner. Previous tacks with canvas remnants visible, previous tack holes as well as accession number MHAA 232 in pencil on stretcher. Crack along the wood grain also visible (encircled with red) (photograph by Hannes Elsenbroek)

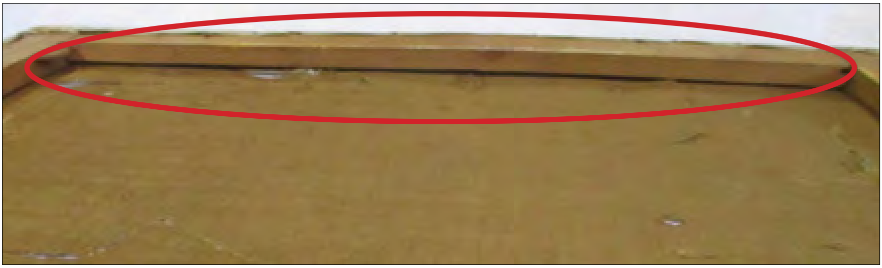


Figure 9: Arched warping of the left vertical stretcher member (photograph by Hannes Elsenbroek)

Figure 10: Cracks along the wood grain of the right vertical and lateral members of the secondary support (encircled with red). Accession number in white ink with consolidant also visible (photograph by Hannes Elsenbroek)

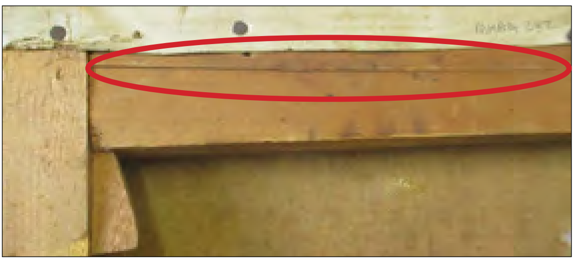


Figure 11: Running crack along the wood grain of the right vertical stretcher member (photograph by Hannes Elsenbroek)

Figure 12: Insect webbing on the lateral bottom member of the stretcher. To the right is what it looks like under 100x microscopic magnification (photograph by Hannes Elsenbroek)

Figure 13: White stains on the left vertical stretcher member. To the right is what it looks like under 100x microscopic magnification (photograph by Hannes Elsenbroek)

Primary support:

- Medium-weight canvas tabby weave pattern (one under and one over) (figure 14) (warp 16 x weft 12 per cm^2). Unsure if it is linen or cotton.
- Accession number MHAA 232 written in pencil on tacking margin on the primary support located on the lower right vertical back of the painting (figure 16)
- No canvas selvedge present
- Only one piece of canvas used for painting
- Extensive tears (both lateral and vertical) and multiple localised tears causing overall slackness of the surface plane (figure 17)
- Poor condition as canvas is very brittle and deteriorated, discoloured to yellow-brown, very dusty

- Multiple areas of material loss (figure 17)
- Serious distortion and buckling on lower half due to lack of tension caused by extensive tears (figure 17)
- Canvas secured to secondary support with tacks (stable condition) on the tacking edge and also on the verso of the secondary support (average tack spacing about 60 mm but varies on tacking edge, and average tack spacing about 80 mm but much more irregular on the verso of the secondary support) (figures 8, 10, 11)
- Tacking margin has stains, material loss and cracks with a width of 15 mm along the side of the painting (figure 14). The corners of the tacking margins along the side edges of the painting have material loss with the wood of the stretcher bars visible. The tacking margin on the verso of the secondary support has an average width of about 12 mm, but it decreases to about 8 mm to the left vertical member of the secondary support (figure 17)
- Previous restorative patchwork on two areas (figure 17). One smaller rectangular patch made from canvas and adhered to the primary support with an adhesive (figure 18). One larger square patch made from canvas and adhered to the primary support with an adhesive and a bitumen-like black substance, which may also have been used as an adhesion agent (figure 19).

Figure 14: Side view of bottom left corner showing canvas with fibre and ground loss as well as stains and also tacks that attach the canvas to the stretcher frame (photograph by Hannes Elsenbroek)

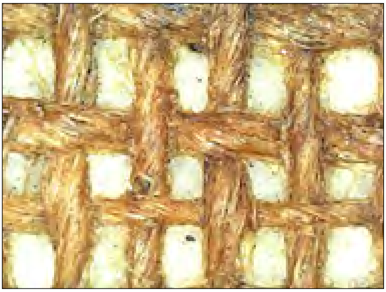


Figure 15: Canvas tabby-weave pattern under 10 x microscope magnification.
Note the cream-white ground in between the fibre thread weave pattern (photograph by Hannes Elsenbroek)

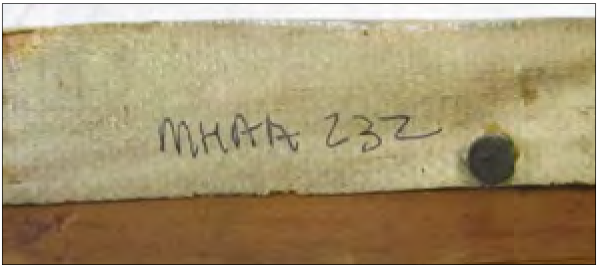


Figure 16: Accession number in pencil on primary support located on the lower right vertical backside of the painting (photograph by Hannes Elsenbroek)

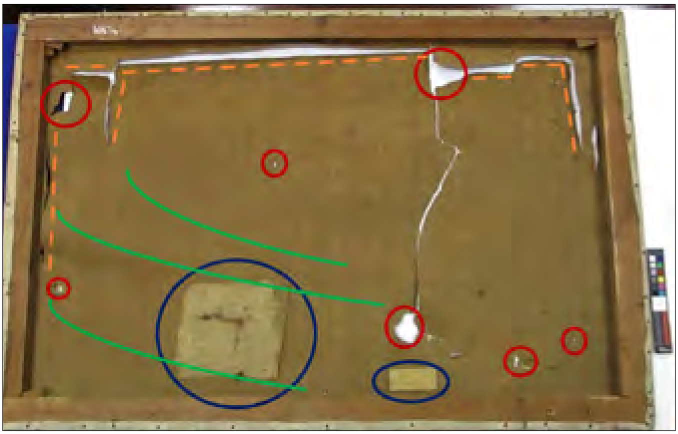


Figure 17: Verso view of the painting with scale bar showing major and smaller areas of material loss of the primary support (encircled in red), previous restorative patchwork (encircled in blue), extensive tears (indicated by the orange stippled lines) and surface plane distortions (indicated by the green curved lines) (photograph by Hannes Elsenbroek)

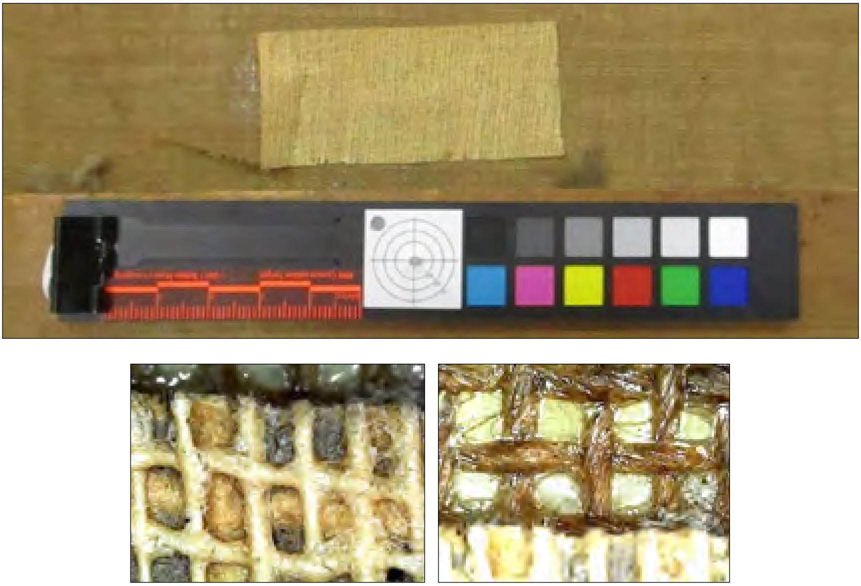
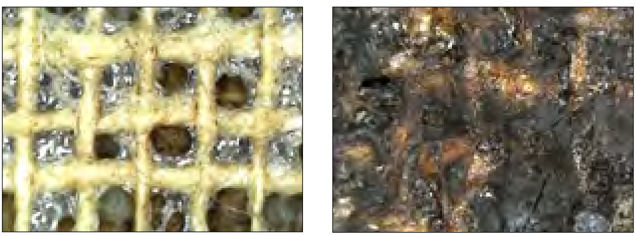


Figure 18: Smaller rectangular canvas patchwork with scale indicator (above). Patchwork under 10x microscopic magnification shows canvas tabby thread weave pattern (bottom left). The surrounding area of patchwork under 10x microscopic magnification reveals that an adhesive was used to adhere the patch to the back of the painting's primary support (bottom right) (photograph by Hannes Elsenbroek)

Figure 19: Larger square patchwork with visible black substance with scale indicator (above). Patchwork under 10x microscopic magnification shows canvas tabby thread weave pattern with adhesive used to adhere the patch to the primary support of the painting (bottom left). Black substance under 10x microscopic magnification may be a bitumen-like substance used as an adhesive and/or filler agent (bottom right) (photograph by Hannes Elsenbroek)



Due to the poor and unstable condition of the painting, there were a few factors that prevented the immediate gathering of other data through various imaging techniques such as reflected infrared photography, raking-light photography, specular axial-light photography or even normal-light photography to serve as a proper working photo. The first of these factors was the instability of the painting due to its extensive tears. The abovementioned investigative imaging techniques require the painting to be positioned upright on an easel facing the camera and other lighting equipment. If the painting were placed upright, the force of gravity would cause the flaps from the tears to pull downwards, creating the risk that the tears would extend, causing further material loss. To prevent any movement of loose canvas material, it was decided to build a backing support for the inner back part of the painting. However, due to age and the atmospheric changes over time, the canvas has distorted along the large lateral tear by curling/buckling up to the side of the upper vertical member of the stretcher frame secondary support, as shown in figure 20.

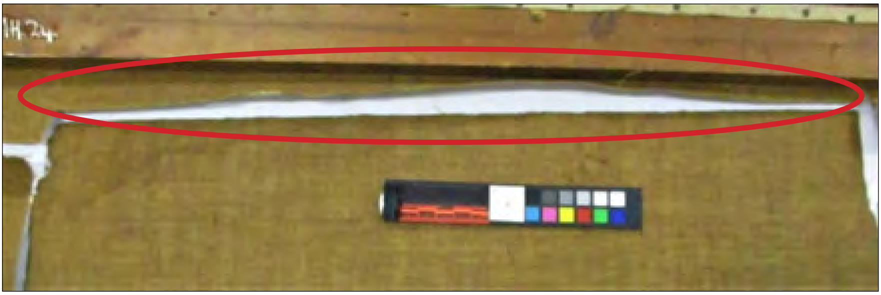


Figure 20: Curling/buckling of canvas at edge of tear up towards the upper vertical member of the secondary support (photograph by Hannes Elsenbroek)

This buckling edge of the canvas has hardened over time, and the backing support risks applying too much constant force to this area, which may cause another crack or tear to form. Therefore, before a backing support could be made, it was first necessary to relax the canvas back into shape and flatten the lifted, buckled area.

But before this form of remedial treatment could be carried out, the surface area of the canvas that required treatment first needed to be dry-cleaned. This step was necessary because the canvas contained a lot of dust and dirt, and introducing moisture to this dust could cause mudding to occur while also risking transmigration of dirt into the ground layer from behind. The dry-cleaning entailed first stabilising the loose areas of the canvas with small pieces of masking tape, taping up tears along the horizontal or vertical perpendicular tabby canvas thread weave pattern as shown in figure 21. Then, a piece of wax paper and Melinex lining were slid underneath the painting in sizes large enough to cover the entire surface of the painting and wrap around the sides. The wax paper acts as a protective barrier between the paint surface and the Melinex, while the Melinex prevents the wax paper from tearing when wrapped over the painting. A piece of Eska board, cut to the same size as the painting, was clipped onto the front of the painting to secure the Melinex and wax paper wrapped over the front of the painting. The painting was then lifted and leaned upright against the wall so that the pocketed areas between the canvas and the wooden support could be vacuum-cleaned with a micro-attachment as seen in figure 22. The micro-attachment used had a long, flat edge that easily sucked up accumulations of dust or dirt pockets in the slits between the canvas and the stretcher.

Figure 21: Stabilising remedial treatment for dry cleaning (photograph by Hannes Elsenbroek)

Figure 22: Micro-attachment on vacuum cleaner nozzle to remove accumulations of dust or dirt pockets in the gap between the canvas and the stretcher frame (photograph by Hannes Elsenbroek)

Figure 23: Further dry-cleaning of the canvas surface with polyurethane sponge (photograph by Hannes Elsenbroek)

After all the dust accumulations in the pocketed side areas of the painting had been removed, the painting was placed face-down on the table surface and the tape removed. Most pieces of tape could be removed with ease since the canvas surface was very dusty. Another micro-attachment nozzle with a small brush was attached to the vacuum cleaner and the entire backside of the painting was lightly brushed and vacuum cleaned. After this, polyurethane make-up sponges were used to remove the remaining dust in the areas on which the canvas flattening treatment would be carried out as seen in figure 23. After these areas were sufficiently cleaned, the flattening process could begin.

Figure 24: Sympatex covering lifted tears during the flattening process (photograph by Hannes Elsenbroek)

The next step in the flattening process was to cover the lifted tear area with a sheet of Sympatex as seen in figure 24. The Sympatex was applied with its glossy side facing the canvas surface area. This glossy side is a non-porous membrane that prevents the canvas from getting wet while still allowing it to humidify and therefore to relax and flatten out (TALAS 2021).

Figure 25: Humidified blotting paper on top of the Sympatex (photograph by Hannes Elsenbroek)

Next, some blotting paper was humidified using a water-filled spray-nozzle bottle. The paper was given two to three sprays to ensure it was humid but not drenched. The humidified blotting paper was placed on top of the Sympatex as shown in figure 25. After this, small Perspex paperweights were placed on top of the blotting paper to weigh the canvas down as seen in figure 26. The humidified blotting paper allows the localised canvas area to undergo an increase in relative humidity while the Sympatex prevents the canvas from getting into direct contact with moisture. The humidified canvas started changing shape after fifteen minutes and was left overnight; the humidity of the canvas was checked every half hour, two to three times, to ensure that it did not become wet but remained humidified.

Figure 26: Perspex weights on top of the humidified blotting paper and Sympatex (photograph by Hannes Elsenbroek)

The following day, the Perspex weights, blotting paper and Sympatex were removed. It was observed that the canvas had completely flattened out in the area where it was treated as seen in figure 27. The decrease in empty space between the edges of the upper lateral tear indicates that the canvas had relaxed and flattened, resolving the buckling of the canvas along the upper lateral member of the stretcher. The backing support could now be made and applied without risking further tearing or splitting of the canvas.

Figure 27: Verso of painting after canvas flattening treatment of the upper part along the extended lateral tear as indicated by the red circle (photograph by Hannes Elsenbroek)

The backing support was made by cutting a piece of polyethylene foam into a size that fit inside the inner area surrounding the stretcher frame members to cover the entire area of the exposed canvas. The corners of the polyethylene foam were also cut to accommodate the stretcher keys. Then, the polyethylene foam was adhered to a piece of Eksa board that was the same size as the entire painting with a glue gun. The polyethylene foam was adhered to the centre of the Eska board to allow the borders of the Eska board to align with the stretcher frame members, ensuring that the polyethylene foam was secured flush to the inner verso of the painting, providing support to the loose flaps from the extensive tears. Once this process had been completed, the investigative imaging photographs could be taken, and the painting surface could be further analysed.

Ground:

- The ground appears a cream-white colour (figure 15).
- It extends to the tacking margins, which may indicate that the canvas was commercially produced and not applied by the artist himself (figure 28). Note the ground loss among the edges of the painting where the canvas is stretched over the secondary support (figure 28).
- The cream-white ground is visible on the picture plane in the bottom right corner (figure 29). It seems that the artist intentionally left the ground unpainted to be incorporated into the composition as a whole, acting as light reflecting off the water surface in between the reeds and other water plants.
- There is ground discolouration in an area surrounding a zig-zag-shaped tear located in the foreground of the picture plane, just below an area of significant material loss (figure 30). It seems that whatever force was responsible for the tear also caused paint loss. The open ground due to paint loss seems to have discoloured to a greenish-grey colour as seen in figure 31. This discolouration may be a result of ageing and/or surface accretions or stains.
- Overall, the ground seems to be in an adequate condition, except for said areas of loss and discolouration.

Figure 28: Cream-white ground extending to the tacking margin on the upper-left corner of the painting. Note the ground loss around the corners and the edges (photograph by Hannes Elsenbroek)

Figure 30: Ground discolouration around the zig-zag tear as indicated by the red circle (photograph by Hannes Elsenbroek)

Figure 29: Exposed ground located in the bottom-right corner of the picture plane. This exposed ground could act as a lighter tone in the picture plane to represent light reflecting off the water surface between reeds and other water plants (photograph by Hannes Elsenbroek)

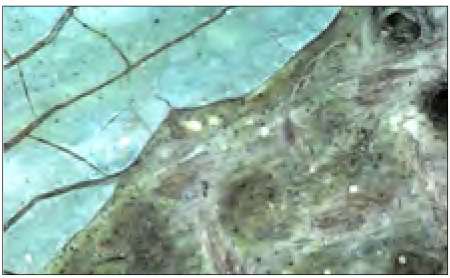


Figure 31: Ground discolouration area under 10x microscopic magnification. Note the cracked paint layer in the upper-left corner section and how the exposed ground due to paint loss in the lower right corner section has discoloured to a greenish-grey (photograph by Hannes Elsenbroek)

Figure 32: Normal visible-light photograph of painting after remedial treatment. Note the polyethylene foam backing support, visible at areas of major material loss, that secures the loose flaps caused by the tears of the canvas. The lighting equipment used to illuminate the painting for photography makes the light masses of the picture plane appear more orange in comparison to its slightly more yellow appearance to the naked eye in normal lighting conditions (photograph by Salomé Le Roux)

The subject of this painting has been painted according to realistic or naturalistic painting conventions to impart a life-like appearance and feeling to the scene. The technique draws on classical academic painting traditions whereby the paint is applied and built up in numerous successive layers. Light masses such as the clouds, sky and reflected light from built structures, plants and the water are applied with thick paint (impasto) where brushstrokes are visible as seen in figure 33. The darker tones, shadows and colour are applied by successive thin, translucent layers of paint (glazes) mixed with a medium such as linseed oil. The darker the tones or shadows and the more saturated the colours, the more layers of glaze have been applied.

Figure 33: Thick application of paint (impasto) with visible brushstrokes encircled with red (photograph by Hannes Elsenbroek)

Figure 34: A mapped-out overview of the locations of the various damage, deterioration and observational data of the painted surface. The fishtail crack is encircled in blue, sigmoid cracks are indicated by the red circles, tape adhesion residue is encircled in yellow, paint and ground loss areas are encircled in purple, paint loss areas are indicated in green, the black-line accretion is indicated by the turquoise circle, gilding residue is encircled in orange, a dark spec is indicated by the pink circle, a light-coloured spec is indicated by the white circle, a bitumen-like substance is shown by the black circle and surface accretions left by the rabbet are indicated by the red stippled line (photograph by Salomé Le Roux)

- No drying cracks or alligator cracks are present. This may be because the painter had knowledge of his technical craft from a traditional academic painting perspective, working fat over lean and waiting for paint layers to dry before applying thin glazes or more paint layers.
- A fishtail crack is present above the treeline on the central left side of the picture plane (figures 34 and 35). Fishtail cracks are mechanical cracks that resemble fish spines and are caused by a line of contact against the back of a painting or a glancing contact on the canvas caused by a hammer when keying out (CCI 2017).
- There are three sigmoid cracks—one located in the sky (figures 34 and 6), one located on the bridge (figures 34 and 37) and one located on the path connecting with the bridge (figures 34 and 38). Sigmoid cracks are also known as concentric or circular cracks and mechanical cracks caused by a knock on the back of the canvas (CCI 2017).
- There is paint and ground loss caused by abrasions (figures 34, 39 and 40) along all edges of the extensive and localised tears. There is also paint

and ground loss where the torn canvas distorted around the upper lateral secondary support member (figures 34 and 41).

- There is paint and ground loss due to flaking located at the trees close to the right vertical stretcher member (figures 32 and 42).
- The entire surface of the painting is covered with ageing cracks. This is inevitable as the painting ages. Ageing cracks are caused by a combination of mechanical forces and the response of the paint, ground and support layers to fluctuations in relative humidity (CCI 2017). Ageing cracks can also be seen surrounding the signature area (figure 43).
- A bitumen-like substance is located on the painting surface in a torn area just below the bridge (figures 34 and 44). This substance had been used as an adhesive for restorative patchwork on the back of the canvas and has transmigrated to the front of the picture plane, leaving dark stains and residues on the paint surface.

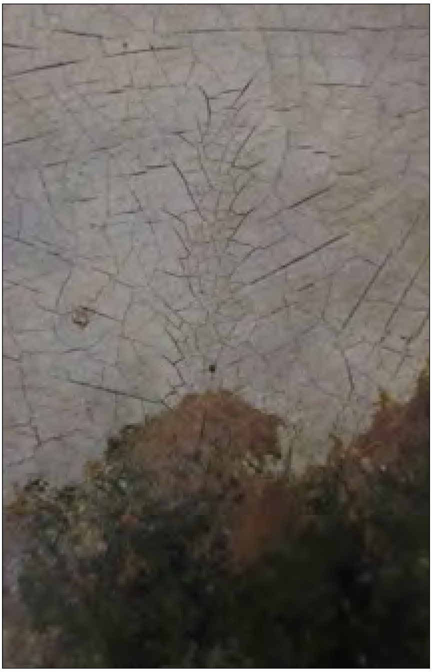


Figure 35: Fishtail crack encircled in red
(photograph by Hannes Elsenbroek)

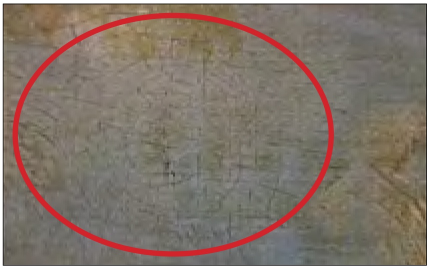


Figure 36: Sigmoid crack in the sky
(photograph by Hannes Elsenbroek)

Figure 37: Sigmoid crack on the bridge
(photograph by Hannes Elsenbroek)

Figure 38: Sigmoid crack on the path connecting with the bridge (photograph by Hannes Elsenbroek)

Figure 39: Paint and ground loss caused by an abrasion located on the left vertical edge of the painting (photograph by Hannes Elsenbroek)

Figure 40: Paint and ground loss caused by an abrasion located close to the upper-right corner of the picture plane (photograph by Hannes Elsenbroek)

Figure 41: Paint and ground loss where the torn canvas distorted around the upper lateral secondary support member (photograph by Hannes Elsenbroek)

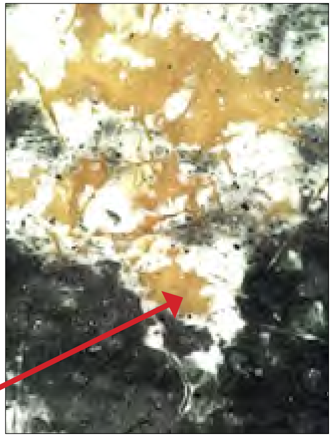


Figure 42: Paint and some ground loss encircled with red and shown under 10x microscopic magnification. Upon close inspection, it seems like the paint and ground flaked off in this area. In the area encircled in blue, it seems like there is a large area of paint loss, although it could also be an area where the artist intentionally left the ground exposed as a lighter tone to indicate reflected light from the foliage of the trees. However, under 10x microscopic magnification, ground loss becomes apparent with the exposed canvas and could rather be seen as ground and paint loss caused by abrasion (photographs by Hannes Elsenbroek)

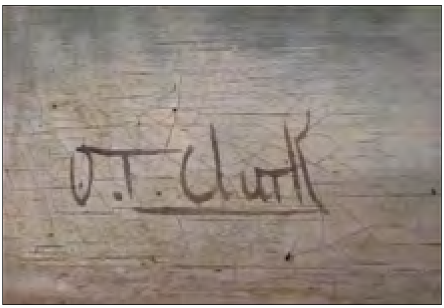


Figure 43: Signature located in the bottom left corner of the painting. Note the aging cracks surrounding the signature (photograph by Hannes Elsenbroek)

Figure 44: Bitumen-like substance from restorative patchwork. To the right is what it looks like under 10x microscopic magnification (photograph by Hannes Elsenbroek)

Varnish layer:

- The whole surface has a coat of varnish which is thinly applied. The varnish has aged to a yellow-brown seen especially in the light areas (figures 45 and 46).
- The overall varnish coat has a matte appearance, although it appears more glossy along the tacking edge (figure 47). This could indicate that the painting was previously displayed in a frame since the glossy strip is where the rabbet of the frame covered the painting surface, decreasing exposure to light and atmospheric factors that cause varnish to fade and discolour.
- The varnish layer appears to be cracked with the age cracks in the paint (figure 48).
- There is a speck (which could be a fly dropping) located in the upper left corner of the painting on top of the varnish layer (figures 34 and 49).
- There is a dirt line along the bottom tacking edge of the painting (figures 34 and 50). Another indication that the painting has been in a frame since, due to gravity, most of the airborne dust particles settle between the gap of the rabbet and the painting surface, leaving a residual dirt line on top of the varnish layer.
- There is a light-coloured speck located in the upper-left corner of the painting. To the naked eye and under microscopic magnification, it seems

like it could be a small area of varnish loss (figures 34 and 51).

- Gilding (gold leaf) residue was found along the bottom tacking edge on top of the varnish layer (figures 34 and 52). The gilding residue could be from its frame where the rabbet made contact with the paint surface. Based on this observation, the frame in which the painting was displayed might have been gilded with gold leaf.
- Tape adhesion residues are visible on the varnish layer situated across the middle vertical tear close to the area of major material loss (figures 34 and 53). This adhesion residue is from tape used as a previous treatment to stabilise the tears, preventing movement that could extend the tears.
- There is black line accretion located in the bottom-right corner along the taking edge (figures 34 and 54). Under microscopic magnification, directional line movement of the accretion is visible and appears to be smeared on the painting surface. Due to its black and tar-like appearance, it is possible that it is the same bitumen-like substance used in the restorative patchwork that can be seen in figure 44.

Figure 45: Varnish discolouration to yellow-brown due to age. Seen especially in the light areas of the painting such as in the foreground light reflected off the water (photograph by Hannes Elsenbroek)

Figure 46: Varnish discolouration to yellow-brown due to age. Seen especially in the light areas of the painting such as in the background sky and clouds (photograph by Hannes Elsenbroek)

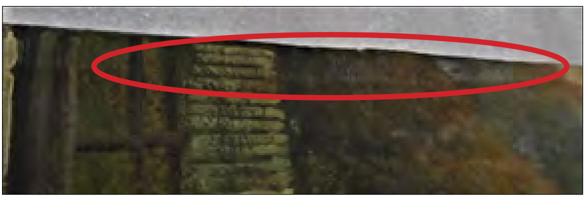


Figure 47: Gloss surface appearance of varnish along the tacking edge of the painting (photograph by Hannes Elsenbroek)

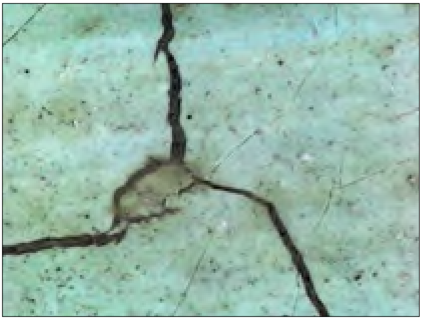


Figure 48: Age cracks surrounding signature under 10x microscopic magnification. It seems that the varnish layer has cracked with the age cracks of the paint layer (photograph by Hannes Elsenbroek)

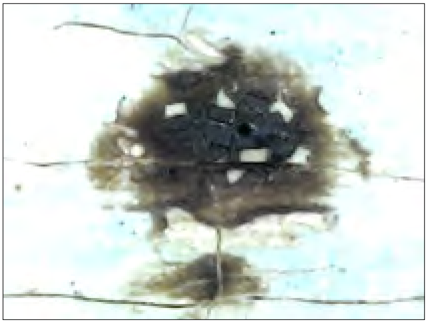


Figure 49: Dark speck (possibly a fly dropping) on the varnish layer. To the right is what it looks like under 10x microscopic magnification (photographs by Hannes Elsenbroek)

Figure 50: Dirt line along the bottom tacking edge of the painting (photograph by Hannes Elsenbroek)

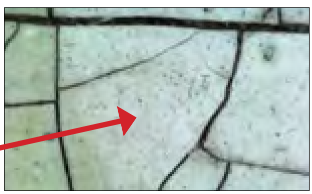


Figure 51: White speck that could be an indication of varnish loss as seen under 10x microscopic magnification to the left. Note the transition from the yellow-brown surface appearance to the lighter white surface on the microscopically magnified image (photographs by Hannes Elsenbroek)

Figure 52: Gilding (gold leaf) residue, possibly from frame. To the right is what it looks like under 10x microscopic magnification (photographs by Hannes Elsenbroek)

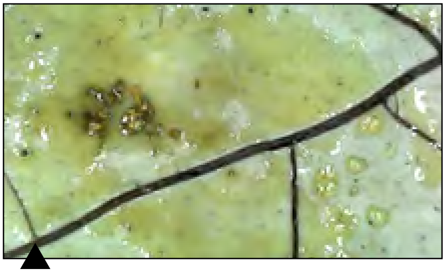


Figure 53: Tape adhesion residue across vertical tear. Appearance under 10x microscopic magnification (to the right). Under microscopic magnification, some foreign organic material can be seen stuck in the adhesion residue (photographs by Hannes Elsenbroek)

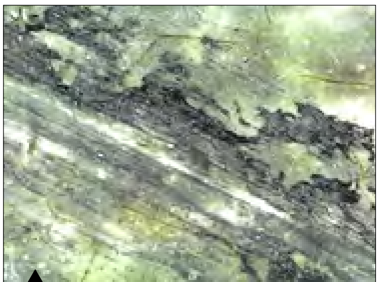


Figure 54: Black line accretion located in the bottom-right corner along the tacking edge. Under 10x microscopic magnification (to the right) (photographs by Hannes Elsenbroek)

Investigative imaging photography

This section involves the examination of the painting under different lighting conditions to reveal more information about it. The normal visible-light photograph, as seen in figure 32, is a record of the reflected light in the visible light spectrum (400–700 nm) from the painting illuminated by visible light. This photograph is very important since it reveals the painting with all its defects visible to the human eye and acts as the point of reference when investigating the painting in different light regions (Dyer, Verri and Cupitt 2013: 3).

An infrared-reflected image, such as figure 55, captures the reflected light spectrum in the infrared region (700–1 100 nm) from the painting when it is illuminated with infrared radiation. Infrared-reflected images may reveal features of a painting hidden from the naked eye such as underdrawings or other concealed features, since infrared radiation is often very penetrative, and numerous materials, such as organic binders and pigments, are usually transparent to it (Dyer, Verri and Cupitt 2013: 4).

Figure 55: Infrared-reflected imaging photograph of the painting under investigation (photograph by Salomé Le Roux)

By studying the infrared-reflected image (figure 55) and comparing it to the normal visible light image (figure 32), it is observed that there are no apparent differences between the two and no underdrawings or concealed features can be found. This means that no preliminary sketch work with carbon medium is present in the painting; however, this does not mean that the artist did not start the painting with an underdrawing or any form of guide sketch since the composition is so complex. Preliminary sketch work could have been done with thinned-out paint, which would have merged with the subsequent paint layers and therefore be undetectable by infrared-reflected photography.

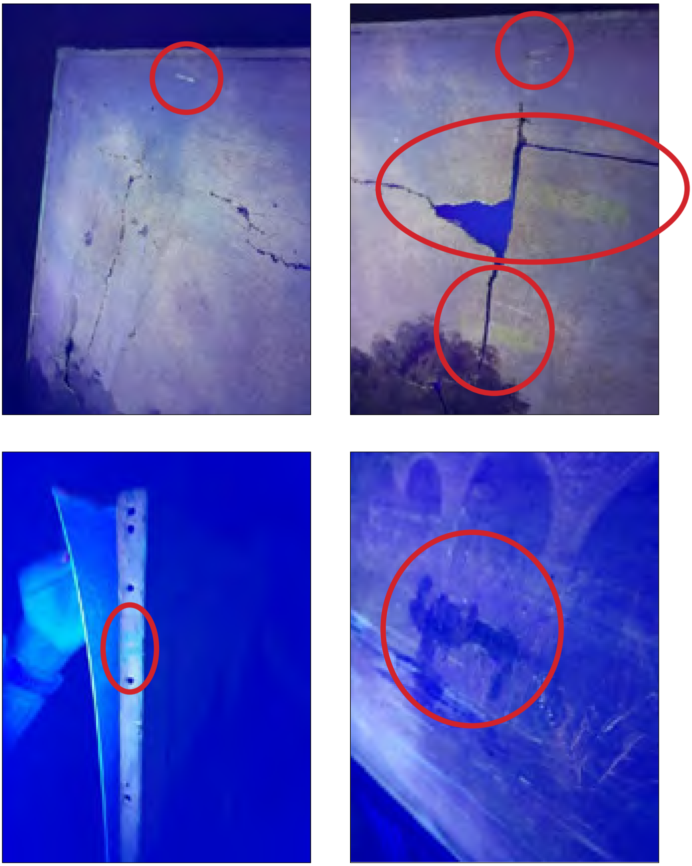


Figure 56: UV-induced luminescence on various parts of the painting (photograph by Hannes Elsenbroek)

Ultraviolet-induced luminescence is another investigative imaging technique used on the painting. Ultraviolet-induced luminescence records the emission of light in the visible light region of the painting when it is illuminated with ultraviolet (UV) radiation (200–400 nm). UV-induced luminescence images reveal the distribution of luminescent material, such as organic binders and pigments, but could also reveal inorganic material on the painting surface. UV examination may also provide information relating to the type of varnish layer and how it was applied to the painting, as well as revealing temporal and methodical information about previous restorations (Dyer, Verri and Cupitt 2013: 5).

As seen in figure 56, UV-induced luminescence revealed some more information about the painting that was difficult to detect with the naked eye. In figure 56 A, the accretion left by the rabbet along the tacking edge becomes more apparent, and another area of paint loss is revealed that had gone unnoticed in normal visible-light conditions. The exposed ground layer luminesces a bright white. This can also be seen in figure 56 B, where more paint loss can be seen above the tear. The tape adhesion residue fluoresces yellow. In figure 56 C, an oil stain can be identified on the side tacking margin as it fluoresces a bright blue. Figure 56 D exposes the full extent of the bitumen-like substance from the restorative patchwork on the painted surface as it fluoresces a mass of bluish-black. The UV examination did not pick up signs of varnish blanching or blooming.

Raking light is another technique that can be employed to reveal more information about the painting. Raking-light examination is one of the simpler forms of imaging; it involves shining an intense light directly across the painting surface, pronouncing irregularities found on the surface. Features relating to the surface topography of a painting such as brush strokes, damage, raised paint and planar deformations become clearer as a result of the shadows they cast across the painting surface. Raking-light examination is often used to examine and document the surface condition of a painting before, during and after conservation treatment (ICOM-CC sa.)

Figure 57: Raking-light photograph of the painting (photograph by Salomé Le Roux)

As seen in figure 57, the application of raking light to the painting under examination reveals the surface topography of the painting in much clearer detail. Tears and folds are more pronounced as are the scattering locations of holes and material loss. Planar distortions such as dents, bulges and distortion curves also become more noticeable.

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