ill. 1. Genesis page with Eclesia and Synagoga, and details of ornamental initials with photomicrographs. Cambridge, UL, MS Dd.1.14, (a, b) fols. 5r, (c) 377v, (d, e) 88v, (f, g) 139v, (h, i) 190v
Our objectives were to identify and compare the painting materials in the manuscripts; to explore the ways in which illuminators used them to create the visual effects mentioned above; to clarify how artists collaborated within a single volume and across several; and to lay the foundations for a future, comprehensive characterisation of the palette and techniques of English illuminators.

Analytical techniques

The manuscripts were examined non-invasively in order to preserve their integrity. Multiple, complementary analytical methods were employed, including imaging and spectroscopic techniques. Near-infrared imaging was performed first in order to investigate the presence and appearance of underdrawing, pentimenti and retouched or inhomogeneous areas. Next, pigments and paint binders were identified by means of fibre-optic reflectance spectroscopy (FORS) in the ultraviolet, visible and near-infrared range as well as X-ray fluorescence spectroscopy (XRF). Observation of each manuscript under magnification supported and clarified the spectroscopic results, and offered insights into the conditions of the paint layers, any damage and the presence of pigment mixtures, layers, glazes and alteration compounds.

The analytical protocol was adapted when working off-site, as different equipment was available in each location. Details about the instruments and the experimental conditions can be found in the Appendix at the end of this paper.

Case studies

A member of the Queen Mary Psalter group

A diverse group of manuscripts centres round the Queen Mary Psalter of the 1310s. Named after its sixteenth-century owner, Mary Tudor, the Psalter has been tentatively associated with Edward II and his queen, Isabelle of France, and was most probably produced in Westminster. Among the late members of the cluster is a Bible dated on stylistic grounds to the 1320s (ill. 1). Its tall, slender, swaying figures with delicate faces and exquisitely modelled drapery (ills. 1a, 1b) are executed in...
tinted drawing, a technique used to perfection in the Queen Mary Psalter. In the Bible, pastel, semi-transparent washes of organic violet (folium or orchil), and insect-based pink and tan (mixed with gypsum and lead white, respectively) are juxtaposed with contrasting areas of verdigris green and red lead. The ornamental initials and borders throughout the Bible are painted in a different technique, using gold and saturated colours (ills. 1c–1i). Often considered the paradigm of medieval illumination, this technique was employed alongside tinted drawing in other manuscripts, notably the Queen Mary Psalter. The artist responsible for the tinted drawings in the Bible may have also contributed the most refined ornamental initials. The rest were collaborative work; despite their stylistic and colouristic homogeneity, they display different levels of execution and suggest the involvement of at least three other hands.

The division of labour in the Bible proposed on stylistic grounds at the start of our investigation was confirmed by the technical analyses, but the latter also raised questions about the illuminators’ working relationships. The four artists responsible for the ornamental initials shared lead white, verdigris, red lead and organic pinks and reds (mostly the same materials used for the tinted drawings), but differed in their choices of blue pigments and paint binders. The light and dark blue passages in the initials were obtained in three different ways. Azurite was the only blue used by two artists in the first section of the manuscript (up to fol. 100r) and by a third one in the Psalter section (fols. 182v–200v); all three created lighter blue tones by adding lead white to the azurite (ills. 1d, 1e, 1h, 1i). The middle and final sections of the manuscript (fols. 130v–167r and fols. 207v–397v), illuminated by the most accomplished artist, are characterised by the preference for lapis lazuli (ills. 1f, 1g). Used alone in flat blue areas, the lapis was either layered over azurite or mixed with lead white to create darker or lighter hues respectively. The artist responsible for the Psalter section was the only one to use a lipidic binder – most probably egg yolk – in orange areas painted with red lead. While harmonising their overall stylistic, colouristic and ornamental repertoire, the four artists retained their distinct preferences for some materials. Was this common workshop practice? Were the four illuminators members of the same workshop? Or did they come together for the timely completion of a prestigious commission?

The concept of medieval illuminators’ workshops is recognized as a distortion that imposes the model of early modern painting ateliers upon the evidence preserved in the original manuscripts and contemporaneous archives.7 In the context of illumination, the medieval scenario that corresponds most closely to the notion of a stable, continuous workshop is that of an artist assisted by family members over a period of time. Apart from such familial structures, medieval illuminators seem to have favoured looser, dynamic associations, as commercial projects or bespoke commissions required.

Such flexible relationships may explain the stylistic and iconographic similarities as well as differences between manuscripts clustered around the Queen Mary Psalter. While the focal point of the artists’ formation and activity was most probably the increasingly metropolitan and affluent city of London, with royal patronage at Westminster, some of them may have been itinerant professionals, at times working on project in different locations.8 By identifying shared or individual palettes, techniques and pictorial vocabulary, joined technical and art-historical analyses could clarify the working relationships, evolving practices and movements of artists involved in the Queen Mary Psalter and the manuscripts associated with it.9

Itinerant artists

Another disparate cluster includes the Pabenham-Clifford Hours of c.1315–1320 and a slightly earlier, fragmentary Book of Hours.10 Their palettes share vermilion, orpiment, azurite, verdigris, organic pinks and silver. In addition, mosaic gold, gypsum and chalk were identified in the Pabenham-Clifford Hours only.

With one exception, all figural decoration in the Pabenham-Clifford Hours was provided by the same artist (ill. 2a). He painted blue and dark pink garments with block areas of flat colour, outlining folds with carbon–black brush strokes (ill. 2f), but modelled light pink draperies with directional brushstrokes and smooth gradations between shading and highlights (ill. 2e). He built flesh tones with a base mixture of lead white and gypsum, organic brown shading, carbon-black outlines of features, lead white highlights and occasional dabs of red lead on cheeks or lips (ill. 2c). He enhanced the gold leaf background with elaborate designs of scored lines, punched dot patterns and scrollwork painted in orpiment.

The historiated initial on fol. 3r displays different materials and modelling technique (ill. 2b). The treatment of the draperies is more painterly, with contrasting shading and highlights creating sculpted effects (ill. 2g). The red lead and azurite were prepared or sourced differently: their particles are coarser and their hue duller than in the rest of the volume. White areas, including flesh tones (ill. 2d), contain pure lead white rather than the gypsum mixture used by the main artist. The scrollwork over the gold leaf is painted with shell gold instead of orpiment and accompanied by azure blue fleurs-de-lis. These differences reveal the involvement of a second illuminator a decade or so later – either completing a previously unfinished image or refreshing the original one, perhaps worn out by tactile expressions of devotion.

The fragmentary Hours contain a homogeneous palette of carbon black, lead white, red lead, azurite, organic pink and verdigris.11 The work of the main artist displays a painterly modelling of draperies, with smooth gradations between mid-tones, shadows and highlights (ills. 3a, 3c, 3d). Blue robes have a base layer of bright blue azurite, shaded with darker, more saturated brushstrokes of the same pigment and highlighted with lead white. The Virgin’s orange (red lead)
ill. 2. Annunciation, Virgin and Child with John Pabenham, and photomicrographs showing modelling of flesh tones and draperies. Cambridge, FM, MS 242, details from fols. 2v (a, c, e, f), 3r (b, d, g)
Further analyses may help trace the illuminators’ collaborations and movements by establishing sub-groups of closely related manuscripts both within and beyond the disparate cluster.

The Macclesfield Psalter is particularly close to the Stowe Breviary in liturgical, palaeographical and iconographic features, but displays a more vivid pictorial narrative and a more subtle modelling technique, indicative of developments in East Anglian illumination during the 1330s. The Macclesfield Master collaborated with the Douai Master in the Douai Psalter and in a copy of Bede’s Historia Ecclesiastica. The Douai Master’s finest extant work is shaded with azurite (ill. 3e) – a unique occurrence in the manuscript. If the artist’s intention was to create the *cangiante* effect characteristic of shot silk fabrics, this would be a fairly early example.

A second illuminator contributed several images in which the modelling of draperies relies on black outlines and a clear demarcation between shaded and highlighted areas (ills. 3b, 3f, 3g). Even though he shared his colleague’s palette, he had not mastered his modelling technique. The same pigments applied differently produced different visual effects.

While the two Books of Hours examined so far preserve no internal evidence as to their place of origin, two other members of their cluster, the Vaux Psalter and the Tickhill Psalter, point to the Midlands. The cluster also has stylistic and iconographic connections with manuscripts of the Queen Mary Psalter group and with East Anglian illumination. The geographical spread suggests the activities of itinerant artists. Preferences for specific painting materials and techniques recurring in nine panels painted across East Anglia and southeast England have been interpreted as an indication of the geographical spread of commissions assigned to the same workshop. Further analyses may help trace the illuminators’ collaborations and movements by establishing sub-groups of closely related manuscripts both within and beyond the disparate cluster.

**East Anglian manuscripts c.1310–1340**

The six East Anglian manuscripts analysed so far were made between the 1310s and the 1330s. They include two of the most firmly localised and datable East Anglian manuscripts: the Gorleston Psalter of the 1310s associated with St Andrew’s Church in Gorleston and the Stowe Breviary made in Norwich in the 1320s. These two volumes share iconographic motifs which also reappear in manuscripts of the 1330s, notably the Macclesfield Psalter and the Douai Psalter. The Macclesfield Psalter is particularly close to the Stowe Breviary in liturgical, palaeographical and iconographic features, but displays a more vivid pictorial narrative and a more subtle modelling technique, indicative of developments in East Anglian illumination during the 1330s. The Macclesfield Master collaborated with the Douai Master in the Douai Psalter and in a copy of Bede’s Historia Ecclesiastica. The Douai Master’s finest extant work...
The six manuscripts share an essential palette of gold, carbon black, lead white, red lead, azurite, verdigris and red/pink organic dyes (probably insect-derived). Additional pigments identified in some of the volumes and considered alongside textual, iconographic and stylistic correspondences help define smaller, tightly-knit sub-groups within the East Anglian cluster.

The Stowe Breviary (ill. 4), the Macclesfield Psalter (ill. 5) and the Trinity Bede (ill. 6) form one of these sub-groups on the basis of shared script, iconography and painting materials.

is the full-page *Crucifixion* added to the Gorleston Psalter probably in the 1330s and closely related to his *Crucifixion* in the Douai Psalter, lost when the latter was nearly destroyed during WWI.\(^\text{19}\) The last two manuscripts analysed to date are the Bromholm Psalter of the 1310s and a copy of Gregory’s *Moria in Job* of the 1320s.\(^\text{20}\) Dated on stylistic grounds, both volumes were illuminated by the Ormesby Master, the main artist responsible for the second campaign of decoration in the Ormesby Psalter – a campaign likely undertaken in Norwich in the 1320s.\(^\text{21}\)

ill. 4. *David playing bells* with UV image revealing use of organic yellow, *Nativity*, photomicrograph of violet drapery with blue azurite particles, hybrids. London, BL, Stowe MS 12, details from (a) fol. 190r, (b) with UV image; (c) fol. 16v; (d) fol. 23r; (e) fol. 150v; (f) fol. 305r
ill. 5. *St Andrew, Anointing of David,* hybrids and photomicrographs showing modelling of flesh tones and draperies. Cambridge, FM, MS 1–2005, details from fols. 1v (a, b), 20v (d, e), 39r (c), 52r (f), 58r (g), 133r (h), 162v (f)
Their palette is characterised by the absence of ultramarine, vermilion and silver found in some of the other East Anglian manuscripts. In addition to the pigments listed above as identified across East Anglian volumes, the Macclesfield Psalter and the Trinity Bede also contain indigo; both of them and the Stowe Breviary use mosaic gold and a purple dye derived from a plant (possibly folium) or a lichen (probably orchil).

Mosaic gold, a synthetic tin sulphide with a yellow–bronze colour and metallic sparkle, was a fairly recent invention. It seems to have enjoyed considerable popularity among early-fourteenth-century East Anglian artists who employed it for a range of colouristic and textural effects. In the Stowe Breviary, mosaic gold provided a shiny yellow used on its own, shaded with verdigris or sometimes probably mixed with shell gold (ills. 4a, 4b). In the Macclesfield Psalter, mosaic gold was modelled with verdigris, a pink/red organic dye or brown (ills. 5a, 5h, 5i).

Dyes that yielded subtle lilac and dark purple hues were used to create some of the most exquisitely modelled draperies (ills. 4c, 4e, 5a, 5e, 5f, 5i). In the Stowe Breviary, varying amounts of azurite were mixed into the organic purple, especially in draperies (ill. 4d), and pale yellow hues were obtained with an organic colourant, as suggested by their bright yellow fluorescence in the false-colour UV image (ill. 4b). Most of the orange initials are glazed with a transparent organic layer which displays a bright orange fluorescence and appears to contain a lipidic substance, possibly a binder.

While the Macclesfield Master supplied the majority of the images in his eponymous work, another artist, the Anointing Master, painted the Anointing of David and several marginal figures (ills. 5c, 5d, 5e). The two artists collaborated very closely, reusing the same patterns and the same palette (ills. 5e, 5f). The only differences are the traces of an iron oxide pigment mixed into the flesh tones and of indigo in the beards painted by the Anointing Master (ill. 5d), while the Macclesfield Master used pure lead white and azurite respectively (ill. 5b). However, both artists applied grey or brown washes over the base flesh tones and small dabs of red lead for the mouths, cheeks and shaded areas. In addition, the Macclesfield Master employed graphically realistic details: eyes inflamed or blood-shot with red lead and veins painted with indigo or azurite enhance sorrowful or anguish expressions (ill. 5b); flesh heavily modelled with carbon black, indigo and verdigris in varying proportions evokes the wild man’s savage existence and character or St John the Baptist’s desert tribulations (ills. 5g, 5h).

The Macclesfield Master’s other collaborator, the Douai Master, used the same materials—lead white, red lead, azurite, grey and brown washes—and the same techniques to create the highly individualised faces in the Trinity Bede (ills. 6b, 6c) and the Gorleston Psalter’s Crucifixion (ills. 7a, 7b). His thick, impasto-like application of lead white lends a three-dimensional, tactile quality to hair, eyebrows and beards. The identical range of materials and techniques employed by the Douai, Macclesfield and Anointing Masters indicate a particularly close working relationship, while the naturalistic details reveal the artists’ intense observations of human anatomy and affect—both recognized among the foremost achievements of fourteenth-century English illuminators.

The artists discussed above reused iconographic motifs which had appeared in the Gorleston Psalter of the 1310s (ills. 4e, 4f, 5e, 5f, 7e). At least one of them, the Douai Master, may have had direct access to the Gorleston Psalter if his Crucifixion was added to the volume upon its execution or shortly after (ill. 7a). The main artist of the Gorleston Psalter’s original campaign was not involved in any of the later manuscripts and his palette differs from theirs in two respects (ill. 7c). The first concerns three materials which do not feature in the Stowe Breviary, Macclesfield Psalter or Trinity Bede: vermilion, ultramarine and silver. The patronage of the Gorleston Psalter may account for these costly materials—the volume has been associated convincingly with John de Warenne, 7th Earl of Surrey and Sussex (1286–1347), a key player in English court politics and a major art patron in East Anglia. Ultramarine—on its own or in combination with azurite—was reserved for the use of the Gorleston Psalter’s main artist (ill. 7c), while azurite was employed by assistants in their own compositions and marginalia (ills. 7d, 7e), and in the flat blue draperies and backgrounds that they may have supplied for images completed by the main artist (ill. 7c).

The second characteristic of the Gorleston Psalter’s original campaign is the absence of the purple dyes, indigo and mosaic gold found in the Stowe Breviary, Macclesfield Psalter and Trinity Bede. An organic purple dye (possibly orchil) was identified only in the subtle violet draperies of the Douai Master’s added Crucifixion (ill. 7a). In contrast to the Psalter’s original campaign—and in unison with the Stowe Breviary, Macclesfield Psalter and Trinity Bede—the Crucifixion does not contain vermilion, ultramarine or silver. However, the Douai Master juxtaposed orpiment and verdigris to obtain the effect created by mosaic gold and verdigris in the Macclesfield Psalter and its relatives. Curiously, a similar effect was achieved in the original campaign of the Gorleston Psalter with verdigris and shell gold (ill. 7e). These experimentations with a range of sparkly yellows—shell gold, mosaic gold and orpiment—juxtaposed with verdigris indicate that the yellow–green contrast must have been in vogue during the early decades of the fourteenth century.

The Ormesby Master’s palette in the Bromholm Psalter and Gregory’s Moralia in Job displays yet another set of variations (ills. 8–9). In addition to the common East Anglian pigments outlined above, he used vermilion (in details and facial features, ills. 8c, 9a), ultramarine (as well as azurite), indigo-based green (instead of verdigris) and an unusually extensive range of organics. The latter contributes to his pastel colour scheme. One of its key components was indigo, featuring not only in blue areas, but also in supposedly green ones where it was either used on its own or was mixed or layered with an organic
In addition to the organics, the gradational modelling of draperies contributes significantly to the overall impression of softness and understated elegance typical of the Ormesby Master's work (ills. 8b, 9a). This subtlety is underscored by the absence of silver and mosaic gold from his palette. While silver is fairly rare in East Anglian manuscripts, the exclusion of mosaic gold seems deliberate. Most probably based in Norwich yellow (ills. 9c, 9d). An insect-based red dye was employed in pink areas and as a glaze over orange ones, occasionally mixed with azurite for contrast (ill. 8d). Organic colourants were also the likely sources of the few pale yellow areas, the brown hues, including the broad washes shading lead white flesh tones (ills. 8c, 9a), and the lilac and muddy green pen flourishing of verse initials in the Bromholm Psalter.

ill. 6. Marginalia, male bust and photomicrographs showing organic glazes over pink and red areas, and modelling of drapery, flesh tones and hair. Cambridge, Trinity College, MS R.7.3, details from fols. 1r (a, d, e, f, g), 2v (i, j), 34r (b, c, h)
ill. 7. Crucifixion with photomicrograph showing modelling of flesh tones, Saul with Doeg and the Priests of Nob, Funeral and hybrid. London, BL, Add. MS 49622, details from fols. 7r (a, b), 68v (c), 214r (e), 215r (d)
in the 1320s and working for patrons associated with the Cathedral, the Ormesby Master was an exact contemporary and perhaps a competitor of the artists responsible for the Stowe Breviary who made liberal use of mosaic gold and saturated pigments. A distinctive palette is central to an artist’s signature style and individual aesthetics.

Some of the Ormesby Master’s most striking iconographic motifs, but not his muted palette, would reappear in the Macclesfield Psalter of the 1330s.26 Explicit visual quotations found in conjunction with pronounced material differences – as in the case of the Gorleston Psalter vis-à-vis the Stowe Breviary and the Macclesfield Psalter – indicate that a number of artists in fourteenth-century East Anglia shared the same figural and ornamental motifs, but only some of them shared the same pigment preferences. While visual repertoire could be disseminated via patterns or replicated by artists consulting earlier, highly esteemed works, the use of the same, distinct combination of pigments implies very close training and collaboration.

The Macclesfield Psalter is an important witness to the connection between painting and illumination in fourteenth-century East Anglia. It is intimately related in style, iconography,
painting materials and techniques to the best preserved medieval English panel painting, the Thornham Parva retable made in the 1330s for the Dominican Priory at Thetford or Norwich. The retable’s palette represents the pigments in general use in the first half of the fourteenth century, including lead white, azurite, a copper-based green, carbon black, yellow earth, vermilion, red lead and red lakes with alum substrates (likely Polish cochineal and lac). The style of the retable is, in turn, related to that of the c.1300 wall paintings in the ante-reliquary Chapel of Norwich Cathedral, which employ an identical palette, mixtures of pigments and modelling techniques.

The palette of the Macclesfield Psalter is closely comparable to that of the retable, although three of the materials used on the panel – yellow ochre, vermilion and silver – are absent from the manuscript. The only other difference is in the purple and violet hues. In the Macclesfield Psalter, they are obtained with a purple dye, whereas the purple in the retable is a mixture of azurite and a red lake. However, this same mixture features (alongside the organic dye) in the Macclesfield Master’s palette; he employed it in the Trinity Bede.

The relationships between the Thornham Parva retable, the Norwich Cathedral wall paintings, the Macclesfield Psalter, the Trinity Bede and the Stowe Breviary suggest that a network of artists, most probably trained in Norwich, were active across East Anglia during the first third of the fourteenth century. They painted manuscripts, panels and frescos, sharing the iconographic motifs and colourants at their disposal. Some of the artists responsible for the Stowe Breviary may have also been involved in the design, if not the painting, of stained glass in Norfolk. The relationship between English stained glass and illumination awaits further research, though positing connections in fourteenth-century East Anglia is particularly challenging due to the exceedingly slim survival of stained glass from this period and region.
Non-identical Twins

Two copies of poetical meditations on the Life and Passion of Christ preserved in Cambridge, at the Fitzwilliam Museum and Trinity College, received illustrations almost identical in format, subject-matter and composition, but different in style. The stiff, angular figures with rigid gestures and ill-humoured, caricature-like expressions are among the most distinctive features of the Fitzwilliam volume (ills. 10a-d), while the protagonist in the Trinity copy have short, rounded frames with formulaic, doll-like faces (ills. 10e-h). Different artists painted the manuscripts in successive decades – the Fitzwilliam copy in the 1350s or 1360s, the Trinity one in the 1370s or 1380s. The illuminator of the Trinity manuscript and the main artist of the Fitzwilliam volume also contributed to the only surviving copy of the *Omne bonum*, an encyclopaedia compiled by the London clerk James le Palmer, which was produced from the 1360s until the 1380s.

The palette of the two copies of the poem is extensive by fourteenth-century standards. In addition to pigments standard in contemporary manuscripts, such as lead white, carbon black, red lead, azurite and arsenic sulphide yellow, both volumes contain less common materials, notably vermilion, silver and an organic purple. Despite their shared colourants, the two volumes differ considerably in the use of blue, green and pink pigments. The Fitzwilliam volume has indigo in grey mixtures and also in green ones (combined with the arsenic-based yellow to produce vergaut), an organic red dye mixed with lead white in pink areas, and both ultramarine and azurite blues – used alone as well as in mixtures. The Trinity manuscript contains only azurite in blue areas and verdigris

ills. 10a-d. *Nativity* (Hand A), *Circumcision* (Hand A), *Agony in the Garden* (Hand B), *Mocking of Christ* (Hand C). Cambridge, FM, MS 259, details from fols. 2v (a), 3v (b), 12r (c), 14v (d).
in green ones, and the organic red dye used in pink areas is mixed with gypsum instead of lead white. While azurite and verdigris were standard components of the fourteenth-century European palette, ultramarine and vergaut were less common.

The main illuminator of the Fitzwilliam manuscript collaborated with two colleagues, as indicated by variations in execution and preferences for blue pigments. The main artist used azurite for dark blue hues and ultramarine (occasionally mixed with azurite) for light ones (ills. 10a, 10b). One of his collaborators (Hand C) did the opposite (ill. 10d). The other (Hand B) used only ultramarine (ill. 10c).

The Trinity volume was the work of a single artist and his style is consistent with London illumination from the third quarter of the fourteenth century, including the *Omne bonum*. His only idiosyncrasy is the use of dark grey flesh tones obtained with a wash of indigo for Judas and the soldiers arresting Christ (ill. 10g). The morally-charged use of colour reveals the artist’s awareness of medieval ideas about skin tones as reflecting the influence of the four elements and the four humours on human physiology and psychology.33

The ill-humoured expressions in the Fitzwilliam copy find closer parallels in contemporary embroidery than in manuscripts.34 It is conceivable that the main illuminator made designs for *Opus anglicanum*.35 His extensive use of indigo, a popular dye, is consistent with practices in the textile industry. Detailed stylistic, iconographic and technical analyses of this manuscript and contemporary examples of *Opus anglicanum* may shed new light on designs and materials shared across the two media – one of the many aspects of artistic exchanges in medieval England that awaits further research.
Summary of fourteenth-century English painting materials and techniques

The following discussion is intended as a preliminary overview, based on the manuscripts analysed for this study. The materials identified in them are presented in the Table at the end of the paper.\footnote{36}

The essential palette of English illuminators remained fairly consistent from the seventh to the fifteenth century, with carbon-based blacks, red lead and verdigris identified in the majority of English (as well as Continental) manuscripts analysed to date by the MINIARE project and by other teams.\footnote{37} Lead white joined the colour scheme from the eleventh century onwards.\footnote{38} These basic pigments were gradually supplemented with a wider range of colourants, especially in deluxe products. By the fourteenth century, English illuminators employed an extensive palette of naturally occurring and synthetic materials, including metals, minerals, earths and organics. The uses of vermilion, silver and indigo-based green mixtures as well as of different blues (ultramarine, azurite and indigo) and yellows (plant-based dyes, orpiment, mosaic gold, yellow ochre and lead-tin yellow) changed considerably over time, but could also be subject to individual preferences, as the case studies above demonstrate.

Indigo is the only blue identified so far in seventh- and eight-century English manuscripts.\footnote{39} From the early ninth century until the late thirteenth, ultramarine was the main – and often the only – blue pigment used by English illuminators, occasionally supplemented by indigo to obtain darker or more muted hues. Ultramarine continued to be used – on its own or alongside azurite and indigo – well into the fifteenth century, especially in prestigious commissions, but by the late thirteenth century azurite had become the standard blue of English illumination. A similar transition from ultramarine to azurite has been observed in English painting in other media – wall, panel, stone and wood sculpture – from the mid thirteenth century onwards.\footnote{40}

The extensive use of ultramarine, especially in thirteenth-century manuscripts, could be tentatively associated with the spread of the Mongol Empire, which facilitated trade from Central Asia to Europe along the Silk Road thanks to the Pax mongolica. The disintegration of the Mongol Empire in the early fourteenth century would have disrupted the trade routes, at least temporarily. European artists had sources of azurite closer to home, in parts of modern-day France, Germany and Hungary. While not as costly as ultramarine, good quality azurite with a large particle size that yielded a deep blue colour with a subtle, sparkly effect was still fairly expensive. The choice of azurite instead of ultramarine in many deluxe fourteenth-century English manuscripts is likely to reflect availability or a desire for different visual effects rather than economic concerns.

While blue was a key, stable component of the colour scheme in English illuminations from the tenth century onwards, the taste for yellow fluctuated significantly. Favoured in early Insular manuscripts, where orpiment was a constant presence, and still observed in English illuminations well into the eleventh century, yellow pigments were employed sparingly between c.1100 and c.1300. The main reason was probably the increasing presence of large areas of gold leaf which made yellow aesthetically superfluous. The association of yellow with marginalised ethnic and social groups may have also played a role, especially during the twelfth and thirteenth centuries when anti-Semitic persecutions intensified, culminating in the expulsion of the Jews from England in 1290.\footnote{41} Yellow reappeared in the course of the 1300s as the expansive gold backgrounds gave way to painted ones, organic yellow dyes facilitated the nuanced modelling of fabrics and mosaic gold enabled convincing simulations of texture.

Unlike the majority of colourants which illuminators shared with artists working in other media, mosaic gold was reserved exclusively for manuscripts. The earliest examples identified so far are in English manuscripts of the 1270s,\footnote{42} while the first Continental occurrences date to c.1300. Though often described as imitation gold, it was not used as a cheap substitute for the precious metal. The manuscripts in which it has been identified, dating from the thirteenth to the sixteenth century, are deluxe examples with large areas of gold leaf and/or shell gold. Shaded in red, brown or most often green, mosaic gold adds a subtle difference to the range of colouristic and textural effects achieved with other metals. Illuminators embraced it for aesthetic rather than economic reasons.

By the mid fourteenth century a wider range of yellows was in use: local plant-based yellows such as broom and weld are observed,\footnote{43} orpiment reappears and yellow ochre provides darker, more muted hues. Organic yellows were also often used to modify green and red hues, or as glazes over areas painted with lead white, such as flesh tones and hair. The earliest examples of the bright, chemically stable lead-tin yellow identified in English illumination so far date to the mid-fifteenth century – more than a century after the pigment’s appearance in English panel and wall paintings,\footnote{44} and in illuminated manuscripts on the Continent.\footnote{45} These preliminary results must be treated with caution, however, given the very small number of fourteenth-century English manuscripts analysed to date.

In addition to yellow, organic dyes yielded a kaleidoscope of other hues: red, purple, violet, pink, tan, maroon and brown. This diversity is related both to the use of different dyestuffs – generally lichen- or plant-derived for purple and often insect-based for red and pink – and to a range of preparation methods which also influenced the degree of translucency or opacity. For instance, different amounts of alum or potash were added to the dye, various substrates were used to precipitate the lake or lead white was added to obtain lighter hues. Purple, violet and lilac were among the hues that early-fourteenth-century illuminators in both England and France were especially eager to add to their palettes.\footnote{46} The role of organics in medieval
illumination in general – and in fourteenth-century England in particular – was far greater than the traditional emphasis in the literature on minerals and metals suggests. Their optical qualities were harnessed further in their use as glazes. Applied as darker, semi-transparent shades over the base tone of folds, they helped artists nuance drapery folds and evoke the three-dimensional human form beneath. Occasionally, glazes of contrasting hues were laid over the base tone to simulate shot silk fabrics – the so-called cangiante commonly associated with fifteenth-century panel painting.

Organics aside, fourteenth-century illuminators pressed the entire palette into service for modelling strategies, which included two earlier techniques. The first one, continuing the Anglo-Saxon tradition of tinted drawing, involved the use of the plain parchment for highlights and the application of increasingly saturated pigments for the mid-tones and shadows. The other technique, first developed by French and English illuminators in the 1260s and 1270s, required gradational modelling, starting with a mid-tone, mixing it with increasing proportions of lead white for highlights and shading it with layers of the saturated pigment – either pure or mixed with darker colourants. The mixing and layering of pigments were indispensable for the gradational modelling of fabrics which fourteenth-century English illuminators developed to perfection.

Both techniques were also crucial for painting anatomically accurate bodies, portraying emotions and even suggesting character. The two common techniques of painting the flesh employed the bare parchment or lead white as the base tone, with features outlined in carbon-black, shaded areas modelled with brown washes, and occasional dabs of red lead or vermilion defining the lips and cheeks. While most illuminators stopped there, a few employed additional pigments, mixtures or layers to create strongly individualised characters and to suggest differences in life style, temperament or moral stance.

The main binding media used in fourteenth-century English manuscripts were most probably egg white (glair), vegetable gums (such as gum Arabic) or animal glue. The non-invasive analytical method currently available (FORS, see Appendix) does not provide conclusive results or distinction between these three organic materials, especially hard to distinguish when painted on parchment. However, FORS offered secure identification of a lipidic binder – most likely egg yolk – in seven of the twelve fourteenth-century English manuscripts analysed.47 Hitherto underestimated, the importance of egg yolk as a binder in medieval illuminations deserves re-evaluation, as it is increasingly identified in manuscripts from the eleventh century onwards.48 Familiarity with egg tempera among some illuminators may suggest that they also worked as easel painters.

Alternatively, it may indicate their awareness of the optical and chemical properties of egg yolk, which were particularly beneficial for certain pigments. In fourteenth-century English manuscripts – as well as in illuminations produced in other periods and traditions – egg yolk was favoured in areas painted with red lead and sometimes vermilion. This selective use may have been related to the handling properties of these pigments and the desire to enhance their warm glow with a thicker, glossier, yellow-coloured binding medium, and/or to awareness of the protective properties of a ‘greasy’ binder against these pigment’s high susceptibility to degradation.

Conclusion

The small corpus of manuscripts presented here offers only a preliminary overview of the painting materials and techniques employed by fourteenth-century English illuminators. The analyses of the twelve volumes establishes several small clusters of manuscripts closely related not only in date, place of origin, textual or visual contents, but also in the choice and use of specific pigments. The characterisation of individual palettes helps distinguish between artists who shared pictorial motifs and those who also shared the same materials. Expanding the current clusters of manuscripts and analysing new ones would develop these preliminary observations as well as test and perhaps amend some of them.

The overview suggests numerous parallels with – as well as several differences from – contemporary English polychrome sculpture, wall and panel painting. Comparative studies of the materials and techniques employed in Continental illumination and painting as well as other media, notably the textile and glass industries, would both enrich and nuance current knowledge about English painting and illumination. Such ambitious journeys require a large crew and we hope that some of its future members are among the authors and readers of this publication. We offer the present paper as an invitation and a sketch of one possible route for future, joint explorations.

Appendix: Analytical equipment and experimental conditions

Near-infrared (NIR) imaging was performed with a 5-megapixel Spectrocam (by Pixelteq) equipped with eight filters covering the spectral range from 350 nm to 950 nm. For the purpose of infrared imaging, we used either an 800 nm long-pass or a 925 nm band-pass filter with 50 nm FWHM. Illumination was provided by one or two lamps fitted with low voltage 35W SoLux bulbs (colour temperature 4700K, beam-spread 36°). Exposure times were adjusted for each filter individually and ranged from 100 milliseconds to 2 seconds.

At the British Library, imaging was performed in collaboration with Dr Christina Duffy with a Megavision EV camera system equipped with a number of filters and different configurations for illumination (see http://www.mega-vision.com/cultural_heritage.html for details).

Fiber optic reflectance spectra (FORS) in a spectral range
Table: Pigments identified in fourteenth-century English manuscripts

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A question mark indicates a pigment's likely presence, which could not be incontrovertibly proven by technical analysis.
At the Fitzwilliam Museum, observations under magnification were recorded with a Leica M80 stereomicroscope equipped with a 1.0× planar lens, yielding magnifications ranging from 7.5× to 60×. A Canon camera was fitted onto the microscope via a T2 attachment and extension, allowing to record high-resolution digital images of the observed areas. When working in other institutions, a handheld digital microscope (by Dino-Lite) was used instead, with magnification up to 200×.

Raman spectroscopy was carried out on manuscripts from the Bodleian Library only in collaboration with Team Pigment from Durham University, using a custom-made system for which technical details and experimental conditions can be found elsewhere.

Acknowledgements

We are grateful to the Zeno Karl Schindler Foundation and the Fitzwilliam Museum’s Marlay Group for funding the Schindler/ MINIARE Fellow (2015–2016), Dr Lucía Pereira-Pardo. We acknowledge the British Academy’s Neil Ker Memorial Fund for supporting our research trips to UK and overseas libraries in 2015–2016. We are indebted to librarians and curators in Cambridge and across the UK who welcomed us to analyse their collections. We thank Prof. Andrew Beeby (Durham University) and Mr David Howell (Bodleian Library), as well as Dr Christina Duffy and Dr Paul Garside for the analytical support they provided during our research on manuscripts in the Bodleian Library and the British Library respectively.

Notes

1 Sandler 1986, I, 15–52. See also Sandler’s contribution in this volume.
4 The analysis preformed by the MINIARE project (www.miniare.org) is informed by the research of the Cambridge Illuminations project (www.fitzmuseum.cam.ac.uk/research/cambridgeilluminations). For a selection of manuscripts that have benefited from the integrated art-historical and technical analyses undertaken by both projects, see Cambridge 2016 and www.fitzmuseum.cam.ac.uk/illuminated.
5 London, BL, MS Royal 2 B.VII; fully digitised at www.bl.uk/manuscripts, with description and bibliography. See also Sandler 1986, I, 30–32; Stanton 2001; Sandler’s contribution in this volume.
6 Cambridge, UL, MS Dd.1.14; Sandler 1986, no. 75; Binski and Zutshi 2011, no. 152. Fols. 5r, 179r, 377v received comprehensive analyses. In addition, blue and orange areas were analysed on fols. 21v, 88r, 88v, 160r, 161v, 171v, 172v, 184v, 186r, 188r, 190v, and 321v, 322r, 332r, 339r, 376v, 377v, 392v, 393v, 395v, 397v.
7 Rouse and Rouse 2000.
8 For a fifteenth-century example, see the contribution by James-Maddocks in this volume.
Slight variations in the palette were identified only in the ornamental border on fol. 27v which contains vermilion, orpiment, a mixture of organic pink and red earth, and a brown mixture consisting of an earth pigment, an organic colourant and probably a copper-based (blue or green) pigment. The overlapping of initials and borders varies from page to page, revealing variations in the order of completion.

For the relationships between these manuscripts, see Sandler 1986, nos. 43–45, 50, 79; Michael 2007; Panayotova 2008b, 20–28.

London, BL. Add. MS 49622 and Stowe MS 12; fully digitised at trin-sites-pub.trin.cam.ac.uk/illuminated, for the latter, Binski and Zutshi 2011, no. 136. For other members of the group see below. Fols. 2v, 3r, 28v, 29r in MS 242 and fols. 23v, 27v, 33r, 37r in MS Dd.8.2 received comprehensive analyses.

For example, the consistent finding of silicon (Si) in azurite blue areas might help identify scribal hands or different phases in the copying of the text. Unlike the text, the black outlines of figures and ornament, where identified, were drawn with carbon-based blacks – a distinction that indicates the clear division between the responsibilities of scribes and artists. The red ink of rubrics is almost always vermilion. Azurite and vermilion were consistently used for blue and red pen-flourished initials.

Analytical results obtained on seventy manuscripts produced in the British Isles between the seventh and the fifteenth century have been published to date, in addition to a survey of blue pigments in over one hundred manuscripts. For the seminal publications, see notes 2 and 3 above. The discussion which follows also includes – in addition to the twelve fourteenth-century manuscripts presented here – unpublished data from eight twelfth– and thirteenth-century manuscripts analysed by the MINIARE project.

The plain parchment was normally used for white in English and Irish manuscripts from the seventh until the tenth century. Although lead white was available on the British Isles throughout this period as the source material for red lead, it began to be used consistently as a white pigment only in the eleventh century.

For examples of artists preserving their individual practices within the same collaborative project, see Cambridge 2016, cat. 26, cat. 29; for workshop practices evolving over time, see Cambridge 2016, cat. 27–28; for shared materials and techniques among illuminators thought of as family members, see Cambridge 2016, cat. 30.

Cambridge, FM, MS 242 and Cambridge, UL, MS Dd.8.2; Sandler 1986, nos. 31 and 29; for the former, see also www.fitmuseum.cam.ac.uk/illuminated, for the latter, Binski and Zutshi 2011, no. 136. For other members of the group see below. Fols. 2v, 3r, 28v, 29r in MS 242 and fols. 23v, 27v, 33r, 37r in MS Dd.8.2 received comprehensive analyses.

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Cambridge, FM, MS 242 and Cambridge, UL, MS Dd.8.2; Sandler 1986, nos. 31 and 29; for the former, see also www.fitmuseum.cam.ac.uk/illuminated, for the latter, Binski and Zutshi 2011, no. 136. For other members of the group see below. Fols. 2v, 3r, 28v, 29r in MS 242 and fols. 23v, 27v, 33r, 37r in MS Dd.8.2 received comprehensive analyses.

For example, the consistent finding of silicon (Si) in azurite blue areas might help identify scribal hands or different phases in the copying of the text. Unlike the text, the black outlines of figures and ornament, where identified, were drawn with carbon-based blacks – a distinction that indicates the clear division between the responsibilities of scribes and artists. The red ink of rubrics is almost always vermilion. Azurite and vermilion were consistently used for blue and red pen-flourished initials.

Analytical results obtained on seventy manuscripts produced in the British Isles between the seventh and the fifteenth century have been published to date, in addition to a survey of blue pigments in over one hundred manuscripts. For the seminal publications, see notes 2 and 3 above. The discussion which follows also includes – in addition to the twelve fourteenth-century manuscripts presented here – unpublished data from eight twelfth– and thirteenth-century manuscripts analysed by the MINIARE project.

The plain parchment was normally used for white in English and Irish manuscripts from the seventh until the tenth century. Although lead white was available on the British Isles throughout this period as the source material for red lead, it began to be used consistently as a white pigment only in the eleventh century.