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# Vibrant colours on the Antonine Wall

## Distance Stones: a new methodology for identifying pigments on Roman sculpture

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### Abstract

Non-destructive analytical techniques are now widely and successfully employed in the fields of materials science and conservation. Portable X-ray fluorescence (pXRF) and portable Raman Spectrometry have proven particularly valuable for the rapid *in-situ* analysis of samples, though their applicability for the analysis of archaeological artefacts where survival of surface treatments can be negatively impacted by post-depositional processes has been under-explored. Roman relief-sculpted monumental inscriptions from the Antonine Wall, commonly referred to as 'distance slabs', have offered an excellent opportunity to deploy these non-destructive techniques to determine whether they were originally adorned with pigments and to identify the colours used. This is a revolutionary approach to identifying colours on ancient sandstone sculpture that transforms our understanding of these unique monuments. Elemental composition analysis by pXRF has confirmed evidence for pigments and this was supported by the Raman results, making it possible to develop and reconstruct a palette of colours that originally brought these monuments to life in vibrant polychrome. The research offers a new methodology for identifying pigments on sandstone sculpture and opens new avenues for investigating other classes of material culture alongside the development of bespoke analytical equipment.

### Keywords

Roman, Sculpture, Antonine Wall, distance stones, distance slabs, frontier, pigments, materials science.

### Monumental Inscriptions on The Antonine Wall

The Antonine Wall marked Rome's north-west frontier<sup>1</sup> and is incorporated into the 'Frontiers of the Roman Empire' UNESCO World Heritage site (Figure 1). It is a turf rampart set on a stone base that cleaved a route across the Forth-Clyde isthmus for some 37 miles and separated the Roman-controlled region to the south from the non-Roman north<sup>2</sup> with outpost and advance forts to the north. Monumental inscriptions were recovered from along the line of the Wall and its environs<sup>3</sup>. They constitute the most impressive and visually impactful body of epigraphic evidence recovered from any Roman frontier<sup>4</sup> and many combine inscriptions and iconography in relief. The monuments are carved from locally sourced sandstone and contain identifiable patterns of epigraphic practice in prescriptive abbreviated Latin. The known examples are dedicated to the Emperor Antoninus Pius, who commissioned the mural barrier around 142 AD. Most record the distance constructed by three legions (*Legio II Augusta*, *Legio VI Victrix* and *Legio XX Valeria Victrix*), normally stationed at York,

Chester and Caerleon. Many include legionary emblems such as a boar for the Twentieth Legion and Capricorn or Pegasus for the Second Legion. The more elaborate examples also contain relief imagery depicting the invasion and conquest of southern Scotland, including the subjugation of troublesome northern tribes and religious practice incorporating the Legions' favoured deities and rituals.

**Insert Figure 1.** Plan of the Antonine Wall © David J. Breeze (used with permission)

I have argued elsewhere against the use of binary terminologies, such as Roman:native traditionally applied to investigations of the interaction between Romans and Iron Age peoples in northern Britain since they perpetuate a negative and derogatory categorisation of indigenous non-Roman populations<sup>5</sup>. I would caution that similar care should be taken with the terminology of the Antonine Wall relief sculptures, commonly referred to as 'Distance Slabs'. Such language conjures an outmoded and inappropriate notion of this body of material culture as bland, uninspiring, functional blocks of stone devoid of any character or intrinsic cultural significance. Even the most cursory of checks will confirm that these are unique and exceptional examples of monumental relief sculpture (Figure 2), which will hereafter be referred to as 'Distance Stones'.

**Insert Figure 2.** Bridgeness Distance Stone (reproduced with permission from the National Museum Scotland)

These monuments serve various functions, primarily as visually impactful propaganda tools to commemorate the Roman conquest of, and authority over, the region<sup>6</sup>. The precision of recorded measurements memorialised in the inscriptions are indicative of the Roman army's concern for accuracy and could also hint at a medium for stoking competition between Legions constructing segments of the wall while simultaneously reinforcing their allegiance to the Emperor in line with the increasingly honorific character of Distance Stone dedications approaching the third century<sup>7</sup>. Critically, given the comparatively short-lived occupation of the Antonine Wall, they place us in the most fortuitous situation of providing a rich and tightly dated body of evidence through which to investigate the unique and culturally dynamic context of life on the frontier without resort to extrapolation based on chronological and regionally distinctive stylistic practices<sup>8</sup>.

Of the 19 known examples, 16 Distance Stones and one plaster cast are held in the collections of the Hunterian Museum at the University of Glasgow, another is in the Glasgow Museums collections, while the most easterly, and arguably most extravagantly decorated, is held by the National Museum of Scotland in Edinburgh. Many were donated to the University of Glasgow then transferred to the Hunterian Museum by antiquarians<sup>9</sup> and landowners during the seventeenth to eighteenth centuries as well as the Canal Commission who donated those recovered during the construction of the Clyde-Forth Canal<sup>10</sup>. While the precise contexts of their original discovery are not always recorded with precision and we cannot state with certainty the circumstances of their original placement along the Wall, the presence of cramp-holes on the rear of many confirm they were mounted onto another structure for stability<sup>11</sup>. To ensure their accessibility and visibility to the widest possible audience, the sculptures were most likely fixed to the southern face of the Wall, probably at high-traffic crossing points<sup>12</sup> or in forts, though the findspots might suggest they were not ultimately deposited at or close to forts. It is even possible that they were positioned along the Military Way to maximise their impact and accessibility<sup>13</sup>.

Monumental relief sculptures are an important medium through which Roman artists provided background and cultural context to mythological, religious or historical events such as the iconic scenes of the Roman army on campaign depicted on the columns of Trajan and of Marcus Aurelius in

Rome<sup>14</sup>. The variety of topics encapsulated on relief defies neat categorisation of the genre<sup>15</sup>, but the incorporation of iconography and epigraphy on the Antonine Wall sculptures combine commemoration, memorialisation, monumentalisation and propaganda. The practice of monumental inscriptions was most prolific during periods of social change particularly the early centuries AD<sup>16</sup>, a timeframe that aligns most fortuitously with Antoninus Pius' campaigns in northern Britain<sup>17</sup> since they preserve a record of this militarised region on the boundaries of Empire<sup>18</sup>.

Because of their perceived permanence in being carved from durable material, monumental inscriptions served as an ideal medium for publicising and preserving the actions and reputations of dedicators long after their death<sup>19</sup>. In other words, monumentality was a mechanism for immortality.

By inscribing combined dedications to both the Emperor and memorialising themselves<sup>20</sup>, the Legions who commissioned these sculptures were effectively aligning their own noble deeds in pursuit of the glory of Rome with those of the Emperor, "Father of his Country". At the same time, the monuments performed a critical role of physically, visually, conceptually and permanently stamping the Empire's irrevocable rights to the captured territories in northern Britain through a commonly employed medium for endorsing ancient treaties<sup>21</sup>. Their placement in high traffic areas to engage the widest possible audience of both Roman and non-Roman participants would have continually validated and reinforced Rome's authority. Further, embedding the message onto large dressed stone lent a degree of permanence to what may have been perceived as an ephemeral frontier structure. Monumental sculpture encapsulates the interplay between inscribed text and iconography to create a sense of audience<sup>22</sup> with variable layers of access to the meanings folded into and permeating through the stone.

Sculpted figures on the northern frontier reflected the heterogeneous character of the Roman army and promoted shared identities of 'Romanness' in militarised regions<sup>23</sup>. The conceptualisation and visual iconography on the Distance Stones depicting various scenes of religious practices and of violence perpetrated by a powerful incoming Imperial army imposing its dominance and superiority over submissive, naked and powerless indigenous warriors would have been alien. However, the intended message of Roman authority and futile resistance could hardly have been missed by local peoples seeing the sculptures, especially if the scenes were brought to life in authentic colour. This would have been incredibly powerful imagery emblazoning itself onto the consciousness of an Iron Age audience unfamiliar with such realistic representations of warfare. People engaging with the sculptures would potentially have faced difficulties of understanding depending on their ability to read Latin, particularly the abbreviated format of the Latin inscribed on the monuments.

## Polychromy on Roman Relief Sculpture

Roman paintings on wall plaster are well attested across the Roman Empire with the plethora of exquisitely, if tragically, preserved frescoes from the walls of Pompeian villas exemplifying the practice<sup>24</sup>. Recipes for the pigments used as well as techniques for their preparation and application survive from contemporary writers, most notably Pliny<sup>25</sup> and Vitruvius<sup>26</sup>. The techniques of painting as well as pigment identification have recently been comprehensively studied<sup>27</sup>.

Colourful pigments survive from Classical Greek statuary, including the exquisite marble sculptures from the Athenian Parthenon displayed in the British Museum. Several retain residual traces of their original pigmentation<sup>28</sup> in concealed crevices despite the best efforts of museum staff to vigorously 'clean' the surfaces periodically between 1811-1938 using a combination of water, acid, copper brushes and copper chisels<sup>29</sup>. Polychromy on Roman sculptures is similarly well attested through

various sources, including small traces of extant pigment on marble statuary<sup>30</sup> (such as the exquisite painted Amazon head from Herculaneum)<sup>31</sup> and sarcophagi<sup>32</sup>. The practice is even evidenced on a rare intaglio depicting a Greek artist applying colour to a Roman sculpture<sup>33</sup>. This has led to a burgeoning scholarly interest in colour on Classical sculpture<sup>34</sup>. That interest has been gathering momentum and now extends to international symposia dedicated to understanding polychromy on ancient sculpture and architecture, most recently hosted at the British Museum<sup>35</sup>, annual meetings of the Association for the Study of Marble and Other Stones in Antiquity (ASMOSIA)<sup>36</sup> and conferences exploring the applicability of scientific technologies for the identification of pigments on artwork and archaeological materials<sup>37</sup>. Poor survival of the pigments due to post depositional processes make their authentic reconstruction challenging<sup>38</sup>, but these recent transdisciplinary approaches combining archaeological investigation with scientific analysis allow for the characterisation of compounds, often from microscopic remains<sup>39</sup>.

Though polychromy on Roman reliefs is increasingly drawing scholarly attention,<sup>40</sup> this is generally the preserve of marble sculpture, for example at Nicomedia in modern-day Turkey (Figure 3) where a marble frieze depicts Roma, Victory, togate Roman citizens and the co-Emperors Diocletian and Maximian<sup>41</sup> participating in the *adventus* procession. The survival of pigment on many stones, such as locally quarried sandstone used for relief sculptures in northern Britain, has been poor to non-existent. The practice of applying pigments to sandstone relief is, however, known from ancient Egypt as evidenced by the recent recovery of a relief sculpture of Ramses from the temple of Kom Ombo dating to c. 1279 BCE to 1213 BCE<sup>42</sup>.

**Insert Figure 3.** Polychromy on marble relief from Nicomedia, reproduced by kind consent of Agturk<sup>43</sup>.

The Roman distance stones and other worked stone recovered from the environs of the Antonine Wall serve as excellent examples of Roman relief sculpture on sandstone. The inscribed texts on the Antonine Wall sculptures operate symbiotically with the dramatic, often brutally violent, iconography carved into them as powerful propaganda tools. These monuments perform a complex role in the transmission of information in a variety of ways to different audiences and demand critical engagement. Whether they are understood through the prism of their material properties<sup>44</sup> or through the concept of materiality<sup>45</sup> or how they perform and transform in different cultural contexts<sup>46</sup>, they are imbued with vitality and significance relating to the interface between people and things beyond their inherent material properties<sup>47</sup>. As such, they must be considered within the sphere of relational, mutually dependent, symmetrical entanglements between things and people<sup>48</sup>. Their cultural significance transcends functionalist descriptive accounts of their epigraphic content or artistic merits and even the skill of the artisans whose work demonstrates a comparatively greater degree of competence in their representation of animals than of humans in the various scenes depicted.

These monumental inscriptions offer opportunities for exploring connections and disconnections of operational sequences within the concept of *chaîne opératoire*<sup>49</sup> taking account of the inherent properties of the raw material and necessary modifications to achieve the desired results within the context of inherited ways of doing and the passing on of technological traditions<sup>50</sup>. Two examples discussed below from Summerston Farm and Bridgeness demonstrate some striking similarities that could well be indicative of the passing on of skills from one artisan to another or, more likely, the development of artistic and technological skills in one individual<sup>51</sup>. The *chaîne opératoire* can be taken to an additional level through the deliberate choices of pigments that were apparently prescriptively applied in specific contexts to ensure the sculptures complied with culturally ascribed traditions. The apparent difference between Mediterranean artists sculpting exquisitely rendered

and idealised images from marble and frontier artisans working locally sourced sandstone might be suggestive not of the culturally ascribed choices or skill of the sculptor, but imposed by the friable character and possibly unfamiliar medium. Here the application of pigments may well have been a useful mechanism for concealing imperfections and for providing an element of realism that would otherwise be challenging to achieve on that raw material.

Visible traces of colour are rarely referred to by curators and conservators, though glimpses have occasionally been snatched when the Antonine Wall inscriptions were wet through cleaning in preparation for new museum exhibitions. Keppie<sup>52</sup> notes inscriptions were “thoroughly cleaned” in preparation for a visit by Queen Victoria and Prince Albert in 1849, “washed in distilled water” in 1976 and “cleaned with a detergent recommended by the National Museums of Scotland” in 1979. A note from a National Museum of Scotland (NMS) curator refers to steam-cleaning of the Bridgeness sculpture in 1999 (Figure 6). These actions, though well intentioned, combine with the harsh acidic Scottish soils to caution against the survival of fragile pigments. Further, it is possible that residue from detergents may mask residual pigment traces.

## pXRF and Raman Spectroscopic Analysis of the Distance Stones

The research presented in this paper stems from exploratory portable X-ray fluorescence (pXRF) analysis undertaken by the writer in 2013 on a Distance Stone dedicated by the Twentieth Legion of unknown provenance in the Hunterian Museum collections<sup>53</sup>. Following cleaning, gilding on the lettering as well as painting of the peltae in a dark brown colour became visible. The results of pXRF analysis confirmed several spots rich in lead, iron, copper and cobalt as well as gold, all of which are reported as deriving from the stone’s repainting and gilding during the sixteenth century when it was embedded into the fabric of Dunottar Castle on the north-east coast of Scotland<sup>54</sup>.

The aim of this present study was to use *in-situ* non-destructive analytical techniques to investigate whether any traces of pigments originally applied to the Antonine Wall monumental inscriptions during the Roman occupation of Scotland in the second century are detectable. As a first step pXRF was used as this is now widely and successfully employed in archaeology and heritage and conservation science<sup>55</sup> to provide non-destructive elemental analysis of materials such as pigments, including minerals and earths. While the technique can classify pigments that are, for example, iron-rich or copper-rich, it cannot provide a full identification of the pigment (the complete compound) such as haematite (iron III and oxide) and azurite (copper carbonate mineral), nor can it analyse organic-based pigments such as madder, *rubia tinctorum*. Portable Raman spectroscopy was used to overcome these limitations, though this technique also presents challenges in interpretation since some pigments absorb source laser wavelengths and cause large fluorescence backgrounds that obscure Raman signals. These challenges are compounded by the characteristics of the materials under study which can be problematic for Raman to detect, i.e. heavily diluted pigments combined with the quartz-rich and heterogeneous character of sandstone from which the sculptures are carved that can prove difficult to ‘fingerprint’ and influence analytical results<sup>56</sup>. The Raman Spectroscopic Library of Natural and Synthetic Pigments<sup>57</sup> and recent work providing a Raman spectroscopic library of medieval pigments<sup>58</sup> as well as other reference sources<sup>59</sup> have been enormously helpful for this analysis, though the challenges set out above make the acquisition of comparably ‘clean’ results devoid of background noise a rarity. This report will summarise the pXRF and Raman results and draw out some conclusions before presenting a palette of colours originally applied to these monuments and a digital reconstruction of one scene from the Bridgeness sculpture.

The pXRF instrument used was a Niton XL3t 900 SHE GOLDD Alloy Analyser, with a 50kV Ag X-ray tube, 80MHz real time digital signal processing and two processors for computation and data storage respectively. Analyses were undertaken in the TestAllGeo calibration within the Soils and

Minerals mode with resolution of c.165 eV at 35 KeV. Many of the forty elements the instrument can in principle detect were present at concentrations below the elements' limit of detection (LoD) or were light elements whose fluorescent peaks at low energies were poorly resolved at low concentrations (Mg, Cl and S), the latter having a value <10000 ppm which is likely spurious. The remaining 16 elements were determined semi-quantitatively at a level significantly above the background levels in untreated areas of the stone with attention focussed predominantly on eight elements deemed to be most relevant based on their detection levels and common presence in pigments from the Roman era (Tables 1 and 2). The element concentrations are recorded in parts per million (ppm) for some (Pb, Mn and Ti) and as weight % element for others (Fe, Ca, K, Al and Si). The surface topography of the sandstone was challenging to mitigate being roughly cut and many analysis spots were on points of relief or on the grooves of lettering or decoration. An additional issue that required mitigation was the variety of textures and colours naturally present on the sandstones that were reflected chemically in a range of background levels of certain key elements, notably iron.

Raman spectroscopic analysis is also becoming increasingly utilised in archaeology, heritage and materials science<sup>60</sup>. Raman directs light through a monochromatic photon beam (a laser) onto a sample causing some of the resulting photons to interact with the sample and the scattering of light in two ways. The Rayleigh scattering has the same energy as the incident light and provides no information on vibrational energy levels contained in the sample. Inelastic scattering refers to the emission of a photon with an energy that lies either above or below the Rayleigh scatter and produces frequency-shifted 'Raman' photons. The Raman spectrometer measures any altered wavelength of photons dependant on the sample under study<sup>61</sup>. Raman analysis was undertaken on the sculptures to progress from the pXRF-determined elemental characterisation of a decorated layer being, for example, iron rich, to providing a fuller compound identification such as haematite or the detection of a preparative layer on the stone such as gesso<sup>62</sup>. It was also desirable to apply a non-destructive technique that may in principle identify organic-based pigments such as madder that pXRF cannot achieve.

The Raman instrument, a handheld SciAps Inspector 500 with a 1030 nm laser, was held against the surface of each object at defined spots corresponding as closely as possible with the pXRF points of analysis. These were analysed rapidly and non-destructively. The SciAps Inspector 500 has been predominantly used in pharmaceutical, plastics and other fields; in the cultural heritage sphere it has been applied to Roman marble sculptures<sup>63</sup>. The programme of analysis reported here is exploratory and revolutionary as it represents the first application to ancient sandstone. As expected, the technique encountered some issues including the heavily diluted character of any potentially surviving pigment and the masking of peaks associated with some pigments.

## The Distance Stones

Nine stones in the Hunterian Museum and the Bridgeness stone in the NMS were analysed to provide a comprehensive comparative dataset, along with stone columns from Bar Hill fort. Altar stones and a statue from locations on or near Hadrian's Wall now in the Great North Museum in Newcastle and Yorkshire Museum, York, were also included for comparative purposes and will be published separately. This present discussion will focus on the Summerston Farm (Hunterian Museum object number F.5) and the Bridgeness (NMS object number X.FV 27) Distance Stones since published accounts confirm visible traces of pigment on both.

## Summerston Farm Distance Stone from near Balmuildy (Hunterian Museum Number F.5.; RIB 2193)

The Summerston Farm Distance Stone (RIB 2193<sup>64</sup>), was carved from buff sandstone and erected by the Second Legion to commemorate the construction of a section of the Antonine Wall between Balmuildy and Bogton<sup>65</sup> (Figure 4). It contains a central panel with the inscription:

*IMP CAES TITO AELIO HADRIANO ANTONINO AVG PIO P P LEG II AVG PEP M P IIIDC LXVIS*  
(For the Emperor Caesar Titus Aelius Hadrianus Antoninus Augustus Pius, Father of his Country, the Second Augustan Legion built (this) over a distance of 3666 ½ paces)

The panel on the left depicts a winged Victory holding a laurel wreath preparing to crown a horseman who rides down two naked, bearded and bound captives. On the right panel an eagle perches on the back of a Capricorn, the emblem of the Second Legion, above another bound captive. The composition of the letters in the central panel and scene in the left panel is strikingly reminiscent of the Bridgeness stone (Figure 2) where a mounted horseman rides down indigenous warriors whose shields lie strewn around them. The critical difference being context – the scene playing out on the Bridgeness sculpture is a brutal one with naked indigenous warriors cut down and decapitated in the heat of a battle, while the Summerston Farm scene depicts events after battle, with the warriors now captured, bound and immobilised while the solitary Roman participant is adorned with honours from the Goddess Victory for his successful exploits in battle. It has been suggested that the same soldier is represented on both of these sculptures as a ‘cinematic’ technique of depicting him enacting progressive stages of killing<sup>66</sup>.

This Distance Stone was chosen for intensive analysis since Keppie<sup>67</sup> notes that traces of red colourant in the left panel and on the inscribed lettering were observed during cleaning in 1976 and these remain partially visible today.

**Insert Figure 4.** Summerston Farm Distance Stone (reproduced with permission from the Hunterian Museum).

Elements detected in relatively high concentrations by pXRF analysis are presented in Table 1. This confirms a cluster of lead well above background (500ppm) on some features in the left panel (5-1, 5-2, 5-41, 5-42, 5-43 and 5-46) and one spot on the right panel, highlighted in yellow. Most of these spots are on the chests of indigenous warriors (Figure 10). There is no visible residue of colour at these locations, but the results suggest they were painted with a pigment high in lead, such as minium lead oxide/red lead (dilead(II) lead(IV) oxide:  $Pb_3O_4$ ), a bright vibrant red. Alternatively, though less likely, the high lead could indicate chance contact of the stone with lead or lead-rich material since the time of deposition. Corresponding results from comparative analysis using an additional pXRF, a Bruker Tracer III-SD, support the former proposal since the Bruker confirms the presence of lead, though at a very low level and without any high spots in the sandstone.

Critically, all spots high in lead are in significant locations concentrated on Victory’s dress; the hair, cheek, chests and thigh of the captives on both the left and right panels; and on the beak of the eagle on the right panel. This strongly suggests that minium was used to depict blood resulting from battle prior to the capture of the prisoners and perhaps the eagle’s beak bloodied as a symbol of Rome feasting off the blood of her enemies. Raman results (Table 3) suggest the presence of yellow orpiment (arsenic(III) sulfide)<sup>68</sup> on Victory’s dress trimmed with white lead (lead(II) carbonate  $2PbCO_3 \cdot Pb(OH)_2$ ).

Natural iron content is c. 0.20% and one spot on Victory’s dress with a value of 0.25% may not provide confirmation of the presence of iron-rich pigment. The Bruker does, however, detect higher than background iron in at least one of the letters (last N of Antonino), on Victory’s dress and behind the rider’s head (which may represent a military standard held by the rider where sculptural details

have worn away). Visible traces of red here are suggestive of high iron oxide red being applied, though there remains the potential for pigments to have leached into unintended features post deposition.

**Table 1:** Selected compositions detected by pXRF analysis in the Summerston Farm Distance Stone

Turning to the Raman results summarised in Table 3, a total of 35 spots of analyses were taken from various features on the left panel, 7 on the right panel and 86 on the letters. Each spectrum was examined and principal peaks noted with comparisons made with the spectrum of a 'clean' background spot on the right side exterior close to a cramp socket.

Collectively, the spectra show peaks in the 469-475  $\text{cm}^{-1}$  region, which corresponds to quartz. A peak at 1161  $\text{cm}^{-1}$  is evident at several significant spots, including several letters, the rider's 'standard', cloak and foot, Victory's face and the stomach of the right captive. This peak corresponds with madder<sup>69</sup> and suggests that madder has been used as a locally sourced alternative to vermilion commonly used in other Roman stone inscriptions and sculpture. Peaks associated with the presence of iron oxides, notably at 610  $\text{cm}^{-1}$  are absent in the equipment's associated Bio-Rad software, but evidenced in more commonly used NuSpec software, as are peaks in several instances at 1600  $\text{cm}^{-1}$ . Thus, an absence of identifiable peaks at 610  $\text{cm}^{-1}$  need not be equated with an absence of iron-rich colorant, but rather that Raman finds it challenging to detect such a colorant at low concentration. This is confirmed by experimental work undertaken during this research that detected only very weak peaks at c. 300  $\text{cm}^{-1}$  and 610  $\text{cm}^{-1}$  in the analysis of replicas using moderate to high concentration of iron oxide/red ochre. Recent work has further verified that red ochres, which are a mixture of iron oxides, clays and silica, are more challenging to detect through Raman than haematite<sup>70</sup>. No lead compounds have been detected.

A poorly defined peak of low intensity at c. 350  $\text{cm}^{-1}$  is common, especially on some of the lettering. This could be orpiment, a yellow-orange mineral that contains arsenic and gives a golden lustre, that has a Raman peak at 354  $\text{cm}^{-1}$ . Alternatively, and here suggested as most likely, it is realgar (arsenic(II) sulphide), a striking ruby-red mineral which is usually found alongside orpiment and referred to by Pliny as *sandarach*, with a Raman peak at 356  $\text{cm}^{-1}$ . Given that this peak appears in association with the 1161  $\text{cm}^{-1}$  peak for madder (Figure 5), it is possible that a small amount of realgar was mixed with madder to produce a deeper red pigment. The Roman practice of mixing organic dyes such as madder and indigo to give a purple pigment<sup>71</sup> or cinnabar with haematite to extend the more valuable and challenging to produce cinnabar corroborates this suggestion<sup>72</sup>. The 350  $\text{cm}^{-1}$  peak on Victory's dress centre fold is strong and combines with a high iron spot nearby detected by pXRF. This could confirm that Victory's dress (Figure 10) was yellow orpiment in the centre and trimmed in white); such a colour scheme is depicted in Pompeiian frescoes as at the Inn of the Sulpicii, Murecine.

**Insert Figure 5.** Raman Spectrometer results for Summerston Farm Distance Stone

## Bridgeness Distance Stone from West Lothian (NMS Number X.FV 27; RIB 2139)

The Bridgeness monumental inscription<sup>73</sup> (RIB 2139<sup>74</sup>) is an exquisitely preserved sculpture (Figure 2) carved from buff sandstone. It is the largest known Antonine Wall Distance Stone and the most easterly example. An inscribed central panel is flanked on either side by *peltae* with griffin head terminals. The left panel depicts a mounted rider under an archway in full military armour with his

cloak flowing behind him; he is carrying a spear in his right hand poised to strike four naked northern warriors whom he appears to be galloping over in the midst, or immediate aftermath, of battle. The spears, shields and swords of the fallen warriors lie strewn around them, one warrior is prostrate on his back still holding his shield, another has what appears to be a *pilum* lodged in his back<sup>75</sup>, a third has been decapitated and a fourth stares forward toward the viewer striking a contemplative pose. The right panel depicts a religious scene with Roman members of the dedicating legion (Second Augustan, as confirmed by the text on their standard) offering sacrifices and libations to the gods on altars under a temple pediment. Led by the legionary legate, A. Claudius Charax,<sup>76</sup> who is pouring a libation onto an altar, they appear to be celebrating *suovetaurilia* (a ritual cleansing of the legion, its personnel and standards involving the sacrifice of a sheep, a bull and a pig<sup>77</sup>) to music being played on a flute<sup>78</sup>. The dedication reads:

IMP CAES TITO AELIO HADRI ANTONINO AVG PIO P P LEG II AVG PER M P IIIIDCL II FEC  
(For the Emperor Caesar Titus Aelius Hadrianus Antoninus Augustus Pius, Father of his country, the Second Augustan Legion (built this) over a distance of 4652 paces)

As discussed above, the Bridgeness text is comparable in format, content and composition to that on the Summerston Farm Distance Stone and the left panel is similar in composition, if not content. On this monument we have a rather terrifying image of warfare in the heat of a brutal battle. It is perhaps significant that the religious context to this stone is restricted entirely to the panel on the right, with a structured scene involving multiple participants reminiscent of scenes on the Trajan's column relief sculpture, though the Bridgeness relief differs markedly in composition, form<sup>79</sup> and articulation. Thus, we have religious symbolism on both monumental inscriptions, but in a slightly different context. On the one hand, incorporating the familiar juxtaposition of victory and piety on the right panel,<sup>80</sup> the Bridgeness sculpture depicts ritual cleansing of the army in a temple setting before or, more likely, immediately after the battle played out on the left panel, probably cleansing the site in advance of the mural barrier's construction<sup>81</sup>. On the other hand, the Summerston Farm sculpture synoptically represents battle and triumph by incorporating Victory honouring the deeds of the *eques* in a scene devoid of the temple setting *after* the battle has been won and under the gaze of the captives taken prisoner during that battle. This is a familiar pose on Roman frontier sculpture that derives from Greek prototypes though, intriguingly, the frontier reliefs depict non-citizen auxiliary riders as opposed to legionaries<sup>82</sup>.

**Insert Figure 6.** Bridgeness Distance Stone highlighting areas with visible red pigment observed by NMS conservator and a note on steam cleaning from the curator.

Close-Brooks<sup>83</sup> notes that "washing the accumulated dust and grime from the front of the Bridgeness sculpture revealed faint traces of red paint in parts of the carving, traces of which now appear pink, and which showed up most clearly when the stone was wet". The NMS curator further corroborates this by recording extant red pigment in several areas following steam cleaning in 1999 (Figure 6). It is possible that plaster casts of this sculpture, such as the one on display in the Hunterian Museum, could have removed extant traces of pigments from the surface. This sculpture is currently embedded into the fabric of the wall of the Roman display of the NMS approximately 2m above floor level. This placement provided very few options to define a 'clean' area for calibrating background readings. Iron content is >1% in several areas, but a value of >2.0% is here considered to be representative of an iron-rich location where pigment was applied.

**Table 2:** Selected compositions recorded by pXRF in the Bridgeness Distance Stone

Elements detected in relatively high concentrations are presented in Table 2. The results confirm five locations with higher than background levels of iron (Figure 7), many are centred round the rider's cloak and have correspondingly higher than background Manganese contents. The cheek of the second left figure is distinguished by 2% iron together with high Manganese, Titanium and Potassium contents; the raised level of the last two of these elements may be due to inclusions in the sandstone and have no connection with proposed pigments. The anomalously high K in the spot on the right soldier's cloak might be similarly assigned, though it is interesting to note high levels in these specific elements appear consistently together. Extant visible traces of red on this particular cloak combined with the presence of high iron here and on the rider's cloak strongly suggest the application of iron-oxide red ochre pigment to colour the cloaks of the Romans red.

**Insert Figure 7.** Iron contents (%) on the x axis at spots on the Bridgeness distance stone

There are scattered spots of lead above 100 ppm at the *top frame, A in AELIO, neck of decapitated northern warrior, right pediment and fallen captive warrior shield*. Traces of red pigment are visible on the neck of the decapitated fallen warrior and the presence of high lead here and on the fallen captive's shield is consistent with red pigment traces found on the captives on the Summerston Farm sculpture and suggest the application of minium (red lead) to depict blood. Its presence on the top frame and pediment is consistent with results of comparative analysis undertaken during this research on an Altar to Mithras from the Great North Museum, Newcastle, where the evidence of red vermilion (Hgs = mercury(II) sulphide) painted onto gesso is clear on architectural features. This suggests minium may have been used to colour the top frame and pediment.

The absence of high calcium and sulphur contents on the Bridgeness sculpture may indicate a lack of gesso (calcium sulphate) or more likely, the removal of residual pigments and gesso by episodes of cleaning.

Turning to the Raman results summarised in Table 3, a total of 39 spots were analysed on this sculpture, including five on the letters and the remainder on other sculptural features. Again, the placement of the stone meant that a true 'background' reading could not be confidently identified for comparative purposes.

As expected, the spectra reveal the presence of quartz at 469-475  $\text{cm}^{-1}$  as well as some peaks at 1161  $\text{cm}^{-1}$ , which indicates the presence of madder, and at 610  $\text{cm}^{-1}$  indicating iron-oxide. Analysis of a spot at *Captive neck red* gave a small peak at 1092  $\text{cm}^{-1}$  which is very close to that at 1095  $\text{cm}^{-1}$  found in sandstone alone but also close to the 1088  $\text{cm}^{-1}$  peak for calcite (calcium carbonate), which suggests a gesso layer. The peak at 1008  $\text{cm}^{-1}$  in the spectrum of the *Horseman right cheek* (Figure 8) is potentially interesting since it is absent in the sandstone and was close to where pXRF found high iron (also in the rider's cloak) but calcium at only background level; indeed, pXRF detected no evidence for the use of a gesso layer.

**Insert Figure 8.** Raman peak at the rider's cheek

On balance and taken together with the evidence of the 1003  $\text{cm}^{-1}$  proposed yellow ochre hair on a Sol Gorgon from York that comparative analysis produced, the 1008  $\text{cm}^{-1}$  peak suggests that yellow ochre (Figure 9) was applied as a layer on top of gesso to produce a skin-tone colour on the rider's face. This corresponds with analysis of a painted marble head of Caligula in Copenhagen dating to c. AD 37-41 that retains traces of several natural pigments in egg tempera as a binding agent<sup>84</sup>. These include madder between the lips and a blend of violet purple madder root and white on the lower

eyelid, with ochre earth and chalk on the skin. The artist employed various techniques to create realistic skin tones in the style of contemporary Egyptian mummy portraits, including layering of natural pigments (brown, red and yellow ochre with chalk). It is highly likely that similar techniques and natural pigments were applied over a layer of gesso on the Bridgeness, and other Antonine Wall sculptures, to create a realistic skin tone on figures.

**Insert Figure 9.** Raman spectrum of yellow ochre<sup>85</sup>

**Table 3:** Results of Raman spectroscopic analysis on the Summerston Farm and Bridgeness sculptures

## Summary and Concluding Remarks

A prescriptive formula for colours expected to appear in specific contexts on Roman frontier relief sculptures is evident, though it is not possible to determine whether the practice of representing features in specific shades was determined by availability of materials, selection by the artist or craft traditions. For example, traces of red in letters are relatively widespread on various types of inscription<sup>86</sup> though pigments could evidently be derived from alternative locally sourced ingredients if they produced the desired colour. This is confirmed by the presence of madder and realgar reds in the lettering of Hunterian stones as opposed to the deeper and richer red of vermilion identified from letters on Hadrian's Wall sculptures analysed during this project. The latter also presented some unexpected results confirming the application of blue to names of dedicators against red depicting the remainder of inscribed letters on altars that warrants further investigation. The lettering of Antonine sculptures appear to have been painted solely in red. Bold red lettering throughout would certainly have made these inscriptions easily legible. High lead in the A of AELIO on the Bridgeness stone indicates the presence of bright red minium, which may have been used to embolden the emperor's name against a different red for the dedicators (Second Legion) – though it is equally possible that minium was used for all the lettering on this stone as no other clear evidence for pigments was recovered from inscribed letters.

A preference for shades of red pigment is further evidenced on iconographic features. Bright red minium (red lead) is present on the chests, beard, head, thigh and cheek of captives on the Summerston relief sculpture, probably to depict splashes of blood on warriors fresh from a battle with the Roman legions. This corresponds with similar features on the Bridgeness sculpture where minium is evident on the shield of a fallen warrior as well as the decapitated neck of another. The latter remains visible to this day, as does the red from iron oxide pigment applied to the rider's cloak and that of the individual on the far right of the sculpture (right panel). Intriguingly, minium is also present on the beak of the eagle on the right panel of the Summerston Farm sculpture, perhaps symbolising Rome feasting off the blood of her captive enemies (Figure 10).

**Insert Figure 10.** Locations of high iron (red) and high lead (blue) on the Summerston Farm Distance Stone.

Yellow ochre is present on skin-coloured areas such as the cheeks of the rider, soldier and fallen northern warrior on the Bridgeness sculpture, potentially confirming layering of colours to achieve realistic skin tones. The lustrous, golden-yellow of orpiment has been applied to adorn the dress of the winged goddess Victory, trimmed with lead white and possibly with splashes of red blood from the nearby captives fresh from battle. This is in line with Victory's depiction on Pompeiian frescoes, or the skirts of the goddess Roma and winged Victory on the Nicomedia relief (Figure 4) where

colours are uniquely well preserved due the sculpture's placement in the interior of an imperial cult building<sup>87</sup>.

It is important to acknowledge that the primary material *foci* of this research, the Antonine Wall monumental inscriptions, have presented significant challenges to analysis using non-destructive techniques designed for use on 'clean' heritage materials that retain visible pigments. These challenges include the high fluorescence peaks emitted by the inherent properties of sandstone masking genuine Raman peaks from pigments. This is compounded by the properties of many commonly used Roman pigments being problematic to identify with Raman combined with their dilution and exposure to debilitating post-depositional processes. These include harsh Scottish environmental conditions, including high rainfall, low temperature, ground saturation and acidic soils combined with cleaning by well-meaning museum staff striving to make the sculptured stones presentable to the viewing public. It is gratifying to conclude that, despite the inherent challenges, it has been possible to physically and digitally reconstruct colours that would originally have adorned these unique and exquisitely crafted sculptures (Table 4).

**Table 4:** Palette of colours on the Antonine Wall Distance Stones

It has been possible to identify and reconstruct the colours used on the Antonine Wall sculpture and to confirm a restricted palette of reds and yellows dominated the repertoire of Roman artisans who painted these inscriptions and sculpted reliefs, with occasional hints of blue, white and black on other examples from northern England. Despite a relatively lengthy list of pigments catalogued by Pliny and Vitruvius, the use of more exotic, expensive and less readily available pigments defined by Pliny as 'florid' was largely restricted to elites, with the notable exception of cinnabar which is known to have been mixed with other minerals. The use of pigments categorised by Pliny as 'austere' which were much more commonly available and accessible across the Empire, including red and yellow ochres, carbon black, *terres vertes*, chalk-based whites and mixtures of these colours<sup>88</sup> is, therefore, unsurprising. Thus, the palette of colours evidenced on the sculpted stones from the Antonine Wall and other northern contexts can largely be placed into Pliny's 'austere' categorisation capable of being locally sourced. The others, including orpiment and realgar, are rarely used and not locally available. These can be categorised as 'florid' and imported from other parts of the Empire.

The early decision to incorporate additional inscribed stones and statuary from northern England into this work for comparative purposes has proven invaluable since they are known to have remained devoid of any intervention since the time of their discovery. Thus, extant pigments have not degenerated and provide useful datasets for comparison against the Scottish evidence. Here too reds and yellows are the predominant colours though with a broader palette.

Working closely with a digital artist, Lars Hummelshoj, it has been possible to digitally reconstruct one iconic scene from the Bridgeness sculpture using these authentic colours then matching them with pantone codes and taking account of experimental work undertaken to determine how the original pigments would have worked with the sandstone. The various reds on the cloak and tunic of the rider and bright minium red depicting blood on the fallen northern warrior's headless body and neck are clearly distinguishable. Slight artistic licence has been taken with the colour of the *cuirass* which has been depicted as bronze, as demonstrated by the representations of the Praetorian Guard on a relief in the Musée du Louvre<sup>89</sup> and those recovered from a shipwreck near Cueva del Jarro dating from first-third century<sup>90</sup> or the striking digital reconstruction of a *cuirass* from the Athenian Acropolis<sup>91</sup>. The bronze terminals of the rider's *pteryges* (the defensive skirt of leather strips worn over Roman soldiers' tunics) have been similarly extrapolated from other evidence<sup>92</sup> such as a life-size sandstone representation of Mars at the Yorkshire Museum.

The result is a strikingly realistic image of warfare that must surely have been a powerful propaganda tool serving to simultaneously strike fear into the hearts of the indigenous population while evoking a sense of dominance for the military audience (Figure 11).

**Insert Figure 11.** Digital reconstruction of the Bridgeness Distance Stone by Lars Hummelshoj

More sensitive technologies currently under development for the heritage sector should identify with better precision spots for analysis using lasers sufficiently sensitive to detect pigments that may have been subjected to dilution and erosion over time. The writer is working with academics in the Particle Physics Experiment team at the University of Glasgow to develop and refine equipment combining Raman spectroscopy and X-ray fluorescence with medipix technologies in portable format that can be tailored to this task. This bespoke equipment will ensure consistency in the spots analysed by both pXRF and Raman. It also offers the very attractive potential for undertaking systematic mapping and X-ray imagery of sculptures and artwork to determine with precision the location of surviving pigments and identify paint layering. It is hoped that the technology and associated software will build a robust methodology and comprehensive data resource for use by other researchers in a variety of disciplines.

This research has demonstrated that non-destructive techniques can be successfully applied to previously unexplored fields of study to identify and facilitate the reconstruction and conservation of pigments applied to sandstone statuary in antiquity. The work stands as a testament to the benefits of integrated and multidisciplinary approaches to materials science. It opens exciting and innovative avenues for future exploration into other strands of material culture studies, including analysis of stone statuary from other epochs, painted terracotta statues, painted wooden panels, frescoes, textiles, organic materials, textiles and stained glass. If combined with emerging technologies to integrate pXRF, Raman and imagery (x-Ray and Multi Spectral) the potential for non-destructive in-situ analysis of archaeological and early historical material culture are exciting and, potentially, limitless.

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- <sup>2</sup> Breeze 2015
- <sup>3</sup> Keppie 1979, 1998
- <sup>4</sup> Breeze 2015, 69
- <sup>5</sup> Campbell 2011, 21 and 2018
- <sup>6</sup> Keppie 1979, 4-5
- <sup>7</sup> Kolb 2015, 658
- <sup>8</sup> Bruun and Edmondson 2015, 19
- <sup>9</sup> Keppie 2012
- <sup>10</sup> *Monumenta Romani Imperii*
- <sup>11</sup> Keppie 1998, 53, Alföldy 2012
- <sup>12</sup> Kolb 2015, 658; Hannon, Rohl and Wilson 2017, 14
- <sup>13</sup> Campbell, forthcoming
- <sup>14</sup> Strong 1961
- <sup>15</sup> Grunow Sobocinski and Wolfram Thill 2015, 279
- <sup>16</sup> Woolf 1996
- <sup>17</sup> Keppie 2004, 44-52
- <sup>18</sup> Ferris 2000, 111-3
- <sup>19</sup> Woolf 1996, 26
- <sup>20</sup> Kampen 2006, 132
- <sup>21</sup> Pliny *Epistles* VIII.6.14
- <sup>22</sup> MacMullen 1982
- <sup>23</sup> Kampen 2006, 128-132
- <sup>24</sup> Piovesan et al 2011, Merello et al 2016
- <sup>25</sup> *Natural History*
- <sup>26</sup> *De Architectura*
- <sup>27</sup> Siddall 2006; Eastaugh et al 2008
- <sup>28</sup> Jenkins and Middleton 1988
- <sup>29</sup> Jenkins 2001
- <sup>30</sup> Østergaard 2011, Cosano et al 2017,
- <sup>31</sup> Happa et al 2009
- <sup>32</sup> Siotto et al 2015
- <sup>33</sup> Abbe 2015, 177
- <sup>34</sup> Wootton et al 2013
- <sup>35</sup> <https://www.9thpolychromyroundtable.com/>
- <sup>36</sup> <http://asmosia.willamette.edu/>
- <sup>37</sup> <https://www.uantwerpen.be/en/conferences/technart-2019/about/>
- <sup>38</sup> Abbe 2015, 174
- <sup>39</sup> Verri et al 2010; Abbe et al 2012; Brinkmann et al 2017
- <sup>40</sup> Del Monte et al 1998
- <sup>41</sup> Sare Ağtürk 2015 and 2018
- <sup>42</sup> <http://luxortimesmagazine.blogspot.co.uk/2018/02/ramses-ii-sandstone-colossus-remains.html>
- <sup>43</sup> Sare Ağtürk 2015
- <sup>44</sup> Ingold 2007
- <sup>45</sup> Miller 2005
- <sup>46</sup> Gosden 2006
- <sup>47</sup> Conneller 2011
- <sup>48</sup> Hodder 2012; Olsen 2010
- <sup>49</sup> Leroi-Gourhan 1993 [1964]
- <sup>50</sup> Roux 2016
- <sup>51</sup> Phillips 1972
- <sup>52</sup> Keppie 1998, 34 and 45
- <sup>53</sup> Keppie 1998, no. 1

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- <sup>54</sup> Camden 1607, 711-12 as translated by Gibson 1695, 939
- <sup>55</sup> Liritzis and Zacharias 2010, Chaplin et al 2016
- <sup>56</sup> Von Eynatten et al 2003, Everett and Gillespie 2016
- <sup>57</sup> Bell et al 2010
- <sup>58</sup> Marucci et al 2018, 1219
- <sup>59</sup> Bell et al 1997, Bouchard and Smith 2003, Castro et al 2005
- <sup>60</sup> Adriaens 2005, Clark 2007, Chen et al 2007, Mateos et al 2015, Bersani and Lottici 2016, Cosano et al 2017
- <sup>61</sup> Crawford et al 2019, Murcia-Mascarós and García-Ramos 2008
- <sup>62</sup> a white paint mixture consisting of a binder mixed with chalk, gypsum, pigment, or any combination of these
- <sup>63</sup> Cosano et al 2017, 191
- <sup>64</sup> RIB I
- <sup>65</sup> Macdonald 1934, 377
- <sup>66</sup> Breeze 2015, 70
- <sup>67</sup> 1998, 77
- <sup>68</sup> a deep-colored, orange-yellow arsenic sulphide mineral with formula  $As_2S_3$
- <sup>69</sup> Marucci 2018
- <sup>70</sup> Marucci 2018, 1222 and 1234
- <sup>71</sup> Clarke et al 2005
- <sup>72</sup> Rozenberg 1997, Kakoulli 1997
- <sup>73</sup> Catalogue of the National Museum of Antiquaries of Scotland, Phillips 1972
- <sup>74</sup> RIB I
- <sup>75</sup> though it could also be the broken lower portion of a leg from the fallen warrior behind him; cf. Phillips 1972, 178
- <sup>76</sup> Stoll 2007, 453
- <sup>77</sup> Ryberg 1955, 104
- <sup>78</sup> Keppie 1979, 9
- <sup>79</sup> Kampen 2006, 127
- <sup>80</sup> Hölscher 2003 and 2015
- <sup>81</sup> Rybert 1955, 104
- <sup>82</sup> Hope 1997, 252
- <sup>83</sup> 1981, 519
- <sup>84</sup> Brinkmann and Koch-Brinkmann 2017, 50
- <sup>85</sup> Marucci 2018.1231
- <sup>86</sup> RIB, 1965
- <sup>87</sup> Sare Ağtürk 2018, 416
- <sup>88</sup> Siddall 2006, 28
- <sup>89</sup> Russell Robinson 1975, 147
- <sup>90</sup> D'Amato 2009, 42
- <sup>91</sup> Brinkmann and Koch-Brinkmann 2017, 129
- <sup>92</sup> D'Amato 2009, 102