Report on Recovery, Examination, Analysis and Comparison of Soil recovered from Productions in the Sheku Bayoh Public Inquiry

for

The Sheku Bayoh Public Inquiry

Produced by

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Forensic Soil Scientist

1st November 2022

[redacted]

Contents

[redacted]

1 Declaration Summary

This report consists of eighty (80) pages each signed and dated. I confirm that the contents of this report are true to the best of my knowledge and belief.

Should my opinion change in relation to any material issue, I will inform the Inquiry as soon as reasonably practical and give reasons.

2 Summary

Summary of Conclusions

2.1 On the early morning of the 3rd May 2015, the ground conditions were wet and conducive to the transfer of exposed soil material to footwear which had been worn outside at that time.

2.2 Mr Sheku BAYOH walked along an assumed route of around 0.67 km in the early hours of 3rd May 2015. Approximately sixty percent of the adjacent area to the assumed route had a natural land cover of soil or vegetation.

2.3 On the morning of 3rd May 2015 PC Craig WALKER was at the police station before being called to the incident in his patrol vehicle.

2.4 Mr Sheku BAYOH's boots (GAY016 (right boot) and GAY017 (left boot)) were dirty. Large soil deposits were observed to be adhering to the welt and soles of both boots.

2.5 PC Craig WALKER's boots (AM001 (left boot) and AM002 (right boot)) contained small traces of debris, mainly on the soles of both boots.

2.6 PC Nicole SHORT's vest (JM019) was heavily contaminated with black fingerprint powder and only a few small traces of soil like material were observed to be present on the back, right hand side of the vest.

2.7 **JM019/Area 1** (Soil from silver strip) on vest worn by PC Nicole SHORT
There is a moderate amount of variation within the replicate analyses of this sample, suggesting a sample of more than one source. The physical and chemical (elemental composition) characteristics of some of the replicate analyses of samples from Mr Sheku BAYOH's right boot

[redacted]

(GAY016/Area 1 and GAY016/Area 2) shared some characteristics of the replicates from PC Nicole SHORT's vest (JM019/Area 1). Some features suggest possible material from the road surface itself (i.e. sulphur potentially from vehicular exhausts, and sodium, potentially from applied salt to road surfaces).

The characteristics of the soil deposit (JM019/Area 1) recovered from the silver strip of the vest worn by PC Nicole SHORT (JM019) is consistent with having originated from the soil recovered from the right boot of Mr Sheku BAYOH (GAY016/Area 1 and GAY016/Area 2). This conclusion is reached as some of the replicates in the material from JM019/Area 1 cannot be differentiated from some of the replicates in the material from GAY016/Area 1 and GAY016/Area 2, using all observed or measured characteristics.

The characteristics of the soil deposit (JM019/Area 1) recovered from the silver strip of the vest worn by PC Nicole SHORT (JM019) can be excluded as having originated from the soil recovered from the boots of PC Craig WALKER (AM001 and AM002) as the shape and size of particles were different and as most replicate analyses had different elemental profiles. The possibility that the geo derived material in JM019/Area 1 originated from the same source as the soils from PC Craig WALKER's boots is eliminated.

The overall conclusion from this sample comparison is that there is 'very limited' support for the proposition that some material in the soil deposit (JM019/Area 1) from the silver strip of the vest worn by PC Nicole SHORT (JM019) could have shared a common origin with the soil recovered from the boots of Mr Sheku BAYOH (GAY016/Area 1 and GAY016/Area 2).

2.8 **JM019/Area 2** (Soil from silver strip near edge of yellow fabric) on vest worn by PC Nicole SHORT

There is a small amount of variation within the sample replicate analyses. The material in sample JM019/Area 2 is likely a single source sample. It is different to all the sample soils recovered from the questioned footwear (GAY016, GAY017, AM001 and AM002) and likely originated from another unknown location.

The possibility that the material JM019/Area 2 (Soil from silver strip near edge of yellow fabric) originated, as a single source, from the same source as any of the material recovered from the footwear worn by Mr Sheku BAYOH is eliminated.

[redacted]

The possibility that the material JM019/Area 2 (Soil from silver strip near edge of yellow fabric) originated, as a single source, from the same source as any of the material recovered from the footwear worn by PC Craig WALKER is eliminated.

2.9 **JM019/Area 3** (Soil from yellow fabric) on vest worn by PC Nicole SHORT
There is a small amount of variation within the replicate analyses of this sample. The sample JM019/Area 3 is likely a single source sample.

This sample JM019/Area 3 comparisons provides the strongest support for a link between the soil on the vest worn by PC Nicole SHORT and the footwear worn by Mr Sheku BAYOH.

There is no support for a link between the soil on the vest worn by PC Nicole SHORT (JM019/Area 3) and the soil on the footwear worn by PC Craig WALKER.

Sample (JM019/Area 3) had a different physical and chemical (elemental composition) profile to the material recovered from PC Craig WALKER's boots (AM001/Area 3 (left boot) and AM002/Area 1 (right boot)). This soil deposit (JM019/Area 3) had a different elemental profile to the soil deposit from (GAY016/Area 1 (Soil to toe at welt right boot of Sheku BAYOH)).

The physical and chemical (elemental composition) characteristics of the replicate analyses from sample JM019/Area 3 (recovered from the yellow fabric of the vest worn by PC Nicole SHORT (JM019)) was similar to soil samples recovered from the boots of Mr Sheku BAYOH (GAY016/Area 2 (right boot) and GAY017/Area 1 and some replicate analyses from GAY017/Area 2 (left boot)).

The characteristics of the soil deposit (JM019/Area 3) recovered from the yellow fabric of the vest worn by PC Nicole SHORT (JM019) is consistent with having originated from the soil recovered from GAY016/Area 2 (right boot) and GAY017/Area 1 (left boot) and some replicate analyses from GAY017/Area 2 (left boot)). This conclusion is reached as the material in JM019/Area 3 cannot be differentiated from the samples GAY016/Area 2 and GAY017/Area 1 using all observed or measured characteristics.

The characteristics of the soil deposit (JM019/Area 3) recovered from the yellow fabric of the vest worn by PC Nicole SHORT (JM019) can be excluded as having originated from the soil recovered from the boots of PC Craig WALKER (AM001 and AM002) and the left boot sample of Mr Sheku BAYOH (GAY016/Area 1). The possibility that the geo derived material in JM016/Area

3 originated from the same source as the soils from PC Craig WALKER's boots is eliminated.

Dr Nicholas SCHURCH's (Schurch, 2022) independent statistical analysis supports my above findings. He concludes that the JM019/Area 3 deposit recovered from the yellow fabric of the vest is from a homogeneous sample that is similar to soil samples recovered from the boots of Mr Sheku BAYOH (GAY016/Area 2 (right boot) and GAY017/Area 1 (left boot) and some replicate analyses of the GAY017/Area 2 samples (left boot)). He concluded that JM019/Area 3 is consistent with sharing a common origin with the GAY017/Area 1 (left boot) and GAY016/Area 2 (right boot) soils.

My overall conclusion from the small amount of predominantly single source soil recovered from JM019/Area 3, using elemental compositional data and surface morphology, provides 'limited to moderate' support for the proposition that some of the material recovered from JM019 (JM019/Area 3) shared a common origin with the soil recovered from the boots worn by Mr Sheku BAYOH (GAY016 right boot (GAY016/Area 2)) and (GAY017 left boot (GAY017/Area 1)).

However, as no comparator sampling was conducted across potential source locations, no alternative propositions could be tested, or conclusions about likelihoods be made.

The conclusions I have drawn in this case are based on information provided to me by the Sheku Bayoh Inquiry. Should this information change, it may be necessary for me to reconsider my interpretation and conclusions. This is best done in advance of giving evidence.

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3 Professional Background - Summary

Professor Lorna DAWSON CBE, BSc, PhD, CSci, F. I. Soil Sci., FRSE, FRSA.
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I am an expert in the scientific matters addressed in this statement and I have been requested to provide a statement in relation to the matters outlined. I am employed as a Principal Research Scientist at the James Hutton Institute, Aberdeen, Scotland, UK, where I am Head of the Soil Forensics Section and hold the qualifications of BSc (Honours) Geography (Edinburgh University, 1979), and PhD in Soil Science (Aberdeen University, 1984). I am a visiting Professor in Forensic Science at the Robert Gordon University and Professor at CESPU, Portugal. I am a Fellow of the Institute of Soil Science, a Chartered Scientist and hold an Expert Witness certificate in Criminal and Civil Law (Cardiff University, 2011, 2012, updated 2017) and in Scots law (Aberdeen university, 2021). I was awarded a CBE in the Queen's birthday honours list, June 2018, for my services to soil and forensic science and was awarded a Fellowship of the Royal Society of Edinburgh in 2019. I have published widely on the subject of forensic soil science; over 100 refereed publications, books, and book chapters. I have worked on over 100 cases involving soil and have presented evidence in 17 including: WA v Rayney, 2012; HMA v Sinclair, 2014; R v Halliwell, 2016; HMA v Willox, 2020. During the past 18 years I have encountered the evidence type involved in this case on many occasions.

A Curriculum Vitae is provided in Appendix 1.

4 Information/Context of Case

4.1 This work is in relation to an Inquiry into an incident which occurred on 3rd May 2015 at Hayfield Road, Kirkcaldy. The Public Inquiry is into the death of Mr Sheku BAYOH.

5 Request

5.1 I was requested by [redacted] the Sheku Bayoh Public Inquiry, on 25th April 2022 to provide a quotation for conducting substance evidence analysis and the

[redacted]

comparison of traces from a vest with two pairs of boots, and subsequently by [redacted] the Sheku Bayoh Public Inquiry, on 12th July 2022. It was discussed and decided that the soil examination work would be conducted after an independent tread mark expert had examined the vest worn by PC Nicole SHORT (JM019), as this type of investigative work should be conducted before any substance analysis can be undertaken to best preserve the integrity of the tread impression.

5.2 On 14th July 2022 I sent a quotation and my availability to undertake the analysis and to produce a full evidential report. On 19th July 2022 I was sent a Confidentiality Agreement through DocuSign to sign which was duly completed and returned on 19th July 2022. I received a set of background information through DocuSign. The contents of this material are in Table 2.

5.3 I was requested to recover and conduct trace evidence analysis and comparison of traces from a police vest worn by PC Nicole SHORT (JM019) with traces from two pairs of boots: one pair worn by Mr Sheku BAYOH (GAY016 and GAY017) and the other pair worn by PC Craig WALKER (AM001 and AM002) on the night/early morning of 2nd/3rd May 2015.

5.4 After a consultation with the Sheku Bayoh Inquiry team, on 24th October 2022, I was requested on 25th October 2022 if I could assess the likelihood of the soil trace recovered from the vest and the soil recovered from Mr Sheku BAYOH's boots having a common origin; and to separately assess the likelihood of the soil trace recovered from the vest and the soil recovered from PC Craig WALKER's boots having a common origin. Unfortunately, without a set of background reference samples to use as an alternative proposition, and without being able to use PC Craig WALKER's boot samples as an alternative proposition, likelihood ratios cannot be provided. If there was appropriate alternative proposition data, likelihoods could be conducted, but the quality of the results would depend on the quality of both the sample and the alternative proposition data. Therefore, I used the scheme of the United States Department of Justice for exclusion of samples that were different, and the scheme of Pye (2007) to assess the strength of scientific evidence to support the proposition of an association between two samples. I also compared my findings with that of an independent statistician (Schurch, 2022).

6 Receipt of items

6.1 The productions which were identified by the Sheku Bayoh Inquiry for examination and analysis consisted of a police vest which had been worn on 3rd May 2015 by PC Nicole SHORT (JM019), a pair of boots which had been worn on 3rd May 2015 by Mr Sheku BAYOH (GAY016 and GAY017) and a pair of boots which had been worn on 3rd May 2015 by PC Craig WALKER (AM001 and AM002).

The productions which were examined and sampled at Cellmark Forensic Services are itemised in Table 1 below.

Table 1: Productions examined and sampled at Cellmark Forensic Services lab, Chorley

Production number	Short descriptions used in this report	Description of origin of production
JM019	The vest	From vest belonging to PC Short
JM019/Area 1	Soil from silver strip	From vest belonging to PC Short
JM019/Area 2	Soil from silver strip near edge of yellow fabric	From vest belonging to PC Short
JM019/Area 3	Soil from yellow fabric	From vest belonging to PC Short
GAY016	Right boot of Mr Bayoh	From right boot belonging to Mr Bayoh
GAY017	Left boot of Mr Bayoh	From left boot belonging to Mr Bayoh
GAY016/Area 1	Soil to toe at welt	From right boot belonging to Mr Bayoh
GAY016/Area 2	Soil at heal of sole	From right boot belonging to Mr Bayoh
GAY017/Area 1	Welt inner aspect mid-section	From left boot belonging to Mr Bayoh
GAY017/Area 2	Sole towards inner aspect of toe area	From left boot belonging to Mr Bayoh
GAY017/recovered soil from I/S of packaging	Soil was recovered from the inner packaging of GAY017/HIH/R1, small clumps of soil	From right boot belonging to Mr Bayoh
AM001/Area 1	Inner aspect upper by opening	From left boot belonging to PC Walker
AM001/Area 2	Sole in arch	From left boot belonging to PC Walker
AM001/Area 3	Sole at toe area	From left boot belonging to PC Walker
AM002/Area 1	Soil at heel	From right boot belonging to PC Walker

Table 2: Documents received at the James Hutton Institute

Date	From	Details
27/07/2022	[redacted] via Connect	PIRC 01176-365 Photographs (pdf)
27/07/2022	[redacted] via Connect	SPA 00025 Left boot acetate lift (pdf)
27/07/2022	[redacted] via Connect	SPA 00024 Right boot acetate lift (pdf)
27/07/2022	[redacted] via Connect	Hearing 1 Instruction for Forensic Expert Substance Analysis Report 16 June 2022 (word)

[redacted]

27/07/2022	[redacted] via Connect	Appendix Productions (Soil Expert) 29 June 2022 copy (word)
27/07/2022	[redacted] via Connect	Within the appendix a link to the Civil Procedure Rules: Part 35 - Experts and Assessors - Civil Procedure Rules (justice.gov.uk)
28/07/2022	[redacted] via Connect	PIRC-00176-Photographs - Expert Witness.pdf
17/08/2022	[redacted]	Bayou - movement of people
17/08/2022	[redacted]	PC Craig Walker boots, Nicole Shorts, police vest, Sheku Bayoh boots information
13/09/2022	[redacted]	SPA-00024 Right boot acetate lift (1).pdf
13/09/2022	[redacted]	SPA-00025 Left boot acetate lift (1).pdf
13/09/2022	[redacted]	SPA-00083 RES_0031 Vest Photo.JPG
13/09/2022	[redacted]	SPA-00084 RES_0032 Vest photo.JPG

7 Use of Assistants

7.1 In undertaking the work in this case I was assisted by other members of the laboratory staff. Their involvement is detailed in the audit trail (Appendix 2), and I have taken their contributions into account when I prepared this statement.

7.2 Mrs Caroline THOMSON, James Hutton Institute, prepared the audit trail and assisted in sample preparation at the James Hutton Institute, Aberdeen. Ms Hannah HOGG, Cellmark Forensic Services, assisted in the sample description and soil recovery in the forensic laboratory at Cellmark Forensic Services, Chorley. Ms Emily HUNTER, Head of Physical Evidence Laboratory, Robert Gordon University, assisted in analysing the samples in the SEM laboratory at Robert Gordon University, Aberdeen. Professor David MILLER, Knowledge Exchange Coordinator, James Hutton Institute, prepared a map of the assumed route walked by Mr Sheku BAYOH on the 3rd May 2015 and conducted an assessment of the type of contact surface material for potential contact along that assumed route. Dr Nicholas SCHURCH (Principal Statistician for Environmental Science and Ecology, Biomathematics and Statistics Scotland) conducted a statistical analysis of the SEM EDXA data (Schurch 2022). Professor Colin CAMPBELL, Chief Executive Officer, James Hutton Institute, conducted critical conclusions check of this report.

7.3 A full record of the work conducted in this case is available for inspection at the James Hutton Institute, Aberdeen.

8 Nature of Examination

8.1 Soil is formed at a particular location as a result of the combined effect of climate, organisms, relief, parent material (geology) and time. The soil organic material is an accumulation of decayed matter such as plants and animals at that location. Soil is composed of minerals and organic material in different proportions (Dawson and Hillier, 2010).

8.2 Soil chemical attributes are characteristic of a sample but are not categoric. Questioned and comparator soils can undergo tests from macroscopic/microscopic examination to inorganic and organic chemical analyses. In this case, the amount of soil stains retained on the questioned item (vest (JM019)) was very small and hence the analysis method available to use on these samples was inorganic elemental composition analysis through SEM EDXA. The inorganic material in a very small sample can be characterised by its relative elemental composition using SEM EDXA, which mainly reflects the inorganic material from which it was derived, and additional chemical material introduced by human activities. SEM also provides a visual presentation of the surface of the sample to allow a comparison of features such as grain size and shape.

8.3 If the results of the tests used between any two samples are similar this indicates that they could have originated from the same place. However, it is also possible that they may be similar to soils from other places and hence comparison with other soils can put the site compared to questioned samples in the context of alternative source locations. If the characteristics of a recovered soil are well outside the range of characteristics of a sample, it may be possible to exclude or rule out that place as the single source of the material.

8.4 In this case question, I was asked to recover and compare the questioned soil samples which were on the vest of PC Nicole SHORT (JM019), with soil samples which were on two pairs of boots. The footwear samples under consideration were the soil samples recovered from the boots worn by Mr Sheku BAYOH (GAY016 and GAY017) and the soil samples recovered from the boots worn by PC Craig WALKER (AM001 and AM002). Trace evidence comparison was assessed according to two recognised schemes (the US Department of Justice scheme and the scheme of Pye (2007), Appendix 9).

8.5 Working with compositional data for statistical summation can be challenging and the dataset generated in this set of analyses has a set of statistical characteristics which requires transformation and expert handling by a statistician. Therefore, the service of an expert statistician was requested to conduct an independent statistical evaluation of the elemental composition data. It was agreed by the Inquiry [redacted] that Dr Nicholas SCHURCH, BioSS would conduct a statistical analysis on the SEM EDXA elemental composition data to examine the core statistical

[redacted]

properties of the data, provide appropriate clustering and produce similarity metrics of the samples with some quantification of the uncertainty of the results (Schurch, 2022).

8.6 The soil samples on the vest were very small (trace in amount) and a direct sampling of the soil onto an SEM stub (Figure 1) was considered the best way to obtain a sample (Pirrie, 2018).

Figure 1: Example SEM stub prior to sample recovery, showing adhesive tape *in situ*

8.7 The samples recovered from the footwear were small to moderate in size. However, as there were uneven surfaces and discrete soil clods adhering to the footwear, the samples from the footwear were recovered using sterile tweezers or brushes and subsequently sampled onto a SEM stub from sterile petri dishes under laboratory conditions.

Note: technical terms are defined in a glossary in Appendix 8.

9 Results

Background information

9.1 Transfer and persistence

9.1.1 I requested, from [redacted] the Sheku Bayoh Public Inquiry, further information about the location of the incident and assumed routes travelled by the two wearers of the two pairs of footwear under investigation on the night in question. I received a file containing the assumed route that Mr Sheku BAYOH took leading up to the incident on Hayfield Road, Kirkcaldy (Table 2).

9.1.2 In the information received, I observed puddles of water sitting on the ground, illustrating that a substantial amount of rain had fallen in the period preceding the incident, and as a result,

[redacted]

the ground surfaces were wet. The main factors that determine the transfer and persistence of soil are length of time after the contact, nature of contact surface, amount of force and duration of contact, and external disturbances following contact (Stella et al., 2020). Soil transfer is typically more effective when soils are wet and saturated (Procter et al., 2019). The amount of soil transferred to footwear has been found to increase with humidity to a maximum depending on the soil type (Werner et al, 2019). In a study by Croft and Pye (2004) where a donor had walked on four types of soil with five different types of shoes, the trace material could be linked to a soil source, although selective transfer would happen. Stoney et al. (2016) investigated the effects of walking sequentially at three different sites with two different types of shoes and showed that soil from the last site visited was always most present on the sole. In general, larger particles are more inclined to decay compared with smaller particles, with a loss of the coarser fractions (sand) (>1 mm in size (Brocard and Peyrot, 2004)), reflecting the variation arising from transfer and persistence as mentioned by Murray and Tedrow (1992).

9.1.3 A study reported soil transfer onto a textile item (a bra) when a body was dragged on the ground. Transfer patterns were observed and were found to be specific to a given source of soil. The quantity of soil transferred to textiles was measured by image processing analysis. Results show that soil type and moisture were the most influential factors on the quantity of soil transferred (Murray et al., 2016).

9.2. Assumed routes travelled

9.2.1 the Inquiry [redacted] informed me that on the 3rd May 2015 PC Craig WALKER was on a mobile patrol in his vehicle on Nicol Street, Kirkcaldy, when he was called to the incident at Hayfield Road, Kirkcaldy at around 07:20 hrs. Therefore, there was limited opportunity for PC Craig WALKER to have contacted soil material prior to the incident. It was established from [redacted] the Inquiry [redacted] that the incident commenced at 07:20 hrs on 3rd May 2015 when the first set of officers arrived and ended at approximately 07:33 hrs on 3rd May 2015.

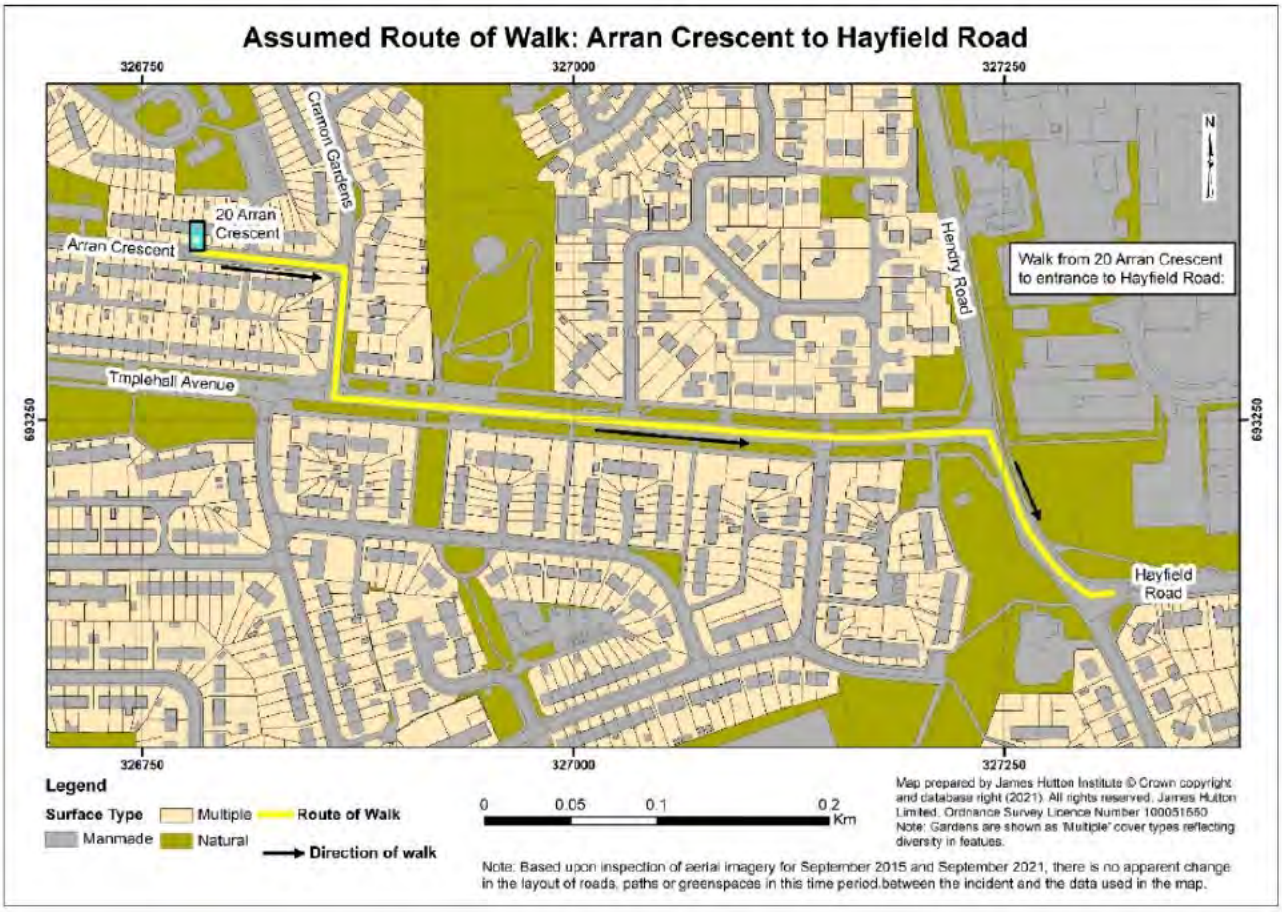
9.2.2 Using the information sent by the Inquiry [redacted], a map was produced to show the assumed route taken by Mr Sheku BAYOH on the morning of 3rd May 2015 (Figure 2). The assumed route was mapped along the middle of the road as there was no information to indicate where Mr Sheku BAYOH had actually walked.

9.2.3 The assumed route taken was estimated by Prof David MILLER to be around 0.67 km long (Figure 2). Based on inspection of aerial imagery from September 2015 and September 2022,

[redacted]

there is no apparent change in the layout of roads, paths, or green spaces in this time period between the incident and the data used in the map.

Figure 2: Assumed route of walk of Mr Sheku BAYOH from Arran Crescent to Hayfield Road, Kirkcaldy.



Source: Professor David Miller, James Hutton Institute

9.3 Soil information

9.3.1 The soil at and around the assumed route taken by Mr Sheku BAYOH was at the side of urban roadways and was classified as man-made urban soil. The assumed route followed by Mr Sheku BAYOH contained grassy verges and areas of planted urban trees (Figure 2, green shading, 'natural' surfaces). The assumed route was assessed and shows that at the edges of the assumed route which was likely walked by Mr Sheku BAYOH at the material time contained c. 60% natural cover for potential exposure to natural surfaces (trees, grass, or bare soil). In line with practice at the time in 2015 for such an incident, no samples were collected along this assumed route following the incident.

[redacted]

9.3.2 No surface soil samples were collected at the incident in 2015. It would not have been expected that soil would have been sampled in 2015. It was not standard procedure at that time for soil samples to be collected at such an incident.

9.3.3 There would be no value in taking such reference samples in 2022 as there would likely have been many vehicles and pedestrians which would have travelled over the location of the incident, potentially transferring soil and associated debris over the 7 years duration, and thus any samples collected in 2022 would be materially different to samples had they been collected in 2015.

Examination and description of productions

9.4 Description and sampling of exhibits examined and sampled

When each item was examined, as per sampling protocols (Dawson, 2022; Pirrie et al., 2021), the whole item was first inspected, inside and out, front, and back, and different aspects and soles of footwear were examined. Areas with noticeable amounts of debris/soil were identified and then sampled, one at a time, changing collection tools between each sample. Each production was examined on a different examination bench. The vest was examined in a different laboratory to avoid any potential cross contamination. Any sample of a different colour or texture was sampled separately, prioritising what appeared to be single source soil samples. Evidence bags were also inspected to check for any loose debris that might have fallen off the items.

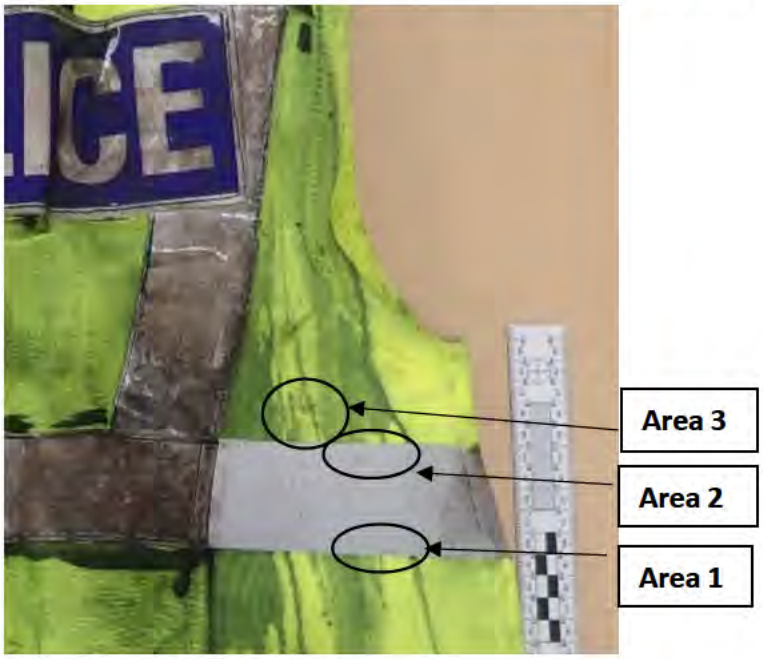
The productions examined are itemised in Table 1 and the images of the productions examined are in Appendix 3.

9.4.1 Vest worn by PC Nicole SHORT (JM019)

9.4.1.1 When we examined the productions in 2022, the vest worn by PC Nicole SHORT (Figure 3 and in Appendix 3: Figure 3.25) was heavily stained with fingerprint powder which had been applied after it had been initially photographed in 2015 (Appendix 3: Figure 3.24) prior to our examination in 2022.

[redacted]

Figure 3: Cropped image of production JM019 (vest belonging to PC Nicole Short) as viewed at Cellmark Forensic Services, Chorley, August 2022, showing areas of the vest where samples were recovered from



9.4.1.2 The vest was in a good general condition. No obvious damage was seen. Some pilling was noticed at the bottom hem. All outer surfaces were examined for any deposits that appeared like soil and the only areas with visible potential soil deposits were on the outside on the back right-hand side, below the armpit. No deposits were observed to be within the foot of the evidence bag.

9.4.1.3 Three areas were identified on the outside of the vest (Figure 3). These were all on the back, right hand side region of the vest, and were subsequently sampled (Table 1 and Appendix 3: Figures 3.26, 3.27 and 3.28). Area 1 (Silver strip) was on the lower edge of the silver strip. Area 2 (Silver strip near edge of yellow fabric) was on the upper edge of the silver strip, below the armpit. Area 3 (from yellow fabric) was on the yellow fabric above the silver strip, below the armpit (Figure 3).

9.4.1.4 A swab was taken of the powder *in situ* on the vest and was subsequently transferred onto a SEM stub and used as a background value for subtraction of chemical values from all SEM samples to minimise any effect from the applied powder on the questioned items.

[redacted]

9.4.2 Boots worn by Mr Sheku BAYOH (GAY016 (right boot) and GAY017 (left boot))

The pair of boots worn by Mr Sheku BAYOH (GAY016 and GAY107) were in a good general condition with no obvious damage. Soil was noticeably present on both the left and right boots mainly on the welts and the soles (Appendix 3: Figures 3.10 to 3.23). No deposits were observed in the foot of the evidence bags.

9.4.2.1 GAY016 (right boot)

All accessible surfaces were examined visually for soil deposits. Soil was observed on the heel and uppers, outer and inner aspects of the welt and the heel and the mid area of the toe on the sole (Appendix 3). Two soil samples were recovered for further analysis from this item (Area 1 - toe at welt and Area 2 – heel of sole).

9.4.2.2 GAY017 (left boot)

All accessible surfaces were examined visually for soil deposits. Soil was observed on the inner aspect, outer aspect of uppers, the inner aspect of the welt, the outer aspect of the welt and the toe area of the welt and the arch and front area of the sole (Appendix 3). The inner packaging contained clumps of soil which were recovered into a separate production vial. Two soil samples were recovered for further analysis from this item (Area 1 - welt inner aspect mid-section and Area 2 - sole towards inner aspect of toe area).

9.4.3 Boots worn by PC Craig WALKER (AM001 (left boot) and AM002 (right boot))

The pair of boots belonging to PC Craig WALKER (AM001 and AM002) were in a fair condition with slight wear to the leather upper of the toe area. No obvious other damage was noted. There was slight soil staining to the boots, mainly on the soles (Appendix 3: Figures 3.1 to 3.9). No deposits were observed within the foot of the evidence bags.

9.4.3.1 AM001 (left boot)

All accessible surfaces were examined visually for soil deposits. Soil staining was observed at the inner aspect by the opening, the arch area, and the toe area of the sole (Appendix 3). Three samples were recovered for potential analysis from this item (Area 1 – inner aspect upper by opening, Area 2 - sole in arch and Area 3 - at sole at toe area). On examination in the laboratory 236, James Hutton Institute, sample AM001/Area 3 (Sole at toe area) was the only sample from this item that was large enough for examination and subsequent analysis.

9.4.3.2 AM002 (right boot)

All accessible surfaces were examined visually for soil deposits. Soil staining was observed at the outer aspect of the welt and slight staining to the toe and arch areas of the sole (Appendix 3). One sample was large enough to be recovered for potential subsequent analysis from this item (Area 1 - soil at heel).

Examination and analysis of samples

9.5 Samples were examined and considered for the most appropriate method using a recognised scheme (ENFSI, 2019). Samples which appeared to contain enough soil for subsequent analysis were examined individually under a light microscope and subsequently under a Scanning Electron Microscope (SEM) as itemised below (Table 3).

Table 3: Sample identifiers with a moderate amount of soil present for SEM EDS analysis.

Lab code	Sample name	Where from
1367039, referred to as 39	AM001/Area 3	Sole at toe area of PC Walker's left boot
1367040, referred to as 40	AM002/Area 1	Soil at heel of PC Walker's right boot
1367041, referred to as 41	GAY016/Area 1	Soil to toe at welt S Bayoh's right boot
1367042, referred to as 42	GAY016/Area 2	Soil at heel of sole S Bayoh's right boot
1367043, referred to as 43	GAY017/Area 1	Welt inner aspect mid-section of S Bayoh's left boot
1367044, referred to as 44	GAY017/Area 2	Sole towards inner aspect of toe area of S Bayoh's left boot
1367045, referred to as 45	JM019/Area 1	Soil from silver strip from PC Short's Vest
1367046, referred to as 46	JM019/Area 2	Soil from silver strip near edge of yellow fabric from PC Short's Vest
1367047, referred to as 47	JM019/Area 3	Soil from yellow fabric from PC Short's Vest
1367048, referred to as 48	Control swab of powder from silver fabric from vest	Control swab of black powder from silver fabric from vest

9.6 Scanning Electron Microscopy Energy Dispersive X-Ray Analysis (SEM EDXA) was conducted on all samples (Table 3: lab codes ending in 39 to 47). The control swab (lab code ending in 48) was also analysed using SEM EDXA, and was shown to contain the elements carbon, oxygen and iron which were subtracted from any subsequent analysis, as these were shown to be present in the black fingerprint powder substance on PC Nicole SHORT's vest (JM019) which had been applied after the incident.

9.7 SEM produces images of a sample by scanning the surface with a focussed beam of electrons. The primary electrons enter the surface of the sample and generate many low energy electrons and an image of the sample can be constructed by measuring secondary electron intensity (e.g. Figures 4a to 4e).

10 Data and Evaluation

10.1 The three recovered questioned samples (JM019/Area 1, JM019/Area 2, and JM019/Area 3) from the vest worn by PC Nicole SHORT were considered individually and compared with the individual samples recovered from the two pairs of footwear.

10.1.1 Appendix 4 (and figures 4a to 4c in the body of text) presents some of the SEM sample images of the vest samples. These show that the samples recovered from the vest worn by PC Nicole SHORT were generally fine grained in texture, although the particles in sample JM019/Area 2 (Soil from silver strip near edge of yellow fabric) were larger and more rounded in shape compared with the other questioned samples (Figure 4b).

10.1.2 The samples recovered from the boots belonging to PC Craig WALKER were very small in amount and were generally much coarser grained in texture (Figure 4e) than the samples recovered from the vest (Figures 4a and 4c) and Figures in Appendix 4. The boots of PC Craig WALKER also contained fragments of dead vegetation.

10.1.3 The samples recovered from the boots belonging to Mr Sheku BAYOH were large in amount and contained, in general, fine textured material (Figure 4d and Figures in Appendix 4) and were similar in appearance to what was observed to be in some of the samples from the vest worn by PC Nicole SHORT (JM019) (Figures 4a and 4c).

Figure 4a: Example of a SEM image of Sample 45 (x80 mag) (JM019/Area 1 (Soil from silver strip) from vest JM019)

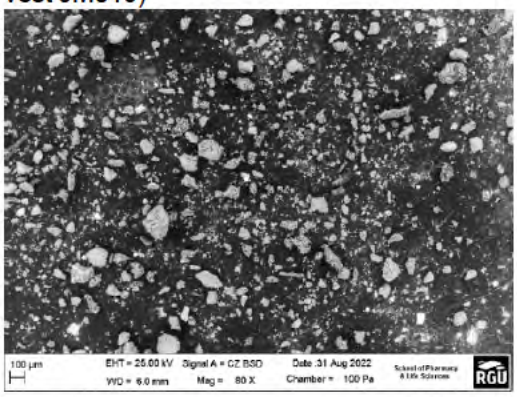


Figure 4b: Example of a SEM image of Sample 46 (x80 mag) (JM019/Area 2 (Soil from silver strip near edge of yellow fabric) from vest JM019)

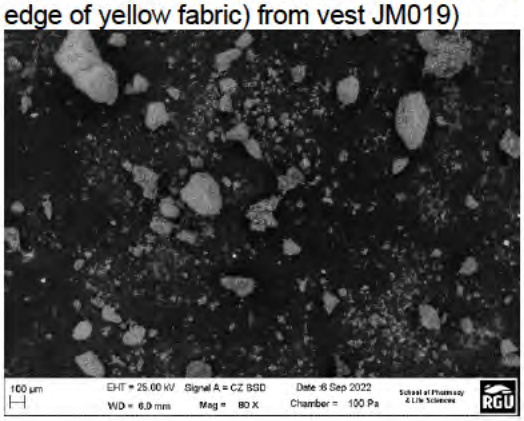
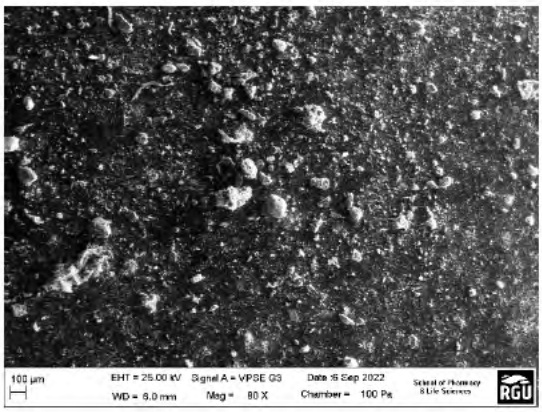


Figure 4c: Example of a SEM image of Sample 47 (x80 mag) (JM019/Area 3 (Soil from yellow fabric) from vest JM019)



[redacted]

Figure 4d: Example of a SEM image of Sample 44 (x80 mag) (GAY017/Area 2 (Sole towards inner aspect of toe area) from Mr Sheku Bayoh left boot)

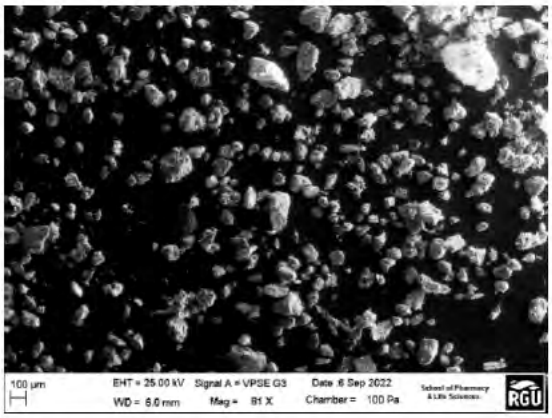
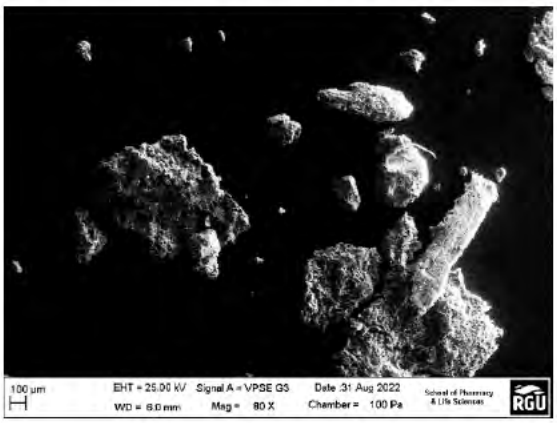


Figure 4e: Example of a SEM Variable Pressure mode image of Sample 39 (x80 mag) (AM001/Area 3 (Sole at toe area) from PC Craig Walker's left boot))



100 microns = 0.1 millimetres; 1000 microns = 1 millimetre

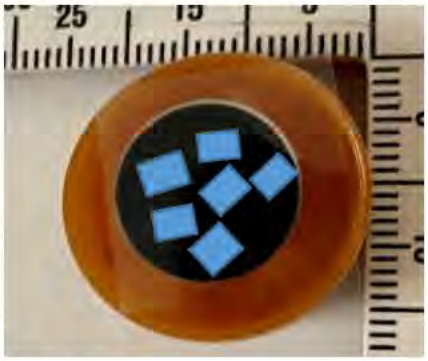
10.2 The Energy Dispersive X-ray Analyser (EDXA) was used to capture the relative elemental composition of each sample.

10.2.1 In addition to low energy secondary electrons, backscattered electrons and X-rays are generated by the primary electron bombardment using SEM EDXA. The intensity of backscattered electrons is correlated to the atomic number of the elements within the sampling volume. Elements in a sample can be distinguished as every element has its own X-ray spectrum which they emit after interacting with the electrons. The analysis of characteristic X-rays emitted from the samples gives the elemental composition information for the sampled area under analysis.

[redacted]

10.2.2 Relative elemental composition profiles were measured on six replicate areas of the surface of the sample stubs (Figure 5) for each of the soil samples examined, using SEM EDXA (Appendix 5). The composition of the black powder could have contaminated the samples recovered from the vest. The elements which were detected in the swab sample taken from the areas of black powder on the vest (carbon, oxygen, and iron) were analysed and subtracted in the computer software to minimise any interaction with the substrate on the vest. This black powder material did not appear to be on the vest in 2015 when it was photographed (Appendix 3: Figure 3.24). Figures presented in section 10 show the relative contribution of all the elements measured without carbon, oxygen, and iron. The element silica is generally found associated with quartz sand grains (silica and oxygen) and aluminium is one of the most common elements found in soil. Histograms were therefore prepared with silica and aluminium included and also with those elements removed to allow the differences in the lesser represented elements to be observed.

Figure 5: Example SEM stub showing an example of 6 replicate areas (blue rectangles of the sample surface as analysed using the Energy Dispersive X-ray spectroscopy analysis

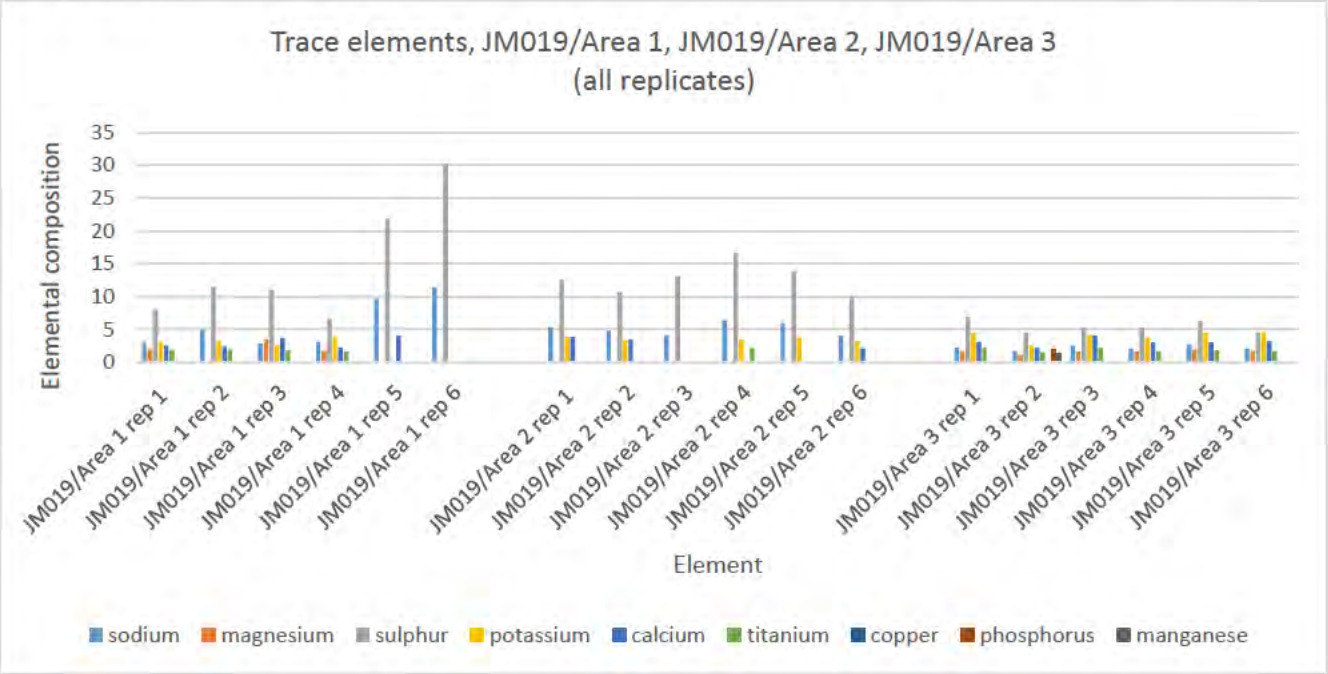


The full elemental composition data are presented in Appendix 5. Individual charts of specific sample comparisons discussed are presented below.

10.2.3 Sample JM019/Area 1 was heterogeneous in nature (Figure 6 and Figure 9). Some of the replicates of sample JM019/Area 1 (replicates 1, 3 and 4) are similar to most of the replicates in sample JM019/Area 3 (apart from replicate 2). Sample JM019/Area 1 appeared to have material from more than one source and could be the result of washed material from debris above its position on the vest.

[redacted]

Figure 6: Trace element composition of the three questioned samples recovered from PC Nicole Short's vest (JM019)

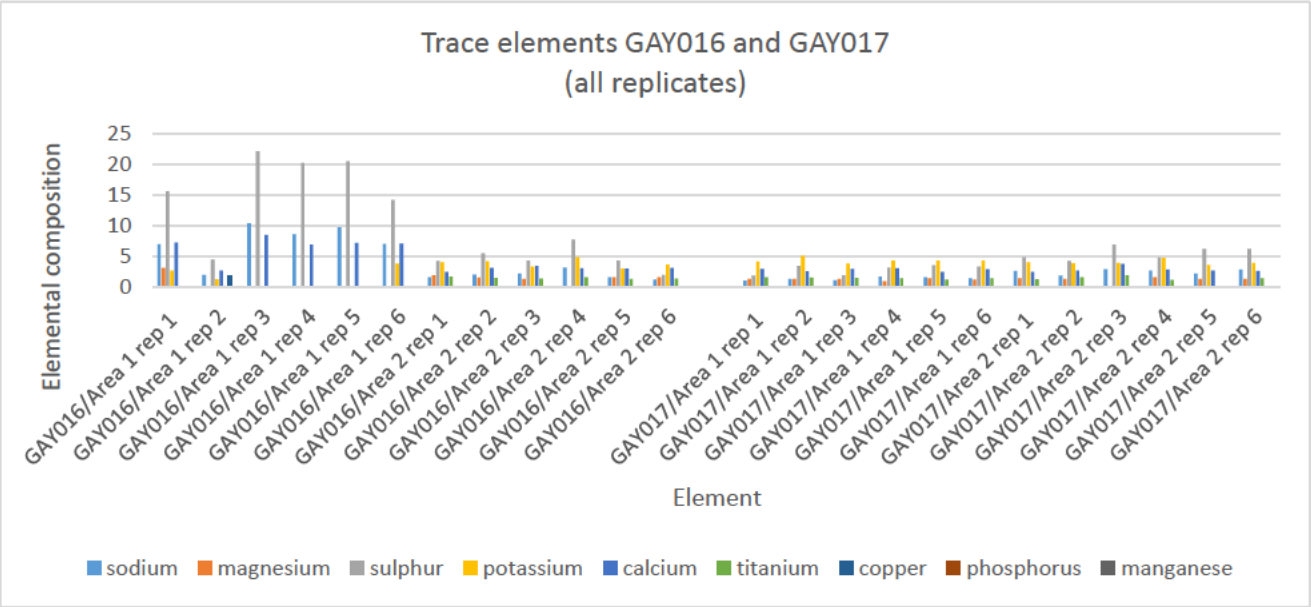


Samples JM019/Area 2 and JM019/Area 3 were more homogeneous and likely originated from predominantly single sources.

Samples JM019/Area 1 and JM019/Area 2 contained higher relative contributions from sodium and sulphur, possibly from the road surface, while JM019/Area 1 (replicates 1 to 4) and JM019/Area 3 had wider elemental profiles characteristic of soil.

[redacted]

Figure 7: Trace element composition of the four samples from Mr Sheku Bayou's boots

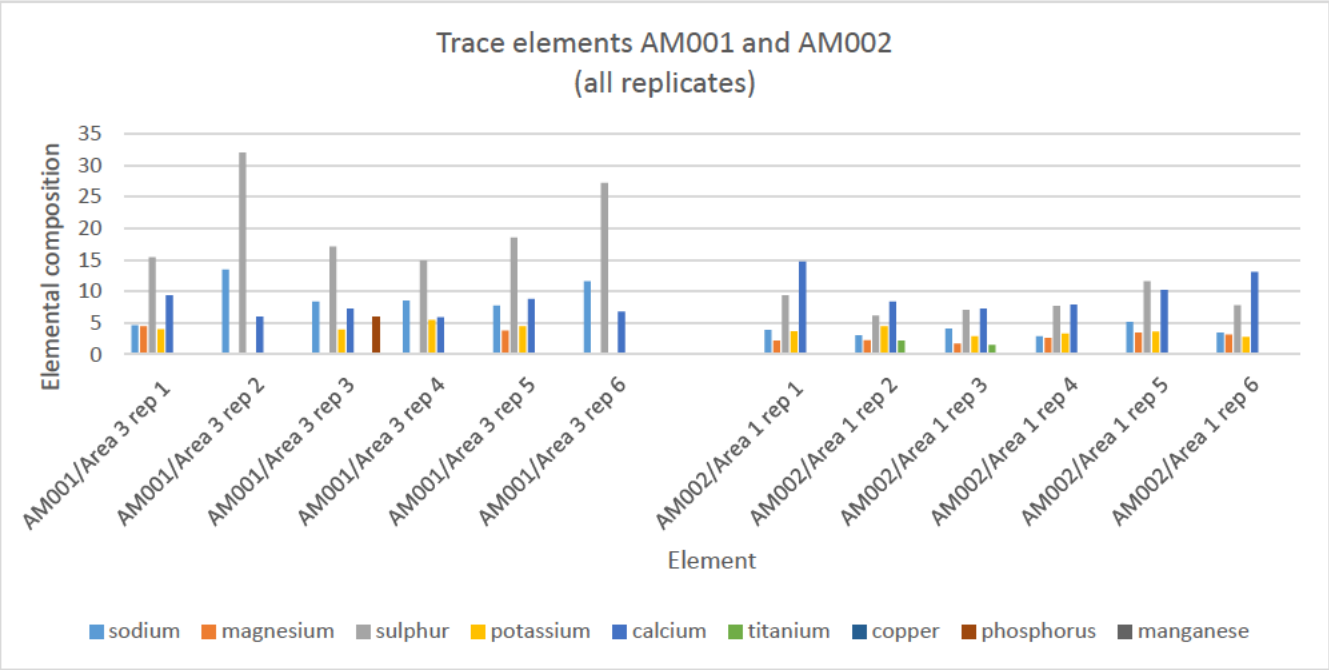


10.2.4 Three of the samples recovered from Mr Sheku BAYOH's boots are overall similar to each other (GAY016/Area 2, GAY017/Area 1, and some of the replicates in GAY017/Area 2) (Figure 7).

GAY016/Area 1 is different to the other samples recovered from the footwear worn by Mr Sheku BAYOH, and shows a greater relative contribution of the elements sulphur, sodium, and calcium. These elements may have originated from the road surface. Replicate 2 from sample GAY016/Area 1 is an outlier.

[redacted]

Figure 8: Trace element composition of the two samples from PC Craig Walker's boots



10.2.5 The samples recovered from PC Craig WALKER's boots (AM001/Area 3 and AM002/Area 1) (Figure 8) have some consistent differences. AM001/Area 3 has greater proportions of sulphur and sodium, again likely originating from the ground surface.

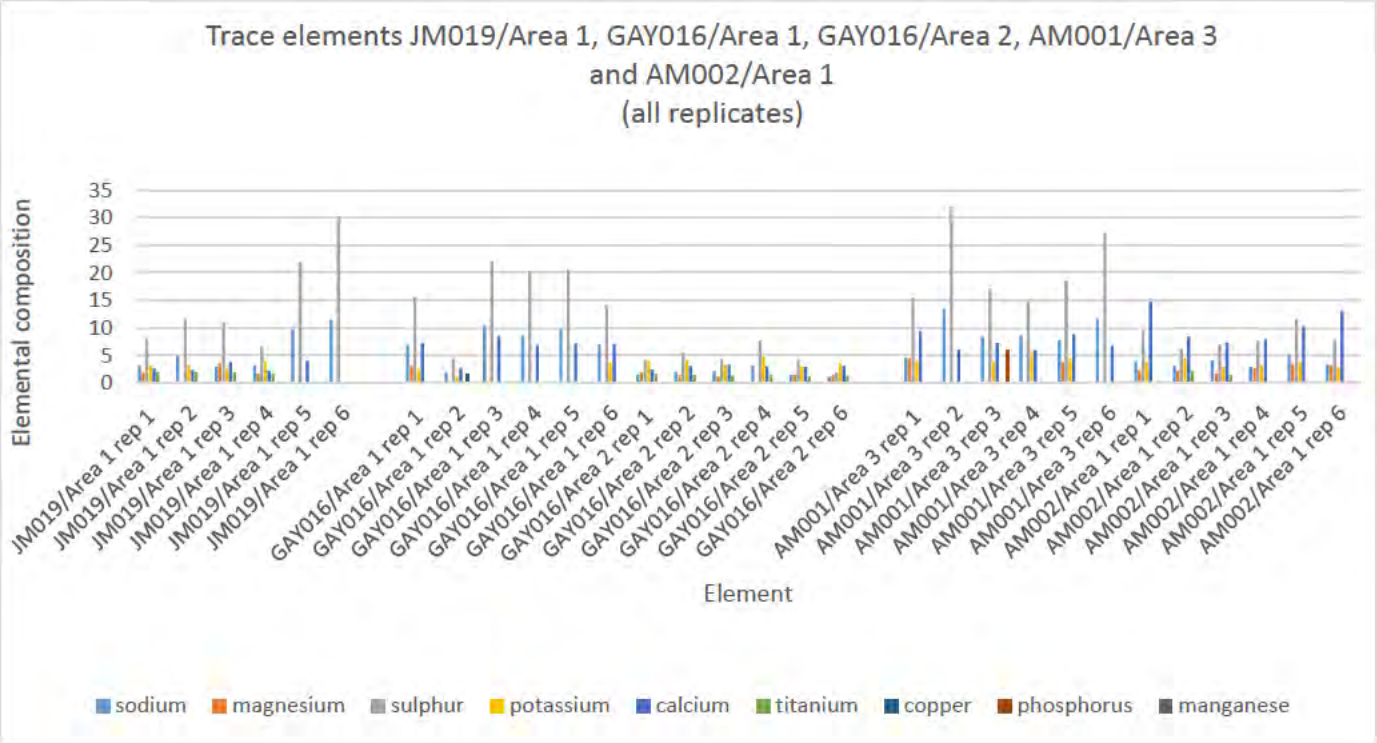
10.2.6 Sample JM019/Area 1 (Soil from silver strip) from vest worn by PC Nicole SHORT
Some soil samples from the footwear have different elemental composition profiles to sample JM019/Area 1. The relatively high sulphur and sodium in JM019/Area 1 (in replicate 5) are similar to that in sample GAY016/Area 1 (in replicates 3, 4 and 5) and AM001/Area 3 (in replicates 2 and 6) (Figure 9). Replicate 6 in JM019/Area 1 is an outlier.

Sulphur dioxide is known to combine with nitrogen oxides and ammonia to form particulate matter (Gov, UK, 2022), suggesting a potential source for the greater relative contribution of sulphur in these samples. The higher levels of sodium seen in these samples could have originated from applied road salt (sodium chloride).

Replicate samples 1, 3 and 4 of sample JM019/Area 1 have a wider distribution of elements and are in general similar to replicates 1 and 2 in sample GAY016/Area 2 (Figure 9).

[redacted]

Figure 9: Trace element composition of sample JM019/Area 1 (Soil from silver strip) of vest worn by PC Nicole Short compared with trace element composition of samples GAY016/Area 1, GAY016/Area 2, AM001/Area 3, and AM002/Area 1



10.2.7 Sample JM019/Area 2 (Soil from silver strip near edge of yellow fabric)

There is a relatively small amount of variation in the sample replicates in this sample, suggestive of a single source.

Soil samples from the footwear have in general different elemental composition profiles to sample JM019/Area 2 (Appendix 5: Figures 5.1d, 5.1e and 5.1f).

All sample replicates of JM019/Area 2 have relatively high contributions from sodium and sulphur. Their source may have been from road surface materials such as with JM019/Area 1 replicates 5 and 6, and AM001/Area 3 replicates 2 and 6, and GAY016/Area 1 replicates 3, 4 and 5.

10.2.8 Sample JM019/Area 3 (Soil from yellow fabric of vest)

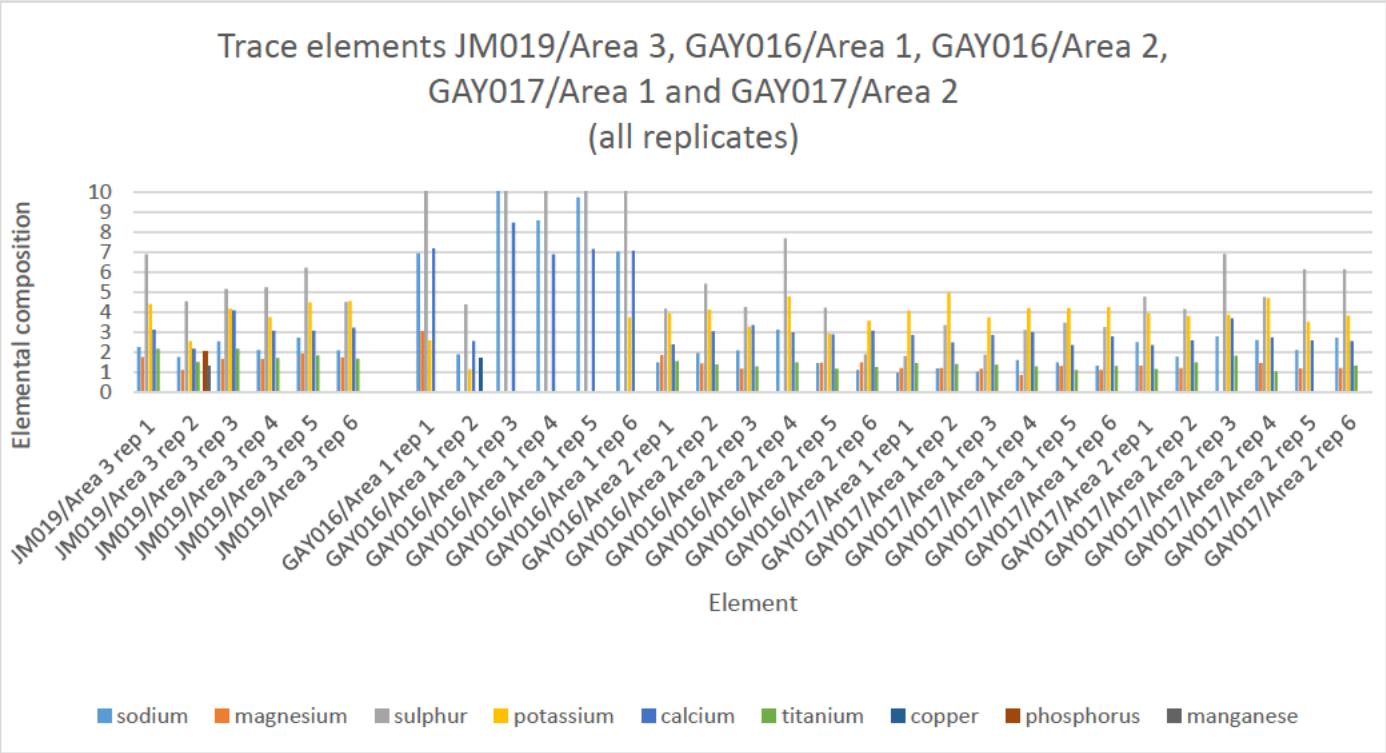
There is a small amount of variation in the sample replicates in this sample, suggestive of a single source. Replicate 2 JM019/Area 3 is an outlier.

[redacted]

Some soil samples from the footwear have different elemental composition profiles to sample JM019/Area 3 (Appendix 5: Figures 5.1g, 5.1h and 5.1i).

Sample JM019/Area 3 is similar to GAY016/Area 2, GAY017/Area 1 and to a lesser extent GAY017/Area 2 (replicates 1, 2 and 4) Figure 10. There is some variation within the replicates from the footwear, with magnesium not being detected within their elemental compositions of GAY016/Area 2 replicate 4 and GAY017/Area 2 replicate 3.

Figure 10: Trace element composition of sample JM019/Area 3 (Soil from yellow fabric) of vest worn by PC Nicole Short) compared with trace element composition of samples GAY016/Area 1, GAY016/Area 2, GAY017/Area 1, and GAY017/Area 2



10.2.9 Both soil samples recovered from the boots worn by PC Craig WALKER (AM001/Area 3 and AM002/Area 1) were different in relative elemental composition to sample JM019/Area 3 and can be excluded as sharing a common origin with JM019 Area 3 (Appendix 5: Figures 5.1g, 5.1h and 5.1i).

10.2.10 The soil sample from (JM019/Area 3) had a trace elemental profile that was different and could be excluded as sharing a common origin with AM001/Area 3, AM002/Area 1, and also GAY016/Area 1(Appendix 5: Figures 5.1g, 5.1h and 5.1i and Figure 10 above).

[redacted]

All replicate samples from AM001/Area 3 and AM002/Area 1 had relatively high levels of calcium (Ca) as did GAY016/Area 1. All replicates of JM019/Area 3 had low levels of calcium as did three of the soil samples from the boots worn by Mr Sheku BAYOH (GAY016/Area 2, GAY017/Area 1, and GAY017/Area 2).

10.2.11 Three soil samples recovered from the boots worn by Mr Sheku BAYOH (GAY016/Area 2, GAY017/Area 1 and to a lesser extent GAY017/Area 2) could not be excluded as sharing a common origin with soil sample JM019/Area 3. These soil samples originated from the heel of the sole of Mr Sheku BAYOH's right boot (GAY016/Area 2), the soil at the welt inner aspect mid-section of Mr Sheku BAYOH'S left boot (GAY017/Area 1) and the sole towards the inner aspect of the toe area (GAY017/Area 2) of Mr Sheku BAYOH's left boot.

10.2.12 However, it is possible that soil sample JM019/Area 3 may be similar to soils from other places and comparison with other soils can put the comparison to questioned samples in the context of alternative source locations. This was not possible in this case due to the passage of time since the incident in 2015.

10.2.13 Working with compositional data for statistical summation can be challenging and the dataset has a set of statistical characteristics which requires transformation and expert handling by a statistician. Therefore, the service of an expert statistician was requested to conduct an independent statistical evaluation of all the elemental composition data (Schurch, 2022).

10.3 Statistical evaluation of the elemental composition data

10.3 The soil elemental composition statistical similarity assessment report provided by Dr Nicholas SCHURCH (2022) describes an independent statistical analysis of the elemental compositional data generated. I provided the verified elemental compositional data to Dr Nicholas SCHURCH. The statistical analysis involved an assessment of the dataset, appropriate quantification of the uncertainties in the dataset, data transformation, hierarchical sample clustering using an appropriate distance metric and Principal Component Analysis (PCA). A threshold-based null hypothesis test was also used to categorize whether the questioned soils (JM019/Areas 1, 2 and 3) are consistent with, or inconsistent with, a common origin with the reference soil samples from the footwear. For maximum transparency, Dr Nicholas SCHURCH conducted the analysis with the open source, freely available, statistical software package R, using open source, freely available statistical and visualization libraries.

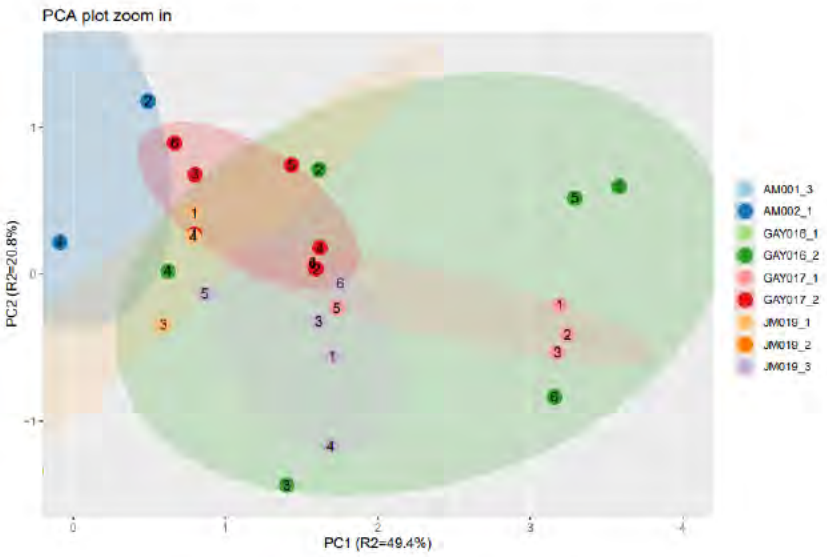
10.3.1 JM019/Area 1. The findings of Dr Nicholas SCHURCH generally support my findings. He says that the JM019/Area 1 replicates are from a heterogeneous sample with some similarities to several of the known samples in this examination. In his opinion the soil sample JM019/Area 1 is most similar to samples GAY016/Area 1 and to GAY016/Area 2 which are both soils from the item of footwear (GAY016, the right boot of Mr Sheku BAYOH) and is consistent with sharing a common origin with soils from these locations.

Dr Nicholas SCHURCH says that JM019/Area 1 sample is also consistent with sharing a common origin with AM002/Area 1 soil. Replicates 2, 3 and 4 of AM002/Area 1 are located near to JM019/Area 1 on the PCA plot (Figure 11).

However, the AM002/Area 1 replicates consistently have more calcium represented in their profile than JM019/Area 1. The AM002/Area 1 replicates are also coarser grained than the JM019/Area 1 sample replicates. Therefore I exclude sample AM002/Area 1 as sharing a common origin with JM019/Area 1.

Dr Nicholas SCHURCH states that the replicates from JM019/Area 1 are not tightly clustered, suggesting that these samples are heterogeneous, either because the soil in the sample is from a single source that is naturally heterogeneous or because the soil at JM019/Area 1 is from mixed origins.

Figure 11: PCA statistical plot zoomed in section. Taken from page 17 SCHURCH (2022)



[redacted]

10.3.2 JM019/Area 2. The findings of Dr Nicholas SCHURCH support my findings. He states that the JM019/Area 2 replicates are from a relatively homogeneous sample that appears to be distinct from the other samples in this examination (Schurch, 2022). Replicates from JM019/Area 2 cluster tightly, and are well separated from the other samples, suggesting a separate origin for this soil, and not from the footwear under examination as a single source. The JM019/Area 2 soil is not consistent with sharing a common origin with any of the soils examined here as a single source. Data is not shown for sample JM019/Area 2 on Figure 11 above.

10.3.3 JM019/Area 3. The findings of Dr Nicholas SCHURCH in general support my findings. He states that the JM019/Area 3 replicates are from a homogeneous sample with similarities to several of the known samples in this examination (purple symbols, Figure 11) and sit firmly within the GAY016/Area 2 ellipse (dark green symbols, Figure 11). The sample is most similar to the GAY016/Area 2 (dark green symbols, Figure 11) and the GAY017/Area 1 samples (light pink symbols, Figure 11), which are soils from the right and left boot of Mr Sheku BAYOH, and is consistent with sharing a common origin with these soils. He states that sample JM019/Area 3 also shows some similarity to some of the GAY017/Area 2 replicates (red symbols, Figure 11).

10.3.4 Dr Nicholas SCHURCH concludes that the JM019/Area 3 replicates cluster (purple symbols, Figure 11) and overlaps strongly with the clustering of GAY016/Area 2 (green symbols, Figure 11), GAY017/Area 1 (pink symbols, Figure 11) and, to a lesser degree, GAY017/Area 2 (red symbols, Figure 11). He concludes that the JM019/Area 3 sample is consistent with sharing a common origin with the GAY016/Area 2 and GAY017/Area 1 samples.

11 Conclusions and Opinion

11.1 JM019/Area 1 (Soil from silver strip) from PC Nicole SHORT's vest

In my opinion, the physical and chemical characteristics of some of the samples from Mr Sheku BAYOH's right boot (GAY016/Area 1 and GAY016/Area 2) shared some characteristics of some of the replicates of the questioned sample from PC Nicole SHORT's vest (JM019/Area 1: Figure 12) also with some features which suggests a possible contributory origin from substrates from the road surface (i.e. relatively high sulphur potentially from car exhausts and relatively high sodium, potentially from applied salt).

11.1.1The possibility that some of the material recovered from the sample JM019/Area 1 (Soil from silver strip) from PC Nicole SHORT's vest originated from the same source as some of the

material from GAY016/Area 1 and some of the material from GAY016/Area 2 (right boot of Mr Sheku BAYOH) cannot be eliminated.

11.1.2 Dr Nicholas SCHURCH supports these findings by concluding that sample JM019/Area 1 is consistent with sharing a common origin with soil from Mr Sheku BAYOH's right boot (GAY016/Area 1 and GAY016/Area 2) and that soil sample JM019/Area 1 is most similar to samples GAY016/Area 1 and GAY016/Area 2, which are both soils from a similar location (the right boot of Mr Sheku BAYOH).

Figure 12: Close up of sample JM019/ Area 1 (Soil from silver strip) from PC Nicole Short's Vest, magnified image, scale bar in mm

11.1.3 Dr Nicholas SCHURCH also states that some of the replicates in JM019/Area 1 were similar to AM001/Area 3 soil replicates (reps 2 and 6), with relatively high levels of sodium, sulphur, and calcium. However, the AM002/Area 1 replicates consistently have more calcium represented in their profile than JM019/Area 1 and the grain sizes and shapes are different in the AM001/Area 3 and AM002/Area 1 soils.

11.1.4 In my opinion some of the material in the soil deposit (JM019/Area 1) recovered from the silver strip of the vest worn by PC Nicole SHORT (JM019) is consistent with sharing a common origin with the some of the material in the soil deposit recovered from the boots of Mr Sheku BAYOH (GAY016/Area 1 and GAY016/Area 2). It also has similar grain shape and size and similar elemental compositions as some of the replicates in the soil deposits recovered from the boots of Mr Sheku BAYOH (GAY016/Area 1 and GAY016/Area 2).

[redacted]

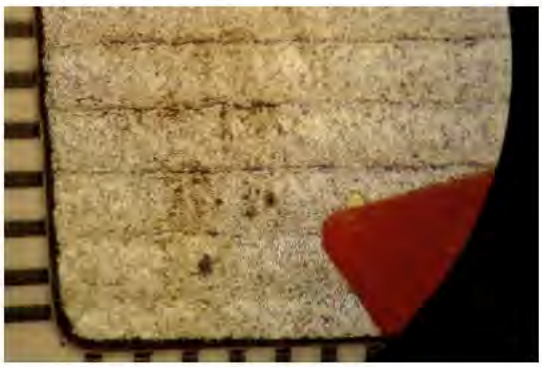
11.1.5 However, as this sample JM019/Area 1 is likely from more than one source, the overall conclusions from this sample comparison is 'very limited' support for the proposition that the soil deposit (JM019/Area 1) from the silver strip of the vest worn by PC Nicole SHORT (JM019) could have shared a common origin with the soil recovered from the right boot of Mr Sheku BAYOH (GAY016/Area 1 and GAY016/Area 2).

11.2 JM019/Area 2 (Soil from silver strip near edge of yellow fabric) from vest worn by PC Nicole SHORT

In my opinion, the material in sample JM019/Area 2 (Figure 13) is different to all the sample soils recovered from the questioned footwear (GAY016, GAY017, AM001 and AM002) in elemental composition and likely originated from another unknown location.

11.2.1 Dr Nicholas SCHURCH (2022) supports these findings and concluded that JM019/Area 2 is distinct and is not consistent with sharing a common origin with any of the soils from the footwear examined.

Figure 13: Close up of sample JM019 Area 2 (Soil from silver strip near edge of yellow fabric) from PC Nicole Short's Vest, magnified image, scale bar in mm



11.2.2 In my opinion the possibility that the material JM019/Area 2 (Soil from silver strip near edge of yellow fabric) originated, as a single source, from the same source as any of the material recovered from the footwear of Mr Sheku BAYOH examined is eliminated.

11.2.3 In my opinion the possibility that the material JM019/Area 2 (Soil from silver strip near edge of yellow fabric) originated, as a single source, from the same source as any of the material recovered from the footwear of Mr PC Craig WALKER examined is eliminated.

[redacted]

11.3 JM019/Area 3 (Soil from yellow fabric) from vest worn by PC Nicole SHORT
Both soils recovered from the boots worn by PC Craig WALKER (AM001/Area 3 and AM002/Area 1) were different in physical and chemical (elemental composition) characteristics to soil sample JM019/Area 3 (Appendix 4) and could be excluded as sharing a common origin.

11.3.1 The possibility that the soil from JM019/Area 3 originated from the same source as AM001/Area 3, AM002/Area 1 and GAY016/Area 1 is eliminated.

11.3.2 Sample JM019/Area 3 was similar in physical and chemical characteristics (elemental composition) to three samples from the footwear worn by Mr Sheku BAYOH (GAY016/Area 2, GAY017/Area 1 and to a lesser extent, GAY017/Area 2) in their physical and elemental compositions.

11.3.3 The soil sample GAY017/Area 1 (Welt inner aspect mid-section) left boot Mr Sheku BAYOH (Figure 18) appeared to be particularly large in amount.

Figure 14: Close up of sample JM019/Area 3 (Soil from yellow fabric) from vest worn by PC Nicole Short, magnified image, scale bar in mm

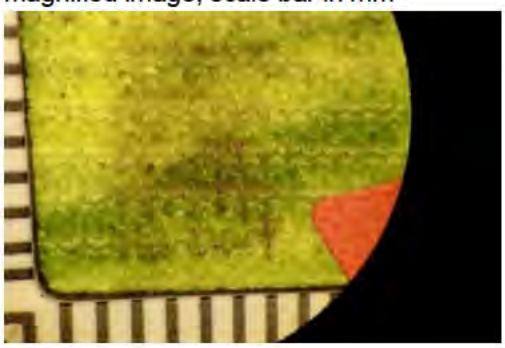


Figure 15: Sample GAY016/Area 1 (Soil to toe at welt) from right boot Mr Sheku Bayoh, magnified image

[redacted]

Figure 16: Sample GAY016/Area 2 (Soil at heel of sole) from right boot Mr Sheku Bayoh

Figure 17: Sample GAY017/Area 1 (Welt inner aspect mid-section) from left boot Mr Sheku Bayoh, magnified image

Figure 18: Sample GAY017/Area 1 (Welt inner aspect mid-section) from left boot Mr Sheku Bayoh

Figure 19: Sample GAY017/Area 2 (Sole towards inner aspect of toe area) from left boot Mr Sheku Bayoh magnified image

[redacted]

11.3.4 Dr Nicholas SCHURCH's findings (2022) from his statistical analysis is that JM019/Area 3 is consistent with sharing a common origin with soil from GAY016/Area 2 (right boot of Mr Sheku BAYOH) and soil from GAY017/Area 1 (left boot of Mr Sheku BAYOH), which supports my conclusions.

11.3.5 The soil deposit (JM019/Area 3) recovered from the yellow fabric of the vest worn by PC Nicole SHORT (JM019) is consistent with sharing a common origin with the soil recovered from the boots of Mr Sheku BAYOH (GAY016 (GAY016/Area 2) and GAY017 (GAY017/Area 1) in physical and chemical characteristics.

11.3.6 The results provide 'limited to moderate' support for the proposition that some of the material recovered from JM019 (JM019/Area 3) shared a common origin with the soil recovered from the boots of Mr Sheku BAYOH (GAY016 (GAY016/Area 2)) and (GAY017 (GAY017/Area 1)).

12 Caveats and overall Conclusions

12.1 There was a very small amount of material adhering to the vest. The material adhering to the vest was potentially compromised by the application of fingerprint powder, although this effect was minimised through the subtraction of the chemical composition of the fingerprint powder. As a result, only microscopy could be used in the soil examination and analysis, with no assessment possible of the organic component in the samples.

12.2 No sampling of the substrate on the ground was conducted at the incident location at the material time. Nor was any sampling conducted along the assumed route walked. These could have been used to evaluate the likely source of the soils on the footwear in question, and could have provided alternative source propositions, although with the passage of time it is no longer possible. It would not have been normal practice to sample the site of the incident in 2015.

12.3 There can be transfer and persistence issues in comparing samples recovered from the vest (in general finer particles remaining and coarser sized grains potentially falling off after transfer) with reference samples consisting of whole soil aggregates. There were in general clods (aggregates) within the tread of the footwear which would contain a wider range of particle sizes in the source sample, compared with material still adhering to fabric, where selective transfer may have taken place. However, despite these potential selective transfer and

persistence effects, similarities in sample characteristics were found.

12.4 Questioned sample JM019/Area 1 appears to be a mixture of sources, while samples JM019/Area 2 and JM019/Area 3 both appear to be predominantly single source substrates and therefore the results obtained for sample JM019/Area 1 (mixture) should be restricted in its evaluative significance.

12.5 As a result of the limited sample size of the questioned samples available, and the compositional nature of the elemental data (being the only data available for comparison between samples), the evidential value of any testing of the proposition that the soil recovered from the vest could have shared a common origin with samples recovered from the two pairs of footwear is restricted to limited to moderate support.

12.6 Despite these caveats, for any test of a comparison between the questioned samples recovered from the vest and the reference samples recovered from the footwear, my main overall evidential findings were that:

- **The possibility that the soil deposit (JM019/Area 3) recovered from the vest worn by PC Nicole SHORT (JM019) originated from the same source as soil from GAY016/Area 2 (right boot of Mr Sheku BAYOH) and GAY017/Area 1 (left boot of Mr Sheku BAYOH) soils cannot be eliminated. This conclusion is reached when the questioned material cannot be differentiated from the exemplar using all observed or measured characteristics.**

- **The very small amount of soil recovered from JM019/Area 3 provides limited to moderate support for the proposition that some of the material recovered from JM019 (JM019/Area 3) shared a common origin with some of the soil recovered from the boots worn by Mr Sheku BAYOH (GAY016 (GAY016/Area 2)) and (GAY017 (GAY017/Area 1)).**

- **The possibility that the soil deposit (JM019/Area 3) recovered from the vest worn by PC Nicole SHORT (JM019) originated from the same source as the boots worn by PC Craig WALKER (AM001/Area 3 and AM002/Area 1) is eliminated.**

13 Appendices

Appendix 1

CV

Professor Lorna DAWSON, CBE, FRSE, FRSA, F.I. Soil Sci, CSci

Qualifications

BSc (Hons, 2:1) Geography, Edinburgh University (1979)

PhD Soil Science, Aberdeen University (1984)

Expert Witness Certificate Criminal law, Cardiff University (2011)

Expert Witness Certificate Civil law, Cardiff University (2012)

Masterclass in Expert Report Writing, Bond Solon (2017)

Expert Witness in Scots Law, Bond Solon, University of Aberdeen (2021)

Measures of Esteem

Chartered Scientist (2009-present)

Fellow of the British Society of Soil Science (2010-present)

Honorary Professorship, Robert Gordon University (2011-present)

Fellow of the Royal Society of Arts (2016-present)

Pride of Britain, Special Recognition Award (November 2017)

CBE Honour, Queens Birthday List (June 2018)

Fellow of the Royal Society of Edinburgh (May 2019-present)

Selected Recent Publications (2013-present)

Testoni S.; Dawson L.; Melo V.; Lopes-Mazzetto J.; Ramalho B.; Salvador F. (2022) Forensic Sciences | Free Full-Text | Soil Colour and Plant-Wax Markers: Application in Forensic Investigations under Urban Subtropical Environments (mdpi.com) 57-71

Donnelly, L.J.; Pirrie, D.; Harrison; Ruffell, A.; Dawson, L.A. (eds.) (2021) A guide to forensic geology. Geological Society, London, Special Publication 2021.

Dawson, L.A.; Di Maggio, R.M.; McKinley, J.; Di Capua, G.; Peppoloni, S., (2021) A proposal for a White Paper on geoethics in forensic geology., Forensic Geology, Geological Society of London Special Publications, 508, 1-10.

Dawson, L.A.; Auchie, D.; Parratt, D. (2021) The judicial system, reporting and giving evidence in court. In: Donnelly, L., Pirrie, D., Harrison, M., Ruffell, A. & Dawson, L. (eds.). A Guide to Forensic Geology. Geological Society, London.

Pirrie, D.; Ruffell, A.; Dawson, L.A. (2021) Geological evidence recovery from exhibits. In: Donnelly, L., Pirrie, D., Harrison, M., Ruffell, A. & Dawson, L. (eds.). A Guide to Forensic Geology. Geological Society, London.

Pirrie, D.; Ruffell, A.; Dawson, L.A.; McKinley, J. (2021) Crime scenes: Geoforensic assessment sampling and examination. In: Donnelly, L., Pirrie, D., Harrison, M., Ruffell, A. & Dawson, L. (eds.). A Guide to Forensic Geology. Geological Society, London.

Ruffell, A.; Pirrie, D.; Dawson, L.A. (2021) Geological evidence analysis. In: Donnelly, L., Pirrie, D., Harrison, M., Ruffell, A. & Dawson, L. (eds.). A Guide to Forensic Geology. Geological Society, London.

Dawson, L.A.; Macdonald L.M.; Ritz, K; (2021) Plant wax compounds and soil microbial DNA profiles to ascertain urban land use type. https://doi.org/10.1144/SP492-2018-65 In: Forensic Soil Science and Geology, Eds RW Fitzpatrick and LJ Donnelly. Geol Soc, London. DOI: https://doi.org/10.1144/SP492-2017-337

Donnelly, L.J; Cassela, J; Pirrie, D; Dawson, L.; Blom, G; Davidson, A; Arnold, P; Harrison, M; Hope, C. (2021) Analysis of soil following a police-led open area search and the recovery of a cold-case homicide grave. In: Forensic Soil Science and Geology, Eds RW Fitzpatrick and LJ Donnelly. Geol Soc, London. DOI: https://doi.org/10.1144/SP492-2017-337

Testoni, S.A.; Melo, V.; Dawson, L.A.; Malakoski, J.; Cunico, E.; Neto, J.A.J. (2020) The use of a sequential extraction technique to characterise soil trace evidence recovered from a spade in a murder case in Brazil Journal of Forensic Sciences 65(6) DOI: 10.1111/1556-4029.14491

Melo, V.F.; Testoni, S.A.; Dawson, L.A.; Salvador, F.A.D. (2020) Sand fraction is not suitable for forensic investigations in subtropical soils. *Revista Brasileira de Ciência do Solo, 44, No. e0190174.*

Prandel, L.V.; Melo, V.F.; Testoni, S.A.; Brinatti, A.M.; da Costa Saab, S.; Dawson, L.A. (2020) Spectroscopic techniques applied to discriminate soils for forensic purposes. *Soil Research, 58, 151-160.*

Pasternak, Z.; Luchibia, A.O.; Matan, O.; Dawson, L.A.; Gafny, R.; Shpitzen, M.; Avraham, S.; Jurkevitch, E. (2019) Mitigating temporal mismatches in forensic soil microbial profiles. *Australian Journal of Forensic Sciences, 51, 685-694.*

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Cal, J.; Dawson, L.A.; Javan, G.T.; Ozsoy, S.; Quaak, C.A.; Senior, T.K. (2018) From experimental work to real crime scenes and the courts. In: Ralebitso, T.K. (ed.) Forensic EcoGenomics: the Application of Microbial Ecology Analyses in Forensic Contexts. Academic Press, Chapter 8.

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Appendix 2

Audit trail

Note: All sample examination, description and preparation for analysis was conducted in a secure forensic laboratory.

Table 2.1: Audit trail

Date	Who	Item	Procedure	Subsample name
11/08/2022	Lorna Dawson/ Hannah Hogg/ Paul Ryder	JM019/HIH/D1	The vest was examined to see if there were any visible stains. (Note: the vest was contaminated with fingerprint powder and from the wet chemical treatment).	Mark examination was to be conducted first. No sampling at this stage.
11/08/2022	L Dawson/ H Hogg	GAY016/HIH/R1	The boot was examined. A description of the boot was conducted, and any soil traces were sampled.	GAY016/HIH/R1/Area 1 GAY016/HIH/R1/Area 2
11/08/2022	L Dawson/ H Hogg	GAY017/HIH/R1	The boot was examined. A description of the boot was conducted, and any soil traces were sampled.	GAY017/HIH/R1/Area 1 GAY017/HIH/R1/Area 2
11/08/2022	L Dawson/ H Hogg	GAY017/HIH/R1	Soil was recovered from the inner packaging, small clumps of soil.	GAY017/HIH/R1/soil small clumps of soil recovered from inner packaging.
11/08/2022	L Dawson/ H Hogg	AM001	The boot was examined. A description of the boot was conducted, and any soil traces were sampled.	AM001/Area 1, AM001/Area 2, AM001/Area 3
11/08/2022	L Dawson/ H Hogg	AM002	The boot was examined. A description of the boot was conducted, and any soil traces were sampled.	AM002/Area 1
11/08/2022	L Dawson/ H Hogg	JM019/HIH/D1	Soil was recovered directly onto SEM stubs from three areas of the vest with vis ble stains: 1) from silver strip, 2) from silver strip near edge of yellow fabric and 3) from yellow fabric.	JM019/HIH/D1/Area 1, JM019/HIH/D1/Area 2, JM019/HIH/D1/Area 3
12/08/2022	L Dawson/ H Hogg	All sub samples	All production labels were signed by L Dawson and H Hogg.	
12/08/2022	L Dawson	All sub samples	All sub samples were brought back to James Hutton Institute, in sealed evidence bags.	AM001/Area 3, AM002/Area 1, GAY016/Area 1, GAY016/Area 2, GAY017/Area 1, GAY017/Area 2, JM019/Area 1 JM019/Area 2, JM019/Area 3
15/08/2022	L Dawson	All sub samples	All sub samples signed into the secure lab at the James Hutton Institute.	
15/08/2022	L Dawson/ C Thomson	Outer bag labelled: CELC00124959	Evidence bag was opened by L Dawson witnessed by C Thomson. It contained SEM stubs: JM019/HIH/D1/Area 1, JM019/HIH/D1/Area 2, JM019/HIH/D1/Area 3	
16/08/2022	L Dawson/ C Thomson	Outer bag labelled: CELC00124958	Evidence bag was opened by L Dawson witnessed by C Thomson. It contained 4 inner sealed bags, AM001, AM002, GAY016 and GAY017 each containing individually wrapped Chorley wraps. The inner bags were checked and opened.	
16/08/2022	L Dawson/ C Thomson	AM001/Area 3	The whole sample was transferred to a labelled petri dish. The sample was described.	

[redacted]

17/08/2022	L Dawson/ C Thomson	AM002/Area 1	The whole sample was transferred to a labelled petri dish. The sample was described.	
17/08/2022	L Dawson/ C Thomson	GAY016/Area 1	The whole sample was transferred to a labelled petri dish. The sample was described.	
17/08/2022	L Dawson/ C Thomson	GAY016/Area 2	The whole sample was transferred to a labelled petri dish. The sample was described.	
17/08/2022	L Dawson/ C Thomson	GAY017/Area 1	The whole sample was transferred to a labelled petri dish. The sample was described.	
17/08/2022	L Dawson/ C Thomson	GAY017/Area 2	The whole sample was transferred to a labelled petri dish. The sample was described.	
17/08/2022	L Dawson/ C Thomson	1367039-1367048	Avoiding any obvious fragments of vegetation - each sample was tipped onto sterile Whatman paper. The sample was collected by twice lightly pressing the SEM stub onto the sample. The appropriate barcode was attached to the SEM stub. Samples for analysis were assigned barcodes - used for SEM analysis to anonymise analysis.	1367039-AM001/Area 3, 1367040-AM002/Area 1, 1367041-GAY016/Area 1, 1367042-GAY016/Area 2, 1367043-GAY017/Area 1, 1367044-GAY017/Area 2, 1367045-JM019/Area 1, 1367046-JM019/Area 2, 1367049-JM019/Area 3, 1367048-control swab of vest
29/08/2022	R Sutherland/ L Dawson/ C Thomson	Sample JM019/HIH/F1	Received elimination samples from Cellmark via Courier.	JM019/HIH/F1, Dry sub sample generated from exhibit GAY017
31/08/2022	E Hunter - L Dawson		SEM-EDXA analysis of all samples (and control swab) at RGU.	1367039-AM001/Area 3, 1367040-AM002/Area 1, 1367041-GAY016/Area 1, 1367042-GAY016/Area 2, 1367043-GAY017/Area 1, 1367044-GAY017/Area 2, 1367045-JM019/Area 1, 1367046-JM019/Area 2, 1367049-JM019/Area 3, 1367048-control swab of vest
01/09/2022	E Hunter - L Dawson		Results were saved into secure folder for samples as submitted.	SEM EDXA analyses
05-6/09/22 and 13/09/2022	E Hunter - L Dawson		Other replicate areas analysed on samples using SEM EDXA at RGU to provide 6 replicates for all sample stubs.	SEM EDXA analyses
06-7/09/2022 and 12/09/2022	L Dawson - Savanna Paige Jacobs and James Christie	Samples examined	FTIR method on questioned samples.	FTIR test
20/09/2022	D Miller - L Dawson	Map created	Map of assumed route walked by Mr Sheku Bayou produced by D Miller.	Map of assumed route Mr Bayoh wa ked
21/09/2022 and 07/09/2022	L Dawson- Sandhya Devalla	Samples examined	RAMAN method on questioned samples.	RAMAN test

[redacted]

Appendix 3

Productions

3.1 Production AM001

Figure 3.1: AM001 (Outer aspect of left boot PC Craig Walker)

Figure 3.2: AM001 (Inner aspect of left boot PC Craig Walker)

[redacted]

Figure 3.3: AM001 (Sole of left boot PC Craig Walker)

Figure 3.4: AM001/Area 3 (Sole at toe area) of left boot PC Craig Walker, magnified image

[redacted]

3.2 Production AM002

Figure 3.5: AM002 (Inner aspect of right boot PC Craig Walker)

Figure 3.6: AM002 (Outer aspect of right boot PC Craig Walker)

[redacted]

Figure 3.7: AM002 (Sole of right boot PC Craig Walker)

Figure 3.8: AM002/Area 1 (Soil at heel) of sole of right boot PC Craig Walker

[redacted]

Figure 3.9: AM002/Area 1 (Soil at heel) of sole of right boot PC Craig Walker, magnified image

[redacted]

3.3 Production GAY016

Figure 3.10: GAY016 (Outer aspect of right boot Mr Sheku Bayoh)

Figure 3.11: GAY016 (Inner aspect of right boot Mr Sheku Bayoh)

[redacted]

Figure 3.12: GAY016 (Sole of right boot Mr Sheku Bayoh)

Figure 3.13: GAY016/Area 1 (Soil to toe at welt) of right boot Mr Sheku Bayoh

[redacted]

Figure 3.14: GAY016/Area 1 (Soil to toe at welt) of right boot Mr Sheku Bayoh, magnified image

Figure 3.15: GAY016/Area 2 (Soil at heel of sole) of right boot Mr Sheku Bayoh

[redacted]

Figure 3.16: GAY016/Area 2 (Soil at heel of sole) of right boot Mr Sheku Bayoh, magnified image

[redacted]

3.4 Production GAY017

Figure 3.17: GAY017 (Outer aspect of left boot Mr Sheku Bayoh)

Figure 3.18: GAY017 (Inner aspect of left boot Mr Sheku Bayoh)

[redacted]

Figure 3.19: GAY017 (Sole of left boot Mr Sheku Bayoh)

Figure 3.20: GAY017/Area 1 (Welt inner aspect mid-section) of left boot Mr Sheku Bayoh

[redacted]

Figure 3:21: GAY017/Area 1 (Welt inner aspect mid-section) of left boot Mr Sheku Bayoh, magnified image

Figure 3.22: GAY017/Area 2 (Sole towards inner aspect of toe area) of left boot Mr Sheku Bayoh

[redacted]

Figure 3.23: GAY017/Area 2 (Sole towards inner aspect of toe area) of left boot Mr Sheku Bayoh, magnified image

3.5 Production JM019 (vest belonging to PC Nicole SHORT)

Figure 3.24: Production JM019 (vest belonging to PC Nicole Short) in May 2015

[redacted]

Figure 3.25: Production JM019 (vest belonging to PC Nicole Short) as viewed at Cellmark Forensic Services, Chorley, August 2022

3.6 Production JM019: Areas 1, 2 and 3 on vest JM019 at Cellmark Forensic Services, Chorley

Figure 3.26: JM019/Area 1 (Soil from silver strip), magnified image

Figure 3.27: JM019/Area 2 (Soil from silver strip near edge of yellow fabric), magnified image

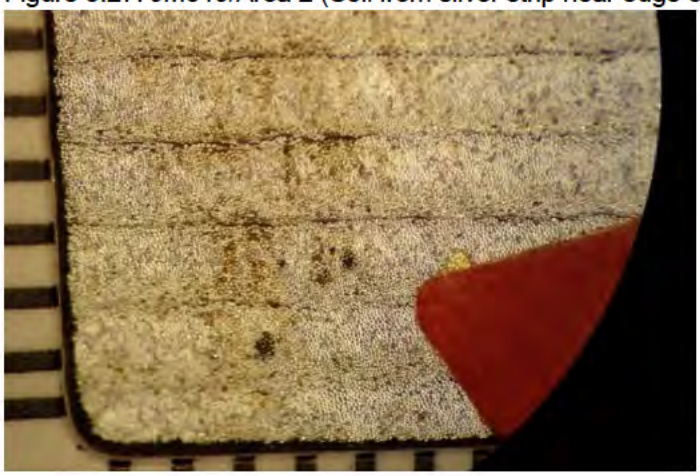
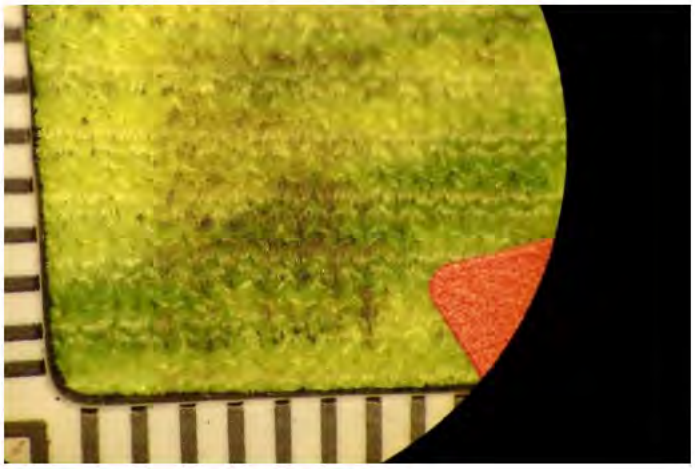


Figure 3.28: JM019/Area 3 (Soil from yellow fabric), magnified image



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Appendix 4

SEM morphological analysis results

Images of example areas on samples under SEM (x80 magnification) using VP (Variable Pressure)

Figure 4.1: Sample 39 (AM001/Area 3 (Sole at toe area) from PC Walker left boot)

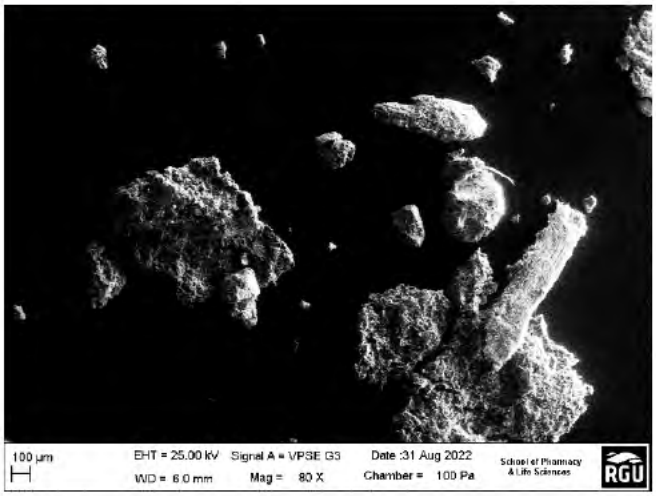
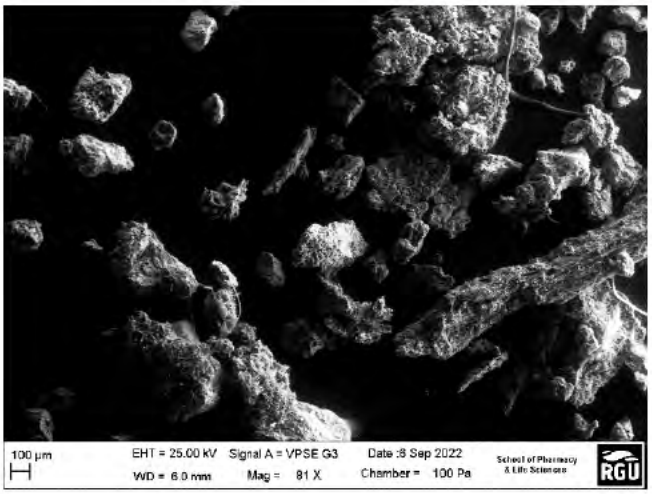


Figure 4.2: Sample 40 (AM002/Area 1 (Soil at heel) from PC Craig Walker's right boot)



[redacted]

Figure 4.3: Sample 41 (GAY016/Area 1 (Soil to toe at welt) from Mr Bayoh right boot)

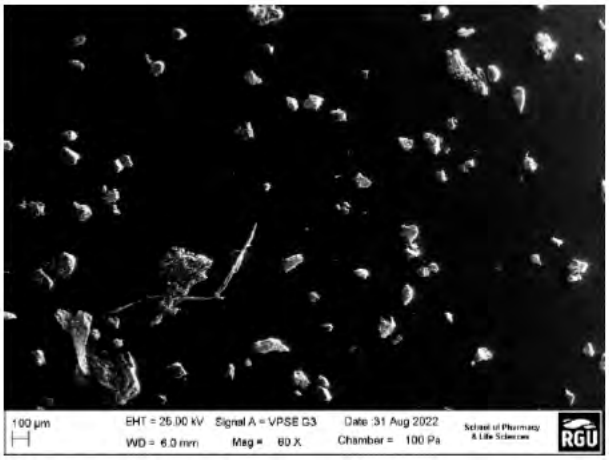


Figure 4.4: Sample 42 (GAY016/Area 2 (Soil at heel of sole) from Mr Bayoh right boot)

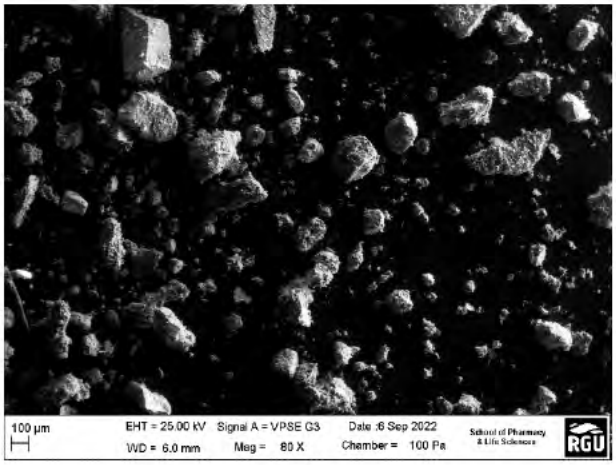
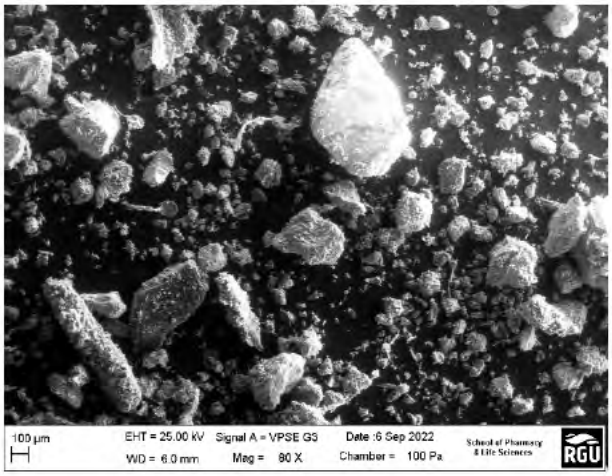


Figure 4.5: Sample 43 (GAY017Area 1 (Welt inner aspect mid-section) from Mr Bayoh left boot)



[redacted]

Figure 4.6: Sample 44 (GAY017/Area 2 (Sole towards inner aspect of toe area) of Mr Bayoh left boot)

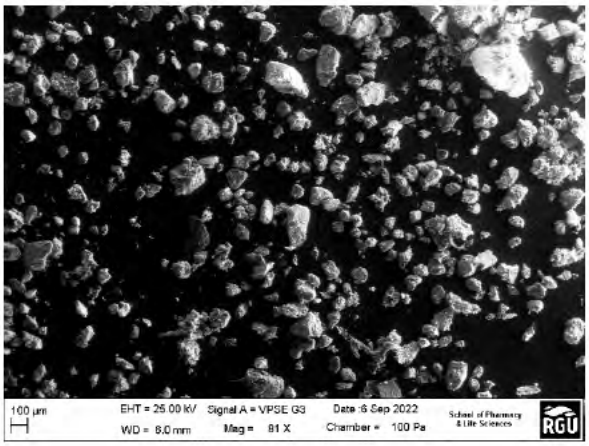


Figure 4.7: Sample 45 (JM019/Area 1 (Soil from silver strip) of vest belonging to PC Nicole SHORT)

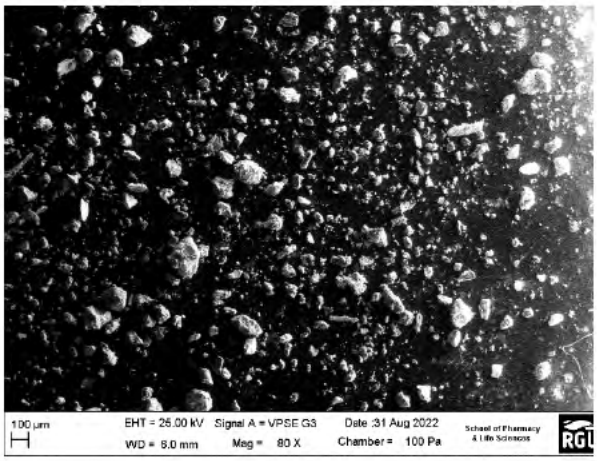
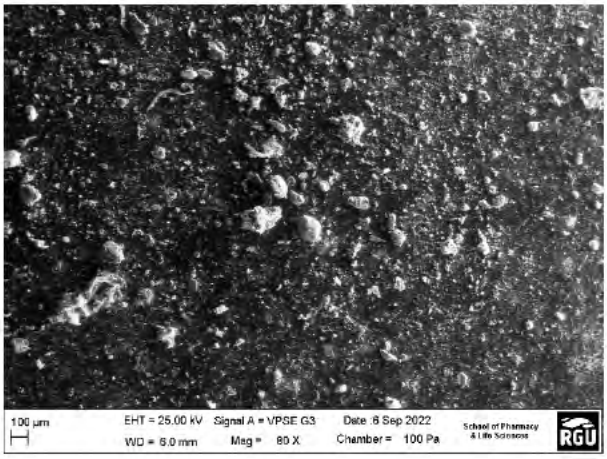


Figure 4.8: Sample 46 (JM019/Area 2 (Soil from silver strip near edge of yellow fabric) of vest belonging to PC Nicole SHORT)

[redacted]

Figure 4.9: Sample 47 (JM019/Area 3 (Soil from yellow fabric) of vest belong to PC Nicole SHORT



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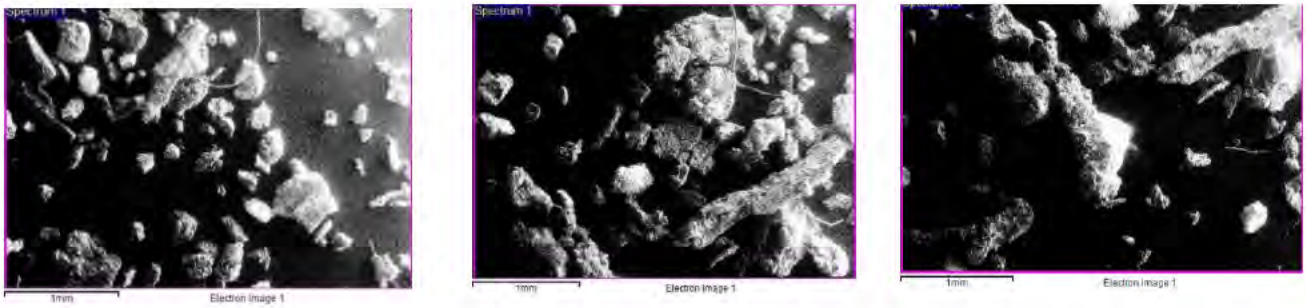
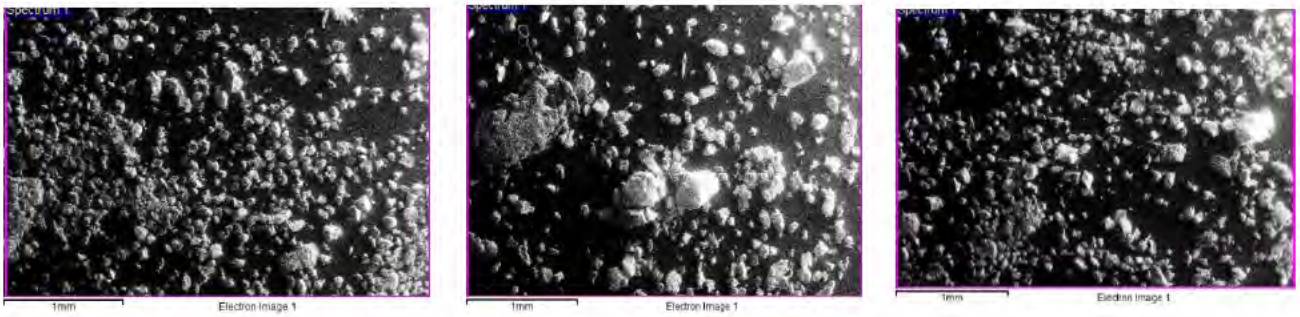
Images from three of the six replicate areas of questioned sample JM019/Area 3 compared with three of the six replicate areas of footwear sample GAY017/Area 2 and AM002/Area 1 using SEM EDXA

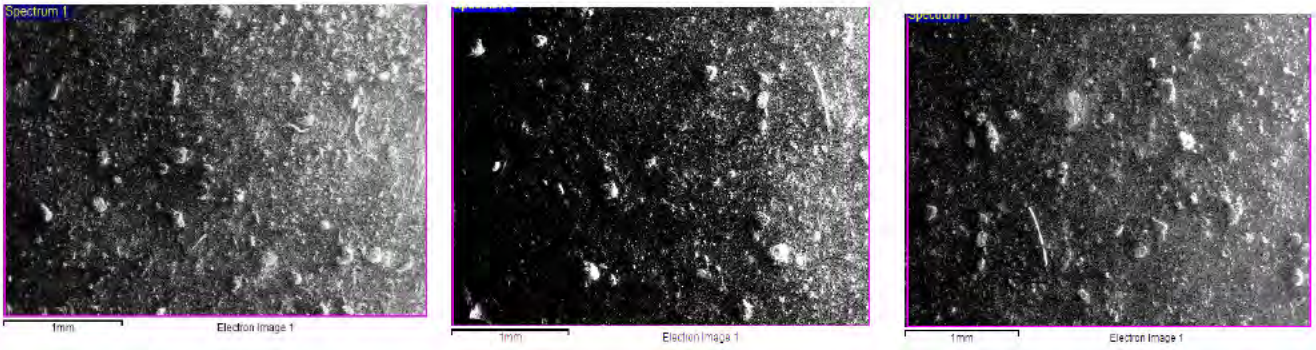
Figures 4.10: Sample 40 (AM002/Area 1 (Soil at heel) from PC Craig Walker's left boot)



Figures 4.11: Sample 44 (GAY017/Area 2 (Sole towards inner aspect of toe area) from Mr Sheku Bayoh's left boot)



Figures 4.12: Sample 47 (JM019/Area 3 (Soil from yellow fabric) from PC Nicole Short's yellow vest)



[redacted]

Appendix 5 SEM EDXA elemental composition analysis results

5.1 Plots of all replicates and mean relative elemental compositions using EDXA, all represented elements except carbon, oxygen, and iron (excluded as found in black fingerprint powder)

Figure 5.1a: All values of 6 replicate analyses from JM019/Area 1 (Soil from silver strip) of vest belonging to PC Nicole Short compared with all footwear samples with all elemental data

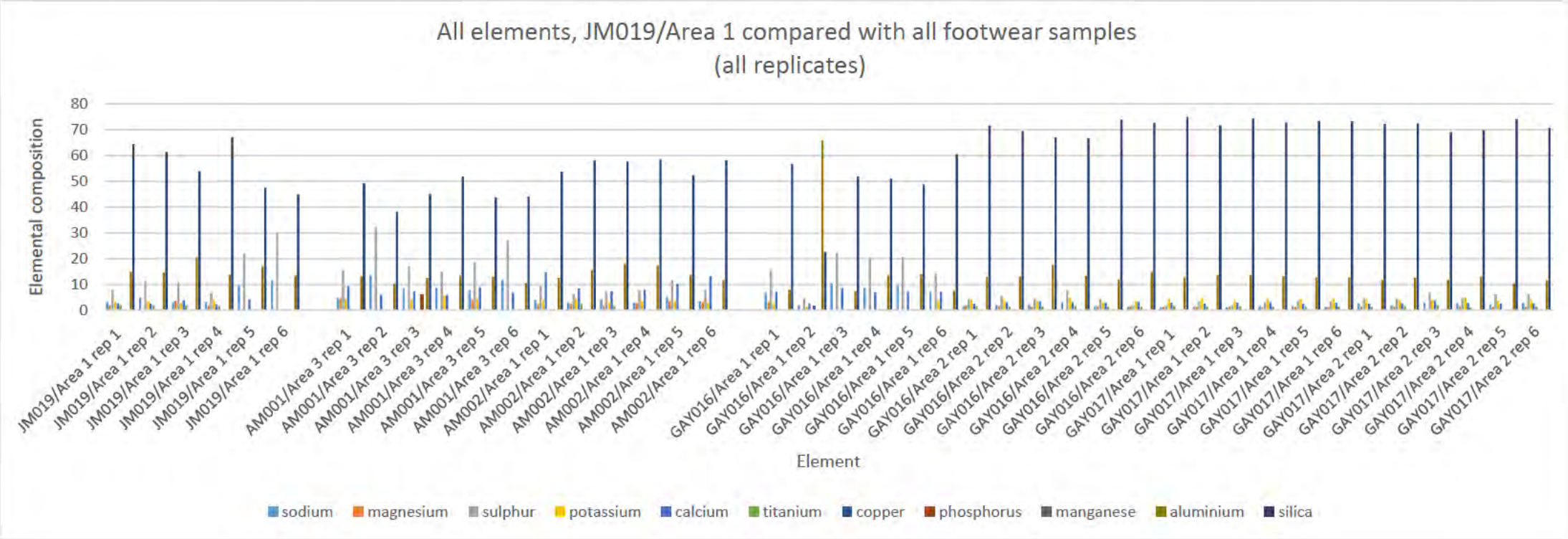


Figure 5.1b: All values of 6 replicate analyses from JM019/Area 1 (Soil from silver strip) of vest belonging to PC Nicole Short compared with all footwear samples with silica and aluminium removed from data set

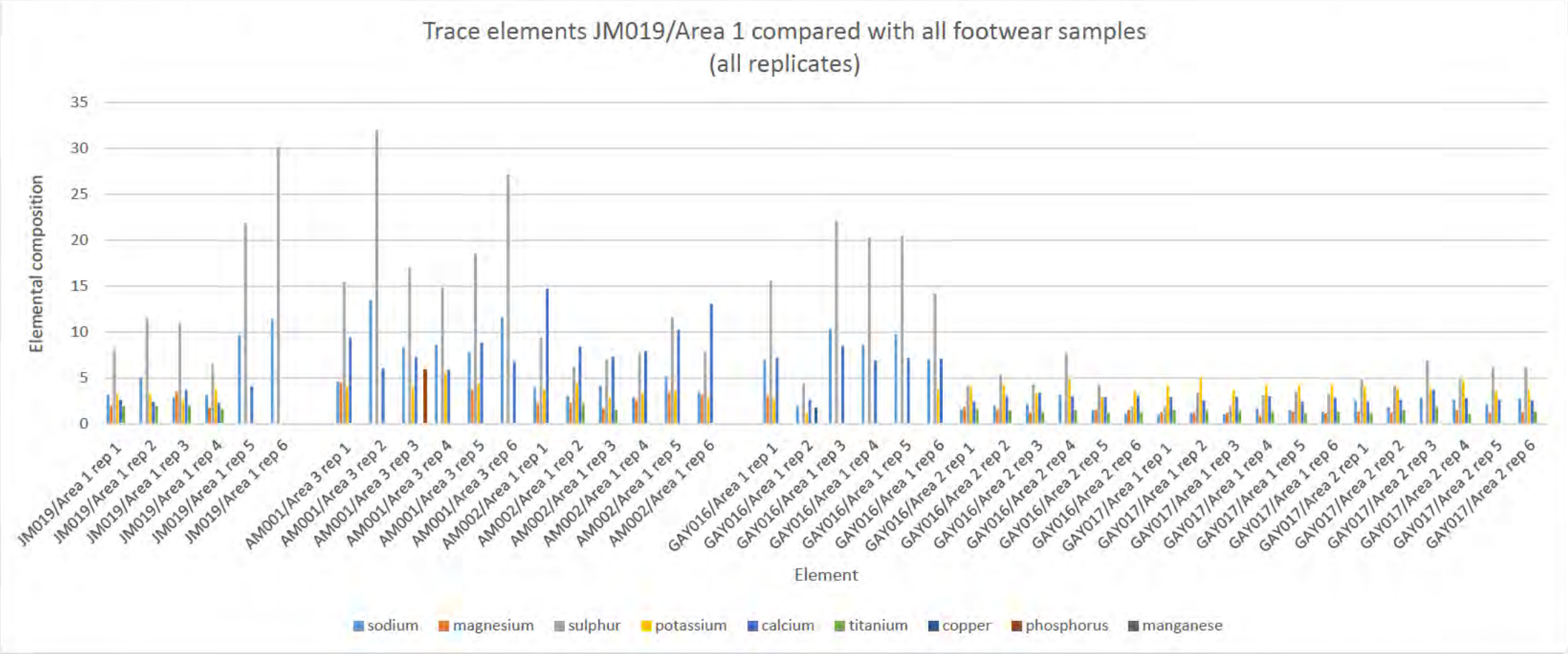
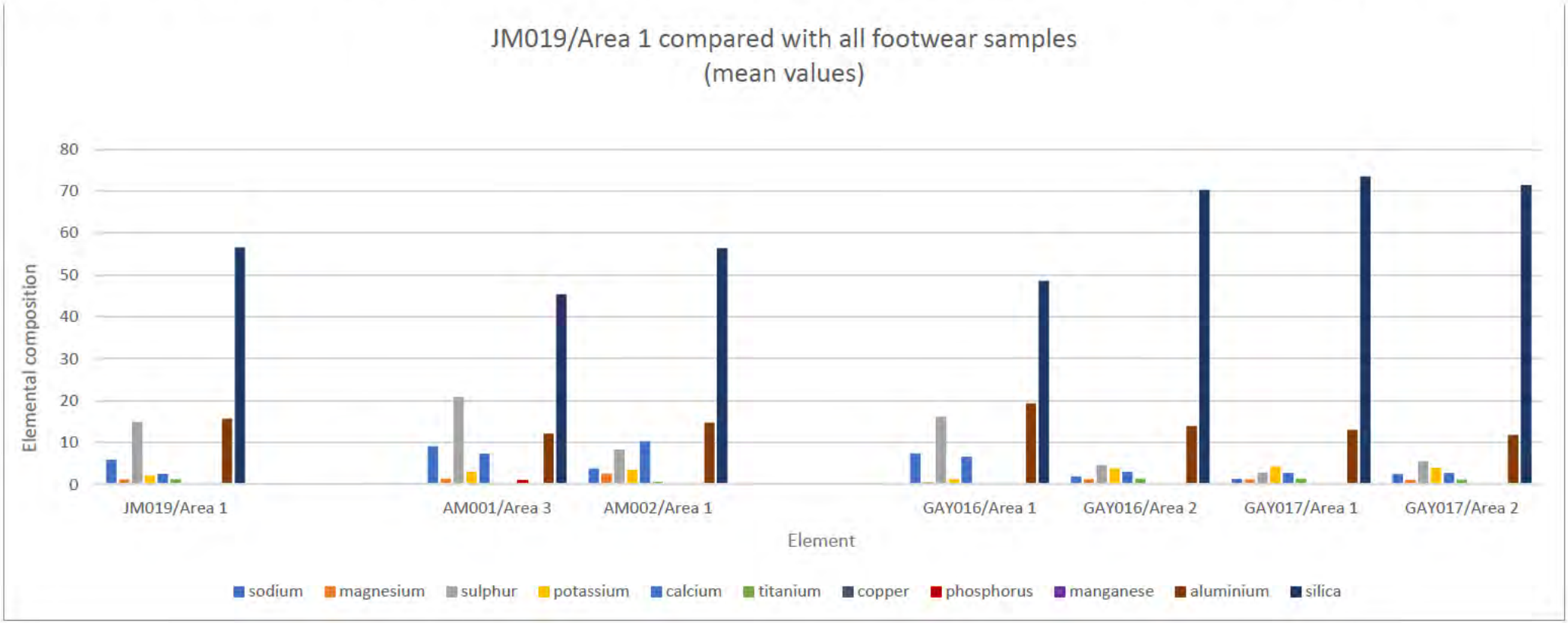
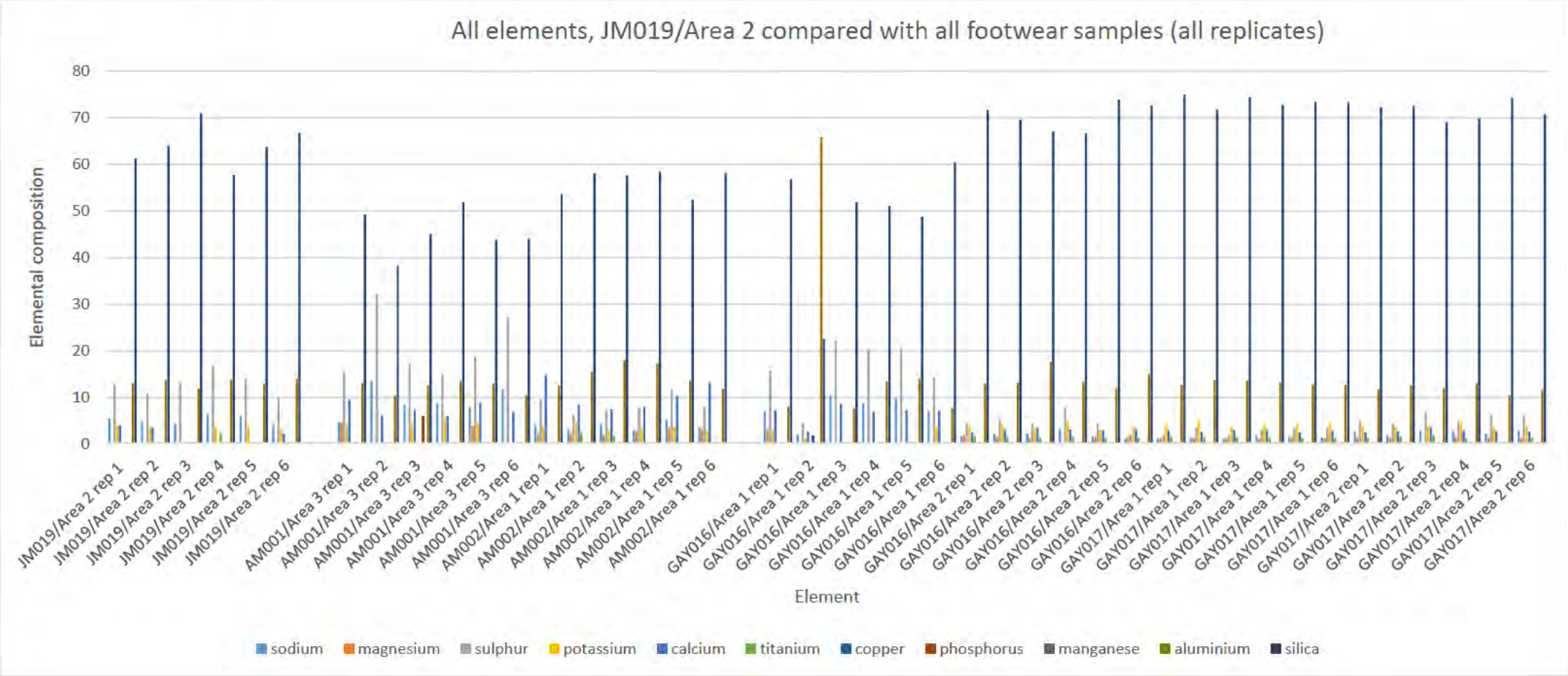


Figure 5.1c: Mean values of 6 replicate analyses from JM019/Area 1 (Soil from silver strip) of vest belonging to PC Nicole Short compared with all footwear samples



[redacted]

Figure 5.1d: All values of 6 replicate analyses from JM019/Area 2 (Soil from silver strip near edge of yellow fabric) of vest worn by PC Nicole Short compared with all footwear samples with all elemental data



[redacted]

Figure 5.1e All values of 6 replicate analyses from JM019/Area 2 (Soil from silver strip near edge of yellow fabric) of vest worn by PC Nicole Short compared with all footwear samples with silica and aluminium removed from data set

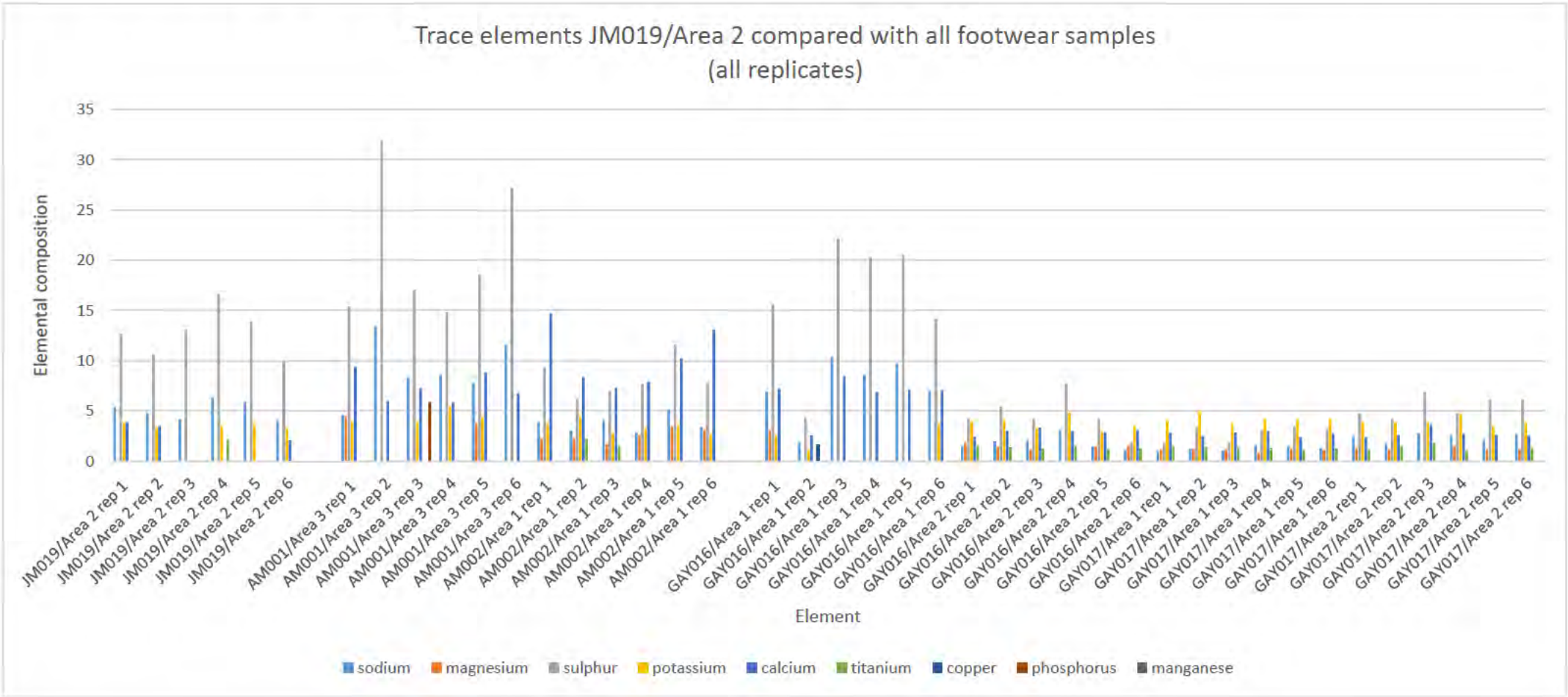


Figure 5.2f: Mean values of 6 replicate analyses from JM019/Area 2 (Soil from silver strip near edge of yellow fabric) of vest belonging to PC Nicole Short compared with all footwear samples

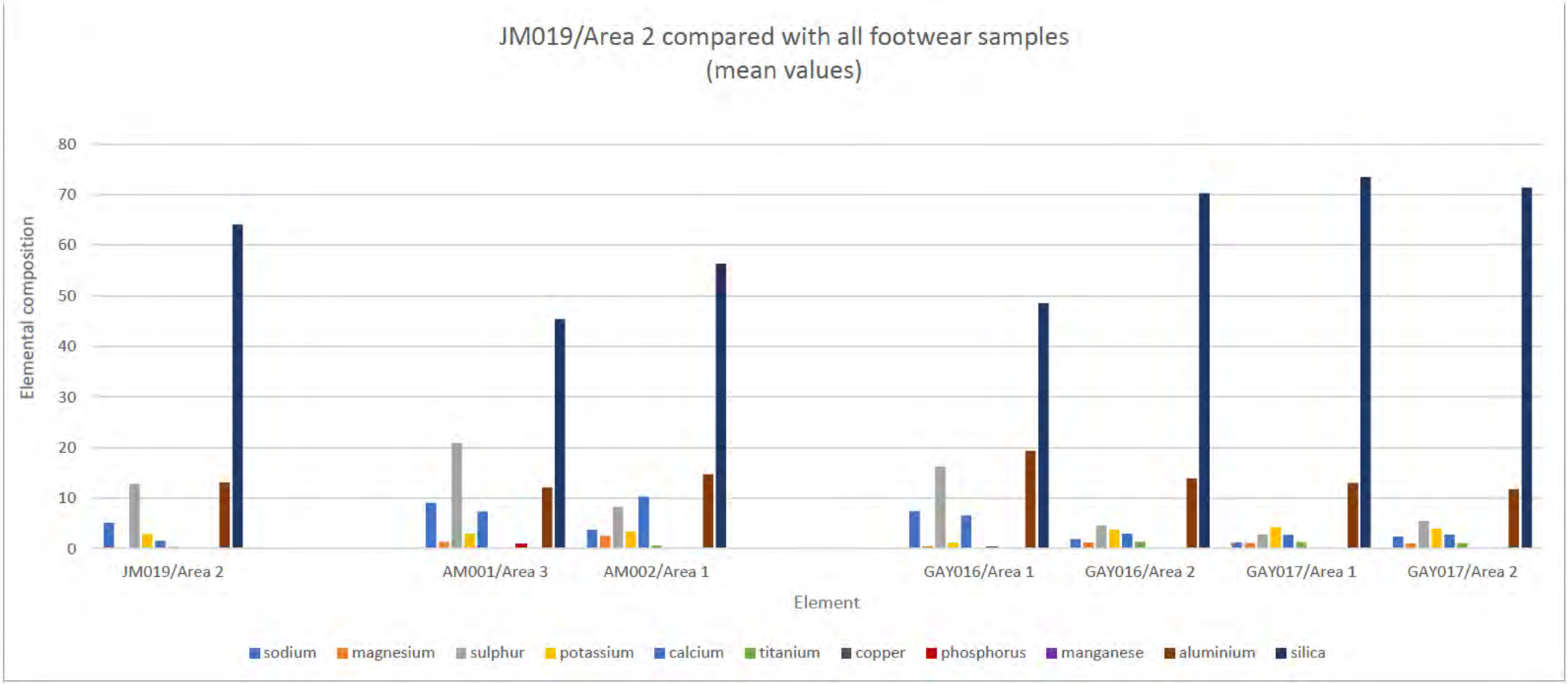


Figure 5.1g: All values of 6 replicate analyses from JM019/Area 3 (Soil from yellow fabric) of vest belonging to PC Nicole Short compared with all footwear samples with all elemental data

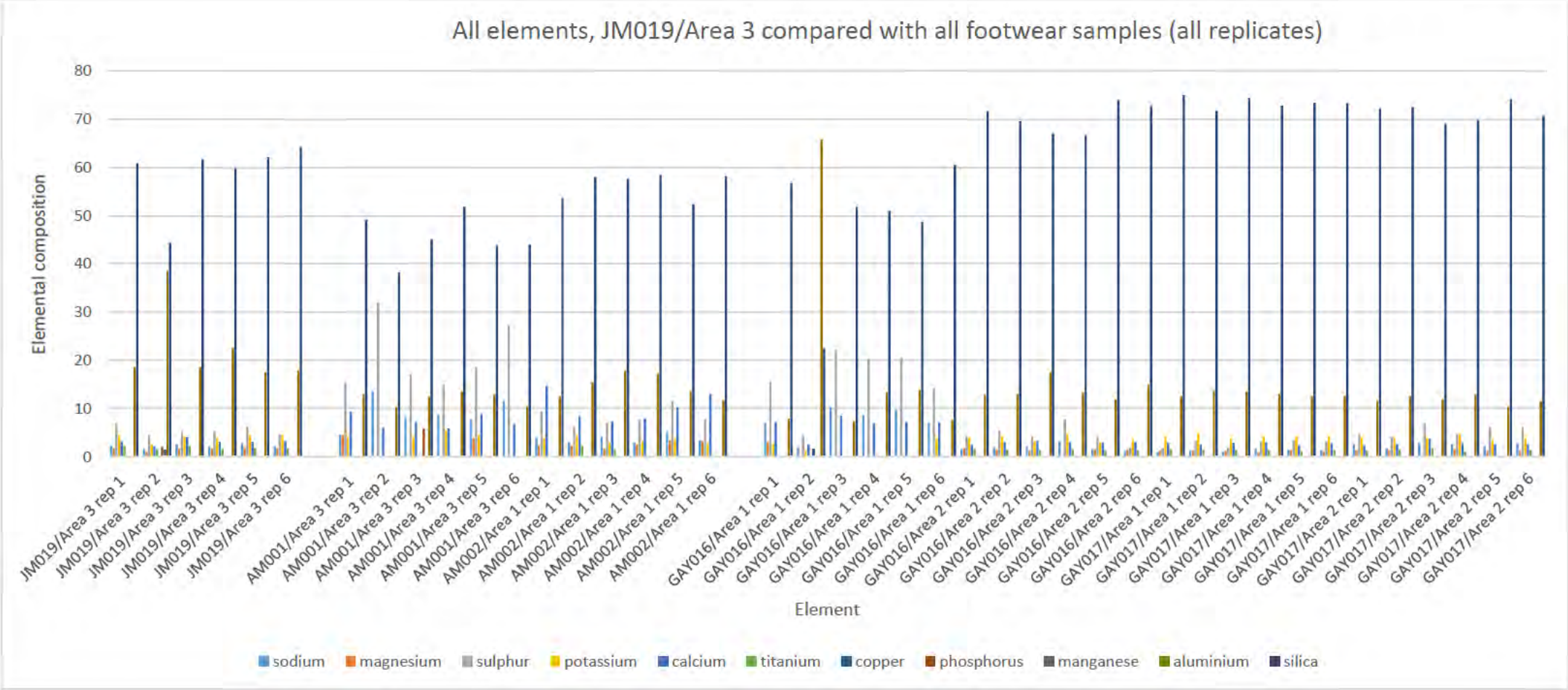
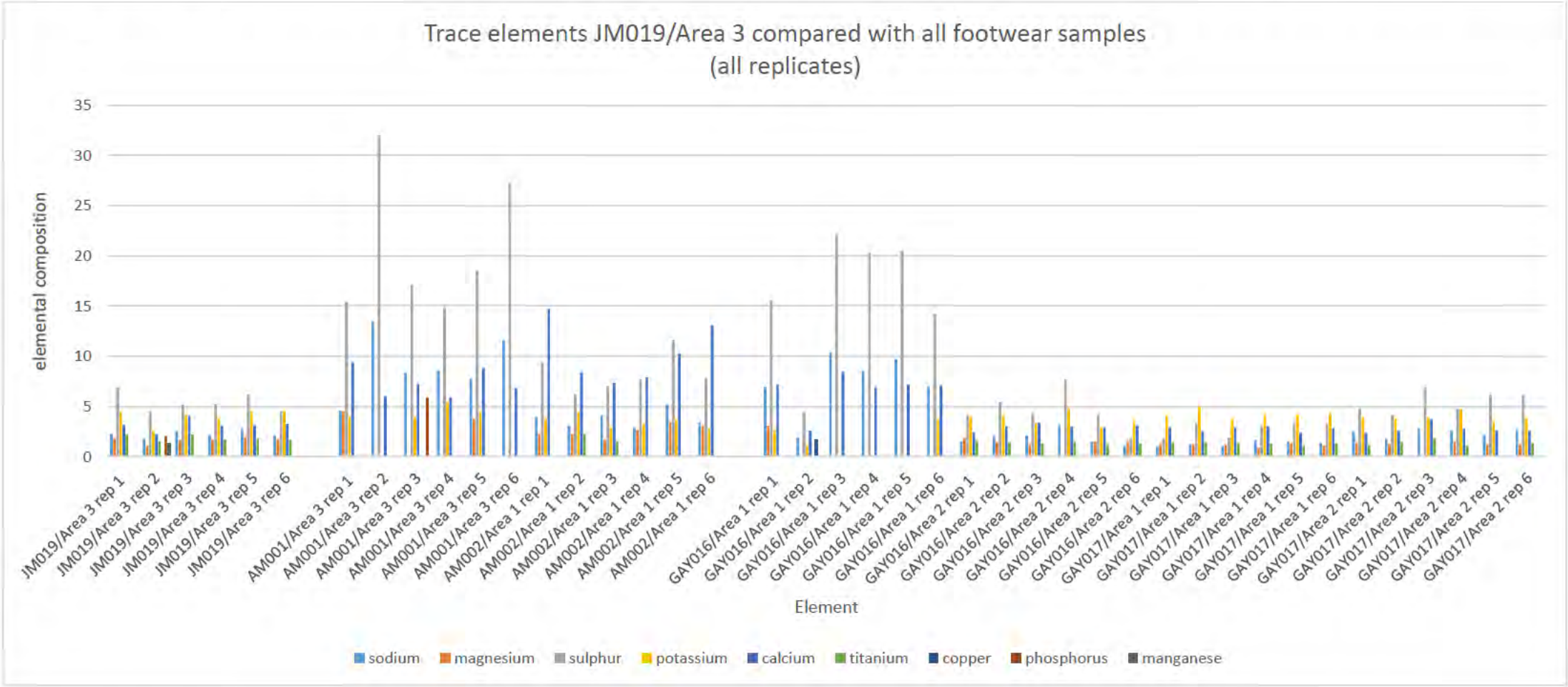
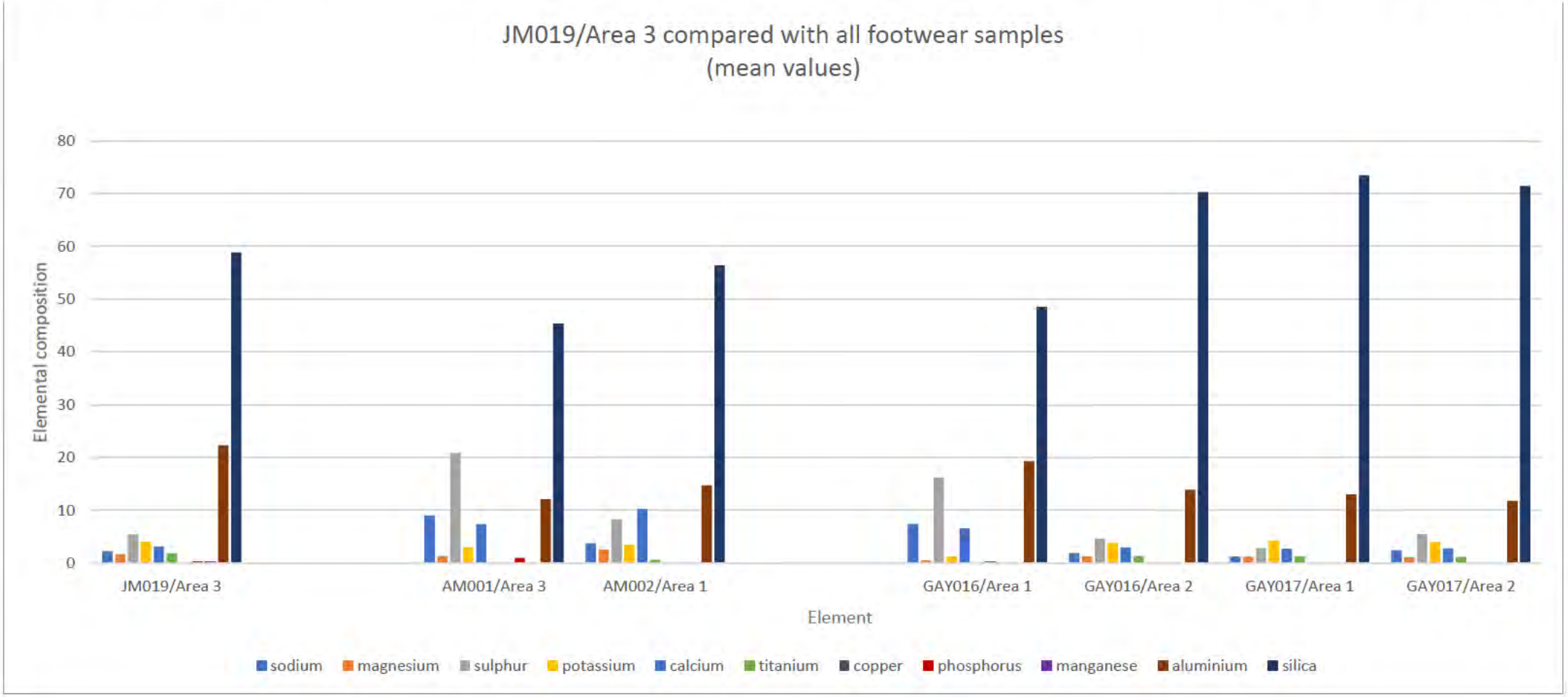


Figure 5.1h: All values of 6 replicate analyses from JM019/Area 3 (Soil from yellow fabric) of vest belonging to PC Nicole Short compared with all footwear samples with silica and aluminium removed from data set



[redacted]

Figure 5.1i: Mean values of 6 replicate analyses from Area 3 from JM019/Area 3 (Soil from yellow fabric) of vest belonging to PC Nicole Short compared with all footwear samples



[redacted]

Appendix 6

Methods

All laboratory work reported is accredited to ISO9001.

6.1 Microscope examination

All dry samples were examined using a Nikon SMZ1500 binocular microscope.

6.2 Scanning Electron Microscopy

SEM allows imaging of the surface texture of a sample. EDXA analysis provides information on the elemental (chemical) composition of the material examined. Control of the microscope is conducted using Zeiss Smart SEM software running the Microsoft Windows XP operating system. All the microscope functions are executed using the main control console or by accessing the appropriate windows menu. For all samples examined they were prepared onto separate SEM sample holders (stubs). The material was pressed onto the stubs which were covered with a double-sided adhesive tab. The prepared samples were subsequently transferred into the chamber of the Scanning Electron Microscope (SEM) for examination. For ease of comparison between samples, SEM photomicrographs were collected at set magnifications; identified by the scale bar size on the lower left corner of each image.

Characterisation of the material analysed in the SEM was determined from the morphology and texture of the particles combined with the use of Back-Scatter Detector (BSD) and Variable Pressure (VP) imaging and Energy Dispersive X-ray Analysis (EDXA). In BSD imaging mode the SEM images obtained are based on density variations. Under BSD imaging conditions, areas of higher average atomic weights appear brighter than areas of lower average atomic weights. Variations in the types of elements present are therefore revealed by variations in brightness.

EDXA analysis provides an inventory of the chemical elements (i.e. aluminium, silicon, etc.) present in the material analysed. No individual characterisation of minerals was conducted using this SEM EDXA.

An elimination stub was prepared with the background contaminants on the vest sample (fingerprint powder) and those elements which were dominant on this stub were removed from the subsequent chemical comparison between samples.

[redacted]

Appendix 7

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Appendix 8

Glossary

Aggregates - Soil aggregates are 'clumps' or 'clods' of soil particles that are held together by clay, organic matter (such as roots), by organic compounds (from bacteria and fungi) and by fungal hyphae. Aggregates vary in size from about 2 thousandths of a millimetre across up to about 2 millimetres across and are made up of particles of varying sizes.

BSD - Back-Scatter Detector. They are placed above the sample in the sample chamber based on the scattering geometry relative to the incident beam.

EDXA - Energy-dispersive X-ray spectroscopy (EDS, EDX, EDXS or XEDS), sometimes called energy dispersive X-ray analysis (EDXA or EDAX) or energy dispersive X-ray microanalysis (EDXMA), is an analytical technique used for the elemental analysis or chemical characterization of a sample. It relies on an interaction of some source of X-ray excitation and a sample.

Element - An element is a substance that cannot be broken down into any other substance. Every element is made up of its own type of atom.

Heterogeneous - Consisting of, or composed of, dissimilar elements or ingredients; not having a uniform quality throughout.

Homogeneous - Consisting of parts all of the same kind; having a uniform quality throughout.

Inorganic - A solid inorganic substance.

Mineral - In geology and mineralogy, a mineral or mineral species is a solid chemical compound with a fairly well-defined chemical composition and a specific crystal structure that occurs naturally in pure form.

Null hypothesis - The hypothesis that there is no significant difference between specified populations, any observed difference being due to sampling or experimental error.

Organic - Relating to or derived from living matter.

PCA - Principal Component Analysis is a dimensionality reduction method that identifies linear combinations of the dimensions of the original data (in this case the chemical elements) and which preserves the maximum amount of information about a sample.

Peds - Aggregates of soil particles formed because of soil forming processes: the natural organization of particles forms discrete units separated by pores or voids. The term is generally used for macroscopic (visible: i.e., greater than 1 mm in size) structural units when observing soils.

Replicate - Repeated analyses of a sample to reflect intra-sample variation.

SEM - Scanning electron microscopy, or SEM, produces detailed, magnified images of an object by scanning its surface to create a high-resolution image. SEM does this using a focused beam of electrons.

VP - Variable Pressure Scanning Electron Microscopy is a technique used to produce high-resolution images with a high depth of field.

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Appendix 9

Similarity schemes used in this report

9.1 Evidential scales used in the United States Department of Justice for forensic geology

Department of Justice Proposed language for testimony and reports for forensic geology discipline:

- State that the possibility that the geo derived material originated from the same source is eliminated.
- State that no conclusion can be reached. Can occur when insufficient material is available or where there is mixing with other material or there has been a change.
- State that the possibility that the geo derived material originated from the same source as the known exemplar cannot be eliminated. This conclusion is reached when the material cannot be differentiated from the exemplar using all observed or measured characteristics.
- State that the geo derived materials were once part of the same broken object. This conclusion can only be reached when two or more parts physically fit together.

Source: https://www.justice.gov/archives/dag/file/877726/download

9.2 Terminology scheme used by Pye (2007) to assess soil and geological evidence

From Pye (2007) page 268.

Verbal Terminology	Relative Ranking	Examples of Type of Evidence
None	0	Different in virtually all respects
Extremely limited	1	
Very limited	2	Some general similarity in terms of color, texture and/or relatively common particle types present
Limited	3	
Limited to moderate	4	General similarity in terms of color and/or texture, similar assemblage of relatively common particle types in common, some of which may have distinctive textural or chemical features
Moderate	5	
Moderately strong	6	Fairly high degree of physical, chemical, mineralogical, and/or biological similarity, including relatively unusual particle types in common
Strong	7	
Very strong	8	High degree of physical, chemical, mineralogical, and/or biological similarity, including several relatively unusual particle types present
Extremely strong	9	
Conclusive	10	Physical fit (rocks) and high degree of physical, chemical, and/or biological similarity; one or more very unusual particle types present

[redacted]

Appendix 10

Declaration

I, Lorna DAWSON declare that:

1. I understand that my duty is to help the court to achieve the overriding objective by giving independent assistance by way of objective, unbiased opinion on matters within my expertise, both in preparing reports and giving oral evidence. I understand that this duty overrides any obligation to the party by whom I am engaged or the person who has paid or is liable to pay me. I confirm that I have complied with and will continue to comply with that duty.

2. I confirm that I have not entered into any arrangement where the amount or payment of my fees is in any way dependent on the outcome of the case.

3. I know of no conflict of interest of any kind, other than any which I have disclosed in my report.

4. I do not consider that any interest which I have disclosed affects my suitability as an expert witness on any issues on which I have given evidence.

5. I will advise the party by whom I am instructed if, between the date of my report and the trial, there is any change in circumstances which affects my answers to points 3 and 4 above.

6. I have shown the sources of all information I have used.

7. I have exercised reasonable care and skill in order to be accurate and complete in preparing this report.

8. I have endeavoured to include in my report those matters, of which I have knowledge or of which I have been made aware, that might adversely affect the validity of my opinion. I have clearly stated any qualification to my opinion.

9. I have not, without forming an independent view, included, or excluded anything which has been suggested to use by others including our instructing lawyers.

10. I will notify those instructing use immediately and confirm in writing if for any reason my existing report requires any correction or qualification.

11. I understand that:

    11.1 my report will form the evidence to be given under oath or affirmation;

    11.2 the court may at any stage direct a discussion to take place between experts;

    11.3 the court may direct that, following a discussion between the experts, a statement should be prepared showing those issues which are agreed and those issues which are not agreed, together with the reasons;

11.4 I may be required to attend court to be cross-examined on my report by a cross-examiner assisted by an expert;

11.5 I am likely to be the subject of public adverse criticism by the judge if the Court concludes that I have not taken reasonable care in trying to meet the standards set out above.

12. [redacted]

13. I confirm that I have acted in accordance with the Code of Practice or conduct for Experts of my discipline, namely as a Chartered Scientist.

14. I confirm that I have read guidance contained in a booklet known as Disclosure: Experts' Evidence and Unused Material which details our role and documents our responsibilities, in relation to revelation as an expert witness. I have followed the guidance and recognise the continuing nature of my responsibilities of revelation. In accordance with my duties of revelation, as documented in the guidance booklet, I confirm that:

14.1 [redacted]

14.2 I have compiled an index of all material. I will ensure that the Index is updated in the event I am provided with or generate additional material;

14.3 In the event my opinion changes on any material issue, I will inform the investigating officer, as soon as reasonably practicable and give reasons.

Signature: [redacted]

Prof. Lorna DAWSON, CBE, BSc, PhD, C Sci, F. I. Soil Sci, FRSA

[redacted]