Investigating London's Post Medieval Pipe Clay Figurines From 1500-1800: Critiquing 3D Approaches to Mould Generation Analysis Via English and Transatlantic Case Studies

By:

Courtenay-Elle Crichton-Turley

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

The University of Sheffield
Faculty of Arts and Humanities
School (or Department) of Archaeology

Submission Date

September 2018

Abstract

This thesis has two main strands to its research, one being the first comprehensive synthesis of London's post-medieval pipe clay figurines dating to the period 1500-1800, combined with examining the potential for inexpensive 3D imaging technology to carry out a new digitised methodology for mould matching and figurine generational analysis. By applying this new digital methodology new insights have been gained on the wider context of these artefacts. The thesis also contextualises the London material with a broad array of academic publications on pipe clay figurines from Britain, Germany, the Netherlands, Poland, Jamaica, and America. This has included an extensive comparison between the previously unappreciated pipe clay figurines from London and figurines from Germany and the Low Countries and a specific comparison with data collected from the United States of America. This compendium of data provides more information to examine a range of questions, such as production, distribution, iconography, intended audience, and the general economic, social, and religious setting in which they operated.

By drawing upon these resources and new avenues of research this investigation offers an insight into pipe clay figurines within Germany and the Low Countries by examining a series of archaeological and contemporary literary sources. Following chapters go on to explore both the London and New World assemblages, presenting details on the distribution of these collections, a contextualised discussion on consumer markets, and iconographical relations of specific case studies. It is from this assemblage that figurines presenting similar stylistic qualities were selected for further analysis via 3D imaging methodologies to comprehend how closely, if at all, the morphometrics of the figurines compare and whether these figurines were produced from related mould groups. The parameters for this analysis are developed in Chapters 4 and 6, which discuss controlled datasets and a series of tests investigating the accuracy of inexpensive 3D imaging technology and their suitability for pipe clay figurine 3D imaging. These tests also analysed other potential influences on the morphometrics of the figurines and designed error parameters to be taken into account so that potential mould relationships could still be observed between figurines that had experienced damage, erosion, or manipulated on removal from their mould. These two strands are then brought together in Chapter 8, where new theories are discussed concerning the causes behind the changing iconography of these figurines, particularly those from London and the New World. This thesis also highlights the wider potential of 3D modelling for artefact studies and the limitations of Structure from Motion in the field of mould analysis. Overall, the research covered within this thesis has provided new details on a previously unstudied dataset alongside a much-needed critique of a new technological approach to 3D modelling and a brand new and revitalising means of carrying out mould-matching analysis of artefacts and other archaeological material.

Acknowledgements

There is a huge array of individuals and organisations that I owe an immense amount of thanks to, and whom without this PhD would not have been possible. Firstly, I would like to thank all those who I have contacted over the years who have allowed me access to pipe clay collections and supported my research, and I apologise if I miss anyone off the list:

The British Museum, Museum of London, Museum of London Archaeology, the National Pipe Archive at the University of Liverpool, London Archaeological Archive Research Centre, Pre-Construct Archaeology LTD, Historic London Towne Archaeology Department, Historic London Town, Department of Research and Collections at Historic St. Mary's City, Maryland Archaeological Conservation Laboratory, George Washington's Mount Vernon, Jamestown Rediscovery, The National Park Services (Historic Jamestowne) and the National Pipe Archive at the University of Liverpool. In particular I would like to thank Bly Straube, Anne Grulich, Sara Rivers-Cofield, Silas Hurry, Merry Outlaw, David Higgins and Susie White, Jacqui Pearce, Al Luckenbach, Karen Hutchins-Keim, Luke Pecoraro, Lily Carhart, Melanie Pereira, Ruud Stam, Gerald Volker Grimm, and Jan van Oostveen.

There are also a few special thanks that I would like to offer, firstly to those of you whom I have met during my time studying at Sheffield, you guys have kept me smiling constantly and it has been an honour meeting you all: Lindsay Wifey-Mitchell, Fiona Eaglesham, Tom Stratford and Islay, Emily Eastwood, Toby Pillatt, Pete and Jude Townend, Sam Bromage, Laura Wright, Darren Kelly, Chezzy and Bre, Scott Thawley, Alix and Dave Barber, Jake Nickles, Adam Clark, Nate and Ben, Mike O'Connell, Duncan Wright, Chris Hardwick, Phil Maier, Adam Fraser, Krissy Moore, Chris Booth and Cat Downey, Aly and Jack Laverick-Fox, Chris Atkinson and Catherine Longford, Amy McCabe and Martyn Cooper, and so many more, sorry for those not mentioned, this list really could go on for a while as I have had the opportunity to meet so many wonderful people along the way.

A huge thank you to the most incredible PhD support family that I could have ever asked for: Jessie Slater, Rachel Sites, Hannah Plumer, Sam Garwood, Ged Poland, Resa Nelson, Liam Lee (honorary archaeologist) and Lenore Thompson, Mik Lisowski and Ania Zolubak, and Cat Miragaia-Daughter and Stefan Knoppe.

I would like to extend a particularly huge thank you to Tracy O'Donnell and Nichola Austen, for our many evenings spent cackling like witches (over wine instead of cauldrons…though the glasses were the size of cauldrons), you both have literally brought me to tears laughing too many times and offered incredible support constantly over the last few years, so thank you.

For those friends not in Sheffield, the Stamford Crew: Vickie Baker, Martin Dunk, Johnny Bedford, Gordon O'Neill, Dick Lester; The St Andrews Ladies: Beth Dunmore, Ruby Munson Hirst, Britt Call, Sarah Brown, Ish Beeson, Nicola Kettle, and Lucy Boler (these last 4 thank you for all the times you have let me crash your homes when working in London!); and The YAT collective who were my reason for starting down the archaeological route in the first place, thank you all for keeping me sane (ish) when I needed to escape!

And now to my two supervisors who I owe a great deal. Thank you Dr Steve Maddock for guiding me through the technological side of this PhD, your input has opened up new research avenues and ventures I had never considered before and for that I am truly grateful. Dr Hugh Willmott, who has my eternal gratitude for allowing me to begin this journey, all your help along the way, and the opportunities that you have provided for me.

To my new extended family, Clan Huggon, thank you so much for all the support you have offered Martin and myself throughout both our PhDs, Alex a particular thanks to you and your chocolate supplies!

For those of my family who have been with me from the beginning of the journey when I first went to University, to my Nan and Grandad, one of whom sadly was not able to see the end of this journey, but I could not have completed it without either of their love and support over the years. You have both been huge mentors in my life and I wouldn't be where I am today without you. To Jay and Lydia Mainstone, thank you for always being there for me! Colin, thank you for being such a supportive brother in all my endeavours. And to Adrian and Mum, I couldn't have achieved half of what I have done over the last decade without you, let alone a PhD, so I am eternally thankful for having two incredibly supportive and encouraging parents.

Finally I would like to thank my small but wonderful family in Sheffield, our two fur babies, Loki and Thor, who have supplied all the cuddles, slobbery kisses, and chewed up slippers a girl could ever wish for, and finally but most importantly Martin Huggon. Martin without you I couldn't have got through this PhD, you have supported me through all the amazing times but also all the incredibly difficult times, you have been my rock (and my spell check), thank you for always being there for me and putting up with me throughout this.

Contents

Title Page……………………………………………………………………………………………………i

Abstract……………………………………………………………………………………………………ii

Acknowledgements…………………………………………………………………………………iii

Contents Page…………………………………………………………………………………………..v

List of Charts.. xi

List of Figures xii

List of Graphs xxxiii

List of Maps xxxiv

List of Tables...xxxv

Technical Terms and Abbreviations xxxix

Introduction ..………………………………………………………………………………………………1

Chapter 1

Post-Medieval Pipe Clay Figurines in Society...11

1.2 A Guide to Figurine Manufacturing 12

1.3 Thesis Aims...16

1.4 Past Research of London's Post-Medieval Pipe Clay Figurines...............................18

1.5 The Distribution of Pipe Clay Figurines 18

1.6 Production of Pipe Clay Figurines in Germany and the Netherlands 19

1.6.1 Germany…………………………………………………………………………………………..21

1.6.1.1 Breslauer Platz; A preliminary case study 21

1.6.2 The Netherlands..29

1.6.2.1 A Beguinage in Schiedam..30

1.6.2.2 The Old Varkenmarkt, Leiden 32

1.6.2.3 Putsteeg, Utrecht...33

1.6.2.3 Amersfoort, Floating Statues and Pilgrimage 35

1.7 Anticipated Outcomes 40

1.8 Chapter Summary 41

Chapter 2

3D Digital Surrogate construction within Archaeology 43

2.1 Popular Imaging Technologies Employed within Artefact Replicating...................45

2.1.1 Laser Scanning 46

2.1.2 Structured Light Scanner 47

2.1.3 Photogrammetry 49

2.2 The Structure-from-Motion Software Specifics...50

2.3 The Laser Scanner and Structured Light Scanner...53

2.4 The Costs...54

2.5 The Comparison Software, CloudCompare..55

2.5.1 CloudCompare results 55

2.6 Workflow for Artefact 3D Imaging and Literature Review.......................................60

2.7 Chapter Summary...70

Chapter 3

Accuracy Trial Methodologies and Results 73

3.1 The Hardware...74

3.2 The Heritage and Archaeological Work Environment 75

3.3 Methodology of 3D image Capturing; SfM, Laser Scanning and Structured light Scanning 76

3.3.1 SfM imaging methodology and setup 76

3.3.2 Laser Scanning Image Capturing Set up 79

3.3.3 Structured Light Scanning Image Capturing Set up 79

3.4 The Simple Test Object Trials: methodology 81

3.4.1 Comparison Results 82

3.4.2 Conclusion to the Simple Test Object Comparisons 86

3.5 The Archaeological Object Trials 89

3.5.1 Methodology 90

3.5.2 Results 90

3.6 Chapter Summary 104

Chapter 4

London's Post-Medieval Pipe Clay Figurines 107

4.1 Royal Memorabilia 107

4.2 Religious Iconography 112

4.2.a Madonna and Child 112

4.2.b Christ as a Babe 113

4.2.c The Passion of Christ 116

4.2.d The Cockerel on a Column 118

4.2.e Saints 125

4.2.f Angels 128

4.2.g Clerics 129

4.3 Adult Knickknacks 131

4.4 Children's Toys or Adult Trinkets? 133

4.5 A Question of Luxury....138

4.6 Distribution and Context....139

4.7 Chapter Summary....150

Chapter 5

Clay in the Colonies....151

5.1.1 The Charles Gift Site at Patuxent River Naval Air Station's, Maryland....151

5.1.2 St John's Site in St Mary's City....157

5.1.3 The Van Sweringen Site....160

5.1.4 The Mareen Duvall Middle Plantation, Annapolis, Maryland....163

5.1.5 James Fort and New Towne....165

5.1.6 The Washington Residence at Mount Vernon....168

5.1.7 Chaney's Hills Site, Anne Arundel County....171

5.1.8 Port Royal, Jamaica....173

5.1.9 Miscellaneous Models....174

5.2 Chapter Summary....174

Chapter 6

A Critique & Contribution to Current Product and Mould Comparison Analysis....177

6.1 Critique of past methodologies....179

6.2 Metric Variabilities....183

6.2.1 Methodology....184

6.2.2 Unfired vs fired....187

6.2.3 Fired vs fired....191

6.2.4 Fired and unfired vs mould halves....193

6.3 Methodology Discussion and Summary 197

Chapter 7

Figurine Matching Case Study: London's Post-Medieval Pipe Clay Figurines 203

7.1.1 Charles Gift Site King Compared to London Blackfriars King, NextEngine ...203

7.1.2 King Comparison Results Using SfM, Agisoft Photoscan 209

7.1.3 Cockerels A5176, 4973b and a19159 214

7.1.4 Whitechapel King 1854,1130.43 and Thames King 1856,0701.1657 220

7.1.5 Dorothy Holding a Basket: 1854,1130.45; 1854,1130. 46 and 4972............225

7.1.6 Man in Hat 1854,1130.47 Compared to 4975 236

7.1.7 Robed King 1854,1130.44 and Bankside King 17681 241

7.2 Chapter Summary..245

Chapter 8

A Review of the Developments of Material and Technique 247

8.1.1 New Insights into London's Post-Medieval Pipe Clay Figurines.......................247

8.1.2 London in Comparison to Germany and the Netherlands 249

8.1.2.1 Martin Luther and the Reformation: Examining the Effects on Religious Art in Germany, the Low Countries and England. 259

8.1.3 The Impact of European Religious and Political Change on the Colonies........268

8.2 The Comparative Data...271

8.2.1 Evaluation of Artefact 3D Workflow...275

8.2.2 Further application proposals for 3D comparison.......................................277

8.3 Conclusion 280

Bibliography…………………………………………………………………………………………………285

Appendices

Please see disk in the rear of thesis for Appendix 1 and 4

Please contact author for Appendix 2, 3 and 5

Appendix 1

Pipe clay figurine database, 199 entries.

Appendix 2

Accuracy Trials for Simple test objects and artefact trials employed in Chapter 3

Appendix 3

Pipe Clay figurine 3D models employed in Chapter 7

Appendix 4

Close up sections of Roque's 1746 map employed in Chapter 4

Appendix 5

3D Elephant scans and comparisons employed in Chapter 6

List of Charts

Chapter 2

Chart 2.1 Displaying classification of popular 3D imaging technologies within artefact research 45

Chart 2.2 Popular SfM software employed within artefact 3D imaging, references cite projects, their accessibility and costs. 52

Chart 2.3 Displays the laser scanners and structured light scanners which will be trialled within this thesis. 53

Chart 2.4 Process workflow for artefact 3D digitisation. 62

Chart 2.5 3D research workflow for this thesis. 72

Chapter 6

Chart 6.1 Demonstrating sequence of mould generation (in blue) and mould derivative production (in purple). 178

List of Figures

Chapter 1

Figure 1.1 A collection of post-medieval pipe clay figurines from the British Museum, from left to right: St Catherine and wheel, Madonna and Child, Nude male with flowers, Christ with bird, and a lion. 11

Figure 1.2 A pipe-maker preparing a mould for the gin press at Henry Leigh's factory, Portchester, Hampshire. (Image from Ayto 1994, 19 ©Hampshire County Council collection. Provided by the Hampshire Cultural Trust.) 12

Figure 1.3 Examples of clay moulds used to produce pipe clay figurines, to the left: Madonna and Child pipe clay figurines c.1720-1750 (author's image courtesy of LAARC). To the right Clay mould of a monk, from Breslauer Platz, 1429 *(Image to the left of writing from,* Neu-Kock *1988, 6).* 13

Figure 1.4 Portrait of a Young Girl with Carnations, 1663, Netherlands. Note the painted figurine amongst the flowers J. Rotius 1663, (Image provided by Art Gallery of Ontario) 15

Figure 1.5 The Feast of Saint Nicholas (to the left), a tradition where good children receive gifts from the Saint. Note the figurine of the cockerel in the child's bucket (with detail of the cockerel to the right). (Painting by Jan Steen, 1665-1668, held in the Rijksmuseum, Public Domain) 15

Figure 1.6 Map displaying locations of pipe clay figurines addressed in this thesis. 19

Figure 1.7 Tin-lead alloy of Mary and Infant Jesus, Dordrecht, 1275-1350 20

Figure 1.8 Annotated Map showing Cologne c.1572, the blue circle indicates Breslauer Platz & Cologne Cathedral. (G. Braun 1572, from The Hebrew University of Jurasalem & the Jewish National & University Library). 22

Figure 1.9 Breslauer Platz stove from the north 22

Figure 1.10 A floor plan of Breslauer Platz Stove (Neu-Kock 1988, 3-4) 23

Figure 1.11 Clay mould of a monk, from Breslauer Platz, 1429 (Image to the left of writing from, Neu-Kock 1988, 6) 23

Figure 1.12 Examples of schlusen from Zeeland 23

Figure 1.13 Complete enthroned Madonna and child statuette and rear of a fragment of enthroned Madonna showing the rosette. (Neu-Kock 1988, 13, 15, 36) 25

Figure 1.14 Fragment of Madonna and Child. (Neu-Kock 1988, 13, 15, 36) 25

Figure 1.15 A fragment of Saint Catherine with Wheel. 25
Figure 1.16 An array of Christ child Statues from Breslauer Platz (Neu-Kock 1988, 18) 25
Figure 1.17 Four pipe clay figurines of the Christ Child (From Heitz in Lemmel et al. 2009, figures 128-129, 240) 26
Figure 1.18 A polychrome wood figurine of the Christ Child all are from Germanishes Nationalmuseums Nuremberg.(From Heitz in Lemmel et al. 2009, figures 128-129, 240) 26
Figure 1.19 Angel figurine. 28
Figure 1.20 A series of knights on horseback. 28
Figure 1.21 A seductive female. 28
Figure 1.22 A series of couples 28
Figure 1.23 a man holding a wedding ring out for the woman 28
Figure 1.24 Fools with musical instruments 28
Figure 1.25 Two mould halves and figurine of Mary and Child from Utrecht ca.1425-50 29
Figure 1.26 Front and Rear of milkmaid figurine made by John Boot, initial 'IB' seen on the rear. 29
Figure 1.27 Pipe clay figurines of the Christ child from a Berguinage at Schiedam burnt down in 1494. (Ostkamp 2012 figure 9.6, 111) 31
Figure 1.28 Madonna and Child from a cesspit in Tiel.(Figure 5 in Oostveen 2014, 7) 31
Figure 1.29 Hand coloured map of Tiel, Joan Blaeu from 1649, with excavation area circled. 31
Figure 1.30 A 15th-century mould from Leiden 32
Figure 1.31Excavation plan displaying waste pits R and L, where the pipe clay figurines were recovered 33
Figure 1.32 Saint Catherine, four of this style were recovered. 34
Figure 1.33 Virgin and Child, six of this style were recovered. (Image from Ostkamp and Helbergen 1974, 61) 34
Figure 1.34 Saint Barbara, seven of this style were recovered. (Image from Ostkamp and Helbergen 1974, 63) 34
Figure 1.35 Christ holding a dove, two of this style were recovered. (Image from Ostkamp and Helbergen 1974, 66) 34
Figure 1.36 A large figurine of Saint Nicholas 34

Figure 1.37 A Large figurine of Virgin and Child. 35

Figure 1.38 A mould fragment of Virgin and child. 35

Figure 1.39 Our Lady of Foy, pipe clay figurine, held in the Parish church of Notre-Dame de Foy, Southern Nertherlands. to the left the front and to the right the rear collection (Reesing and Hoyle 2007/8, Figure 7, 150). 37

Figure 1.40 The Pedlar, 1515. Madrid, Museo del Prado, Ref.nr. P02052 (Public Domain)...38

Figure 1.41 Circle of Joachim Patinir, St Christopher. Private collection (Reesing and Hoyle 2007/8, Figure 10, 152)..39

Figure 1.42 Our Lady of Meerveldhoven. Meerveldhoven, parish church of St Lambertus, North Brabant. The statue has been venerated here since late medieval times and in the choir there is a full size oak tree with statuette of the Virgin in its branches. (photo: Jacq. Bijnen, SHEV, Reesing and Hoyle 2007/8, figure 11, 153).......39

Chapter 2

Figure 2.1 The recording Principle of structured light scanning. It is compiled of a line projection system which combines a digital projector and digital camera. (a) 'Graycode method' (b) 'M-Projection or working range'. (Hess 2015, fig 2.45, 70) 48

Figure 2.2 Set up of the structured light scanner, followed by calibration. 48

Figure 2.3 From dense cloud to textured model. Above images show the surface reconstruction of a dog pipe clay figurine from LAARC. On the Left is the Dense cloud of the Digital surrogate and on the right is the textured 3D image. The blue tiles represent the varying camera angles. This model was generated in Agisoft. 50

Figure 2.4 Blender Made Monkey Mesh...56

Figure 2.5 Results from identical meshes comparison in CloudCompare. 56

Figure 2.6 Manipulated Monkey version 1 57

Figure 2.7 Results from original Monkey vs manipulated Monkey 1 (CloudCompare 2015). 57

Figure 2.8 CloudCompare Scalar difference compared to Blenders measurements. 57

Figure 2.9 Manipulated Monkey version 2 (Blender 2.75 Foundation 2015) 58

Figure 2.10 The results from CloudCompare, Original Monkey Vs Manipulated Monkey 2 (CloudCompare 2015, 11/02/16) 58

Figure 2.11 3 Series of CloudCompare Scalar difference compared to 3 series of Blenders measurements of Manipulated Monkey version 2. 59

Chapter 3

Figure 3.1 Ideal set up of the equipment (image created by author) 77

Figure 3.2 The 6 stages of image capturing for SfM 3D modelling (Diagram created by author) distance of the camera from the object is relative to the size of the object in each stage. 78

Figure 3.3 NextEngine Setup 79

Figure 3.4 Set up of eyeU camera's and projectors on tripod and frame. 80

Figure 3.5 Image to display the Structured Light Set up during calibration. 80

Figure 3.6 Displays the distances which should be present between the cameras and the calibration board. 81

Figure 3.7 This diagram demonstrates the varying positions the calibration frame needs to be positioned in during each level of image calibration. Each of these board positions should be repeated on three levels, one at lowest height, one at medium height (also the height the artefact will be positioned at) and one at highest point, to give full calibration coverage). 81

Figure 3.8 Images of the simple test objects to be used within the accuracy trials, a rectangular prism, a pentagon prism and a star prism. 82

Figure 3.9 Diagrams displaying where the measurements were taken, the red arrow refers to the height of the object within table 3.2 and green arrow refers to the width of the object. 83

Figure 3.10 Star Prism 3D models. A) NextEngine Star. B) Structured Light Scanner. C) Agisoft Photoscan. D) Autodesk 123D Catch. E) Visual SfM. F) 3DF Zephyr Pro 84

Figure 3.11 Rectangular Prism 3D models. A) NextEngine. B) Structured Light Scanner. C) Agisoft Photoscan. D) Autodesk 123D Catch. E) Visual SfM. F) Zephyr Pro. 84

Figure 3.12 Pentagonal Prism 3D models. A) The Next Engine. B) The Structured Light Scanner. C) Agisoft. D) Autodesk 123D Catch. E) Visual SfM. F) Zephyr Pro. 84

Figure 3.13 Results to show mesh differences between the NextEngine and the Autodesk star. 88

Figure 3.14 Results to show mesh differences between the NextEngine and Autodesk rectangle prisms. 88

Figure 3.15 Results to show mesh differences between the NextEngine and the Autodesk pentagon. 88

Figure 3.16 Post-Medieval pipe clay figurines, from left to right: a sheep LIVNP.2009.14.27, a female with inscription on plinth LIVNP.2009.14.10 and a cleric LIVNP.2009.14.12. All of these objects were found during canal dredging in Amsterdam. (All of these objects have been imaged by the author with permission from Dr. D.Higgins and Dr. S.White, Liverpool). 89

Figure 3.17 From top left to right: an Anglo-Saxon glass counter from Little Carlton, Lincolnshire (authors image, artefacts courtesy of Dr. H. Willmott) a medieval stone hand holding a lute, from Thornton Abbey, Lincolnshire (authors image courtesy of Dr. H. Willmott) and below, a piece of animal bone found on the Thames foreshore (author's image). 90

Figure 3.18 Diagram to display where measurements were taken upon LIVNP.2009.14.10 91

Figure 3.19 Screen Shots of the NextEngine's 3D model and mesh of LIVNP.2009.14.10 92

Figure 3.20 123D Catch, to the left 3D model of LIVNP.2009.14.10 with 62 images. The middle and right images display 3D model of LIVNP.2009.14.10 with 50 images. 93

Figure 3.21 Screen Shots of the Agisoft's 3D model and mesh of LIVNP.2009.14.10 93

Figure 3.22 A) Agisoft PhotoScan close up of inscription. B) A 2D photo of the inscription to show a contrast in clarity between a 3D representation of the image and a 2D representation. 94

Figure 3.23 Diagram to display where measurements were taken upon LIVNP.2009.14.27 94

Figure 3.24 NextEngine textured 3D model and mesh of LIVNP.2009.14.27 95

Figure 3.25 Agisoft's PhotoScan textured 3D model and mesh of LIVNP.2009.14.27 95

Figure 3.26 Autodesk's 123D Catch textured 3D model and mesh of LIVNP.2009.14.27 95

Figure 3.28 NextEngine textured 3D model and mesh of LIVNP.2009.14.12 97

Figure 3.29 Agisoft's PhotoScan textured 3D model and mesh of LIVNP.2009.14.12 97

Figure 3.30 Autodesk's 123D Catch textured 3D model and mesh of LIVNP.2009.14.12 97

Figure 3.32 NextEngine textured 3D model and mesh of the Anglo-Saxon glass counter. 99

Figure 3.33 Agisoft's PhotoScan textured 3D model and mesh of the Anglo-Saxon glass counter. 99

Figure 3.34 Autodesk's 123D Catch textured 3D model and mesh of the Anglo-Saxon glass counter. 99

Figure 3.36 The NextEngine's textured 3D model and mesh of the medieval stone hand playing a lute 101

Figure 3.37 Agisoft's PhotoScan textured 3D model and mesh of the medieval stone hand playing a lute 101

Figure 3.38 123D Catch's textured 3D model and mesh of the medieval stone hand playing a lute 101

Figure 3.40 The NextEngine's textured 3D model and Mesh of the animal bone 103

Figure 3.41 Agisoft's PhotoScan textured 3D model and Mesh of the animal bone 103

Figure 3.42 123D Catch's textured 3D model and Mesh of the animal bone 103

Figure 3.43 Mesh Comparison of LIVNP.2009.14.10 models, created by the NextEngine and PhotoScan. Mesh displays that on average there is between 0.15 - -0.66mm² difference in meshes. The red indicates some noise in the background which has not been edited out, but which is not on the actual figurine itself. 105

Chapter 4

Figure 4.1 King Figurine from Blackfriars underpass, Greater London (Author's images, courtesy of The British Museum, GM181.1969.25134) 108

Figure 4.2 King figurine, Cannon Street, London. 108

Figure 4.3 Portraits, from top left to right Charles I, Charles II, James II when Duke of York, on lower line, Henry Duke of Gloucester, and the Duke of Albemarle; a sixth oval with 'A perpetual Almanacs', a ship and a tree. Engraving 1660-70 Robert Walton (Walton 1660, Image from ©Trustees of the British Museum.) 108

Figure 4.4 A depiction of Charles I on a tin glazed earth ware dish. London. 1653. C.71-1998 (Image from © Victoria and Albert Museum, London 2019) 109

Figure 4.5 Terracotta model of King William III. Made by John Nost the Elder ca.1695 (Image © Victoria and Albert Museum, London 2019) 109

Figure 4.6 Jug with portrait of William III, ca. 1689-1702 (Image from © Victoria and Albert Museum, London 2019) 109

Figure 4.7 Queen (Elizabeth) figurine. Bankside, City of London. (Author's images, courtesy of The British Museum, 17681) 110

Figure 4.8 A print of Queen Elizabeth I from 1612 made by Renold Elstrack and published by John Sudbury and George Humble. (Image from ©Trustees of the British Museum. Catalogue nos 1854,1113.117, 30/01/2017) 110

Figure 4.9 A print of Queen Elizabeth I from 1659 published by Robert Walton, number 23 in his Kings and Queens set. (Image from ©Trustees of the British Museum. Catalogue numbers 1870,0514.2919) 110

Figure 4.10 To the left, the lion with band found on Queen's Street, London. To the right, a close up of the lions tale depicting the paint remains on the figurine (Authors images, courtesy of MoL. 20309) 111

Figure 4.11 Seated Lion in two halves. (Authors image, courtesy of London Archaeological Archive and Research Collection, NHU.481.50) 111

Figure 4.12 Lion, Holland (Image from Personal comm. R. Stam) 111

Figure 4.13 Lion, Holland (Image from Personal comm. R. Stam) 111

Figure 4.14 Standing Madonna and Child, A. Maitani. c.1330 Wood with Poly Chrome. Perugia, National Art Gallery of Umbria. (Image from Plazzotta et al. 2006, pl 2) 112

Figure 4.15 Madonna and Child. Billingsgate, City of London (Private collection, image from Timeline 2011) 112

Figure 4.16 Inverted Image of the Madonna and Child clay mould. Found in Greater London. (Author's image, courtesy of LAARC. LIG88) 113

Figure 4.17 Madonna and Child figurine. (Author's Image, courtesy of The British Museum 1856,0701.1652) 113

Figure 4.18 Crowned Madonna and Child, London. (Author's Image, courtesy of The British Museum 1855,0512.17) 113

Figure 4.19 Christ with a dove (Author's Image, Courtesy of The British Museum OA.9366) 114

Figure 4.20 Christ with dove and olive branch. Lambeth Road, London (Authors Image, Courtesy of LAARC) 114

Figure 4.21 Christ in a basket/cradle, Easington (Image from PAS DUR-069221)........114
Figure 4.22 Wood cut displaying a New Year's greeting in a ribbon, and the Christ child wearing paternoster beads and holding a dove. (From Heitz, Neujahrswunsche des xv. Jarhunderst, in, Lemmel et al. 2009, figure 133, 245) 114
Figure 4.23 Pipe clay figurine Nativity arrangement. Westerwalds, Germany 115
Figure 4.24 A pipe clay cow and praying woman, potentially the Virgin Mary (Image from Timeline 2013) 115
Figure 4.25 Christ on crucifix. From Haydon Street, London. Late 15th century (MOLA 1990) 116
Figure 4.26 A thief being crucified next to Christ. Found at Carmarthen Greyfriars, Wales. 15th-16th century, 28.5cm in width (Image from Redknap 1997, 51 with permission From © National Museum Of Wales) 117
Figure 4.27 crucifixion of Christ in Pipe Clay, Amsterdam, 1475-1525. 117
Figure 4.28 Anonymous Artist, Lamentation, dotted print, in the Gdansk Library of the Academy of Science glued to the inside cover of Sermones aurei de Sanctis, Nuremberg, Antonius Koberger, 1478 (Figure 37, Deluga 1995) 117
Figure 4.29 fragmented cockerel on a stand. 118
Figure 4.30 Cockerel on a stand. 118
Figure 4.31 St Peter denouncing Christ on a sarcophagus displaying a cockerel on top of the central column (Callisen 1939, Fig 2, 163 artwork in the public domain; photographer unknown) 118
Figure 4.32 Ravenna, S. A'pollinare Nuovo: Mosaic, with a cockerel on a column in the centre of the image (Callisen 1939 Fig 12, 171 artwork in the public domain; photographer unknown) 119
Figure 4.33 Florence, Museo Nazionale: Ivory detail, with cockerel atop a column in the centre of the piece (Callisen 1939, Fig 4, 164 artwork in the public domain; photographer unknown) 119
Figure 4.34 The suffering of Christ .Wandbild, Nr. 222 E. G. May, Verleger 1864 – 1877 N (33 R) 545/2009 Sammlung: Museum Europäischer Kulturen(© Photo: Museum Europäischer Kulturen der Staatlichen Museen zu Berlin - Preußischer Kulturbesitz)..120
Figure 4.35 Pendant, Christ a Man of Sorrows with cockerel on a column to the left, 1590. Gold, enamel and pearl (Image by M. Fernandez from the Kunstgewerbemuseum, Berlin) 121

Figure 4.36 Silver medal. 1679, (obverse) Wheatsheaf with crossed sword, orb and crown on top. (reverse) Cockerel standing on orb to left in field, Netherlands. (Image from ©Trustees of the British Museum. M.1918, accessed 01/02/2017) 121

Figure 4.37 Two pipe clay figurine forms depicting Christ riding on a cockerel, Zeeland. 121

Figure 4.38 Study for a print by Johann Ulrich, Mary the Virgin of Sorrows adoring a reliquary of the Holy Blood, with a crowing cockerel lower left, 1700. Germany (Image from ©Trustees of the British Museum. 2009,7076.1AN703551001, accessed 01/02/2017) 122

Figure 4.39 Isolation of the little Girl carrying the bucket of treats, from The Feast of Saint Nicholas. 122

Figure 4.40 Close up of Tobacco Clay Pipe with cockerel imagery, London. 123

Figure 4.41 Range of Cockerel Tobacco Clay Pipes from London 123

Figure 4.42 A) To the Left Watermen's Arms pipe embossed with a cockerel on a column; and B) To the right a variant on the Hanoverian bowl, embossed again with a cockerel on a column. 124

Figure 4.43 Men playing a game of Cockshy. Anonymous engraving of the 1683/4 Frost Fair on the Thames. 125

Figure 4.44 Two different cock shy designs made from lead alloy from 18th century London, no further information given (With permission from Forsyth and Egan 2005 fig 7.1 and7.3, 240) 125

Figure 4.45 St Catherine and Wheel. City of London. (Author's image courtesy of The British Museum's 1854.0814.8) 126

Figure 4.46 St. Dorothy with basket 126

Figure 4.47 Saint Barbara with Tower, Dorset Rise, London (Author's Image, Courtesy of LAARC) 126

Figure 4.48 Saint Mark. Greater London, (Author's Image, Courtesy of LAARC ALA884174) 126

Figure 4.49 High altar in the Church of Saint Mary, Zwickau, Saxony. Mary surrounded by eight female saints. By 'Master of the Zwickau High Altar', 1479 126

Figure 4.50 Saint Mark with lion drawing, 16th century (Image from ©Trustees of the British Museum. T,12.45, AN403155001 accessed 01/02/2017) 127

Figure 4.51 16 female saints 1500-1526, Germany, woodcut print by Hans Wechtlin (Image from ©Trustees of the British Museum. E,8.176, accessed 01/02/2017) 127
Figure 4.52 Detail of a miniature of burning costumes of the 'hommes sauvages', displaying a figurine on the chimney hood, *Jean Froissart's Chroniques, Vol. 4, Netherlands, c. 1480,* (*© British Library Board Royal MS 18 E II, f. 206r. Biggs 2013 accessed 21/06/2017)* 128
Figure 4.53 Angel, found at London Wall (Author's image, courtesy of MoL. A3886) .128
Figure 4.54 Front and back of a Cupid or an Angel. Aldgate, building VII, Greater London (Image from Weinstein 1984, 122-4 © Society for Post-Medieval Archaeology, reprinted by permission of Taylor & Francis Ltd.) 128
Figure 4.55 Cherub head. Aldgate, London. (Author's image, courtesy of MoL. A23836) 128
Figure 4.56 Ecclesiastical male. London Wall. (Image from London Museum 1940, Pl. XCI, No. 1) 129
Figure 4.57 Cleric with maniples, Lower Thames Street (Authors Image, courtesy of MoL) 129
Figure 4.58 A set of maniples from the late 14th century, German (image from © Victoria and Albert Museum, London online collection 1262-1864, accessed 02/02/17) 130
Figure 4.59 cleric with tabard embossed with a cross from Fosters Lane, London, (authors image, courtesy of LAARC) 130
Figure 4.60 Woodcarving by Tilman Riemenschneider of the Fourteen Holy Helpers, 1520-30, held within the Mainfränkisches Museum, Wüzburg, Germany 130
Figure 4.61 Staffordshire made Salt glazed stoneware Cleric, 1740. 130
Figure 4.62 Male urinating. Greater London. 131
Figure 4.63 Courtesan with pipes Greater London (Authors Image, courtesy of the British Museum, M.592) 131
Figure 4.64 Naked male holding a bouquet of flowers and grapes, potentially a representation of Bacchus. Front and back. 131
Figure 4.65 Male figure with tip-staff and badge with initials 'PB'. Aldgate, Greater London 132
Figure 4.66 John Jackson1699 shop advert, items included 'Silver Toys…Ivory Toys…all sorts of Toys for Children…Curiosities for Gentlemen and Ladies'. (Cat.no.8.45 Image

from ©Trustees of the British Museum. Heal Collection, in, Forsyth and Egan 2005, 33) 133

Figure 4.67 A detailed section of plate X from Matthäus Schwarz of Augsburg autobiographical costume book, 1509. Showing a sick little boy with nurse, who is trying to amuse him with toy knights on horseback (With permission from Forsyth and Egan 2005, fig. 36, 145) 134

Figure 4.68 A detailed section of an engraving which Jacob Cats used to illustrate the emblem 'Schoon voortgedaen is half vercocht' which depicts a market stall selling a range of toys, such as dolls, hobby horses and drums, 1632 (With permission from Forsyth and Egan 2005, 153, fig. 38) 135

Figure 4.69 redrawn detail from a copy of c.1170 manuscript (now lost) detailing two men playing with puppet knights, an image which accompanied a Latin legend underlining the futility of those who waste time with vain pursuits. Entitled Hortus Deliciarum by Herrad von Landsberg of Strabourg (With permission from Forsyth and Egan 2005, fig 15, 61) 135

Figure 4.70 Soldier with musket, Eden Street, Greater London (Image courtesy of Steve Nelson and Pre-Construct Archaeology Ltd) 136

Figure 4.71 knight figurine. From London Wall 136

Figure 4.72 Front and rear of woman on a plinth. Found at London Wall (Author's Image, Courtesy of MoL. 4971) 137

Figure 4.73 Painted pipe clay figurine, female consort. (Authors photo with permission from Museum of London, 5036) 137

Figure 4.74 Female figurine, mid to late 16th century, lead alloy (With permission from Forsyth and Egan 2005, 154, fig 4.14). 137

Figure 4.75 Portrait of Three Young Girls, from the Circle of Robert Peake (fl. 1598-d. circa 1626) (Sotheby's 1988 figure 3, 19) 137

Figure 4.76 Christopher Anstey with his daughter.(Hoare 1775, © National Portrait Gallery, London 3084, Public Domain) 137

Chapter 5

*Figure 5.1 Front and back of kingly figurine found at the Charles Gift Site, Maryland.*154

Figure 5.2 Site Plan of Nicholas Sewalls primary and secondary homes and clay extraction pit. 155

Figure 5.3 James II coin pendant, from site 44ST130, Virginia 156

Figure 5.4 The foundations of the St John's site (Image from Miller 2006, 1 with permission from Miller and ©Historic St. Mary's City) 158

Figure 5.5 Front fragment and back fragment of cherub head (Authors image's, with permission from Historic St Mary's City) 159

Figure 5.6 a fused 3D scan of the two halves fused together. (Authors 3D scan, with permission from Historic St Mary's City) 159

Figure 5.7 Van Sweringen site during excavation (Image Courtesy of Historic St. Mary's City, Hurry and Grulich 2015, 6) 160

Figure 5.8 Reconstruction of the Van Sweringen House (author's image) 160

Figure 5.9 Madonna statue fragments, (front 1.94 in / 4.96 cm , back 1.29 in / 3.28 cm) 18ST1-19-297C/AA and 18ST1-19-332H/AA (Authors image, with permission from Historic St Mary's City) 162

Figure 5.10 Gentleman statue with oak leaf. (.69 in / 1.75 cm tall) 18 ST1-19-259/AA 162

Figure 5.11 A male figurine with acorn leaf from Mount St Vernon. (Image belongs to the author courtesy of George Washington's Mount Vernon) 162

Figure 5.12 A figurine from the Duvall Plantation. 162

Figure 5.13 Portrait of Prince Charles II with oak leaf to the right of the image, British Museum Collection (Figure 11 from Glasses and Relation *1921)* 163

Figure 5.14 The Oak Medal of Charles II (Figure D from British Numismatic Journal vol. V p.251 in Glasses and Relation 1921, 260) 163

Figure 5.15 Seven of the ten pipe clay figurine fragments found on the Duvall. (Doepkens 1991) 164

Figure 5.16 Complete Madonna and Child. 164

Figure 5.17 Front and rear of Gentleman with oak leaf symbol figurine. 164

Figure 5.18 Reconstruction of the James Fort site (With permission fromn Straube 2013. 264, Figure 1) 167

Figure 5.19 Lady in Horned Hat, head. 167

Figure 5.20 Ceramic soldier mould (Authors Image, with thanks to the NPS, Jamestown, Virginia, USA) 167

Figure 5.21 Archaeological Base Map of the Site of James Towne, the green circle indicates refuse pit 2. 167

Figure 5.22 Lady with dog, front and rear (Author's Images with thanks to the Mount Vernon Archaeology Department) 168

Figure 5.23 3D model of the front of the lady (Author's 3D model with thanks to the Mount Vernon Archaeology Department) 169

Figure 5.24 Front and rear of Gentleman with staff and hat, with Oak leaf on the rear of his legs (Author's Images with thanks to the Mount Vernon Archaeology Department) 169

Figure 5.25 A Site map to display the location of the midden and also the slave quarters, marked nos6. 170

Figure 5.26 Image of George Washington's Home taken in a NE direction, the midden was located in this grassy area. (Author's image) 170

Figure 5.27 Invoice from R. Cary & Co. Showing Purchase for Patsy Custis from London toy Store Unwin & Wigglesworth 'from Unwin & Wrigglesworth— '3 Neat Tunbridge Toys 1/' 171

Figure 5.28 Invoice from R. Cary & Co. Showing Purchase for Jacky Custis from London toy Store Unwin & Wigglesworth (R. Cary & Co. 1760, courtesy of The Library of Congress, Washington, DC, accessed 21.12.15 15.53) 171

Figure 5.29 These two fragments of the same figurine, long coated gentlemen, the fragment to the left displays the rear of the lower half of this gentleman from hips to knees, and the right fragment shows the front of the gentlemen, again from the hips to knees. (Author's images, with thanks to Historic Londontowne's archaeological laboratories) 172

Figure 5.30 The fragment on the right displays the rear of a male's head. The fragments are dated to the mid to late 17thC. 172

Figure 5.31A location, plan, and section of the 1967 test pit (Hume 1986, Figure 2 and 2a, 9-10) 174

Figure 5.32 The pipe clay figurine which was discovered within the test pit (Hume 1986, Figure 2 and 2a, 9-10) 174

Chapter 6

Figure 6.1 Numbers per mould type. 181
Figure 6.2 Above a mould half used to make the figurines, below an example of the fired elephant (Author's images, with thanks to Dr. David Higgins for creating the specimens) 184
Figure 6.3 NextEngine scanning results example. 185
Figure 6.4 Overview of data shown in comparison screenshots 187
Figure 6.5 A) Model A vs Unfired model, with the colour scalar represented on Model A. 188
Figure 6.6 B vs Unfired model, with the colour scalar represented on Model B. 189
Figure 6.7 C vs unfired model, with the colour scalar represented on Model C. 190
Figure 6.8 A vs B, displaying comparison on model B. 191
Figure 6.9 Shows model A vs C, with the results displayed on model C 192
Figure 6.10 Shows model B vs C, with the results displayed on model C 192
Figure 6.11 Close up of Histograms with their upper and lower quartiles displayed. 194
Figure 6.12 Unfired vs mould half 1 195
Figure 6.13 Unfired vs mould 2 195
Figure 6.14 Mould half 1 vs A 195
Figure 6.15 Mould half 2 vs A 196
Figure 6.16 Mould half 1 vs B 196
Figure 6.17 Mould half 2 vs b 196
Figure 6.18 Mould half 1 vs C 197
Figure 6.19 Mould half 2 vs C 197

Chapter 7

Figure 7.1 Charles Gift Site King (top two images) and London Blackfriars King (bottom two images) (author's Images courtesy of Historic St. Mary's City Archaeological Museum and Museum of London) 204
Figure 7.2 The Charles Gift Site (top) and Blackfriars (bottom) king figurines, with red circles highlighting areas of erosion that are likely to produce areas of difference in the analysis. Such areas include heavy erosion seen along the cloak edges, the crack in the

middle section of the Charles Gift Site king's cloak, the neckline breaks, the sword breaks, the leg breaks and the break on the right arm of the Blackfriars king's arm. .205

Figure 7.3 Results displaying the Blackfriars King with colour scalar in comparison to the Charles Gift Site King/mm 206

Figure 7.4 Blackfriars King compared to Charles Gift Site King, with 2mm parameters set in place. 206

Figure 7.5 Blackfriars King front and rear compared to Charles Gift Site King, with 1mm parameters set in place. 207

Figure 7.6 Blackfriars King compared to Charles Gift Site King, with 0.5mm parameters set in place 208

Figure 7.7 The pattern of regions which correlate with expected regions of metric variation due to erosion. 208

Figure 7.8 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.003m parameter set (3mm). 211

Figure 7.9 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.002m parameter set (2mm). 211

Figure 7.10 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.001m parameter set (1mm). 212

Figure 7.11 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.0005m parameter set (0.5mm). 212

Figure 7.12 SfM histograms on the left side compare to the NextEngine Histograms on the right side. 213

Figure 7.13 from left to right Cockerels A5176, a19159 and 4973b. (Author's images courtesy of the Museum of London) 214

Figure 7.14 The post production differences between each of these cockerels, highlighted by red circles. 214

Figure 7.15 Structural similarities between the three cockerels, highlighted by green circles. 214

Figure 7.16 A5176 compared with a19159, results displayed on a19159, 3mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. High similarities seen in the main body, indicated by the large space of white and light blue. 216

Figure 7.17 A5176 compared with a19159, results displayed on a19159, 2mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. High similarities seen in the main body, indicated by the large space of white and light blue. 216

Figure 7.18 A5176 compared with a19159, results displayed on a19159, 1mm parameter. Significant difference along figurine seams, expected due to seam scrapping after moulding. Some areas are shown not to be in the 1mm parameter, however the majority of the figurine is still present. 217

Figure 7.19 A5176 compared with a19159, results displayed on a19159, 0.5mm parameter. Significant difference along figurine seams, expected due to seam scrapping after moulding. Some areas are shown not to be in the 0.5mm parameter, however the majority of the figurine is still present. 217

Figure 7.20 A5176 vs 4973b, results displayed on 4973b, 3mm parameter. Significant difference along the beak, tail base and wing base, indicated by the red colouring. A majority of a5176 is shown to be slightly reduced in size in comparison to 4973b, indicated by the large regions of blue. 217

Figure 7.21 A5176 vs 4973b, results displayed on 4973b, 2mm parameter. Significant difference along the beak, tail base and wing base, indicated by the red colouring. A majority of a5176 is shown to be slightly reduced in size in comparison to 4973b, indicated by the large regions of blue. 217

Figure 7.22 A5176 vs 4973b, results displayed on 4973b, 1mm parameter. 49.48% of the model comparison remains at the 1mm parameter, showing that there are still similarities present at this level between the figurines, with A5176 displayed as the slightly smaller figurine still. 218

Figure 7.23 A5176 vs 4973b, results displayed on 4973b, 0.5mm parameter. 24.24% of the figurines are still shown to be present. 218

Figure 7.24 a19159 vs 4973b, results displayed on a19159, 3mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. A majority of a19159 is shown to be reduced in size in comparison to 4973b, indicated by the large regions of blue. 218

Figure 7.25 a19159 vs 4973b, results displayed on a19159, 2mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. Some areas around the cockerel's eye are present within this parameter. A majority of *a19159 is shown to be reduced in size in comparison to 4973b, indicated by the large regions of blue.* 218

Figure 7.26 a19159 vs 4973b, results displayed on a19159, 1mm parameter. 68.56% of the model comparison remains at the 1mm parameter, showing that there are still similarities present at this level between the figurines, with a19159 displayed as the slightly smaller figurine still. 219

Figure 7.27 a19159 vs 4973b, results displayed on a19159 0.5mm parameter. 32.84% of the figurines are still shown to be present. 219

Figure 7.28 Hypothetical appearance of suggested mould generation, 4973b is not shown as no specific assignment of generation can be consigned. 220

Figure 7.29 The top two images display the front and rear of the Whitechapel King, and the bottom two images display the front and rear of the Thames King (Author's images with thanks to the British Museum) 221

Figure 7.30 The top two images display the front and rear of the Whitechapel King, and the bottom two images display the front and rear of the Thames King, the erosional variation between the two figurines is indicated with the red circles. Significant areas of difference are seen on the neck break, sword pommel, damage to the top of the left thigh on the Thames King figurine, damage to the right of the Thames King's cloak, base damage, the crack along the Whitechapel King's left ankle and the curatorial ink on both the figurines. 222

Figure 7.31 2.6 - -2.99mm parameter results, displayed on the Thames King. 66% of the Thames King is smaller, indicated by the blue regions. High areas of differentiation are shown to correspond with the regions marked out on Figure 7.30. 223

Figure 7.32 2mm parameter results, displayed on the Thames King. However 99.59% of the figurine features are present within the 2mm parameter. 224

Figure 7.33 1mm parameter results, displayed on the Thames King, with 90.42% of the figurine faces still present at the 1mm parameter. 224

Figure 7.34 0.5mm parameter results, displayed on the Thames King, the image displays the rear of the comparison to the left and the front of the figurine comparison to the right. 55.30% of the model comparison remains at the 0.5mm parameter, showing that there are still large similarities present at this level between the figurines, with the Thames King still displayed as the slightly smaller figurine. 225

Figure 7.35 from left to right front and back of figure 1854,1130.45, in the middle is the front and back of figurine 1854,1130.46 (author's images courtesy of The British Museum) and to the right is the front and back of figurine 4972 (authors image courtesy of the MoL) 226
Figure 7.36 Areas of likely variation on the models marked in red. Some is due to erosion and breakage, but significant parts of the left two figurines are affected by the museum stickers..226
Figure 7.37 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46, 1mm parameter. To the left is the rear of the figurine, to the right is the front of the figurine. Note the circular area on the rear of the figurine, indicating the museum reference sticker rather than actual size variation on the figurines themselves. 227
Figure 7.38 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46, 0.5mm parameter. Areas which begin to be removed are the features which have the potential to most highly affected by erosion, shrinkage and mould extraction, as expected. 228
Figure 7.39 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46, 0.25mm parameter. High level of faces remain with many specific features such as the basket details still present...228
Figure 7.40 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46. 0.05mm parameter, the main outline of the figurine is still present. 229
Figure 7.41 1854,1130.46 compared to 4972 with results shown on 4972 lower half, 1mm parameter, angle displays the removal of faces along the figurines breaks at this level. 230
Figure 7.42 1854,1130.46 compared to 4972 with results shown on 4972 lower half, 0.5mm parameter. The texture has been removed on this image so the colour scalar can be seen clearer. Majority of figurine details still present, though 4972 is marginally larger than 1854,1130.46. 230
Figure 7.43 1854,1130.46 compared to 4972 with results shown on 4972 lower half, 0.25mm parameter. The majority of the figurine is still present, with a large proportion of 4972 0.25mm larger than Dorothy 1854,1130.46. 231
Figure 7.44 2mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy. Faces which were removed were those along the break.62% of 4972 is larger by up to 0.5mm. 232

Figure 7.45 1mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy. Though majority is slightly larger by up to 0.5mm, the features are represented in white which displaying matching features locations. 232
Figure 7.46 0.5mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy. Majority of features are still present at this parameter. 232
Figure 7.47 0.25mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy 232
Figure 7.48 the 2mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. Faces lost along break line. 87% of 4972 is larger by up to 0.5mm. 233
Figure 7.49 1mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. 2% of the faces have now been removed, these are concentrated along the break line of the figurine. 233
Figure 7.50 0.5mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. 90% of the remaining faces are larger on 4972 than Dorothy 1854,1130.46. 234
Figure 7.51 0.25mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. 87% of the faces are still present. 234
Figure 7.52 2mm parameter. Dorothy 1854,1130.45 compared to 4972 upper half. Faces lost along the break. 65% of the 4972 figurine is larger by up to 0.5mm. 235
Figure 7.53 1mm parameter. Dorothy 1854,1130.45 compared to 4972 upper half. Faces lost due to whole of the break line being removed. 235
Figure 7.54 0.5mm parameter. Dorothy 1854,1130.45 compared to 4972 upper half. 235
Figure 7.55 0.25mm parameter. Dorothy 1854,1130.45 compared to 4972upper half. The main area affected by feature removal at this parameter is seen within the figurines facial features. 235
Figure 7.56 Hypothetical family order of the 3 compared Dorothy figurines. 236
Figure 7.57 left two images display man 4975 (Museum of London) and the right two images display man 1854,1130.47 (British Museum). 237
Figure 7.58 Top two images display man 4975 (Museum of London) and the bottom two images display man 1854,1130.47 (British Museum). The red circles indicate areas of erosional scarring. 237
Figure 7.59 2mm parameter, with results shown on man 4975. 52% of 4975 is smaller, so preliminary results suggest that the 4975 man is from a later generation. Though

some specific features are highlighted white, such as the buttons, showing minimal movement between figurines features. 20% is highlighted red – this looks like movement from mould removal issues. 239

Figure 7.60 1mm parameter with results shown on man 4975. Around 5% of features are in the exact same locations, highlighted white on the model. 239

Figure 7.61 0.5mm parameter, with results shown on man 4975. Majority of features which have been removed in this parameter are concentrated around the figurines face, expected due to this region being highly affected my removal from the mould. 240

Figure 7.62 0.25mm parameter, with results shown on man 4975. 60.5% of the faces are still present. 240

Figure 7.63 The two images above are of King 1854,1130.44 and the two images below are of King 17681 (Author's image, with thanks to The British Museum and the Museum of London). 241

Figure 7.64 Non-textured 3D images of the left two images are of King 1854,1130.44 and the right two images are of King 17681. The red circles indicate areas of erosional scarring. 242

Figure 7.65 3mm parameter shown on figurine King 17681. A Large orientation is based around the 0 marker, this suggests preliminarily that the figurines are from same generation. 243

Figure 7.66 2mm parameter shown on figurine King 17681. The hand, orb and belt placement are all shown in white. Peak indicators displayed on expected broken and eroded areas. 244

Figure 7.67 1mm parameter shown on figurine King 17681. The regions which have started being removed at this parameter are those expected, these are the highly eroded and broken regions. 244

Figure 7.68 0.5mm parameter shown on figurine King 17681, 32.1% of the faces are present. 245

Chapter 8

Figure 8.1 Madonna and Child mould, recovered from the Ling House Site, London, NGR: TQ32878180. (Authors image courtesy of LAARC) 250

Figure 8.2 Dürer's Meisterstiche, Top left; Melancolia I. Top right; Knight, Death, and the Devil. At the bottom, Saint Jerome in His Study (1513-14), engraving. (Images from ©The Metropolitan Museum of Art 2017b;a;c [open access]) 261

Figure 8.3 Dürer's Erasmus of Rotterdam, 1526, the inscription reads "This image of Erasmus of Rotterdam was drawn from life by Albrecht Dürer''. Engraving. (Image from ©The Metropolitan Museum of Art, 2017*[open access]*) 262

Figure 8.4 The figurine can be seen to adorn the fire hood, with close up detail of this figurine to the right, in this detail of a miniature of burning costumes of the 'hommes savages' during a masked dance in Paris, at the beginning of Chapter 32, from Jean Froissart's Chroniques, Vol. 4, Netherlands (Bruges), c. 1480, (© British Library Board , Royal MS 18 E II, f. 206r. Biggs 2013 accessed 21/06/2017) 268

Figure 8.5 Camera Dome for 3D imaging, used by the Institute of Computer Science II (Image from Klein and Schwartz 2012) 276

List of Graphs

Chapter 6

Graph 6.1 Objects produced from the same mould 200

Graph 6.2 Objects from the same generation. 200

Graph 6.3 One object is from a later generation than its comparative object. 200

Graph 6.4 One object is from an earlier generation than its comparative object. 200

Chapter 8

Graph 8.1 Distribution rate of figurines in London by type of context they have been recovered from, a total of 15 figurines were analysed. 249

Graph 8.2 Rate of Virgin, Cleric and Saint Figurines recovered between 15th-19th Centuries, London. 264

Graph 8.3 Graph to show the amount of religious figurines from different centuries in London, the rest of England, Wales and Scotland. 264

Graph 8.4 Graph to show the amount of figurines from different centuries in London, the rest of England, Ireland, Wales and Scotland. 265

List of Maps

Chapter 4

Map 4.1 Map displaying the distribution of 77 of the 121 figurines so far known in London. Top image displays general figurine distribution across Greater London, lower image displays a close up of those figurines found in Central London. (Map created by Author, using Palladio v1.2.4) 140

Map 4.2 Brief overview of figurine distribution on Roque's 1746 map(Adapted map created by Author on John Roques 1746 Map of London [Public Domain]) 141

Chapter 5

Map 5.1 Map of the east coast of America and the northwest of the Caribbean. Red points show the sites where pipe clay figurines have so far been located in America, these include: the Charles Gift Site at St Mary's City, Maryland, the Duvall Middle Plantation in Maryland, St John's Site in Maryland, Van Sweringen in Maryland, New town in Jamestown, Virginia, Jamestown in Virginia, Mount Vernon in Washington D.C., Chaney's Hill in Anne Arundel County, Permaquid in Maine, Leonard Calvert Site in St Mary's City and the Drummond Plantation in Maryland.... 152

List of Tables

Chapter 2

Table 2.1 Summary of costs of SfM, laser scanner and structured light scanner, costs were assessed during the 01.2016-08.2016. 54

Table 2.2Accuracy trial statement released by NextEngine 60

Table 2.3 Analysis and Critique of past methodologies of digital surrogate workflow .. 63

Chapter 3

Table 3.1 Hardware specifications 74

Table 3.2 The dimensions of the test objects 83

Table 3.3 Star Prism results, results are all measured in MeshLab and 3D models shown in Figure 3.10. Colour comparisons are in relation to the original object (pictured in Figure 3.8) 85

Table 3.4 Rectangular Prism results, results are all measured in MeshLab and 3D models shown in Figure 3.11. Colour comparisons are in relation to the original object (pictured in Figure 3.8) 85

Table 3.5 Pentagonal Prism results, results are all measured in MeshLab and 3D models shown in Figure 3.12. Colour comparisons are in relation to the original object (pictured in Figure 3.8).. 86

*Table 3.6 The margin of error seen within between the 3D models created by the Structured Light Scanner and those measurements taken from the actual objects. Trial 1 and 2. Trial 1 consisted of the following calibration levels: for the star: 77.1%; and for the rectangular and pentagonal prisms; 81%. For Trial 2 all three objects had a calibration value of 87.1%. The equipment recommends that you use 75% and above.*87

Table 3.7 displaying the error differences in mm between the 3D images and the original objects 88

*Table 3.8 Metric results of LIVNP.2009.14.10 3D models and some general comments*91

Table 3.9 Metric results of LIVNP.2009.14.27 3D models and some general comments. 94

Table 3.10 Metric results of LIVNP.2009.14.12 3D models and some general comments. 96

Table 3.11 Metric results of the Anglo Saxon glass counter models and some general comments. 98

Table 3.12 Metric results of the Medieval stone hand and lyre models and some general comments. 100

Table 3.13 Metric results of the animal bone models and some general comments ... 102

Chapter 4

Table 4.1Figurines recovered from religious contexts, with five from London and one from Wales. 143

Table 4.2 Secular Context 145

Table 4.3 figurines from taverns/public house assemblages. 148

Table 4.4 potential market place assemblages and production assemblages 149

Chapter 6

Table 6.1 Stylistic dating for saint figurines (summarised from Van Den Dorpel 2013, 22) 180

Table 6.2 Stylistic dating for Virgin Mary and Christ Child figurines (Summarised from Van Den Dorpel 2013, 22) 180

Table 6.3 Summary of NextEngine data. 185

Table 6.4 Summary of comparison results, all results in mm² 186

Chapter 7

Table 7.1 Figurine comparison list 203

Table 7.2 Different stages of figurine parameters, the affecting face count and the overall surface area percentage representation 208

Table 7.3 Different stages of the SfM approaches to the Charles Gift Site and Blackfriars figurine comparison parameters and the affecting face count and overall surface area percentage representation. 210

Table 7.4 Different stages of figurines A5176 compared to a19159, parameters and the affecting face count and over all surface area percentage representation. 215

Table 7.5 Different stages of figurines A5176 compared to 4973b parameters and the affecting face count and over all surface area percentage representation. 215

Table 7.6 Different stages of figurines a19159 compared to 4973b parameters and the affecting face count and over all surface area percentage representation. 216

Table 7.7 Summary of Whitechapel compared to the Thames King comparison results. Results are in mm. 223

Table 7.8 Different stages of figurine parameters and the affecting face count and overall surface area percentage representation. Dorothy 1854,1130.45 compared to 1854,1130.46 with results shown on 1854,1130.45. 227

Table 7.9 Different stages of figurine parameters and the affecting face count and overall surface area percentage representation. Dorothy 1854,1130.46 vs 4972 with results shown on 4972 lower half. 229

Table 7.10 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. Dorothy 1854,1130.45 vs 4972 with results shown on 4972 lower half. 231

Table 7.11 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. Dorothy 1854,1130.46 vs 4972 with results shown on 4972 upper half. 233

Table 7.12 Different stages of figurine parameters and the affecting face count and overall surface area percentage representation. Dorothy 1854,1130.45 vs 4972 with results shown on 4972 upper half. 234

Table 7.13 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. 1854,1130.47 Compared to 4975, results shown on man 4975. 238

Table 7.14 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. 243

Chapter 8

Table 8.1 Post-medieval pipe-clay figurine comparisons between Germany or the Low Countries and British or British Colonies. 251

Table 8.2 Figurine comparisons which have no identical counterparts present between the Germany or the Low Coutnries and the UK, but display the same iconographical topic. 256

Table 8.3 Figurines utilised in comparison study in Chapter 7 with hypothetical 5% over firing shrinkage measurement and the actual difference recorded during the comparisons. 274

Technical Terms and Abbreviations

3D Mesh - The structural build of a 3D model. This mesh consists of polygons and use X, Y and Z axes to define the models height, width and depth.

Graphical User Interface, GUI - This allows users to interact their electronic devices through graphical icons.

Histogram – A representation of the distribution of numerical data.

LAARC – London Archaeological Archive Research Centre

MoL – Museum of London

MOLA – Museum of London Archaeology

Photogrammetry - A passive image based technological approach whereby the aim is to recreate an object in a digital 3D format with metrically precise dimensions. The input is photographs and the output generated is a 3D model.

Point Cloud – A set of data points which record a large number of points on the external surface of an object which is being recorded.

SIFT (Scale-invariant feature transform) – These are feature detection algorithms. These algorithms are then employed to reconstruct the camera pose and 3D dimensional scene geometry.

Structure from Motion, (SfM) - A form of photogrammetry which uses a series of 2D images that have been captured via an individual moving around a fixed object or structure with a camera.

VR – Virtual Reality

Introduction

The research for this thesis has been motivated by two central themes. The first was the desire to document, classify and contextualise London's post-medieval pipe clay figurines dating to the 16^{th}-18^{th} centuries. The second motivation was to examine the potential for the employment of Structure from Motion (SfM) 3D imaging technology, in particular the utility of the approach for figurine and mould metric comparisons. This research has aimed to help further current understanding of pipe clay figurine production and distribution by providing the first in-depth analysis of material from England, alongside offering a new digital methodological approach to examining pipe clay figurine mould generations. These approaches are intended to help revitalise the static research field of mould generational analysis (discussed in Chapter 6), as well as provide valuable comparative evidence for pipe clay figurines in Continental Europe, in particular Germany and the Low Countries.

Once the primary dataset which is concerned with London's post medieval pipe clay figurines from the 15^{th} – 18^{th} century, has been explored, a preliminary examination of figurines recovered from the rest of the UK and English Colonies within America will be undertaken. From this base further investigation will examine the employment of these figurines and attempt to shine light on the following research questions and discussion points:

- Who were these figurines produced for?
- What purposes were they created?
- How can 3D imaging aid in understanding whether there are manufacturing relationships seen between figurines located in England with those recovered from other countries.
- How can 3D mesh comparisons of figurines develop insights on internal figurine relations and generation analysis and how can this new method of comparison aid in the exploration of the scope and scale of manufacture and manufacturing relationships within England.
- These initial stages will then aid in the design of a more precise method of mould generation analysis for this study and for future studies concerned with mould-made artefact generation analysis. Currently, there are no standardised computer-based comparisons of moulded objects applied within these studies. This project employed digital morphometrics, and compared and critiqued differing 3D imaging methods to evaluate and produce a suitable and accurate digital process of examination for mould made artefacts.
- Exploration of figurine distribution both contextually and geographically will be undertaken, providing new knowledge on whether there are differences between regions, social contexts, or on individual sites into how these figurines might have been used and viewed.

- Evidence for commercial transmission will be investigated and how do differing iconographical motifs cater for differing locations and social groups?
- Iconographic differences between those figurines recovered within the Low Countries in contrast to those recovered in London will be highlighted and discussed.
- Finally what does their geographical distribution inform on our understanding of the cultural value that these items held due to their wide-reaching presence across Europe and into the New World?

This thesis will approach these questions by initially investigating post-medieval pipe clay figurines in their broader context and examines, in Chapter 1, the method of their production, presenting a summary of the previous research within the field of post-medieval pipe clay figurines. A general global distribution of these figurines is then provided, before exploring the origins of pipe clay figurine production in Germany and the Netherlands. This exploration reviews the archaeological material recovered from known production sites, such as Breslauer Platz in Cologne, Germany, The Oude Varkenmarkt in Leiden, and Putsteeg in Utrecht, as well as discussing domestic archaeological examples recovered from undisturbed archaeological contexts. Together, this information from production sites and domestic environments provide preliminary but unique insights into the society of this region and the role the pipe clay figurines played. Finally contemporary literary sources that mention these figurines are also explored, for example the Christ figurines discussed in *The Revelations* written by The Blessed Margaret Ebner, a Dominican nun, texts discussing religious pipe clay figurines being scraped and used as '*heavenly medicine'* (Knippenberg 1970, 93), and the Amersfoort floating pipe clay figurine, mentioned in an account given in the chronicles of Jan de Waal, the rector of Saint Agnes during the second half of the 15th century (Mulder 2016, 243). By examining the cultural and ideological influences which are imbued in the objects, Chapter 1 begins to present the versatility of these figurines across a wide range of spheres and shows that these figurines were not restricted to the poorest levels of society, as had previously been suggested (e.g. Van Den Dorpel 2013, 12; Gaimster 2007, 261). This chapter then goes on to explore the gradual decline in distribution of these figurines within Germany and the Netherlands, examining how the effects of social and religious upheavals, such as Martin Luther's 95 theses and the Reformation, had a significant impact on religious experiences, and a concurrent negative effect on the production and distribution of pipe clay figurines. It is at this time that a shift is seen in the distribution of these figurines, and from the 16th century onwards there is a noticeable shift to the UK as the main consumer market (Henry-Buitenhuis 1990, 65).

Before exploring the London post-medieval pipe clay figurine market (presented in Chapter 4), Chapters 2 and 3 introduce the digital technologies which will be incorporated into this study to help analyse mould and figurine generations. Chapter 2 offers an introduction to the current common imaging technologies which are employed within artefact studies, before a more in-depth study is presented into SfM and the different SfM software that will be investigated within this thesis. Following this will be a discussion covering two further 3D imaging technologies, laser scanning and structured light scanning, which will be employed within this study. The purpose of employing a range of 3D imaging technologies is to produce a comprehensive analysis on the accuracy and viability of using SfM for artefact analysis over other 3D imaging technologies. Finally, Chapter 2 will then examine a range of 3D imaging comparison software packages to ascertain which is most suitable to compare and contrast 3D meshes. This technique which will then be later employed in the mould generation analysis carried out in Chapter 7. Chapter 2 concludes with a discussion on the dissemination and development of past comparison studies which will contribute to the structure of this thesis' 3D accuracy trials in Chapter 3.

Chapter 3 begins with a discussion on the hardware and varying imaging environments which are presented within this chapter, and the frequent issues which arise within the field of 3D artefact analysis, including topics such as non-photographic studio work conditions. The experiment specifications for the different SfM software packages mentioned in Chapter 2 are then outlined, which include a NextEngine Laser scanner and the Projector Optoma Ex330e DLP combined with Cameras U Eye UI 1545LE-M-HQ structured light scanner, all of which will initially be trialled upon a series of geometric test objects. Following on from the results of these trials the software and hardware which produced the lowest quality results are removed from the accuracy trials, and a second set of trials on archaeological objects is undertaken with the remaining 3D imaging methodologies which comprised Agisoft's Photoscan, Autodesk's 123D catch, and the NextEngine. Following on from this the results will be reviewed to consider which 3D recording methodologies are most suited for varying artefact groups and for the research questions proposed in this thesis, with a specific concentration on mould analysis. These discussions help to provide ideas of specific academic applications of 3D modelling within artefact studies, providing a means of answering often-reoccurring critiques of 3D modelling technology raised by archaeologists (Forte 2000; Sims 1997; Hermon S, Nikodem J 2006; Reilly 1989). Chapter 3 further highlights that while there are benefits to using SfM within artefact analysis, there are also considerable issues, especially within artefact generation research. This is due to its inability to examine objects at the macro-level required for this study, however, it can be used as a suggestive tool, indicating whether an artefact may fall within the research parameters and justify the employment of more expensive 3D technologies such as laser scanning to carry out more detailed morphometric analysis (a topic discussed further in Chapter 7).

Chapter 4 then goes on to present the London post-medieval pipe clay figurine assemblage which has been collated for this thesis. The chapter divides the figurines in to four distinct groups: royal memorabilia, religious iconography, adult knickknacks and curios, and children's toys. Alongside an examination of the iconography of the individual figurines within these groups their contemporary importance, the meaning behind specific iconographic details, and their position within the consumer market are also explored. Focusing upon the figurines for which sufficient location and context data survives (a total of 77 figurines) an examination into the distribution of these figurines across London and further afield in the UK is also presented. The examination of the figurines' iconography together with their find location provides a deeper understanding of their functionality within the varying social spheres that they have been recovered in; most of note are the religious, secular domestic, public house, and potential market place assemblages. This chapter shows how the figurines were an adaptable form of material culture for a wide variety of contemporary needs and social issues. Discussing these issues helps to highlight how the manner of their cheap and fast production, as well as their robust nature, was well suited to a range of consumer market requirements, from both political and religious propaganda to public house ornaments and children's toys.

Understanding the versatile and durable nature of the figurines makes it unsurprising that they were part of the material culture being taken to the New World during the expansion of English, French, and Dutch colonies in America and the Caribbean. Though not a common artefact, the pipe clay figurines do appear across many of these new colonies. As such this thesis has also examined the material available across the Atlantic as an extension of the London assemblage, helping to further understanding on the contextualisation, functionality, and roles the figurines played within differing social contexts. Chapter 5 explores these different sites and the figurines recovered from them, alongside, when permissible, the context in which they were found. A total of eight sites are discussed in detail, all of which are located along the East Coast of America. It is rare that items with such low commercial value and which were not meeting essential needs are recovered in the earlier stages of colonization, so the presence of pipe clay figurines is unusual and offers an interesting insight into how the new colonies connected to broader popular religious and cotemporary political trends which circulated Europe (Hurry and Grulich. 2015, 1). Chapter 5 suggests that the presence of the pipe clay figurines within the English colonies displays an underlying significant that their owners held for these objects. The high-status contexts that some of the figurines that have been recovered in the New World helps to demonstrate that figurines could hold significant personal worth and respectability among a variety of social classes. By examining the figurines from London in combination with those recovered in the New World a clearer comprehension of the figurines distribution among varying social spheres is assembled.

What is seen within both Chapter 4 and 5, is that often the imagery portrayed on the figurines is frequently pertinent to the context in which they are recovered, for example depictions of saints, Christ, and the Virgin Mary are often recovered within homes owned by Catholics or in areas where worship was less controlled (such as

Maryland), and kingly figurines are often connected to statesmen's households. These chapters help to highlight how the pipe clay figurines present a crucial artefact resource in the understanding of changing cultural values in the period of 1500-1800. Close examination of these figurines combined with 3D modelling has produced an increased understanding of the figurines symbolic roles, functions, and their social topography (Gaimster 2015, 63). This helps to form a developed comprehension of the scale of figurine distribution routes, as well as to explore the similarities and differences in consumer demands between countries, discussed in more detail in Chapter 8.

The 3D methodologies and figurine generation and relation analysis presented in Chapters 6 and 7 offer future researchers a new methodology for the identification of figurine generational and family analysis, a methodology which can be applied to larger mould-made assemblages. This procedure not only helps to understand relationships between the figurines themselves, but also displays the circulation of production as sister figurines from the same generation, and potentially even the same mould, have been found in two separate countries, England and America. In Chapter 6 an evaluation of the state of the field of moulded artefact studies is presented It includes a discussion on the static situation this research field has become grounded in, and a critique is offered. The chapter then goes on to provide a new development within this research field, employing the discussed 3D methodologies to enhance moulded artefact analysis. A new methodology for mould generation analysis is then presented, a method which offers researchers more metrically accurate results for generation analysis and figurine pairing, alongside providing an analysis of statistical metric errors which can occur during figurine production. These include the variables which arise during manufacturing, such as seam scrapping, excess residue, object distortion on removal from a mould, and the effects that firing has on the shrinkage of a pipe clay figurine, as well as the differing erosion rates artefacts experience depending on their deposition conditions. These metric variabilities are explored using a control group of pipe clay elephant figurines which were produced for this thesis. The figurines from this control group were 3D modelled prior and after firing, as was the mould they are formed from. Each of the stages of figurine production was then compared to each other using CloudCompare. The separate figurines are also compared to each other using the same method.

These 3D comparisons firstly display the physical changes the figurines individually experienced, through two separate stages of surface area loss during the production process. Secondly the methodology indicates that even figurines which are produced from the same mould can still present specific and significant idiosyncratic differences between each other, relating to their individual firing conditions and their interactions with the mould, both on implanting and removal. This 3D comparative analysis highlighted that despite these objects having been produced from the same mould and not experiencing any depositional erosion, on average they presented a ±0.7mm surface variation between the figurines. This analysis has been coupled with Kibblewhite *et al* (2015) work on the degradation processes of pipe clay to produce metric variability parameters which have been employed during in the 3D comparison examinations. These parameters, alongside histogram analysis, help to determine whether figurines are related, and if so, how closely. This methodology has then been employed in an examination of the London pipe clay figurine dataset (Chapter 7). A total of 14 figurines were examined, broken into six groups.

Within the primary stages of these comparisons the employment of structure from motion for generation analysis has also been re-addressed. Using two kingly pipe clay figurines, one from Blackfriars in London and the second from the Charles Gift Site in Maryland, USA, Agisoft's comparison results were compared to those results offered by the NextEngine laser scanner. It was concluded that while SfM, can be used as a suggestive examination into figurine generational analysis, due to the inability of the software to record figurine morphometrics in the detail which this thesis requires, it is not suitable as a stand-alone procedure for figurine generational analysis. Following on from this conclusion, the chapter continues to present the remaining five groups of figurine comparison results. The application of the 3D comparison methodology, which is outlined in Chapter 6 and applied in Chapter 7, demonstrated the ability to observe the relationships between different mould-generated figurines. The methodology offers a detailed argument for examples of earlier, later, and same generation pipe clay figurines. Due to the high level of detail provide through 3D comparison analysis, in some select circumstances an argument has been offered for figurines being produced from the same mould. Overall, the chapter demonstrates how the 3D methodology developed in this thesis can provide a clearer indication of comparison accuracy than previous studies, which can be utilised for any object made from a mould.

The newly collated data presented in Chapter 7 is then used in combination with the archaeological and historical research presented on these pipe clay figurines outlined in Chapters 1, 4, and 5, and collectively discussed within Chapter 8. This final chapter sets out to show how the two parallel strands of investigation which form this thesis, firstly provide a full synthesis of the post-medieval pipe clay figurines from London, contextualised with supporting materials from England, North America and the Caribbean, as well as a handful of figurines from Ireland and Scotland. Secondly it demonstrates how this artefact assemblage has then gone on to be employed to establish a pivotal methodology for 3D generational analysis and figurine/mould matching. These two avenues of research are brought together in Chapter 8, summarising the major developments in theory and context for these figurines. Initially the chapter begins by exploring the new insights into London's post-medieval pipe clay figurines specifically, discussing the correlation that is seen between the figurine iconography and their finds location, the figurines versatility both in function and form, and issuing a challenge to previous notions which viewed pipe clay figurines as cheap copies of more expensive medias produced for an underprivileged consumer market.

The 3D comparison data in Chapter 7 provided a means of investigating patterns of production and consumption within London and further afield, and this will only improve as more material is produced from further excavations within the city. Production origins of the London pipe clay figurines is also discussed within this Chapter, reflecting upon the question of whether these figurines were imported from the Low Countries or produced within England, and if so by whom. With only a single pipe clay figurine mould having so far been recovered in London and no specific production centres yet to be recorded in the city, or the rest of the UK, the question about production location cannot yet be concluded. As a counter suggestion to a previously proposed view that the figurines were imports from the Germany and the Low Countries, iconographic comparisons have been drawn up between the figurines which have been recovered from London contexts to those recovered from Germany and the Low Countries. While there are similar thematic groups, the styles differ substantially between the differing countries. At the very least, this comparison indicates that either there are production centres located in the UK and yet to be located, or European production centres were producing specific styles for the purpose of exportation to an English market. There was also a clear shift in the consumption of these artefacts, with the majority of figurines recovered from Germany and the Low Countries dating to prior to the Reformation, where a high percentage of religious pipe clay figurine iconography is seen, and the majority of figurines recovered from England dating to the 16th – 17th centuries. This increase, alongside a transition in figurine design, with simpler and plainer designs becoming more prevalent, indicates a clear link in the nature of post-medieval pipe clay figurine production with the pre- and post-Reformation influences which controlled the religious art markets within late medieval and post-medieval Europe.

The effects of the social and religious upheavals discussed within Chapter 8 help to demonstrate not only why there was a shift in distribution and potentially production of these pipe clay figurines, but also to explain the transitioning iconography. A clear trend is displayed within this discussion which traces the rise and fall of the distribution areas of pipe clay figurines alongside the shift in religious and secular policies. Several transitions include the shift from elaborate pipe clay figurines produced within Germany and the Low Countries during the late medieval and early post-medieval to a plainer design during the sudden rise of figurines within England. The cessation of certain elaborate and condemned imagery, brought abought due to the Lutheran reforms in Germany and the Low Countries, are seen to thrive in simpler compositions within the London markets up until the 18th century. From the 18th century these forms of figurine also decline in England, specifically a decline in those of a religious nature. This possibly reflects the state of the shifting religious and political environment, as England moved from the turbulent 17th century, into a generally more politically balanced and stable government and saw the beginnings of some religious toleration in England during the 18th century. That being said, the display of openly Catholic and Jacobite imagery would no longer have been politically savvy given the clear dominance of the Church of England and the successful political manoeuvring that saw William III and later George I be preferred over James II, and such displays of affiliation likely moved to more geographically specific and subtle media. Therefore, this period would have seen a reduced need for such politically and religiously charged iconography displayed on mass-produced items that could quickly shift imagery depending upon the changing circumstances, and instead focus on production of standardised and unproblematic forms.

Following on from the discussion concerning the impact of social, political and religious and the affect these had on pipe clay figurine production within England, the influence of these issues is then deliberated in relation to the pipe clay figurine assemblage from the New World. What this exploration exhibits is a similar pattern of object subjectivity to the influences of political and religious transitions. The opportunity Catholics had to find a new home for their Catholic faith after the Lutheran persecution in Europe correlates with the iconography present amongst the pipe clay figurine assemblage, whilst the presence of kingly figurines and potential representation of Jacobite affiliations offer further insight into the expressions of political ideologies circulating the colonies during the 16th and 17th centuries. Parallel to the reduction of figurines within London, a reduction of figurines in the colonies is also experienced during the 18th century. This reduction may have been brought about by similar causes as those discussed in relation to London, or, as discussed in section 8.1.3, this reduction may be due to a series of events affecting trade between the New World and England.

Alongside offering new theories and information developed on the London and New World pipe clay figurines, Chapter 8 presents how this progress has been aided by the extensive 3D imaging and artefact matching procedures presented within Chapters 6 and 7. This section discusses how the digital comparison methodologies has offered not only an initial, but also vital development in the investigation of pipe clay figurines, and has opened up the possibilities for furthering these investigations via a broadening of the dataset to include figurines from European contexts. The evaluation of this thesis's 3D workflow and presentation of digital data reiterates the importance of choosing appropriate 3D imaging technologies for the intended project and, for research orientated projects, the urgent need to employ simple, yet structured 3D digital workflows, similar to the one presented in this thesis, which offer clear and standardised approaches to projects which employ and analyse 3D surrogates. With the 3D workflows evaluated and the success of the 3D comparative methodologies presented, a discussion on future applications of these procedures is then covered. This suggests innovative research avenues both within the field of mould generational analysis and broader research fields, such as assessments of the degradation affects that pollution and subsidence have on archaeology, that can employ this same 3D comparative analysis to interpret these varying materials. This section then leads into the overall conclusion which has been formulated for the compendium of research collated during for this thesis.

Chapter 1

Post-Medieval Pipe Clay Figurines in Society

This chapter will introduce 15th- to 18th-century post-medieval pipe clay figurines, the processes used to manufacture them, and an examination of their origins and general distribution within Germany and the Netherlands. This chapter will also begin to demonstrate how the pipe clay figurines are a versatile group of objects, which were present at all social levels and across a wide variety of contexts. It is therefore essential to examine them via their interactions between these different groups or individuals within a hierarchal context (Gaimster 2007, 259), as well as through the surrounding cultural and ideological influences in which they were imbued with meaning and function. Both the group and individual interactions reside on a shifting scale of complexity and diversity, as well as from the local to inter-regional and eventually cultural scale. It is these differing social scales which may influence the effect that material culture may, on a sub-conscious level, have had on an individual's or group's behavioural response to their material culture (Gaimster 2007, 259). Alongside stoneware drinking vessels and stove tiles, pipe clay figurines (Figure 1.1 displays a selection of these) are a key element within the Hanseatic ceramic market, which extends from the Baltic to London, between the 14th to 18th centuries. Within their short lives, these figurines, together with other ceramic objects, offer good indicators to the changes within the religious and political spheres during these and later periods (Gaimster 2007, 260).

Figure 1.1 A collection of post-medieval pipe clay figurines from the British Museum, from left to right: St Catherine and wheel, Madonna and Child, Nude male with flowers, Christ with bird, and a lion. (Authors images, courtesy of The British Museum)

1.2 A Guide to Figurine Manufacturing

This thesis will be examining pipe clay figurines which have been recovered from London contexts dating between the 15th and 18th centuries. The term pipe clay which is used in reference to these figurines is of a later date, as pipes for smoking tobacco were unknown in the 15th century. However these pipe clay figurines were produced from the same locally-sourced fine, white clay that was also employed within the tobacco pipe industry, and it is thought that some similar moulding techniques were employed (Figure 1.2). For these reasons it has been presumed that in England pipe-makers might have produced such figurines as a side-line to bolster their businesses against the varying levels of demands for clay pipes (Gaimster 2003, 136) and prior to this, imported from either Germany or the Netherlands. Clay pipes were frequently affected by laws, for example, James I's taxation on tobacco in 1604, where it rose from 2*d*. to 6*s*. 10d per lb, and changing fashions, specifically with the introduction of popular new smoking apparatuses, such as the cigarette, in the early 19th century (see Higgins 2007, 684). However as there is relatively little contemporary literature on the process of pipe clay figurine manufacture between the 15th to 18th centuries, and no clear evidence of figurine production centres having yet been found within the UK, a question appears as to whether this production assumption is an accurate supposition. This long-standing assumption amongst pipe clay scholars that these figurines were produced by British pipe manufacturers, without any documentary or archaeological evidence has structured how these figurines have been incorporated into wider literature. As the first study of this British material this thesis will critique this assumption to provide a more definitive answer that focuses on the figurine typologies to examine the source of manufacture.

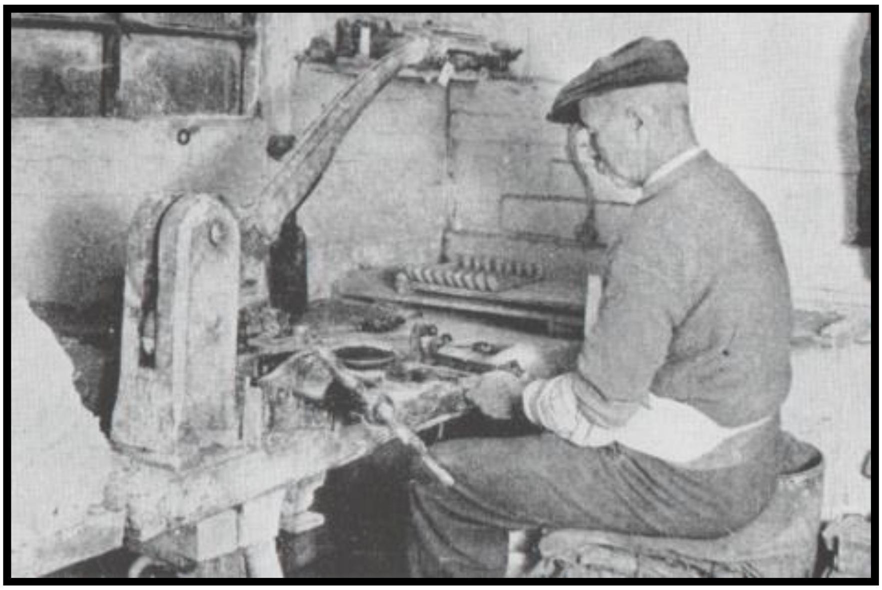


Figure 1.2 A pipe-maker preparing a mould for the gin press at Henry Leigh's factory, Portchester, Hampshire. (Image from Ayto 1994, 19 ©Hampshire County Council collection. Provided by the Hampshire Cultural Trust.)

For those figurines produced in England, it seems reasonable to assume that English sources of clay were used when possible, and cheap clays of high quality were imported when this was not possible for the production of figurines, a similar process which is present in tobacco pipe manufacturing. For example, from the 17th century London pipe makers began to import clay from counties such as Dorset, Cornwall, Devon, Shropshire and Kent in order to satisfy the London consumer's needs (Ayto 1994, 19). The clay arrived in dry blocks which were then beaten to dust and mixed with a cask of water. The paste was then cleaned of any impurities and left to dry. This was then kneaded and stored in cellars until it reached the correct plasticity (Grulich n.d. 8). To produce the figurines, two halves of a mould made of either clay (Figure 1.3) which were popular in the low countries, metal, which became more popular by the 17th century (specifically brass or iron, though there has been mention of tin and lead moulds) or wood were then greased (Gaimster and Weinstein 1989, 11, and for more details on tobacco pipe production see Oswald 1985, 6). The only figurine mould currently known from the UK is a ceramic mould recovered from London dating to 1720-1750 (figure 1.3), which may hint at continuation of the Low Countries preference for ceramic moulds. However, the absence of any other mould evidence may also potentially suggest that production centres may have favoured metal or wooden moulds, materials which are easily reused once their initial purpose is complete. The clay moulds themselves were created from original wooden, positive reliefs, referred to as patrix (Reesing and Hoyle 2007/2008, 147).

Figure 1.3 Examples of clay moulds used to produce pipe clay figurines, to the left: Madonna and Child pipe clay figurines c.1720-1750 (author's image courtesy of LAARC). To the right Clay mould of a monk, from Breslauer Platz, 1429 *(Image to the left of writing from,* Neu-Kock *1988, 6).*

The moulds were then greased and covered in a thin layer of wet clay which was then pressed down firmly with a piece of cloth. This process ensured that the mould details were finely filled. Thicker second layers of clay are then applied. The centre of the figurines could either be left hollow, or filled, examples of both are commonly known (Reesing and Hoyle 2007/2008, 147). There are two suggestions on how the figurine halves were then joined, either by the pressing together of the filled moulds Another suggestion is that the separate mould halves were left to dry slightly, the two impressions were then removed from the moulds and the front and backs of the figurines were then attached to each other using wet clay and the seam edges were smoothed (Reesing and Hoyle 2007/2008, 147).

It has been previously thought that, for those figurines which were produced with no central hollow, that once the clay had taken its form and dried partially within the moulds, a thin wooden rod was inserted into one half of the figurine, with the purpose of allowing for airflow and reduction in figurine breakage during firing (Gaimster and Weinstein 1989, 11). However, there are now two alternative theories on the presence of these perforations on the underside of the figurine. First, they may have been created when attempting to separate the figurine from its mould. A piece of wire or a rod may have been used as a lever to disconnect the unfired figurine from its mould, leaving a thin hole behind (D. Higgins pers. comm.). Second, the perforations may have been purposefully created in order to be able to place the figurine on a wall hanging nail or rod (Van Den Dorpel 2013, 13), which would allow a broader variety of ways to display the figurines, such as seen in Figure 1.4 whereby a figurine stands on a stick amongst an arrangement of carnations. In some instances, before the figurine was fired it may have been further worked by hand to smooth the seam created by the two halves of the mould, and a base may have been added to the figurine if required. Following this the figurines would then be placed into a kiln and fired at around 950-980 degrees Celsius (Kügler 1995), ensuring that the light colour of the clay remained unaffected. Once fired these figurines were sometimes painted or occasionally glazed to varying degrees (Gaimster and Weinstein 1989, 11). The heights of these pipe clay figurines would usually vary between 5-10cm, however both larger and smaller examples are also known.

Figure 1.4 Portrait of a Young Girl with Carnations, 1663, Netherlands. Note the painted figurine amongst the flowers J. Rotius 1663, (Image provided by Art Gallery of Ontario)

Figure 1.5 The Feast of Saint Nicholas (to the left), a tradition where good children receive gifts from the Saint. Note the figurine of the cockerel in the child's bucket (with detail of the cockerel to the right). (Painting by Jan Steen, 1665-1668, held in the Rijksmuseum, Public Domain)

Typologically figurines fall into the following broad categories: royal memorabilia, religious iconography, adult knickknacks and curios, and children's toys. Within the category of religious iconography, seasonal gifts are also included, such as those figurines which were placed on seasonal feast cakes, a topic discussed by a Delft magistrate in 1607 (Knippenberg 1962, 54). There are a few references to these figurines being directly related to medical practise as well. Some texts discuss how plain religious figurines were produced and then scraped with an unnamed implement and the powder from this was used as 'heavenly medicine' and fed to the sick (Knippenberg 1970, 93). Assignment of figurines into one of these categories is not always straightforward because some figurines were created with two, or even more meanings. For example, a cow may represent just a cow and be used as a children's toy, or it may be a part of the nativity scene. A second example are figurines of cockerels, either representing a child's toy, a stick topper (See Figure 1.5, in the child's bucket at the fore of the picture is a cockerel on a stick), or a devotional figurine referring to St Peter's denunciation of Christ (Callisen 1939, 160). It is this style of subtle iconography that allows the figurines to hold entirely different meanings to different individuals, or even the same individual in different circumstances. A more in-depth examination into figurine iconography will be presented in Chapters 4, 5, and 8.

The relative quantities of figurines produced and the scale of the industry within the UK during the 16th-18th century are unknown. This thesis will address questions concerning the origins of clay pipe figurines, and the iconographic similarities between some of the London figurines and those produced in mainland Europe. Traditionally it has been suggested that large quantities of these figurines may have been imported into the UK from Germany and the Netherlands due to their iconographic similarities. Likewise, it has also been suggested that these figurines were produced in England by Continental immigrants or using imported German or Danish moulds, thus giving the appearance of a foreign product despite being made on British soil (Gaimster and Weinstein 1989, 14). Another issue to consider when answering such questions include the potential difficulty of carrying out a petrographic study into the compounds of the clays used in figurine production in order to locate the origin of the figurine. Importation of clay into London from surrounding local regions for figurine production, as well as importation of clays into both Germany and the Netherlands from the south of England and Belgium's French Maas region is well documented within the historical sources (Grulich n.d. 8), so petrographic analysis may only result in origin of the raw material rather than the final production site.

1.3 Thesis Aims

The area of investigation which this thesis is examining will primarily be concerned with pipe clay figurines which have been recovered from London contexts between the 15th-18th centuries. This dataset will then be expanded to include a preliminary exploration of figurines recovered from the rest of the UK and English Colonies within America. From this base further investigation will examine the employment of these figurines. Who were these figurines produced for? And for what purposes were they created? Furthermore, examinations into their distribution both contextually and geographically will be explored, providing new knowledge on whether there are differences between regions, social contexts, or on individual sites into how these figurines might have been used and viewed. Alongside this the evidence for commercial transmission will be looked at and a more nuanced discussion about how differing iconographical motifs may be catering for differing locations and social groups will be developed. For example, it will be tested if there are iconographic differences between those figurines recovered within the Low Countries in contrast to those recovered in London. Examining geographical distribution will also create a more in-depth understanding of the cultural value that these items held due to their wide-reaching presence across Europe and into the New World. Distribution mapping of the figurines as a collective, accompanied by maps displaying the geographical spread of iconographical trends will enable further development in the theory and contextualisation of these figurines within their contemporary societal frameworks.

The initial stages of data collection for the London pipe clay figurine catalogue (appendix 1) consisted of compiling published figurines from grey literature, articles, and excavation reports. The catalogue was further developed during visits to The British Museum, Museum of London, Museum of London Archaeology (henceforth MOLA), London Archaeological Archive Research Centre (LAARC), Museum of London Archaeology Services (MOLAS), Pre-Construct Archaeology (PCA), and The Minories Project. Further figurines from London were added to the databases which were recovered by the Official London Mudlarks and the Society for Pipe Clay Research. When complete London's initial dataset and area of investigation was expanded to a preliminary look at the entire UK as well as an examination of those figurines which had been recovered from colonial sites, specifically those in North America and Jamaica. This wider investigation was supported via a review of literary sources followed by a series of visits to the following museum and archaeological stores: National Pipe Archive at the University of Liverpool (UK); Historic St Mary's City Archaeological Museum (Maryland, USA); Historic London Town (Maryland, USA); The National Park Services (Historic Jamestowne) and Jamestown Rediscovery (Virginia, USA); and George Washington's Mount Vernon Archaeology Labs (Virginia, USA).

Alongside the usual methodologies for recording finds within a catalogue, such as 2D images, feature measurements, weights, descriptive notes, and contextual details, the figurines have also been 3D imaged. The 3D methodologies, which will be discussed in more detail in Chapters 2, 3, and 7, offer a method for not only a more accurate digital record of artefacts but also allows for the incorporation of digital investigative methodologies into wider archaeological research. These methodologies involve digital comparison of figurines and moulds as a means to indicate accurate positive and negative examples of manufacturing relationships. The development of this methodology on the London dataset will not only help to produce a more precise comprehension of mould generation analysis for this study but also for future studies concerned with mould-made artefact generation analysis.

1.4 Past Research of London's Post-Medieval Pipe Clay Figurines

Previous work concerning London's 15th-18th-century pipe clay figurines has concentrated on either singular or small groups of figurines rather than a comprehensive study of the entire available material. Individuals who have worked on these materials include David Gaimster's analysis of a few figurines held in the British Museum and by MOLAS (Gaimster and Weinstein 1989; Gaimster 2003; Gaimster 2007; Gaimster 2015), Chris Jarret and his analysis of a cockerel figurine (Jarrett 2017, 39-45), Jacqui Pearce's study of a lady figurine (Pearce 2016, 208-210), and Silas Hurry and Anne Grulich's paper discussing a pipe clay king from America in contrast to similar figurines from the Low Countries and England (Hurry and Grulich 2015). Finally, Rosemary Weinstein's work which discussed two figurines recovered from excavations at Aldgate, London (Weinstein 1984). This number of publications only increases slightly when the rest of the UK is incorporated, for example Terrence James and Dee Brennan's paper presenting two figurines recovered from the Carmarthen Greyfriars excavations (James and Brennan. 1998).

These limited works, though offering some preliminary information on these figurines, do not provide a comprehensive review of the material. Lack of this analysis has halted further discussion on transatlantic links, regional iconographical characteristics of figurines, and overall contextual and societal conceptions of these figurines both within London and across broader trade networks. By incorporating these works into this thesis' data collection a more developed foundation can be produced for pipe clay figurine research within both London and the UK, one which will offer more in-depth insights and answers to a range of iconographical, contextual, distributional, and production related questions which circulate these figurines.

1.5 The Distribution of Pipe Clay Figurines

Pipe clay figurines are typically found in Central and North Western Europe from the 14th century through to the end of the 17th century, with a high proportion of these finds coming from Germany, especially the Rhineland, and the Netherlands. Figurines have also been found in Belgium, Czech Republic, Poland, especially from Silesia (Kowalczyk 2010, 1), Hungary, Slovakia, Austria, the United Kingdom, and the New World (See Figure 1.6).

It is the Netherlands which is considered to be the birthplace of these figurines, created by the *Bilderbäcker,* specialised craftsmen who produced clay depictions, both in statuette form and relief. *Bilderbäcker* is a documented 15th-century German term (Henry-Buitenhuis 1990, 64), which literally translates to 'image bakers', although they may also be referred to as *Bildermacher*, image makers. In Dutch, the name

Hilligebacker (Neu-Kock 1988, 7) was sometimes applied, along with *Bilddrucker* and *Beeldedrucker* (Borkowski 1998, 51; Borkowski 2004, 207). These craftsmen are discussed in a range of contemporary archival sources from both Frankfurt in 1446 and 1452 (Geyskens 2002, 11), and Cologne in 1514, where a source refers to a *Bilderbäcker* called Johannes von Gummersbach who left Cologne as he felt '*hard done by'* (Neu-Kock. 1988, 6). Sources recovered from Utrecht discuss how some of the workshops were supposedly located in Utrecht, Leiden and Liège in the Low Countries, Cologne, Worms (Neu-Kock 1988), Augsburg in Germany, Zittau in Upper Lusatia and

Figure 1.6 Map displaying locations of pipe clay figurines addressed in this thesis. (Map created by Author, using Palladio v1.2.4)

Zwickau in Saxony (Kowalczyk 2010, 2). There were also a number of workshops, such as Kruselerpüppchen in Nuremberg, that favoured sculpting figurines by hand instead of using the two-piece moulds utilised at the sites above, and as such are not grouped in the same category of production workshops as those which employ two piece moulds (Kowalczyk 2010, 2). Some of the production sites mentioned in the documentary sources have since been confirmed archaeologically through excavation, such as at Breslauer Platz in Cologne (Neu-Kock 1988, 2). These excavations offer a great insight into the processes, demands and iconography behind these pipe clay figurines within Central and Western Europe, elements that will be discussed in the next section.

1.6 Production of Pipe Clay Figurines in Germany and the Netherlands

Germany and the Netherlands present some of the earliest evidence for the production of pipe clay figurines, and though their iconography is broad, there is a significant concentration of mass production devoted to the creation of religious figurines. The production of these affordable religious figurines finds its roots in tin-lead alloy figurines, such as those recovered from Amsterdam, Dordrecht, Kampen and Nieuwlande, ca.1300 (Van Den Dorpel 2013, 8-10), and consist of representations of Mary with the Infant Jesus (Figure 1.7). The sudden appearance of affordable religious figurines is tied to the influence and teachings of the mendicant orders, the Dominicans and Franciscans in particular. Their influence, which was bolstered by the urban location of their friaries, promoted personal faith and private devotion. These orders also preached in the vernacular, ensuring that the word of God was more accessible to the common people. Individuals such as Bernard of Clairvaux changed religious emphasis further by highlighting the human nature of Christ, presenting Christ as the visible path to an invisible God (Os and Honée. 1994, 164). Christ's emotions, humanity, and experiences from the New Testament were again accentuated by the vernacular teachings offered by the mendicant orders.

This promotion of the New Testament renewed interest in monastic life, and led to additional investment and the founding of new monasteries and other religious institutions (Henry-Buitenhuis 1990, 64). This shift in the orientation of faith and the resurgent support for religious houses created an increase in the demand for devotional images, a demand which was filled via the inexpensive but fast production of pipe clay figurines (Os and Honée.. 1994, 159). These figurines were so sought after due to their easy mass production and affordability that many religious sites established their own production of these figurines, such as the Friars Minor in Dordrecht, the Carthusian Charterhouse in Delft, and the Observants in Amersfoort (Ostkamp 2012, 117). *Bilderbäcker's* and *Hilligebacker's* still operated many of the production sites independently, especially in town centres where a more extensive selection of iconography was produced. Both examples of these production sites will now be discussed in more detail below.

Figure 1.7 Tin-lead alloy of Mary and Infant Jesus, Dordrecht, 1275-1350
(Image from Ostkamp 2001, 194)

1.6.1 Germany

In Cologne, the production of pipe clay figurines was already active during the 14th century (Ostkamp 2012, 112). Though rare, these initial examples still display the apparent demand for these figurines, and the locations of these early figurines were not just restricted to the locality of their production site, providing an early demonstration of trade between Central and Western Europe, seen at locations such as Zwolle Castle in the Netherlands. Excavations here produced a pipe clay Virgin and Child dated no later than ca. 1363, when the Castle was destroyed. The figurine was of an incredibly similar composition to those being produced within Cologne in the early 14th century, and it is thought that this figurine was imported into the Netherlands from Cologne (Ostkamp 2012, 112). The countless later finds from the 15th century that are present within the archaeological record, both in Germany and the Netherlands, display the enormity of production of these figurines and the scale of this mass production culture (Ostkamp 2012, 112). This is clearly seen in the example of the production site at Breslauer Platz, Cologne, which provides an informative case study.

1.6.1.1 Breslauer Platz; A preliminary case study

One of the better-understood workshops is that at Breslauer Platz in Cologne (Figure 1.8), which was excavated by Stefan Neu in 1978 (Schäfke *et al.* 1988, 1). Here, a pottery kiln was excavated (Figure 1.9-10), originally established in the 15th century and likely still active in the 17th century. The kiln was situated in a residential district on the southern side of the Goldgasse, 250m from the apse of the Cologne Cathedral. The placement of this high-temperature workshop within the centre of this residential area is of particular note, as usually they would be expected to be located on the outskirts of a city (Neu-Kock 1988, 2). The rubbish pits located on the southern side of this kiln included evidence for production waste, along with many fragments of figurines that seem to have broken during firing. In total, more than 700 fragments were recovered, including some partial and complete moulds (Figure 1.11) (Schäfke *et al.* 1988, 1), although 300 of these were too fragmented for positive identification. Nonetheless, the remaining sherds offer observations on late medieval social aspects such as fashions, 'folk' art, popular religious representations, and displays of everyday life or desires, such as scenes from the bathhouses (Neu-Kock 1988, 6). Whilst a useful and important case study, the potential of the Breslauer Platz figurines will only expand with a better understanding of comparative material that help to elucidate on questions concerning similarities or contrasts in production techniques, iconography, and quality. Understanding aspects such as these will help to identify potential differences between consumer markets and explore ideas concerning the potential of *Bilderbäcker* and mould migration and circulation from Germany and the Netherlands to the rest of Europe and the New World.

Figure 1.8 Annotated Map showing Cologne c.1572, the blue circle indicates Breslauer Platz & Cologne Cathedral. (G. Braun 1572, from The Hebrew University of Jurasalem & the Jewish National & University Library).

In Cologne, the figurine production process is thought to have been similar to that discussed in section 1.2. Cologne also offers good examples of copy-mould alterations. This method employs the core style of a mould, but then alterations to the accessories are added. *Bilderbäcker's* would copy the master mould and then create individual moulds from these copies by adding slight alterations to the mould copy. This enabled *Bilderbäcker*'s to offer a broad range of styles within a singular category for the consumer market, while simultaneously allowing their costs to remain low, as each master mould could provide the basis for multiple different moulds producing a range of different motifs (Neu-Kock 1988, 8). Examples of this are displayed among the knights riding horses, whereby elements on the knights' armour or horses harness have been altered, though the core design maintained.

Figure 1.9 Breslauer Platz stove from the north (Neu-Kock 1988, 3-4)

[redacted]

Figure 1.10 A floor plan of Breslauer Platz Stove (Neu-Kock 1988, 3-4)

[redacted]

Figure 1.11 Clay mould of a monk, from Breslauer Platz, 1429 (Image to the left of writing from, Neu-Kock 1988, 6)

Figurines made at Breslauer Platz were all unglazed and unpainted, and examples of painted figurines from other sites in Cologne are scarce. Those that are known used the paint to accent features rather than paint the entirety of the statuette (Neu-Kock 1988, 8). Though examples of glazed figurines are rare, there is a range of figurines found at Cologne and other production centres such as Zeeland in the Netherlands which display random streaks and splashes of glaze upon them. However, it is thought that these streaks have accidentally occurred due to *schlusen,* an incident whereby glazed ceramics are fired in the same kiln as non-glazed figurines. Condensation, which contains some pigments from the glazed ceramics, forms on the roof of the kiln and drips onto the non-glazed statuettes, examples of this can be seen on a series of figurines from Zeeland (Figure 1.12).

Figure 1.12 Examples of schlusen from Zeeland (Van Den Dorpel 2013 figure 57, 101)

A broad range of iconography has been recovered from the Breslauer Platz assemblage. These demonstrate intent to please clientele with differing tastes, with motifs addressing politics, religion, and secular activities, a similar situation to that seen in England (see Chapter 4). However, figurines were not always aimed at the more mature consumer, with some of the animal figurines having closer analogies to children's toys (Neu-Kock 1988, 14). This broad range of figurines offer researchers a different avenue of insight into the changing piety and varying visibility of the everyday life, wishes, and needs of the population, not only within Cologne but across all the areas in Germany and in the Netherlands who purchased these figurines (Neu-Kock 1988, 7).

Representations of the Madonna comprised a significant proportion of the figurines recovered from Breslauer Platz, indicating the rise in popularity of the Madonna cult during Late Medieval piety (Neu-Kock 1988, 17). The most popular depictions of Madonna from this production site include the enthroned Madonna, the crowned Madonna, and the Madonna with Child. These figurines varied in quality; for example, the enthroned Madonna were highly detailed throughout, with the back of the throne being embossed with a rosette (Figure 1.13). Other examples, such as the standing Madonna (Figures 1.14) could vary in quality from finely detailed designs to figurines with more thickset details (Neu-Kock 1988, 18). Alongside these depictions of Madonna and Madonna and Child, there were also a high frequency of other female saints such as St Anne, St Catherine (Figure 1.15), St Ursula, and St Barbara, again reflecting the rise in the worship of the Marian cult and switch to the concentration of Christ's more human elements.

This form of worship was also observable through the large collection of Christ child depictions which have been recovered (Figure 1.16). Often these representations of the Christ child display him naked or in a loincloth usually holding a globe, dove, rosary beads, or making a blessing gesture (Neu-Kock 1988, 21), though there is a more full selection of these depictions seen in Bonn, where the Christ child is also depicted holding two globes or sitting and playing the lute. Along with this range of nude Christ children, there were also a large corpus of dressed Christ babes, a style favoured in Münster and Bonn, but also seen in Cologne. The large selection of Christ children recovered from across Germany may be linked to both specific religious holidays and female worship. Traditions of giving depictions of the Christ child to family and friends on New Year's Day as a form of well-wishing was popular during the 14^{th}-16^{th} century. This style of gift presentation is known from Nuremberg, as mentioned in a New Year's letter from Abbess Caritus Pirckheimer to Michel Behaim, Master of the Works for the City of Nuremberg, discussing how the monastery of Saint Klara were sending small figurines of the Christ Child, *dominus tecum*, as presents (Lemmel *et al*. 2009, 240).

This specific utilisation of the Christ Child figurine in a devotional function may offer a suggestion as to why such significant amounts of Christ Child figurines have been

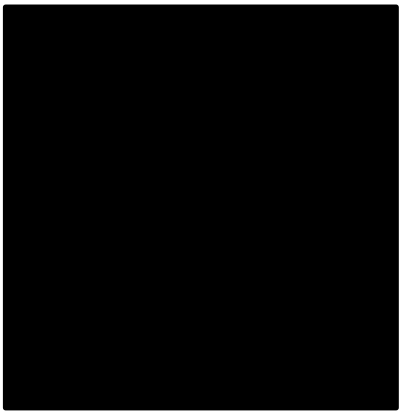


Figure 1.13 Complete enthroned Madonna and child statuette and rear of a fragment of enthroned Madonna showing the rosette. (Neu-Kock 1988, 13, 15, 36)

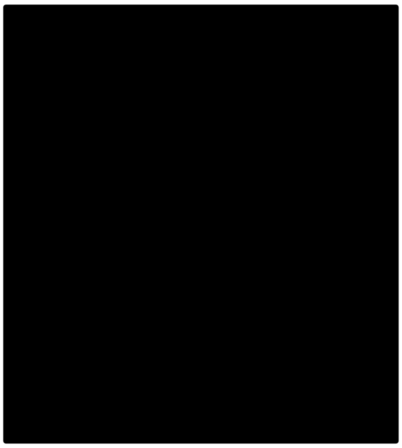


Figure 1.14 Fragment of Madonna and Child. (Neu-Kock 1988, 13, 15, 36)

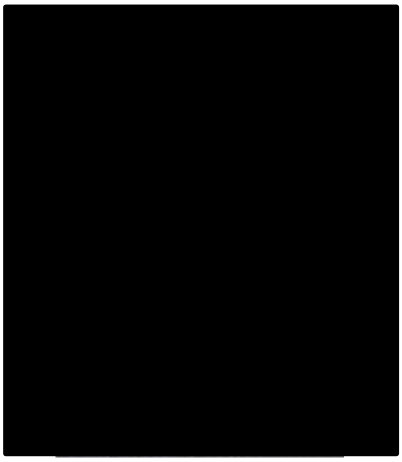


Figure 1.15 A fragment of Saint Catherine with Wheel. (Neu-Kock 1988, 13, 15, 36)

Figure 1.16 An array of Christ child Statues from Breslauer Platz (Neu-Kock 1988, 18)

Figure 1.17 Four pipe clay figurines of the Christ Child (From Heitz in Lemmel et al. 2009, figures 128-129, 240)

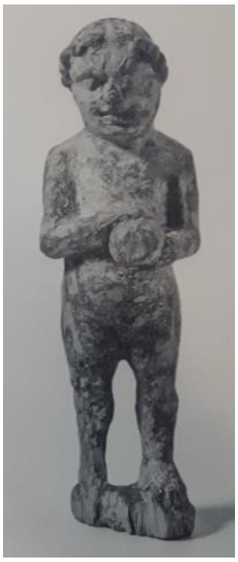


Figure 1.18 A polychrome wood figurine of the Christ Child all are from Germanishes Nationalmuseums Nuremberg.(From Heitz in Lemmel et al. 2009, figures 128-129, 240)

discovered across multiple locations. Nunneries were also known to have handmade these Christ figurines, often out of clay or wood (Figure 1.17 and 1.18), and sent them to individuals as tokens of well-wishing and holiday greetings, or as an accompaniment to a sack of devotional gifts. These gifts came with an ulterior motive, and via these tokens, the nuns hoped to promote private devotion for families within their own homes (Lemmel *et al*. 2009, 241).

The second explanation for the existence of the vast corpus of Christ child figurines is due to the use of the Christ child for spiritual rocking and cradling, a concept recommended to nuns in religious text (Neu-Kock 1988, 25). The Blessed Margaret Ebner speaks of such a connection with a figurine of the Christ child within her major works *The Revelations.* Ebner, who was a Dominican nun born around 1291 in Donauwörth, Germany, entered the church in 1305. Within her writings she discussed how a statue of the Lord in the manger spoke to her, saying “if you do not suckle me, then I will draw away from you and you will take no delight in me” (Ebner et al. 1993, 132). Margaret, on hearing these words, took the Christ in a manager and “placed it against my naked heart…my desire and my delight are in the suckling through which I am purified by His humanity” (Ebner *et al*. 1993, 132). Other religious representations that are seen within the Breslauer Platz collection include angels of Annunciation or torture (Figure 1.19), monks, and adult Christ, both as the man of sorrows and during crucifixion, although these latter two subjects are rarely presented. Though depictions of male saints, bishops, and the Fourteen Holy Helpers are seen in other regions of Germany production, these male saints were not seen at Breslauer Platz (Neu-Kock 1988, 30).

Knights on horseback, in a range of styles, were another iconographic form of pipe clay figurines recovered from Breslauer Platz (Figure 1.20), and were also popular in Worms during the same period. Often a small perforation under the knight's arm is present where a lance would have once been slotted in (Neu-Kock 1988, 32). Along with these depictions of riders, other potential toys include varying depictions of animals such as a variety of birds and cows, though some of these could also be employed within nativity depictions. For the more mature consumer market figurines of lovers, dancers, musicians (Figure 1.24), coquettish females (Figure 1.21), or shared bath scenes were also present (Neu-Kock 1988, 33), displaying an avid lust for life by certain sectors of the consumer market. Less lude scenes included couples in love (Figure 1.22) and moments of marriage (Figure 1.23), with not only the bride and groom being recreated in clay, but also the matchmaker or marriage broker being produced, the latter often presented as a male figure wearing a dagger and presenting a ring (Neu-Kock 1988, 34). Although examples of some of the moulds that created these figurines were recovered from Breslauer Platz, a higher concentration of moulds have been found within the Middle-Rhine area (Neu-Kock 1988, 39), and it is thought that this area may have concentrated on the production of the moulds, before distributing them to other regions. However, whether those moulds found at Cologne were produced in the Middle-Rhine area is not certain. Either way, there must have been a very active exchange of both craftsmen and products between Cologne and Worms due to the similarity of figurines appearing at both of these sites, an exchange which expanded from these two regions across Germany.

Germany has produced a wide range of contexts in which pipe clay figurines have been excavated, mostly dating from the 14th- to early 16th century (Gaimster 2003, 136), and from both domestic and ecclesiastical contexts, with depictions of saints, the Virgin Mary and Christ, in particular, being prevalent (Neu-Kock 1988, 18). This vast swathe of examples allows researchers to begin to comprehend the function of these figurines, especially when rare finds are found in immaculate condition. For example, the Cologne Diocesan Museum holds a wooden house-shaped shrine depicting The Annunciation, and dates to the mid-15th century. Surviving within the shrine were a number of complete large-scale moulded ceramic figurines (Neu-Kock 1988, 40), and this example presents a potential function for these pipe clay figurines within the domicile, as personal shrines. Although production in Germany seemed to flourish for a few centuries, a cessation appears to occur *c.*1525 (Gaimster 2003, 136). This may have been caused or exacerbated by the progression of the Reformation in the north–west of Europe, which caused some disruption to the export and trade industries. This topic will be discussed in more detail after a series of case studies from the Netherlands has been examined.

[redacted]

Figure 1.19 Angel figurine.
(Neu-Kock 1988, 9)

[redacted]

Figure 1.20 A series of knights on horseback.
(Neu-Kock 1988, 26)

[redacted]

Figure 1.21 A seductive female.
(Neu-Kock 1988, 25)

[redacted]

Figure 1.22 A series of couples
(Neu-Kock 1988, 1)

[redacted]

Figure 1.23 a man holding a wedding ring out for the woman
(Neu-Kock 1988, 28)

[redacted]

Figure 1.24 Fools with musical instruments
(Neu-Kock 1988, 27)

1.6.2 The Netherlands

There is significant evidence of large-scale production occurring across the Netherlands (Oostveen 2011, 1). The earliest evidence comes from Utrecht, including at Putsteeg, where two 15th-century waste pits produced two moulds of a female saint, probably Mary, and in a well 30 small pipe clay figurines were also discovered, consisting of the Christ child with a dove, Mary with Child, and the saints Catherine and Barbara (Ostkamp 2012, 123). From a second site in central Utrecht, at Tolsteeg Gate, production waste from figurine manufacturing has also been recovered, including moulds and figurines (Figures 1.25), though there has been no report published on these, or any related contextual material (Ostkamp 2012, 123). Further examples of manufacturing sites have been discovered in Amsterdam, Gorinchem, and Veere, the last of which produced a rare example of an altar set of pipe clay figurines (Ostkamp 2012, 117). Excavations in Zeeland have yielded over 140 figurines, and in Leiden 40 pipe clay figurines and 28 parts of moulds were recovered during the demolition and renovation of some of the buildings within the Old Varkenmarkt. Finally, in Gouda evidence was recovered not only for the production of figurines, but also for the identity of one specific manufacturer - John Boot. Boot was a famous tobacco pipe maker from the late 17th and early 18th century (Moerings 2014, 1) who marked his pipes and figurines with the initials 'IB', and this monogram has been found on several of the figurines recovered archaeologically (figure 1.26).

Many monasteries, including the Franciscan friary in Dordrecht, the Carthusian Charterhouse in Delft, and the Observant friary in Amersfoort (Ostkamp 2012, 117) also partook in the production of pipe clay figurines. A number of figurines have been recovered with the signature of monks, the best-known example pertaining to a

Figure 1.25 Two mould halves and figurine of Mary and Child from Utrecht ca.1425-50 (Ostkamp 2012 figure 9.2, 109)

Figure 1.26 Front and Rear of milkmaid figurine made by John Boot, initial 'IB' seen on the rear. (Adapted Image from Mayenburg 2015 accessed 14/12/2016)

Carthusian monk named Jost Pelsers but signed with ‘ Judocus Vredensis’ or ‘Judocus Vredis’, with examples of his work being recovered from his hometown, Vreden in Weddern (Van Den Dorpel 2013, 18). At each of these sites moulds have been found which indicate the production of pipe clay figurines. The most popular form was the individual standing figure, which could be employed singularly or as part of a group such as the apostles of Munster or the group recovered from a cesspit in Putsteeg, Utrecht (Ostkamp 2012, 117, 123).

The large quantity of religious figurines seen within the Netherlands displays a shift in the form of prayer, with a focus on personal meditation on experiences as described in the New Testament, similar to that which is seen to occur in Germany. Stories which become more prevalent within Dutch personal religious iconography include aspects such as the Adoration of the Magi, the mockery of Christ, the Crucifixion, the Lamentation, and Christ as the Man of Sorrows (Ostkamp 2012, 121). This shift demonstrates how a transition to the concentration of Christ as a common man had begun, and with this transition the imagery of Mary was also as equally perpetuated within iconography, usually carrying Christ within her arms. Alongside images of Mary and Christ, the Netherlands also produced large quantities of male and female saints, the most popular being Nicholas, Christopher, Anthony Abott, Jerome, Peter, Ursula, Elisabeth, Catherine, and Barbara (Ostkamp 2012, 122). Using a comparable approach to that employed in the previous sections with the contextualisation of pipe clay figurines within Germany, the following section will present a series of case studies examining not only production sites but also written records and archaeologically contextualised examples of figurines recovered in the Netherlands.

1.6.2.1 A Beguinage in Schiedam

Due to a great fire that burnt down Schiedam in 1494, there are significant sealed and undisturbed archaeological contexts remaining that provide a unique view of the society of this region. A living room in one of the affected Beguinages, a building which housed female Christian lay religious orders, is a pertinent example. Within the archaeological remains from this room, the vestige of a cabinet was discovered which contained a group of degraded items, among them two small pipe clay figurines of the Christ Child (Figure1.27) (Ostkamp 2012, 111). The finds from this site are typical to those found at other Beguine and convent sites within the Netherlands, such as the former Beguine house in Gorinchem, where a similar Christ Child was also discovered. The frequent occurrences of the image of Christ, both at his birth and at his death demonstrate the discussed shift in religious practice during the late 13th century. Furthermore, the context in which the Christ child is found within a female Christian religious order supports the concept of popular female association with Christ as a babe.

Christ as a babe imagery appears within female religious orders in a variety of forms within the Netherlands, either as a singular holding a cross, paternoster beads, or a dove, or in the arms of the Virgin Mary, another highly popular image within female orders, especially with the rise of the Marian Cult. A Convent of Saint Agnes in Tiel which once stood in Koninginnestraat (Figure 1.29) demonstrates the popular perpetuation of this image further. Excavations in 1983 uncovered a cesspit, within which two layers (7 and 8) were associated with the Convent of Saint Agnes, located on this site during the 15th and 16th centuries, before being closed by 1659 turned into storage for guns (Oostveen 2014, 4-5). Within these primary layers, a headless pipe clay figurine of the Madonna and Child were recovered (Figure 1.28).

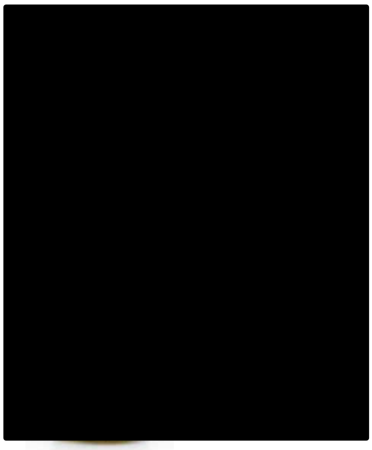


Figure 1.27 Pipe clay figurines of the Christ child from a Berguinage at Schiedam burnt down in 1494. (Ostkamp 2012 figure 9.6, 111)

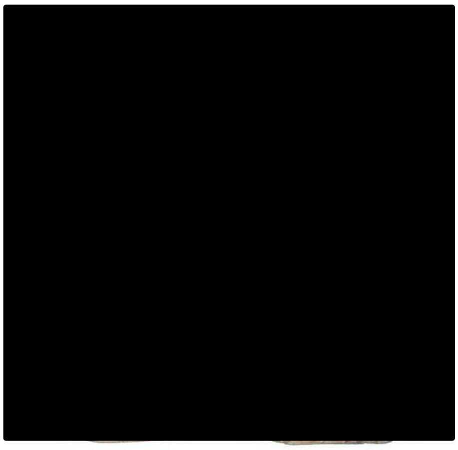


Figure 1.28 Madonna and Child from a cesspit in Tiel.(Figure 5 in Oostveen 2014, 7)

Figure 1.29 Hand coloured map of Tiel, Joan Blaeu from 1649, with excavation area circled. (adapted from Oostveen 2014, figure 4, 6)

Due to the fall of Spanish control in the area and the rise of Protestantism some scholars, such as Oostveen, have speculated that this headless figurine represents a symbolic act that reflected the treatment of the figurine, and by association the convent, with Saint Agnes's death, who was beheaded by a sword (Oostveen 2014, 7). This suggestion is purely speculation, and accidental breakage must be considered just as likely as ritualistic destruction. No matter the manner in which the figurine came to be broken, its presence on this site still offers great insight into forms of worship present in female religious orders and the style of idols used within them.

1.6.2.2 The Old Varkenmarkt, Leiden

Excavations across Leiden have provided an extensive collection of figurines and moulds. In total there were 40 recognizable figurine fragments and 28 mould fragments found (Figure 1.30 displays one example). These 15th-century moulds have signs of frequent use, leading to wearing on the details of the figurines, which were, with the exception of one example, all unpainted. From this evidence it is clear that there was a 'heyligenbacker' operating in the area during the late 15th century (Rijksmuseum n.d.). Overall the collection contains a significant quantity of Christ Child figurines, with the iconographic repertoire consisting of Christ with a dove, Christ with a globe, and Christ accompanying Mary. There were also several further styles of religious iconography represented within this collection including Saint Catherine with her sword and wheel (the tools of her executioner), Saint Adrian, and a kneeling figure with a monk. Fragments of an inscribed pedestal have also been recovered from Leiden, with the inscription reading AMICTA, likely part of a longer text from the Revelation of John 12:1, potentially reading '*et signum magnum apparuit in caelo, milier amicta Sole et luna sub pedibus eius et in capite eius corona set larum duodecim'.* This translates to '*and there was a great sign appeared in heaven: a woman clothed with the sun, with the moon under her feet and a crown of twelve stars on her head',* referring to an apocryphal representation of Mary (Rijksmuseum n.d.). The figurines and moulds recovered at Leiden reflect the wider material from the Netherlands, and is significantly similar to Utrecht (discussed below).

Figure 1.30 A 15th-century mould from Leiden
(Rijksmuseum n.d. Public Domain, accessed 11/11/2016)

1.6.2.3 Putsteeg, Utrecht

The oldest evidence for pipe clay production in the Netherlands comes from Utrecht. During a 1974 excavation carried out at Putsteeg, by the Archaeological Department of the City of Utrecht, two 15th-century waste pits were uncovered. Within pits R and L (Figure 1.31) a series of religious pipe clay figurines were recovered alongside waste kiln furniture from earthenware and stoneware production (Ostkamp and Helbergen 1974, 49). In total 21 pipe clay figurines and one mould fragment (Figure 1.38) were recovered. The iconography observed includes The Virgin Mary and Child (Figure 1.33), the Christ Child with a dove (Figure 1.35), Saint Catherine (Figure 1.32), Saint Nicholas (Figure 1.36), and Saint Barbara (Figure 1.34). This iconography represents a similar collection to those observed elsewhere in the Netherlands and Germany, as discussed above (Ostkamp and Helbergen 1974, 50). This ceramic assemblage also contained 45 pottery sherds, excluding the pipe clay figurine statuettes. These 45 pieces represented locally produced pottery and dated the assemblage to the end of the 14th- and first half of the 15th century. This, therefore, offered a good indication as to the production period of these pipe clay figurines (Ostkamp and Helbergen 1974, 50). Though many of the pipe clay figurines which were recovered were of the more typical smaller stature, two significantly larger free-standing statues of Saint Nicholas and Mary with Child (Figures 1.36 and 1.37) were also found among the assemblage (Ostkamp and Helbergen 1974, 51). Furthermore, some of the examples of Mary kneeling before the Christ child from this region have also been discovered with smoke stains from candles or oil lamps on the statuettes surface. This again offers a further indication as to the context of use and display these figurines may have been utilised in, such as on altars (Ostkamp 2012, 116).

Figure 1.31Excavation plan displaying waste pits R and L, where the pipe clay figurines were recovered (Image from Ostkamp and Helbergen 1974, 49)

[redacted]

Figure 1.32 Saint Catherine, four of this style were recovered. (Image from Ostkamp and Helbergen 1974, 60)

[redacted]

Figure 1.33 Virgin and Child, six of this style were recovered. (Image from Ostkamp and Helbergen 1974, 61)

[redacted]

Figure 1.34 Saint Barbara, seven of this style were recovered. (Image from Ostkamp and Helbergen 1974, 63)

[redacted]

Figure 1.35 Christ holding a dove, two of this style were recovered. (Image from Ostkamp and Helbergen 1974, 66)

[redacted]

Figure 1.36 A large figurine of Saint Nicholas (Image from Ostkamp and Helbergen 1974, 66)

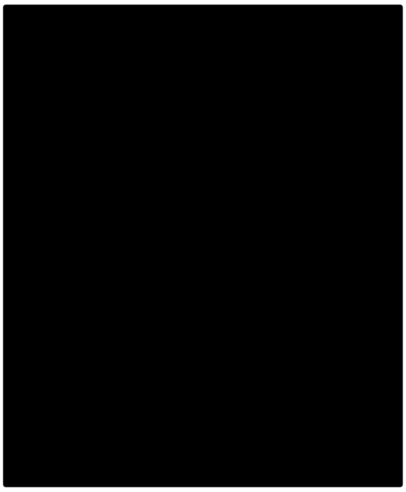


Figure 1.37 A Large figurine of Virgin and Child. (Image from Ostkamp and Helbergen 1974, 67)

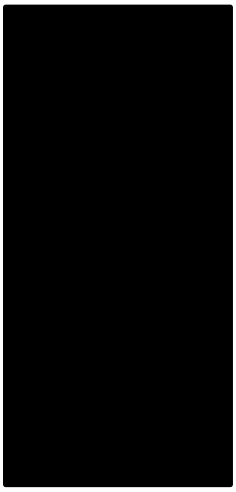


Figure 1.38 A mould fragment of Virgin and child. (Image from Ostkamp and Helbergen 1974, 67)

1.6.2.3 Amersfoort, Floating Statues and Pilgrimage

Alongside countless archaeological examples of pipe clay figurines being present within religious contexts, there are also a handful of contemporary written records which present examples of these figurines within their daily functions. One of these is an account given in Jan de Waal's chronicles, a rector of the convent of Saint Agnes, where he relays the troubles of Amersfoort during the second half of the 15th century, revolving around the issues of population growth, immigration, and plague. However, amongst these hardships, he also discusses the economic prosperity being generated from pilgrimages centring around the veneration of a pipe clay statuette of the Madonna (Mulder 2016, 243). The chronicles state that this Madonna figurine was found 'miraculously' in December 1444 by a maidservant called Friet Alber Gysendochter. The figurine was supposedly discarded into the river due to its previous owners' embarrassment of entering the monastery with such a primitive statuette of the Madonna (Ostkamp 2012, 112). The maid then found the figurine floating on the exact spot where it had been flung, and recovered it. She then informed her confessor Jan Van Schoonhoven of this, who in turn arranged for the figurine to be housed at the Marian fraternity within the Chapel of Saint Job, later named the Chapel of Our Lady due to the statuette. The figurine was said to have worked miracles, which were recorded in a folio that has now been lost. However, three copies of the folio have survived, two of which are quasi-duplicates, both written in the late 16th century and preserved within Amersfoort, and the third is a 17th-century copy held in Brussels. Around 542 miracles were associated with the statuette, dating from 1444 to 1545, with the first seven years being the most eventful (Mulder 2016, 243). The use of figurines as epicentres of pilgrimages is not restricted to this sole example. Within the Belgian province of Namur a Mary figurine was recorded to have been found on July 6th 1609 in the cavity of an oak tree, sealed behind iron bars. It has been suggest that the placement of this figurine may have acted similarly to holy statues located along roads in the present day (Ostkamp 2001, 215). This figurine was only discovered along the Pilgrims Way when a tree was felled by a ship builder named Innocentius de Lumoir, but due to the wood which had been ‘eaten out by worms for at least 2 feet across’ (P.Bouille, *Den oorsrponck ende mirakelen van onse Lieve Vrouwe van Foy by Dinant; In 't Francoijs beschreven deur P. Petrus Bouille ende vert ae It in onse gemeyne sprake deur P. Iacobus Susius*, Louvain 1624, p. 12: "...wel twee voeten breet vande wormen ghesteken was." As cited in Reesing and Hoyle 2007/8 footnote 16, p 150) Gilles de Wanlin, a local carpenter was hired to chop the tree into blocks for firewood. It was during this process a figurine was discovered within the tree behind three iron bars. The figurine of Madonna was then taken to a nearby farm and placed once again in a niche in an oak tree, close to where the first oak tree stood. After several attempts by individuals to steal the figurine, Baron Louis de Beaufort de Hamal, Lord of Celles, transferred it back to his house chapel of his castle (P. Dagobert Gooren 1959, 135). Records discuss how from this moment on pilgrims travelled to this site due to the miracles which were said to have happened there. According to the account of Jesuit Pierre Bouille, the Virgin cured a compound fracture of Marten Pieletens in 1616 (P.Bouille, *Den oorsrponck ende mirakelen van onse Lieve Vrouwe van Foy by Dinant; In 't Francoijs beschreven deur P. Petrus Bouille ende vert ae It in onse gemeyne sprake deur P. Iacobus Susius*, Louvain 1624, pp. 27-28: "...moyelijcke gesleten heyd,... door het geweit des quaets durende gheheele 15 dagen sonder eenighe ruste of verminderinge der pijnen." As cited in Reesing and Hoyle 2007/8 footnote 16, p 150). After a series of these miracles, Ferdinand I of Bavaria, Prince-Bishop of Liége began ecclesiastical investigations on November 2nd 1618 a religious investigation at Château de Vèves in Celles. After receiving the churches approval and due to the high rate of pilgrimages made to the site a chapel was built in which the statuette was then given a place of honour. This chapel was then replaced by the present church, which was consecrated on September 8th 1626, which still serves as the pilgrims church today.

Wooden sculptures were produced of the statuette, especially during the Counter Reformation and titled Our Lady of Faith: Notre-Dame de Foi. At present and recorded in the Lexicon for Theology and Church (1932, Freibucg, col. 79 as mentioned in P. Dagobert Gooren 1959, 135) approximately 114 of these images are known and have been produced in both large and small scales. Many of these images have been constructed from the ‘miracle’ oak or at least contain a piece of it, if only a shaving. These replicas were accompanied by a certificate of authenticity (Reesing and Hoyle 2007/8, Figures 13, 14 , 17 and 18 , 158-61). Further replicas were also produced in a range of other materials including pipe clay, brass or copper (Reesing and Hoyle 2007/8, 163). In 1959 a festival was thrown in Foy to commemorate the 350 years since the figurine was found (P. Dagobert Gooren 1959 135-7). The statuette itself stands 22.4cm high and is 7cm wide (figure 1.39). The core is solid, apart from a narrow shaft (Reesing and Hoyle 2007/8, 150). According to a witness and recorded by Bouille, the Child’s head and arm had been damaged when the tree was being chopped into fire wood, and a local maidservant reattached them, this damage and conservation is clearly visible (Reesing and Hoyle 2007/8, 150).

[redacted]

Figure 1.39 Our Lady of Foy, pipe clay figurine, held in the Parish church of Notre-Dame de Foy, Southern Nertherlands. to the left the front and to the right the rear collection (Reesing and Hoyle 2007/8, Figure 7, 150).

Further study of this figurine, has also demonstrated that the figurine, though once believed to be pipe clay, and is very similar to pipe clay is actually constructed from a calcium and fluorite mixture. However this does not reduce the importance of this figurine in pipe clay figurine contextualisation as it is accounts such as this which help to provide further contextualisation for complex nature of this style of figurines building an image of the functionality of these figurines within differing religious spheres. Furthermore while this particular figurine is not produced from pipe clay, early accounts of the figurine produced by Pierre Bouille, written in 1620 state that the figurine was hollow, produced by a potter and describes it as pipe clay, however later in 1624 the description changes stating that the figurine was cast, a process which currently is thought only to have become popular in the Low Countries at the end of the 16th century (Reesing and Hoyle 2007/8, 156).

The presence of images of Saints in trees is long known in the Low Countries evidence for this purpose is presented in artistic pieces, for example on the outer wings of Hieronymus Bosch's *Haywain* triptych (Figure 1.40). In this oil painting, in the background a figure is seated at the base of a tree with bag pipes, above in the tree is a tabernacle containing a statuette. In the Circle of Joachim Patinir, *St Christopher* (figure1.41) to the background of St Christopher, a monk kneels in front of a tree, praying to the above tabernacle (Reesing and Hoyle 2007/8, 152). The presence of saints in trees is related to the importance of trees in pre-Christian pantheism and the attempts by the church to root out heathen worship, by making their presence orientate around the Christian faith. In attempts to legitimize these statues, the local clergy declared that they were capable of performing miracles if worshiped (for full discussion see Reesing and Hoyle 2007/8, 152). Further examples of saints in trees include Our Lady of Meerveldhoven. Meerveldhoven, parish church of St Lambert (figure 1.42), Our Lady of Jesus Oak near Brussels, Our Lady of the Thorn in Ingelmunster, Our Lady of the Cherry in Oudenaarde, Our Lady of the Hazel in Courtrai, and Our Lady of the Weeping Tree near Ghent. Several miraculous images of this kind were also venerated in the north: Our Lady of the Holy Oak in Oirschot, Our Lady of the Lime-Tree in Uden, and Our Lady of the Miracles on the Lime-Tree in Oisterwijk (See J.A.F. Kronenburg, Maria's heerlijkheid in Nederland, 8 vols., Amsterdam 1904-14; W. Giraldo, Duizend jaar mirakels in Viaanderen: een volkskundige benadering, Bruges 1995; C. Harline, De wonderen van Jfezus-Eik: mirake her halen uit de zeventiende eeuw, Am sterdam 2003. As cited in Reesing and Hoyle 2007/8, 153).

Figure 1.40 The Pedlar, 1515. Madrid, Museo del Prado, Ref.nr. P02052 (Public Domain)

[redacted]

Figure 1.41 Circle of Joachim Patinir, St Christopher. Private collection (Reesing and Hoyle 2007/8, Figure 10, 152).

[redacted]

Figure 1.42 Our Lady of Meerveldhoven. Meerveldhoven, parish church of St Lambertus, North Brabant. The statue has been venerated here since late medieval times and in the choir there is a full size oak tree with statuette of the Virgin in its branches. (photo: Jacq. Bijnen, SHEV, Reesing and Hoyle 2007/8, figure 11, 153).

1.7 Anticipated Outcomes

Having now offered a deeper understanding of pipe clay figurine manufacturing and the history of production within Germany and the Low Countries, it is worth considering what may be seen within English speaking contexts, which is the primary focus of this thesis. The commercial exchange that flourished between England and the Hanse makes it plausible to assume that these pipe clay figurines were a part of a more significant network of cultural transactions. However, the specific nature of these transactions needs to be addressed. For example, were the figurines which circulated in London imported from Germany or the Low Countries, or were they produced on English soil? If they were produced on English soil, who were they produced by: English craftsmen; or craftsmen originally hailing from the Low Countries or Germany who crossed the Channel for religious, social, or economic reasons? Furthermore, was there a specific iconographic market produced specially for English consumers and how did the popularity in figurine styles differ between the countries, if at all. These are all questions which will be investigated during the comparative analysis, based upon the first comprehensive examination of the available dataset of London pipe clay figurines, undertaken in the following chapters. To examine these questions 3D imaging was employed to produce accurate models for analysing whether figurines came for the same mould or similar mould generations. This form of 3D analysis has further analytical implications, allowing the comparison of figurines where contemporaneous comparison is prevented, such as those held by different museum stores or even recovered from different countries, for example allowing comparison of figurines from London with those from the American colonies. The methodology for this digital comparative analysis, as well as the tests carried out concerning the accuracy of these methods, will be presented in Chapters 2, 3, and 6, with the specific pipe clay figurine comparative results being discussed in Chapter 7.

It was anticipated that the figurines recovered from London would include examples originating from the German and Low Country productions centres. This was both due to London's commercial connections with the areas, and because of the documented migration and circulation of individuals between these countries. A difference in iconographic designs was also predicted to be seen in the London material, with additional subjects of iconography expected within the pipe clay figurine repertoire potentially reflecting different contemporary fashions, such as the booming ceramics trade in royal memorabilia seen within London. This expected difference in iconography may also help to highlight the possibility of domestic manufacture within London, and if present the scale of the manufacturing. For example, rather than assuming that clay tobacco pipe makers produced these figurines as a sideline to their business, was it possible to see a separate minor cohort of pipe clay figurine producers within London, and if so were these English craftsmen or migrant artisans? Finally, the results presented from the 3D comparison analysis were examined for examples of mould generations within the English-speaking contexts. Such outcomes would provide a new avenue for investigating the transmission of production.

1.8 Chapter Summary

While production levels of pipe clay figurines can be seen to be prevalent within the Low Countries prior to the 15th century, both the Reformation and the nailing of Martin Luther's 95 theses to the door of the chapel in Wittenburg had a significant impact on religious experience, and a concurrent negative effect on the production of pipe clay figurines. Many areas ceased production of religious figurines entirely, with only secular figurines being produced after the Reformation (Ostkamp 2012, 126). A few Catholic areas continued to manufacture sacred figurines, such as Limburg, North Brabant, Zeeland, and Flanders, but from the early 16th century onwards there was a noticeable reduction in figurines within the Low Countries, and a shift to the UK as the main area of consumption, and thus likely the main area of production of the pipe clay figurines (Henry-Buitenhuis 1990, 65). It is clear that the Low Countries produced a large corpus of material from the 14th - 15th centuries, with examples of both moulds and figurines being recovered. There have been many attempts to create a chronology of typology, but there have been considerable difficulties associated with this endeavour. This has included a lack of contextual data and firm evidence for the whole production process. In reference to the latter point, those which have been recovered with contextual data, such as those recovered from Tolsteegate, were often poorly recorded and lack publication (Van Den Dorpel 2013, 22), a subject that will be discussed further in Chapter 6. What is certain is that the iconographic styles and distribution of production sites and find sites appear to reflect contemporary historical events, mentalities, and religious affiliations. These ceramic finds help to demonstrate the effects of the Reformation on the urban populations and suggest the migration of artisans and merchants from the Low Countries and Germany into London and South-East England during the same period (Gaimster 2003 137-138). Before exploring these effects in connection with both London and the New World, the 3D digital technologies which will be employed to help to develop this study will be introduced in the following Chapter.

Chapter 2

3D Digital Surrogate construction within Archaeology

'The digital surrogate is the closest fidelity to the actual object that can be achieved digitally and theoretical representations for other purposes might be extracted from the surrogate'

(Arnold And Geser 2008, 67)

Throughout the history of image capturing technologies, rapid development and adoption of techniques has been a continuous driving force behind technological advancements. 3D modelling began 50 years ago, being first employed with analogue procedures carried out within cartographic and mapping projects (Remondino *et al.* 2014, 144). The growth in this technology has encouraged a boom of virtual reality and 3D projects within heritage studies, seeing 3D imaging as an important method of interaction between archaeology or history and the general public (for a detailed description of the history of VR see Frischer *et al.* 2002). Over the past few years there has been a huge leap forward in the development of 3D imaging technologies, and until recently these developments were time consuming and incurred high costs, prohibiting many archaeological projects from partaking of these technological advances (Pollefeys *et al*. 2003, 2).

These recent developments have helped to enable not only the digital preservation of irreplaceable artefacts for future studies (Ikeuchi 2013, 1), but also allow specialists to approach the handling of archaeological finds in a whole new manner. They have enabled the improvement of conservation concepts by allying these 3D digital *surrogates* with GUI based application tools (see Okamoto, Y. *et al*. 2005). These advances offer the potential to produce accessible 3D datasets available for analysis and visualisation on a global scale (Kersten *et al*. 2012, 1).

Structure-from-Motion (SfM) is one of the technologies at the forefront of this new wave of 3D *surrogate* software, presenting itself to users as a cheap and easy-to-use alternative to laser scanning and structured light scanning. In the following two chapters the above claim will be evaluated via an investigation of the technique's accuracy. These accuracy trials will not only examine the different accuracy levels between some of the most popular SfM software employed currently within artefact 3D imaging, but also compare these software packages against popular and inexpensive laser scanners and structured light scanners. This will help inform users on whether SfM software is a feasible alternative to use within artefact 3D imaging.

Due to the quick developments of this technology, and the nature of open source software, some of these software packages have either been unmonitored, or their accuracy levels untested. Therefore, it is essential that guidelines for both the acquisition of digital data and for post-processing of this data are created to allow a base for assessing these 3D models as a means to validate their accuracy and usability. This will inevitably help to ensure that both money and time are not wasted due to choosing unsuitable equipment or software for a project or due to improper use of the equipment (Amico *et al*. 2012, 13). Often the function of the modelling equipment is not always suited to the task which it is required to carry out. This may result from unsuitable benchmarks offered by scanning manufacturers which hold relevance related to engineering projects, rather than to archaeological projects (Amico *et al*. 2012, 14). What becomes clear through various case studies which employ both 3D scanning and photogrammetry is that there is a need for guidelines to be created for the heritage sector to guide individuals on how to gather their data and to display the varying levels of post-processing stages which need to be undertaken to provide usable 3D models within both the public and research heritage sectors.

The following sections of this chapter will first offer an introduction to the different current imaging technologies that are employed within artefact studies. This will then be followed by a more in-depth examination into SfM and the different SfM software that will be investigated within this thesis. Following this will be a discussion on the laser scanning and structured light scanning apparatuses, which will be employed as comparisons against the chosen SfM software packages. Following on from this will be an examination into the various 3D imaging comparison software packages to ascertain which is most suitable to compare and contrast 3D meshes. This chapter will then be concluded with the dissemination and development of past comparison studies which will contribute to the structure of this thesis' 3D accuracy trials in Chapter 3.

These sections aim to offer an affordable and accurate means to produce a methodological guide for individuals who have no previous grounding within 3D modelling. It also aims to help to define standards of application for 3D data communication, ensuring that the process of 3D digital *surrogate* creation is a transparent practise to allow for the deconstruction and critical evaluation of the models. This will produce further suggestions on how to integrate this form of research into archaeological investigations within the commercial, research and public sectors and make it a viable and valuable scientific investigatory tool to assist within artefact studies.

2.1 Popular Imaging Technologies Employed within Artefact Replicating

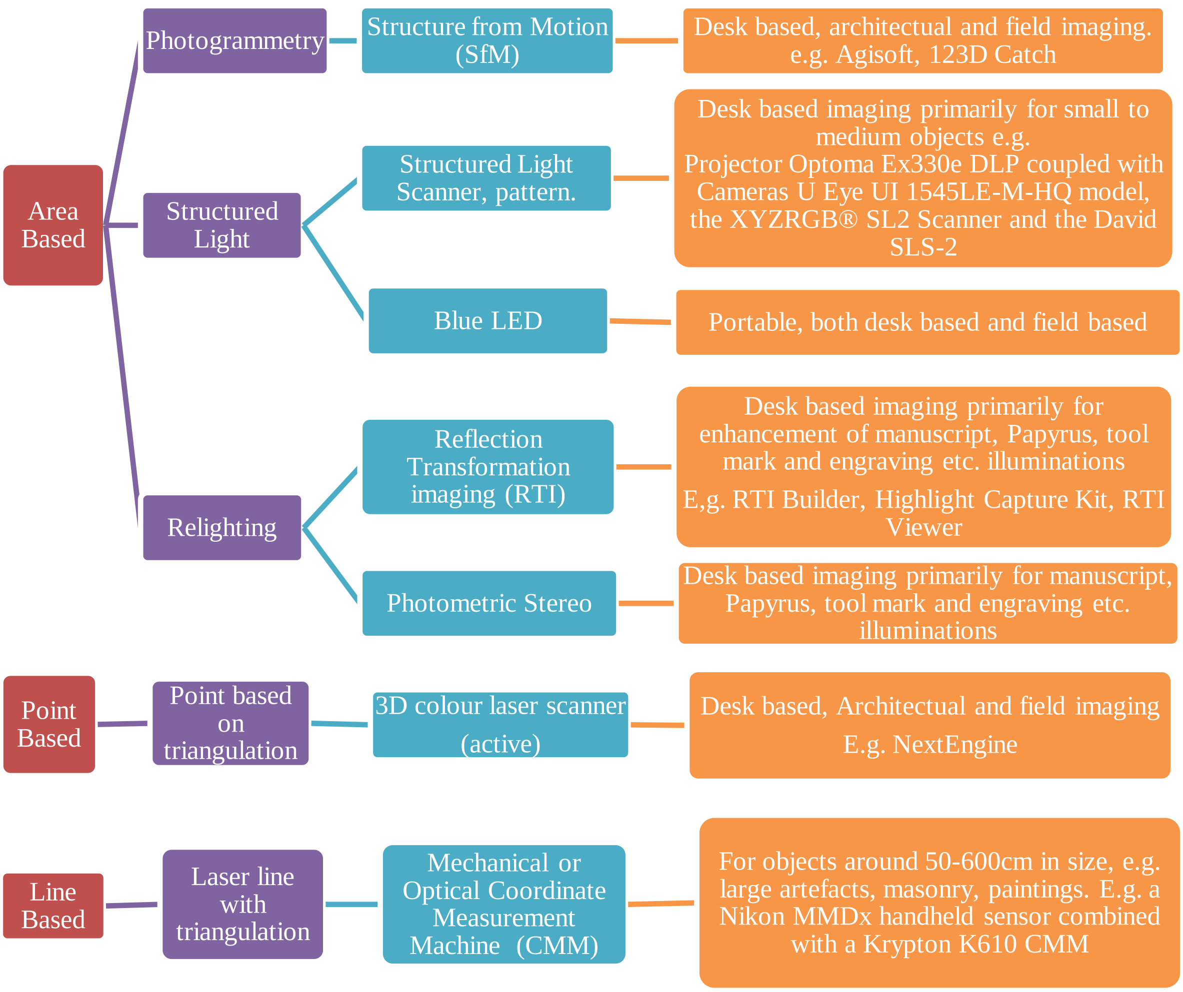


Chart 2.1 Displaying classification of popular 3D imaging technologies within artefact research (Adapted from Hess 2015, figure 2.24, 56)

Advancements in 3D imaging technologies has enabled us to reproduce 3D digital *surrogates* of a range of archaeological features, from buildings and landscapes to material culture and skeletal remains. There is a range of digital methodologies which archaeologists employ to allow recording of datasets in detail, with a shorter time scale and with higher accuracy in comparison to older recording methodologies; Chart 2.1 displays a brief classification of some of the most prevalent 3D imaging technologies employed within artefact studies. Although there are a huge range of 3D imaging technologies available, this thesis will only be examining Laser Scanners, Structured Light Scanners and Photogrammetry, as it is these three which are the most pertinent to this thesis's research. Methodologies such as mechanical/optical CMM, suitable for large scale artefacts, or RTI (Reflectance Transformation Imaging) and photometric stereo, which are more suited to tasks such as engraving illumination, are not suitable for imaging this thesis' dataset.

The three technologies, laser scanning, structured light scanning and photogrammetry, which will be trialled within this thesis all work at highly differing rates and produce different accuracy levels. Each technology also varies considerably in their financial costs and expertise required to employ them. Below each of these technologies will be discussed in more depth.

2.1.1 Laser Scanning

There are two forms of laser scanning, ‘active’ and ‘passive’. The difference in classification between these two types concerns the sensor properties for recording the light waves. Those sensors which are deemed passive are those which do not emit a light or laser beam onto an object, and record using photographic receptor sensors. The active lasers are conversely classified due to their emission of a light or laser beam (Hess 2015, 55), and it is this latter laser scanner which will be employed within this thesis.

Active laser scanners were initially developed to help engineers and surveyors, but soon their application was adopted within the heritage sectors due to advances within their precision systems and the development of systems that could work in more ‘real world’ situations as opposed to sterile environments. Currently there is a wide range of models available from different companies. This can make direct comparison between these differing instruments difficult as each has varying technical specifications and their measuring capabilities are based on different principles (Fröhlich and Mettenleiter 2004, 1), alongside there still being no standard test protocols for the evaluation of terrestrial 3D scanning systems (Guidi *et al*. 2007, 59).

These systems, which consist of a range of measurement systems in combination with laser beam deflection (Fröhlich and Mettenleiter 2004, 2), are based upon time/distance equations: the time taken for a laser to travel to and bounce back from an object enables the instrument to determine the position of the targeted point. The points which are measured are chosen by the machine, not the user. The results of these measured points accumulate to create a 3D point cloud. The accuracy of these measurements relies mainly upon the intensity of the laser beam which is being reflected back, thus these results are directly related to the reflectivity upon an objects surface (Fröhlich and Mettenleiter 2004, 2), an issue which presents problems when attempting to scan shiny or translucent artefacts. Often manufactures will present the specific accuracies concerning the range measurements, however, accuracy levels connected to the system itself are frequently not defined (Fröhlich and Mettenleiter 2004, 2).

The two most common laser specimens employed are time-of-flight (TOF) lasers and triangulation lasers. TOF lasers are efficient at operating over large areas/distances, and as such are better suited for recording buildings and landscapes; however, they do have restricted accuracy. Triangulation lasers, contrastingly, have a limited range, only a couple of meters, with a much higher accuracy (Georgopoulos *et al*. 2010, 251). There are also Close Range Laser Scanners (CRLS), which use a much higher resolution to capture a more focused area in high density detail, with details down to a tenth of a micron being captured. Therefore, it should be noted that there is no singular laser scanner which has been developed that is best suited for all conceivable applications. Some are better suited for indoor, close range work, while others are better in large outdoor environments. Individuals must choose scanners carefully, dependent upon the desired application of these scanners (Fröhlich and Mettenleiter 2004, 1).

Currently, some of the most popular laser scanners for close range object analysis being employed within the heritage sector appear to be the NextEngine, the Fuel 3D Scanify, the MakerBot, and the Matter&Form MFS1V1 (see Tucci *et al*. 2011; Amico *et al*. 2012; Guidi *et al*. 2007; Hermon 2011 for examples), which range in basic prices from just over £400 to just over £2,500. However, each of these systems also come with additional costly add-ons, meaning that these starter price often increases.

2.1.2 Structured Light Scanner

Structured light scanners are a popular alternative to the market-dominant laser scanner. The recording principles of this are displayed in Figure 2.1, with the most common apparatus setup either employing a single, duo or trio camera function with additional digital projector. Within this study, the duo camera set up has been employed for metric quality assessment, and trio camera set up for texture quality assessment (see Figure 2.2). The digital projectors project patterns or a sheet of light onto an object and detect the distortions present on the surface of an object, which is then recorded by one or more cameras which are off-set from the projector. Their systems are based upon a similar principle to those found within photogrammetry whereby image pairing is translated into surface information (Georgopoulos *et al*. 2010, 250). Specific software is employed for setup calibration of the equipment which includes camera geometry parameters and relative positioning of the image acquisition (Georgopoulos *et al*. 2010, 252). Some of the more favoured structured-light-scanner apparatus include a Projector Optoma Ex330e DLP coupled with Cameras U Eye UI 1545LE-M-HQ model, The XYZRGB® SL2 Scanner, and the David SLS-2.

[redacted]

Figure 2.1 The recording Principle of structured light scanning. It is compiled of a line projection system which combines a digital projector and digital camera. (a) 'Graycode method' (b) 'M-Projection or working range'. (Hess 2015, fig 2.45, 70)

Figure 2.2 Set up of the structured light scanner, followed by calibration.

Although there are many successful projects which employ this equipment, detailed examples of which can be seen in the 3D scanning of Shackleton's hut located on the South Pole and The Mongolian Deer Stone Project (see Bathow and Breuckmann 2011), the employment of this equipment does come with its limitations, the most significant of which is lighting. Recording is usually required to be undertaken within a dark room or if outdoors at night time, environments which may not always be available readily. Furthermore, the time to calibrate this equipment at the beginning of every new project does add considerable time concerns if time restraints are an issue. If calibration is not completed correctly, the scanned data quality will be lower than expected and systematic errors may be experienced.

2.1.3 Photogrammetry

Photogrammetry is a passive image based technological approach whereby the aim is to recreate an object in a digital 3D format with metrically precise dimensions. Though the most recent of the developments in 3D technology, it is still making quick advances both within the professional field and in the amateur field, as varying levels of interfaces are often provided by different photogrammetry software packages.

Structure-from-Motion (SfM) is a form of photogrammetry which uses a series of 2D images that have been captured via an individual moving around a fixed object or structure with a camera. SIFT (Scale-invariant feature transform) algorithms are then employed to reconstruct the camera pose and 3D dimensional scene geometry. The algorithms detect a series of image features from each of the photographs, therefore it is crucial that the object remains static for the algorithms to be able to match and detect these features. Subsequently these are then continually monitored throughout a series of images to ensure the correct positioning of each feature. It is these features that are then rendered and presented as a 3D sparse and dense point cloud and represent the geometry of the object in a localised coordinate frame (Doneus *et al.* 2011, 82).The point clouds that are created are a series of points which are defined by their spatial coordinates and radiometric RGB data (the system employed for representing colours on a computer screen) which have been produced as a result of the processing of a series of 2D images of an object using one of the SfM software (Bartoš *et al.* 2014, 68). It is this output which can then be further employed in a variety of ways including reconstruction of density, point cloud consistency and quality of texture (Figure 2.3). When this procedure is aligned with stereo-matching algorithms, a detailed 3D digital *surrogate* can be generated in a fully automated way. These reconstruction solutions operate upon pixel values, which generates detailed mesh models from the initial sparse point cloud. This enables better handling of finer details of the object or scene. The final stages of these software also allow for texture to be added to the scenes/objects as well (Doneus *et al.* 2011, 82).

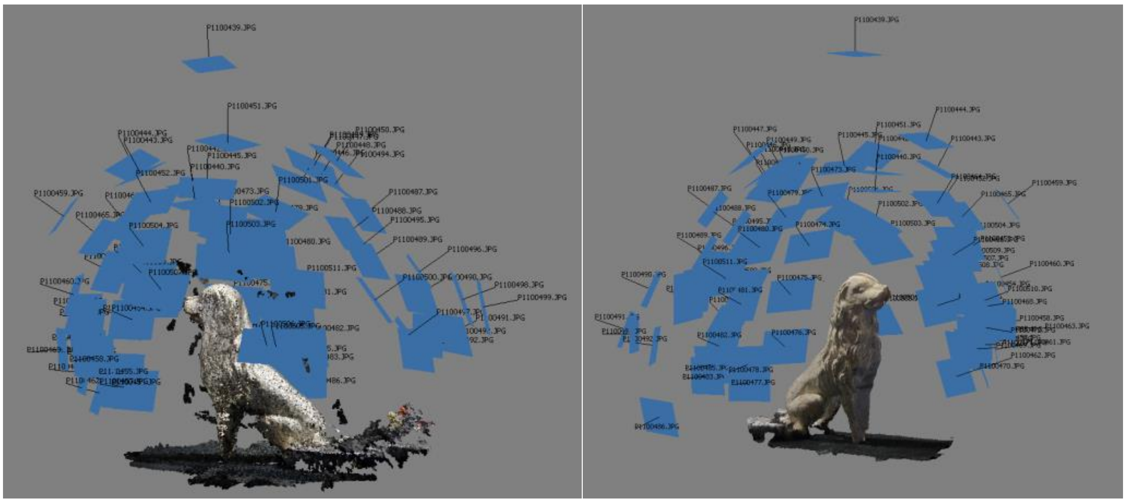


Figure 2.3 From dense cloud to textured model. Above images show the surface reconstruction of a dog pipe clay figurine from LAARC. On the Left is the Dense cloud of the Digital surrogate and on the right is the textured 3D image. The blue tiles represent the varying camera angles. This model was generated in Agisoft.

Many of these new SfM software packages look to be a promising alternative for image orientation and 3D reconstruction, with their rise in popularity being further bolstered by their environmental flexibility, easily accessible equipment (camera and computer), lack of the requirement for calibrated optics, and the nature of their availability; either open source, web based or low cost software. Such features are significantly more financially affordable than alternative 3D modelling approaches such as laser scanning or structured light scanning (Remondino *et al.* 2014, 144). Furthermore, due to the use of cameras within SfM, the sensors are capable of accurately recording high-resolution colour images, which make this method ideal for the documentation of the current condition of objects, enabling the potential to obtain details to the order of 10-50 µm (microns) (Hess 2015, 62). However, the metrological accuracy and reliability of many of these image based systems is still to be ascertained, and will be examined in Chapter 4 via vigorous testing, using clear accuracy statements, benchmarks, and defined evaluations of these different SfM software packages. A guide for close-range SfM guidelines is also still lacking in the heritage sector. This will be addressed in Chapter 4 where guidelines will be constructed which set out a clear, scientific methodology for small scale object recording and 3D digital *surrogate* production.

2.2 The Structure-from-Motion Software Specifics

This section will cover the different software, hardware, and equipment specifications which will be employed within this thesis. It also must be noted that consideration has been given to ensure that as technology advances and new software is made available, re-testing of the software already employed will occur as it is inevitably updated, alongside the potential for testing any new software that is made available. The results that are then recorded from the different software and hardware will also provide date stamps. This will ensure that the data from these accuracy tests can be understood in relation to stages in software development. The software and hardware specifics covered within this thesis were collated during 2016-2017.

The SfM software packages which are to be investigated within this research are based upon those which are currently popular in heritage research projects, summarised in Chart 2.2 In the early stages of this research it was decided that certain photogrammetry software will not be included within these trials due to immediate drawbacks that were presented at the onset, for example, ARC 3D Web service which is only available for non-commercial use (Bartoš *et al*. 2014, 64) and the open source software Bundler.

Though Bundler is popular within heritage circles, previous research (see MacDonald *et al.* 2014) has already demonstrated that this SfM software produces significantly lower accuracy levels than laser scanning, alongside having a non-user friendly downloading process and interface. To be able to download and use bundler, users must have a good level of computer programming knowledge as the programme requires the prior understanding of path scripting during downloading before the programme can be used. Once downloaded, users then also have to have moderate coding knowledge to be able to use the software. While the aim of trialling SfM software is to comprehend the most accurate software to be employed within artefact 3D imaging, simultaneously, the user friendly element cannot be ignored as this is also a vital feature to be considered.

Agisoft Pro edition

- Standalone software, developed in St Petersburg, Russia.
- £2312.65, for the professional edition, which is the company license, or for the Standard edition £118.31, both include all future updates.
- This software automatically generates textured 3D models using digital photo sequences, with no upper limit of photo quantity. Though processing is automatic users are offered a range of chances to alter processing parameters.
- Computing of large datasets, of 100 images or more, requires a computer which contain 6GB RAM with a 64bit operating system.
- Built in are a range of useful tools e.g. geo-referencing, measurement functions and python script customizer.
- The software saves the data from all processing stages on to the local personal computer. (Agisoft 2015; Torres et al. 2012; Barsanti et al. 2013)

Autodesk Recap/ 123D Catch

- A free service available online which allows users to upload their digital data onto a cloud server which then generates digital spatial models.
- Processing procedures are not made public, this a very closed system.
- After processing is carried out a mesh is generated rather than a point cloud. It is this mesh which can then be imported into additional software such as MeshLab and studied further.
- 123D catch allows individuals to edit the model by deleting areas, and scale the models. It also allows you to adjust the quality of mesh from mobile, standard or maximum, offering users, though minimal, a level on input decisions during the processing stages of this program (Bartoš *et al*. 2014, 67).
- A few immediate disadvantages include;
  - The software's reliance on the internet. This halts processing in the field unless individuals have access to the internet. Interruptions within internet connection will also disrupt the 3D modelling process and causes data loss. This latter issue can be incredibly time consuming if data loss occurs towards the end of the processing stages, as a repeat in process will need to occur.
  - This is a closed system, the input a user may have during the processing is minimal and the level of information offered to individuals concerning the specifications of processing are hidden, halting researchers from understating the software specifications, potentially affecting full comprehension of accuracy of a model. (Autodesk 2014; Bartoš et al. 2014; Torres et al. 2012; Lulof et al. 2013; Dunn et al. 2012)

Photosynth, Microsoft

- Free web based, open source software, with downloadable point cloud.
- Can process up to 200 images, however the processing system which is employed is closed off to the user.
- Immediate disadvantages include the software's reliance on the internet, and data loss if this connection is broken. Alongside the closed system it employs, removing user choice. (Bartoš et al. 2014; Torres et al. 2012; Lulof et al. 2013; Dunn et al. 2012)

Visual SFM

- A free graphical user interface (GUI) open source software (created by Wu 2011).
- This project has been built upon a previous version, SiftGPU and Multicore Bundler Adjustment algorithms. This new addition allows users to run tools such as PMVS/CMVS (Created by Yaskutaka Furukawa) within this program (Bartoš *et al.* 2014,64). To run this software VisualSFM also requires a series of other packages: Gtk, SigtGPU, CUDA, GLEW and GLUT, these are usually combined in pre-constructed packages of the software (Torres *et al*. 2012, 4-5).
- Immdiate disadvantages; this software requires users to have a highlevel of computer knwoeldge before use.
- (Wu 2011; Shah et al. 2015; Bartoš et al. 2014; Torres et al. 2012)

Zephyr Pro

- This SfM software, which is also referred to as 3DF Samantha and Stasia is a standalone software, which can then export its models in a variety of file types to be used in secondary mesh examination software packages such as MeshLab and CloudCompare (Examples of this software in application can be seen in the following papers; Toldo *et al*. 2013; Toldo 2013).

Chart 2.2 Popular SfM software employed within artefact 3D imaging, references cite projects, their accessibility and costs.

2.3 The Laser Scanner and Structured Light Scanner

The laser scanner and structured light scanner that were employed during these trials consist of the software and hardware bundles set out below (see Chart 2.3 and Table 2.1) The decision to use this equipment was influenced both by the equipment readily available within the department, in respects to the structured light scanner, and also by what is currently a popular choice during artefact 3D modelling, the NextEngine.

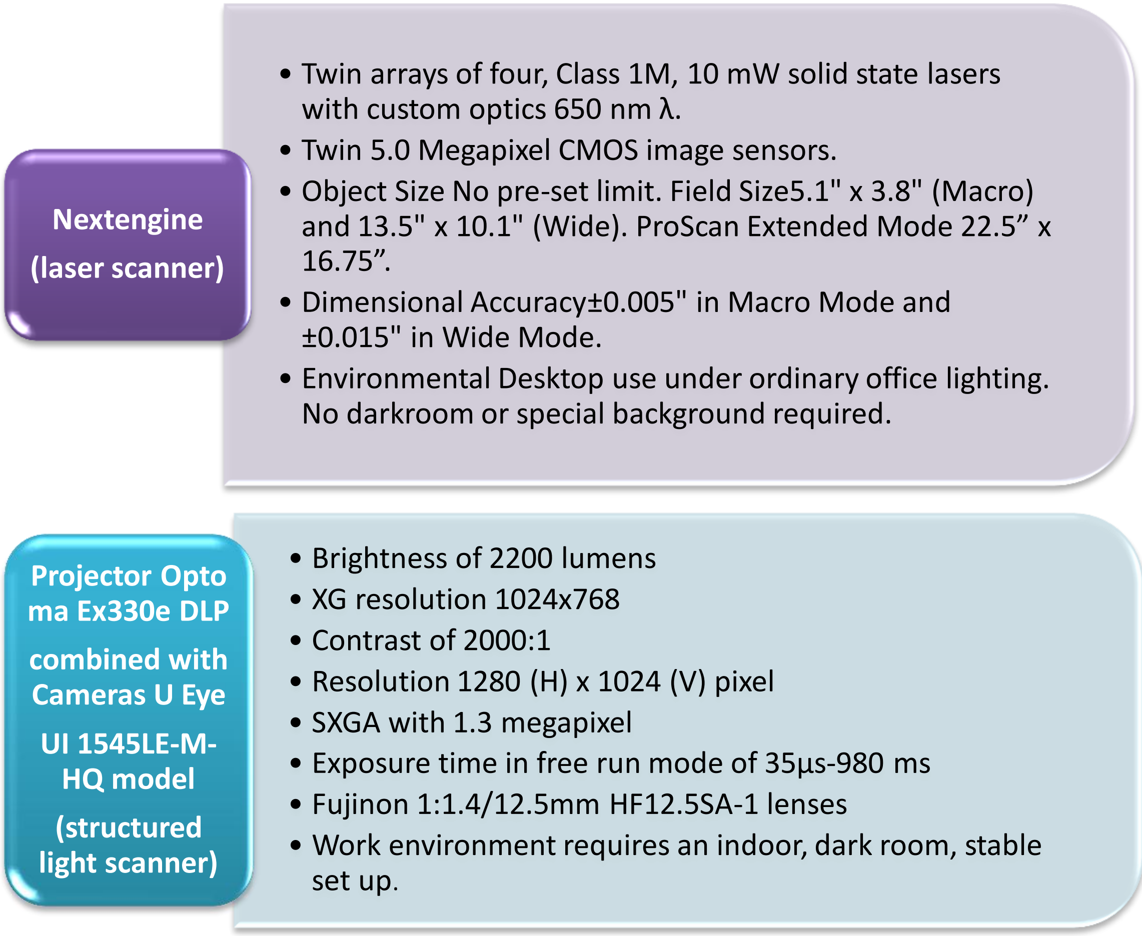


Chart 2.3 Displays the laser scanners and structured light scanners which will be trialled within this thesis.

2.4 The Costs

The cost of the equipment and software may also be a large factor to consider when choosing which 3D technology would be most suited for a project. Some projects may be small scale, or organised by either student or amateur bodies, such as community projects, neither of which may be able to, or wish to, invest high quantities of money into 3D modelling software. Table 2.1 below shows some obvious economic advantages towards the photogrammetry methods as opposed to the major costs that come with laser scanning and structured light scanning.

Table 2.1 Summary of costs of SfM, laser scanner and structured light scanner, costs were assessed during the 01.2016-08.2016.

The Products	Hardware and software required	Total Cost (rounded to the nearest 10)
Structured Light Scanner Projector Optoma Ex330e DLP combined with cameras U Eye UI 1545LE-M-HQ	2 camera sensors and lenses, a high-resolution projector, tripod and frame, relevant cables, Geomagic (£1500 for a company, or £150 for an individual), computer, and software dongle.	Software = £2990 (company) £1640 (individual) Hard ware = £3,050 Total = £6,300 for a company £4950 for an individual
NextEngine	3D Scanner Ultra HD, ScanStudio ProScan, ScanStudio CAD Tools, black bases, standard computer	£ 5000
Agisoft	Computer and camera with recommended specs. For Agisoft professional edition £2675 For the Standard edition £136	Company cost (multi license) + computer + camera = £3,200 Individual Cost + computer + camera = £750 There is also an option for educational discount.
VisualSFM	Computer and camera with recommended specs. Free Software	£600 (cost of an average computer and 16mp digital camera)
123D Catch	Computer and camera with recommended specs. Free Software	£600 (cost of an average computer and 16mp digital camera)
Zephyr Pro	Computer and camera with recommended specs. Software Package	Total = £3,300 (£600 is for computer and camera)
Photosynth, Microsoft	Computer and camera with recommended specs. Free Software	£600 (cost of an average computer and 16mp digital camera)

These immediate cost comparisons highlight a significant danger that has arisen from the surge of photogrammetry software. Due to its easy-to-acquire criteria for use and low cost, there has been a resulting reduction in financial demand for the carrying out of photogrammetry and 3D modelling, which has pushed an increased use of the technique more widely. Unfortunately, there has been very little accuracy and academic regulating and no standard issue of documentation and publication being provided for users. As such, the quantity of material being produced that may not be of viable use makes it even more crucial to obtain an assessment of the accuracy and reliability of these automated procedures (Bartoš *et al.* 2014, 64). It is these issues, of understood accuracy levels and clear guidelines for use and publication which also propel further investigation into these software, specifically in this thesis' case in connection with artefact studies, to ensure that not only are the most accurate software being employed, but also that they are being employed to a standardised methodology appropriate for artefact 3D imaging.

2.5 The Comparison Software, CloudCompare

CloudCompare is the software which has been chosen to carry out mesh comparisons between the differing imaging technologies. It has been chosen due to its accurate comparison results (see section 2.5.1), which were collated via artificially creating meshes within Blender (Blender 2.75 Foundation 2015), an open source 3D graphics software. These artificial meshes were then compared as identical meshes and then manipulated meshes to test whether the comparison software was able to accurately display comparison results, which CloudCompare achieved. The software is also free and user friendly, with an informative user interface, for example, the comparison colour scalar bar gives clear immediate indication of mesh differences. Finally, the software is also quick and can be used commercially as well as individually. Other software packages such as Geomagic and MeshLab were considered but not chosen due to either high cost (Geomagic costs around £1,400 for a company licence), or lack of software compatibility (MeshLab would not compare Blender meshes). The section below will present the accuracy trials and results for CloudCompare.

2.5.1 CloudCompare results

To understand whether the results which CloudCompare displays are accurate a series of accuracy tests were run on the software using Blender. The initial stages of testing were to explore whether CloudCompare was able to understand if two objects were identical. Within Blender a mesh of a Monkey's head was created (Figure 2.4) and exported twice, as two identical files. These files were then loaded into CloudCompare and a cloud to mesh comparison was run upon them.

As Figure 2.5 shows, the results of the comparison test demonstrated that the meshes were identical, with no distance between the meshes, the anticipated result. The next stage of testing was to explore how accurately CloudCompare was able to match regions of similarity and difference on meshes. Using Blender to create a manipulated version of the original mesh, both the original and manipulated versions were loaded onto CloudCompare (Figure 2.6). The mesh comparison function was run again and gave the results seen in Figure 2.7. These results show that CloudCompare registered that there was a difference between mesh distances, displayed in the red scalar. This mesh distance shows the difference as a maximum of 1.22cm away from the original mesh. If these results are then compared to the measurements offered to us in Blender (Figure 2.8), an accurate reading of mesh distance from the original mesh to the distorted mesh can be seen. A third set of trials were then run on the CloudCompare comparison function with the monkey form manipulated even further (Figure 2.9), presenting a more complex range of variations for the software to compare and measure against the original mesh (see Figure 2.10 for comparison). Once more the results which were attained from this trial demonstrated the accuracy of this software.

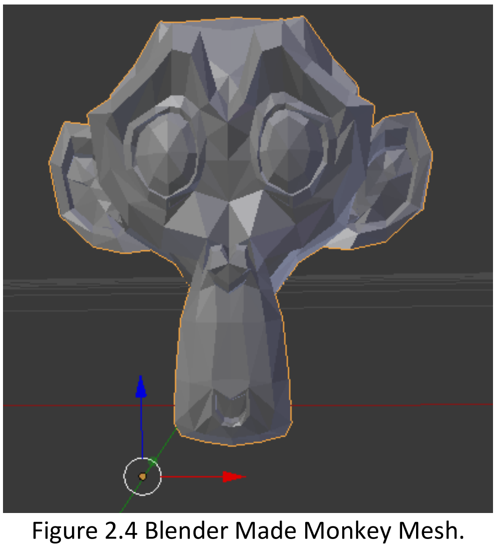


Figure 2.4 Blender Made Monkey Mesh.
(Blender 2.75 Foundation 2015)

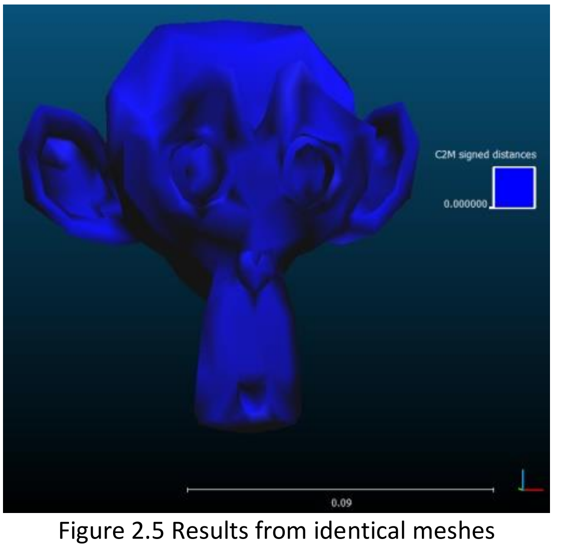


Figure 2.5 Results from identical meshes comparison in CloudCompare.
(CloudCompare 2015, 11/02/16)

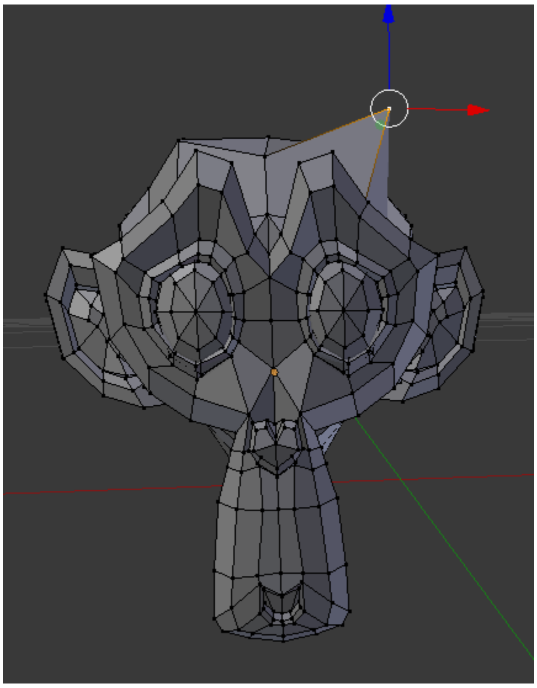


Figure 2.6 Manipulated Monkey version 1 (Blender 2.75 Foundation 2015, 11/02/16)

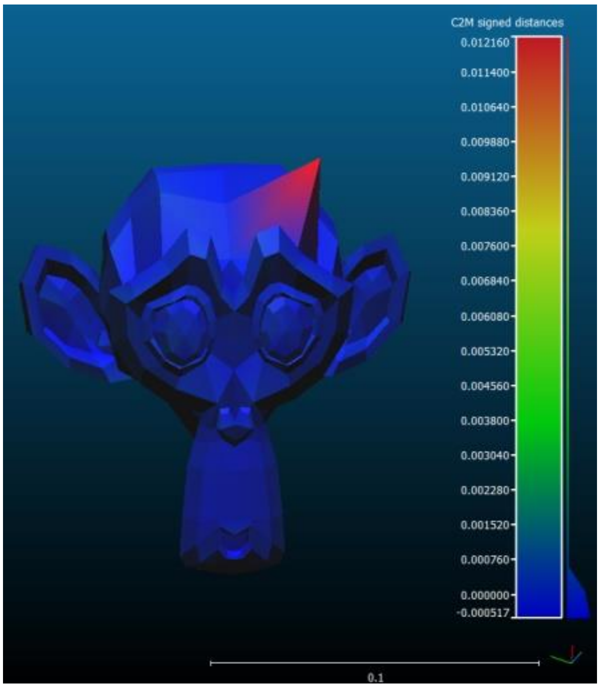


Figure 2.7 Results from original Monkey vs manipulated Monkey 1 (CloudCompare 2015).

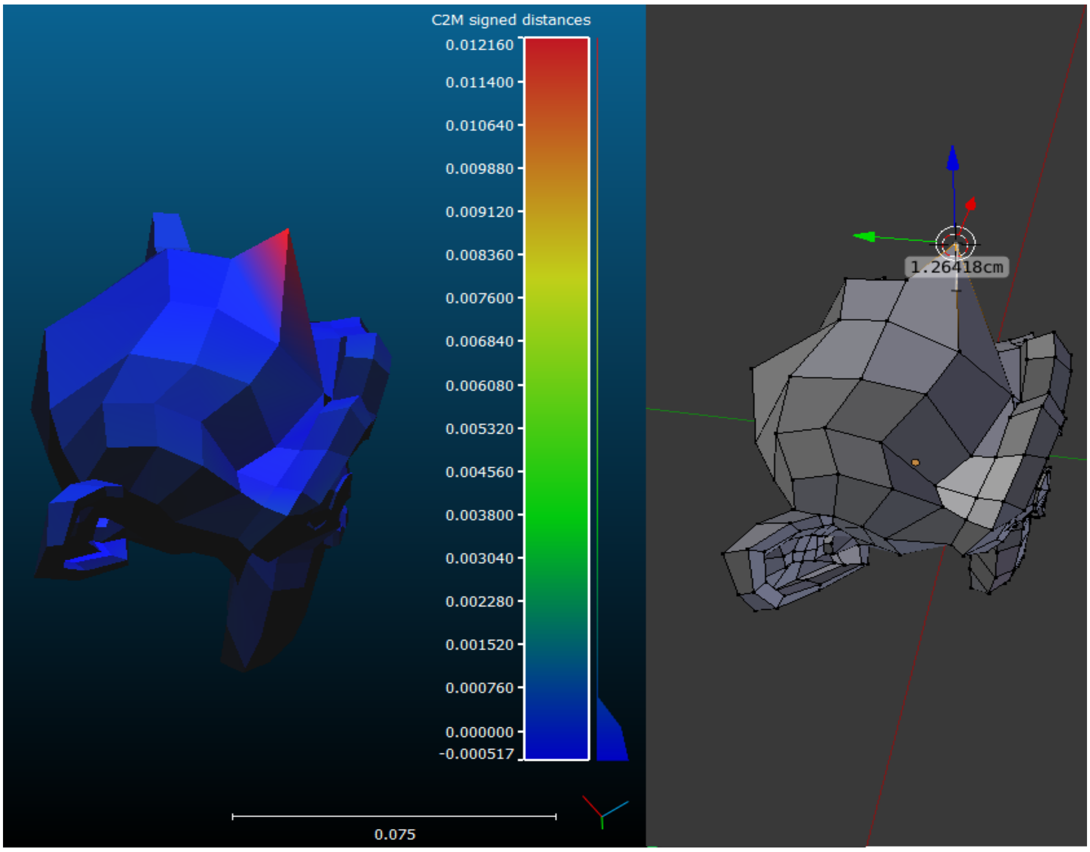


Figure 2.8 CloudCompare Scalar difference compared to Blenders measurements.

Figure 2.9 Manipulated Monkey version 2 (Blender 2.75 Foundation 2015)

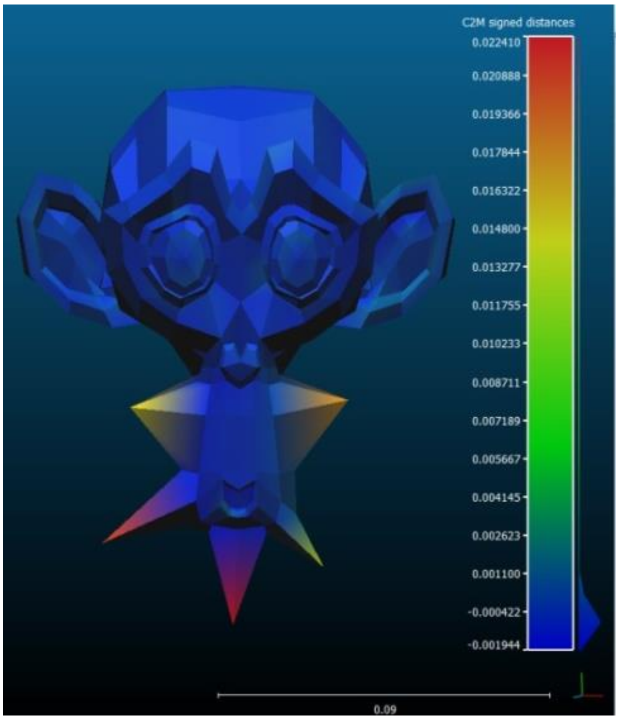


Figure 2.10 The results from CloudCompare, Original Monkey Vs Manipulated Monkey 2 (CloudCompare 2015, 11/02/16)

Figure 2.11 displays a selection of CloudCompare scalar images (Figure 2.11) which display the mesh distance differences between the Original Monkey and the Manipulated Monkey Version 2 compared to those measurements taken within Blender. In all cases the CloudCompare measurements are accurate and the software has been able to detect and accurately measure and cope with the various changes made to the mesh. Therefore, due to the accuracy of CloudCompare displayed within this series of trials, it can be concluded that this software is both financially suitable (free) and sufficiently accurate to test and compare the accuracy of the meshes created during the SfM and scanning trials. Before the method and results of those trials are presented, below will discuss several different comparison studies that have already taken place over the past few years. These comparison studies will present what has already been learnt about certain 3D imaging methods and accuracy procedures and how this can be built upon and further improved within this thesis' accuracy trials.

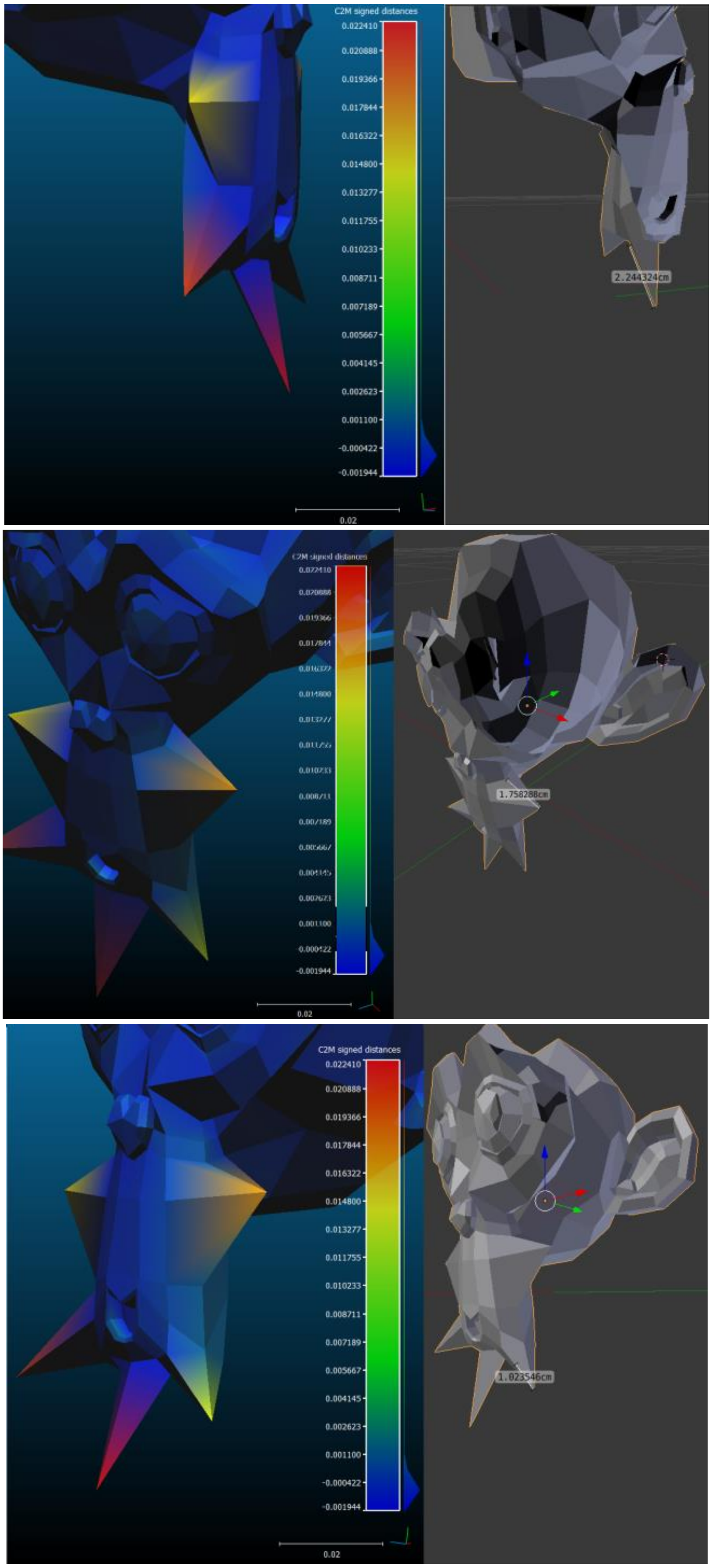


Figure 2.11 3 Series of CloudCompare Scalar difference compared to 3 series of Blenders measurements of Manipulated Monkey version 2.

2.6 Workflow for Artefact 3D Imaging and Literature Review

Investigating performance evaluations for differing 3D imaging techniques is a relatively new topic, which has generated a wealth of studies as an attempt for researchers to evaluate specific applications of 3D imaging (for example, Hess 2015; Balzani *et al*. 2001; Tucker 2002; Boehler *et al.* 2003; Kersten *et al.* 2004; Russo *et al.* 2007; Guidi *et al.* 2007). These examples will be discussed in more detail below but while there are some notable exceptions to these comparison papers (Hess 2015), virtually all of these attempts by researchers and the developers of the 3D imaging technologies are utilising different evaluative approaches. Each of these approaches employs highly variable terminologies, technologies, and methodologies, and do not offer clear definitions or presentation of the accuracy parameters and trialling processes employed. This is clearly shown in Table 2.2, which offers the accuracy trial statement released by NextEngine.

Table 2.2Accuracy trial statement released by NextEngine

Company and Product	**Accuracy trial Statement**	**3rd party evaluations recommended by Nextengine**
NextEngine	*"Accuracy calibration and validation is unique to our active measurement process and we don't share details for competitive reasons."* (Correspondance with the Support team at NextEngine 2016)	*"Multiple independent 3rd party validation has benchmarked our performance equal to the $40,000 USD FaroArm 3D Scanner. Here is one from the HD model, we now ship the Ultra HD model: https://www.youtube.com/watch?v=GXEKNf48w9A%20 We do both intrinsic and extrinsic calibration for volumetric accuracy then cross check accuracy within each scan envelope (Macro Mode & Wide Mode) to validate published specification are true across the entire scan area. Most Scanner companies will publish the highest performance that can be achieved within a small scan area. We on the other hand publish a much lower accuracy value which represents the outer most areas of each scan mode measurement envelope. For Example:-Macro Mode accuracy is +/- .005" but at the optimal focal length +/- .001" is a routine accuracy value. -Wide Mode accuracy is +/- .015" but at the optimal focal length +/- .005" is a routine accuracy value. Please find attached our specifications sheet for details on Macro and Wide Modes."* (NextEngine 2016)

The result of these closed-off systems and processes was to create projects which offer only generalised conclusions and limited descriptions of accuracy issues, parameters and results. This matter has been highlighted before by Beraldin *et al.* (2007) and demonstrates how, due to this lack of understanding concerning 3D imaging technology ranges and parameters, some set standards are required (Guidi et al. 2007, 62).

Chart 2.4 demonstrates a detailed workflow (adapted from Hess 2015, Figure 2.64, 80) from research design through to publication and storage, of what should be included within all projects which involve artefact 3D imaging. Guaranteeing that these stages occur within a research project ensures the validity of the work and 3D digital *surrogate* output and also ensures that this research can be applied to their own materials and replicated by others. It offers a clear and transparent methodology of data collection, post processing, application, analysis, publication, and storage. This workflow differs from Hess's (2015) workflow as it takes into account that a lot of archaeological research and data collection is collated by small scale institutions (small museums or university departments), commercial units or archaeological students all of which have limited funds, time and work force (often with only one individual working on a project). Rarely do these groups come with a prior arranged collaborative network (which Hess's projects do), and often individuals have minimal previous experience within computer science.

Although Hess's work sets out a precise seven stage guide from object selection to publication (Hess 2015, figure 2.64, 80), it does not take into consideration some of the initial stages within a project. Rather than being approached by a curator with a project, individuals will often create a project design and then approach a curator with their research agenda, as is the situation with this thesis. Such a difference in initial project creation will create further differences within the workflow. Furthermore, often workflow will rely solely on the individual researcher, areas such as conservation assessment are carried out by the individual in correspondence with the curator. Data storage, an issue not mentioned at all within Hess's workflow, often has to occur at the researcher's expense, and it's omission from the workflow is an oversight which can cause extra overheads and issues throughout a project, especially if researchers are working with large assemblages.

Following on from the step by step guide to artefact 3D digitisation workflow is a series of evaluations presented in Table 2.3. These evaluations present different case studies and archaeological research which have involved the creation of 3D digital *surrogates*. The aim with this discussion is to synthesise current research practices within the framework of the suggested 3D digitisation workflow, providing both an insight into how the heritage sector and associated research projects are carrying out this research and clarifying what stages are being omitted, on what scale, and the wider impact this can have.

1. Compile research aims
- Draw up initial research aims, questions, equipment required, data collection method, and resolution of 3D *surrogate*.
- For equipment choice take into account the working environment, as this may affect equipment suitability.

2. Select data set
- Decide upon a data set on which your research will be based.

3. Obtain Permission
- If required, request and gain access to the data sets. E.g. contact the museums/stores/universities in which they are held.
- Gain permission for use of 3D imaging equipment.

4. Assess object
- Assess that the conservation of the object will remain unaffected by the 3D imaging process, and input correct safety measures to ensure the safety of the artefact, in consultation with the curator.

5. Obtain data
- Using the chosen imaging methodology, create required raw 3D digital *surrogates*, record all equipment and environments used for future reference in later write up stages.
- SfM→set up→Capture images→sparse point cloud→dense point cloud→mesh→textured model→(if required align and sitich seperate models together)→scale→save
- Structured light scanning/ laser scanning→2D archive images→set up→capture images→align→fuse→save

6. Post-process data
- Process data according to the research projects aims: this may include mesh clean up, segmentation, hole filling, editing geometry or colour. However, in some cases raw data may only be required, with either a raw full resolution 3D textured or non textured point *surrogate* being produced. This could also include quality control of object: for example, does the texture of the 3D surrogate look like the original object if required to.

7. Application of data
- Apply your data to your research questions, e.g. a comparison of data sets such as mould and product matching, or tool mark recognition, illustration or inscription illumination etc.

8. Analysis of Data
- Assess the results of the applied data.

9. Write up
- Write up and convert your data (as deemed suitable for your research application), object/period context, theory and conclusion if required.
- Ensure object provenance, digital provenance, object/collection/store/museum information, software, hardware and process method are included.
- If multiple publication outlets forseen, adapt data for the different final purposes e.g. dissemination of data, colour enhance, scale application.

10. Publication
- Publish work via chosen means, e.g. digital 3D gallery, digital article, interactive application, as a shared document for different institutions, downloadable replica/3D print (copyright permissions dependant) etc.

11. Storage
- Formulate a plan for long term data storage of both final results and original raw digital material to ensure reuse of materials is available in the future.

Chart 2.4 Process workflow for artefact 3D digitisation.

Table 2.3 Analysis and Critique of past methodologies of digital surrogate workflow

Workflow Stages	**Developing of 3D imaging Programmes - Workflow and Quality Control** (Hess *et al*. 2015)	**Image-Based Low-Cost Systems for Automatic 3D Recording and modelling of Archaeological Finds and Objects** (Kersten *et al*. 2012)	**Developing an "Archaeological" Benchmarking Procedure** (Amico *et al.* 2012)	**3D documentation of small archaeological finds Arc-Team-Open-Research.** (Bezzi 2012, updated on 4.7. 2016)	**Effective 3D Digitization of Archaeological Artifacts for Interactive Virtual Museum** (Tucci *et al*. 2011)
State research aims, equipment choice and why	'*motivated by the potential of digital technologies for 3D optical surface recording of museum artefacts and cultural heritage, and aims to enable heritage professionals to produce fit-for-purpose 3D digital records for research'* (Hess 2015, 3) The project presents an in-house workflow for the production of benchmarked, visually accurate 3D models of museum objects. This article specifically outlines the workflow *'for the production of 3D models of museum objects, based on colour laser scanning and photogrammetry of selected ancient Egyptian artefacts'* (Hess et al. 2015).	Investigating whether image based systems could be used as substitute for range based systems. They trialled Bundler/PMVS2, VisualSFM, Autodesk 123D Catch beta and Agisoft and the laser scanners they employed were the IMAGER 5006i, IMAGER 5006h and IMAGER 5006	To created archaeological benchmarks to help to define a suitable methodology for 3D modelling of archaeological finds for the purpose of conservation, virtual restoration and digital visualisation. They employed a NextEngine Desktop3D laser scanner. The choice of this scanner was based upon its good reputation and the technical specifications, the high speed of the scanning and relatively low cost for the equipment.	To investigate the difference results presented between Computer Vision and optical sensor 3D modelling within artefact 3D modelling. Microsoft Photosynth, Python Photogrammetry Toolbox, NextEngine Scanner and the Three Phase Scan, and MeshLab for imaging and processing.	To publish high quality models of medium sized artefacts for the purpose of online exhibitions, and to create the most effective means for workflow both in connection with data acquisition and processing, for non-digital specialists. They employed a NextEngine Desktop3D laser scanner, due to its good reputation, the technical specs, and relatively low cost for the equipment.
Selected Data	Egyptian artefacts – from the UCL Petrie Museum	An obsidian stone, Vaihu stone statue found on	A bronze statue, flint tool, ancient human vertebrae,	A small statuette of a female Viking	Figurine of rider on a horse from Greece, bowl

		Easter Island, pottery and masonry fragments from Yeha in Ethiopia and a carved dhow on a wall in, Qatar.	an ancient human tooth and a pottery sherd		from Cyprus, jar from Cyclades, folded arms figurine from Cyclades, stirrup jar from Greece, Phi-type figurine Greece.
Obtain Permissions	Granted from a curator – UCL Petrie Museum	Does not discuss	Does not discuss	Not required	Does not discuss
Assess Object	*For each object proposed, the curator starts to fill in a standardized Object Assessment Document (OAD), recording basic information about the object and specifying any features that are essential to capture. The OAD is then passed to a conservator, who adds a condition report*	Does not discuss	Does not discuss	Not required	Does not discuss
Obtain Data	*If an object is approved for laser scanning, the whole surface is photographed for reference.* *The 3D imaging of an object is then carried out using the most appropriate of the three available types of acquisition for primary and 'raw' data: 3D colour laser scanning, using an Arius3D, as active 3D imaging method; photogrammetry (multiview stereo) and Structure from Motion (SfM) as a passive 3D imaging method.* *For all recorded objects, the highest*	The article does explain the process vaguely, but within the process there are constant changing variables within their tests. This includes continuous changes in equipment, software packages, times in the day, data collection separated by several years and the smoothing of meshes on secondary software such as Geomagic. These constant	Constant parameters include a controlled environment and the lighting to improve the appearance of object textures. Each object was scanned using both the wide and macro modes and in both high and low resolution. Scan amount began at 5, then 7 and finally 9. Odd numbers chosen to overlap the last scan with the first. Repeated this process for	yes but no details	Determine the minimal amount of scans required to capture the whole object with high quality details. Workflow process is given in good detail. Concludes that around 20 scans on average are required, and that with the inclusion of set-up this takes around 2 hours. Extra single scans were added to this set to ensure that blind spots of the objects were also

	obtainable resolution in the acquisition stage was used. *The laser scanning does require transporting the object to the university, rather than taking equipment to a museum.*	variables within their tests produced uneven uses of software packages and scanners across the board, with software such as Bundler being trialled 5 times and Agisoft only being trialled twice. There were also multiple changes in the technology used to create the base data for the trials of the software as well, with three separate laser scanners and two separate structure light scanners being employed as a means to create base models.	each of the 5 objects.		covered.
Post Processing	*Hole-filling, complementing any missing geometry by 3D modelling, and adjusting the colour to match the reference photography.*	In some scenarios there has been merging of point clouds smoothing of meshes on secondary software such as Geomagic. No other post processing is mentioned (Kersten *et al*. 2012, 8)	Post digital acquisition of data the range maps were exported to MeshLab. Single scans were cleaned and several filters were applied for meshes optimization: ‘*remove duplicated faces*’, ‘*remove unreferenced vertex*’, ‘*remove duplicated vertex*’, ‘*remove non manifold vertex*’ and ‘*remove non manifold*	Stated that for their post-processing MeshLab was employed, but no further details were given.	Post processing procedures which occurred included: ‘*correction of topological errors in the polygonal surface… filling of holes in the mesh… texture generation… editing of the photographic texture… noise reduction and surface smoothing.*’ (Tucci *et al.* 2011, 417)

			faces'. These were then saved as .ply, and aligned using an ICP algorithm to obtain the complete model. Manual registration was used for the comparison of the 3D geometry with the choosing of at least four common points (Amico *et al.* 2012, 16). The final stages consisted of the flattening of the range maps '*in order to create a merged file containing all the scans aligned in the previous steps. A continuous surface was reconstructed by fusing the single scans and applying the Poisson Surface Reconstruction algorithm provided by Meshlab (using Octree depth: 12, Solver Divide: 12). The texture was transferred to the model applying Sampling/Vertex Attribute Transfer/Transfer Colour*		

			filter' (Amico et al. 2012, 17)		
Application	to produce '*a model that would be a believable representation whether in a web app, an exhibition, a giant screen, or other display modes.'* (Hess et al. 2015, 3)	To see whether image based systems could be used as substitute for range based systems.	*'aiming at developing an "archaeological" benchmarking procedure for the definition of the most suitable methodology for 3D models creation, to adopt for different research goals such as conservation, virtual restoration and web visualization of archaeological objects.'* (Amico *et al.* 2012, 13)	The goal of this project was to compare different methodologies in documenting small archaeological finds (Bezzi 2012).	The intended application for these models are to be employed within virtual and interactive exhibitions within museums, as well as to provide a scientific archive of highly accurate models for specialists (Tucci *et al*. 2011, 413)
Analysis	*The resulting protocol combines reference photography and 3D imaging with a curatorial comparison using visual inspection of the actual object to its digital counterpart. Any discrepancies between the object and the model, such as inconsistencies in colour, specularity, resolution, hole fills, and layer blending, were recorded in the process log and reported back to the 3D-modelling technician in words and image (using screenshots). Multiple iterations of post processing and review may then be necessary to improve the quality of the 3D model until the visual-surrogate level is reached.*	To assess the data the resulting datasets were compared to reference data of the same objects as captured by terrestrial laser scanner and fringe projection systems using the ICP algorithm. The comparison was then computed in Geomagic (Kersten *et al.* 2012, 2, 5)	Qualitative analyses of the scanned images were discussed with an archaeologist, a ceramist and a paleoanthropologist. Other than a summary of their opinion on texture and geometry of an object no further detail of method of analysis is given, nor benchmark for the basis of their opinions as to which scans were deemed satisfactory or not satisfactory (Amico *et*	Purely a visual comparison between models, judged on which aesthetically looked the best.	Visual analysis, but not elaborated upon.

			al. 2012, 16-17)		
Write up	*A standardized form (a process log) is used to record and track each stage, including information such as the equipment and software used, the processing steps taken, and the comments of the model review.*	Does not discuss	Doesn't discuss	Does not discuss	Each of the fundamental stages of the processing work-flow were recorded and sorted into the project's data archive (Tucci e*t al*. 2011, 418)
Publication	*Articles, the museum has created a variety of digital multiplatform interactive applications. As well as stand-alone interactives, digital outputs and 3D prints can at the current Petrie exhibition at UCL Qatar.*	Article	Article	Article	Article and digital interactive outputs.
Date size and long term storage	Does not discuss	Does not discuss	Does not discuss	Does not discuss	Archive storage and backed onto a second hard drive for permanent storage (Tucci e*t al*. 2011, 418)
Job area of author	Project produced by the 3D Petrie team, alongside a network of colleagues	Geomatics	Digital Cultural Heritage	Digital Archaeology	Geomatics and Communication for Cultural Heritage
Concluding comments	Overall a very well laid out project, perfect orchestration and ticks all the boxes. The method and stages are clear and precise. However as this project points out, they have a large team of specialists, and large fund available for this research, they list what they used, the time spent	Overall the basic concept to test these different software packages within the field in comparison to laser scanners and structure light scanners is a good idea, and forms one main question avenue within this thesis.	Overall this paper's introduction and methodology was presented well and clearly, however, once the 3D trials had taken place the presentation of results lacked actual data and relied on an	Though a very simple trial between four methods of 3D data collection, a very important point is displayed within these results. Although in their opinion the NextEngine offered the most accurate data collection, in their	A reasonable outline of how to produce detailed 3D models, which the reader is informed are detailed enough for research purposes, though no true geometric results are presented. These detailed models

	on a singular object and discuss the expenses loosely, informing individuals not to underestimate these areas. They clearly display that this is a large scale project, with great work flow, however not a sustainable deign for small, low funded projects. Furthermore the time required to 3D image a singular shabtti took three and a half working days, and a team of specialists. This length of time scale is not appropriate for many projects, as most have both restricted budget and time scales, either imposed by their own projects, or imposed by the stores and museums in which they are visiting. For example this thesis has carried out around 70 laser scans, not including also the SfM scans and the structured light scans. If this thesis had followed Hess's design it would have taken approx. 245 working days to complete those 70 scans, as opposed to the 25 days it has taken, without the use of a team of specialists.	However, their methodology and presentation of data and results means that there is little control in these experiments with too many variables to accept their results without question.	acceptance of vague descriptions, with no real clear process of creation and examination of 3D models being formed.	conclusion there was a favour for the open source software due to its low cost and flexibility of use within the field. Overall though the paper was lacking in detail in most areas.	can be reduced in data size to create virtual museums, however, little detail was offered on how this was done, what the utilised data size was, and the difference in details from original model to disseminated model. The lack of: detailed comparisons of data to ensure accuracy, testing of other scanners or methods, and the large time scales pose questions as to whether this methodology is really the most effective and/or accurate procedures to follow for digital data acquisitions.

As discussed both by the 3D-Coform project, whose project aims orientated around creating an affordable and effective 3D documentation mechanism (Arnold 2013), and the EPOCH project, which was active 2004-2008 and aimed to create a Network of Excellence for 3D documentation (Arnold *et al.* 2008a), the need for a development in the standardisation of the design, execution, dissemination, communication, and clear accessible storage of data is essential. As the above projects display, a clear representation of workflow is often not present, with many sections of information missing from the publications or discussed in minimal details. Whist many of the above projects presented clear outlines for the projects aims, chosen data, and chosen equipment, the rest of the work flow stages remain at an unsatisfactory level, with exception given to Hess's (2015) project. That being said, Hess's project, which was concerned with providing readers with a clear workflow to produce accurately collated data, was lacking reference to the discussion of permanent storage. Storage proposals for the data acquired are a key and often overlooked factor amongst digital heritage projects, demonstrated clearly in Table 2.3, where only one project out of the five discussed data storage and future access to this data.

Furthermore, while each project presents a range of valuable insights into this field, there is an array of issues also observable within their collated works. Within the majority of these projects not only is data storage not discussed, but also there is a lack of discussion on obtaining object permissions and initial assessment of objects to ensure that measures are taken to guarantee objects safety during 3D imaging. Presentation of post-processing methodologies and technologies are also often absent or inadequate within the projects. It is essential that this stage is discussed as both a form of method-sharing to improve and encourage development within this field, but also to insure the transparent representation of data which has led to a project's conclusion. Finally, the analysis and assessment of collated data are also often either deficient in clear representation of methodology or are incredibly basic, with many circumstances of data assessment relying on whether the 3D *surrogate* is aesthetically 'good'. While this form of assessment may be suitable for projects where the object's metric accuracy is not essential, such as museum outreach and tourism, it is not a suitable methodology for 3D *surrogates* whose intended use is for research, where often metric accuracy is essential.

2.7 Chapter Summary

Overall it appears that much more care is required in the representation and publication of 3D projects, especially when the main purpose of these projects is to display workflows and methodologies for artefact 3D imaging, such as those discussed in the above section. Without clear and detailed representation of methodologies and data it will not be possible to form a standardised design for the execution, dissemination, and publication of 3D projects, creating unnecessary and reoccurring issues for the growing number of such projects in the heritage sector. One such issue is the question of copyright over the digital data, a question that will arise more frequently unless permissions are clearly established and documented at the beginning of a project. The development of a standardised practise will also enable projects to clearly choose methodologies and equipment that are suited for their research aims. This will protect against circumstances where projects invest in unsuitable equipment and software, a highly positive prospect for the heritage sector when the high costs these technologies entail are considered (as discussed above in section 2.4).

Consequently, this thesis intends to present a clearer standardisation of workflow from execution through to publication of projects to ensure that the above discussed issues are answered. It is to Hess's (2015) project which this thesis gains a good initial framework for its overall 3D workflow. However, while the base design for Hess's (2015) project is both clear and detailed, it does not represent a realistic process for smaller scale research projects or projects which take place in the field, as stated within the publication '*3DPetrie represents an in-house 3D imaging project*' (Hess *et al.* 2015, 2). By building on Hess's (2015) workflow design, both by altering the format and adding extra stages, the workflow design quickly becomes clear and easy to use, follow, and present. An example of this easy work flow in application to this thesis can be seen in brief in Chart 2.5 below. However a more detailed discussion of this workflow will be presented in the final chapter of this thesis, where each of the stages will be summarised in more detail.

Chart 2.5 3D research workflow for this thesis.

Chapter 3

Accuracy Trial Methodologies and Results

This chapter presents a discussion on the methodology that will be employed to allow a critique of the accuracy of the different SfM software in relation to each other, and also in comparison to laser scanning and structured light scanning. The results from these comparison trials will indicate the most suitable current methodologies to be employed for artefact 3D imaging, and also present recommendations on how these methods can be employed to help further research goals and the understanding of different artefact groups. Before these accuracy trials are undertaken, the hardware and the imaging environments will be discussed, to provide the fullest understanding of the parameters of these accuracy trials and all the equipment which was employed.

Following on from this will be the presentation of experiment specifications for the different SfM software packages mentioned in Chapter 2, alongside the NextEngine and the Projector Optoma Ex330e DLP combined with Cameras U Eye UI 1545LE-M-HQ model, which will be trialled upon a series of simple test objects. These objects will consist of a rectangular prism, a pentagonal prism, and a star prism. All of these objects have easily measurable structures, thus enabling a clear understanding of whether the structures of these objects are maintained true to their original forms during 3D imaging.

Following on from these simple test object trials, three post-medieval pipe clay figurines, an Anglo Saxon glass counter, a medieval stone hand, and a piece of animal bone will be employed as a more complex control group to test the levels of accuracy produced from the 3D modelling methods which displayed the best results within the simple test object trials. This will enable an investigation into the accuracy of both the metrics of the objects and the texture produced on a series of archaeological finds, which have been chosen due to their differences in sizes, shape, and production materials. Specifications of both these accuracy trials will be explained later within this chapter.

Following the results from both of these trials will be a discussion on which methodologies seem most suitable for different types of artefacts, but also for the research questions proposed within this thesis. These discussions will help to provide some ideas of specific academic applications of 3D modelling within artefact studies, helping to answer often-reoccurring critiques of 3D modelling technology raised by archaeologists (Forte 2000; Sims 1997; Hermon S, Nikodem J 2006; Reilly 1989). Such critiques include issues concerning the evaluation of 3D models and the purpose of 3D model generation, an area which is caused not only by the lack of training in computer science methodologies within archaeology but also due to the closed box nature of processed 3D models. Once an article becomes published, often only the 3D image itself is displayed, though if this is not digitised it is only a 2D representation, and with little supporting technical information. As discussed in the previous chapter, rarely are the software, cloud density, hardware, and post-processing methodologies employed discussed, all of which are beneficial factors which could contribute to the analysis of data connected to 3D modelling (Hermon *et al.* 2005, 1).

Chapter 4 will examine the London pipe clay figurine assemblages that this thesis has focussed upon, with Chapter 5 going on to present a broader examination into some of the British colonies in America, which were bankrolled by London. These will lay a contextual grounding for the importance of figurine comparison and analysis via 3D imaging, which are discussed in detail within chapters 6 and 7.

3.1 The Hardware

Table 3.1 shows a list of hardware that will be employed during the processing of the 3D models. It is important that this thesis presents all the processing factors employed within each stage, in order for the results to be presented in a full context. The decision to use this equipment was influenced by the parameters recommended by the software packages and scanners being employed within this thesis.

Table 3.1 Hardware specifications

Hardware	Specifications
Laptop – Gigabyte P27K	➢ Core i7-4810MQ ➢ 2.4 GHz ➢ Windows 8.1 64-bit ➢ 12 GB RAM ➢ 128 GB SSD ➢ 1T HDD ➢ NVIDIA GeForce GTX 765M ➢ IntelHD Graphics 4600
Compact digital camera – Panasonic Lumix DMC sz3eb-k	➢ 16.1MP

3.2 The Heritage and Archaeological Work Environment

Understanding the differing work environments that these 3D imaging processes will be taking place within is essential for an evaluation of its archaeological suitability. This is due to there being vastly differing environments for different areas of research that are carried out within the heritage sector. Some of this work was undertaken within museums or offices, both of which often have low lighting but provide power sources and often internet access. In other cases, scanning may take place in the field, often entailing varying environmental conditions ranging from extreme cold to hot desert conditions, high humidity levels, and variable lighting dependent on the sun. These weather variables, alongside a huge range of terrains from fields to forested areas, are but a few of the environmental workspace factors which must be considered. In many cases these environments do not offer access to internet or electricity, other than the occasional car battery during the day and it may not be until the evening that individuals are reunited with the internet and electricity.

Having such variable working environments within the heritage sector means that the software and hardware which is to be employed within a project has to be suitable for those conditions. There is little point, for example, in employing 3D imaging software that relies on internet access if individuals are wishing to create 3D models within the field, a situation which may arise if archaeologists are wishing to record *in-situ* artefacts, structures and contexts. It is therefore worthwhile considering the environmental limitations that may restrain or complicate certain 3D modelling hardware and/or software. Further discussion of these limitations will be presented alongside results of the initial simple test object accuracy trials within section 3.4.

Within the initial stages of simple object accuracy testing and the initial artefact trials the environments in which these trials were set up will depend on the recommended user guidelines of each technique. For example, due to the requirement of low lighting and electricity, the NextEngine will be set up upon a desk within a moderately dark room, with the curtains closed and no lights on, apart from that produced by the screen of the computer. The structured light scanner will be set up within an office which has blackout curtains. The SfM images will be captured using natural light or a diffused lighting, when natural light is not available, similar to what may be experienced in a museum or an office area. In any lighting scenario, it must be ensured that the photographers do not cast shadows on the object being imaged as this will change the surface appearance during image capturing. To aid this issue, when taking images for the SfM software packages within natural lighting, the objects will be imaged in quick succession to ensure lighting remains similar for each object and the same images will be run through each of the SfM software to reduce variabilities within these trials. The methodology of image capturing for each technology will now be discussed.

3.3 Methodology of 3D image Capturing; SfM, Laser Scanning and Structured light Scanning

Both the methodologies adopted for the laser and structured light scanners in this thesis are those used in standard industry practise and suggested by the products' manuals. However, the methodology presented for the SfM technique was developed during the writing of this thesis; the foundations of this methodology lie within Agisoft's User Manual (Agisoft LLC 2011, 5-6), which was chosen as it is already common practise within many archaeological SfM projects (for examples please see Bennett 2015; Olson and Caraher 2015).

3.3.1 SfM imaging methodology and setup

The following sections will present the methodology and set up behind SfM image capturing, and will set out all matters associated with producing reliable 3D surrogates, including elements such as lighting, required equipment, and equipment and artefact set up.

Lighting

Natural light does appear to act as the best source of light, as it offers an even spread over the object and also allows for shadows. If there is not enough natural light to use as a source an artificial diffused light can also be employed; harsh lighting should be avoided as this can produce high levels of colour contrast on an object, artificially creating areas with no shadows or a high density of shadowing. Shadows are required to understand the depths of an object, especially if there are any forms of decoration/grooves/in-dents on the objects that need to be observed. Natural light also gives the most likeness to the actual colour of the object and avoids glare, reduction in detail, colour mutations, and overexposure on white and shinier surfaces. Avoiding artificial lighting also aids in the avoidance of camera flare and intense areas of shadow.

Placing a sheet of glossy photo paper under the object helps to bounce the natural light up onto the object, and ensures that the shadowy crevices are highlighted from underneath. Drawing on the photo paper further aids the software when matching the photos to each other as the SIFT (scale-invariant feature transform) algorithms are able to recognise the patterns seen within the computer vision. Once detected these local features and patterns are then stitched together.

Position of the item

It is important to ensure that the object being imaged is positioned at a level which allows the camera to circulate 360̊ around it. Within this study a small, stable platform was mounted on top of a tripod to allow the best degree of movement around the object. The base of the object can be imaged separately and stitched together in later stages of processing if the base is required in the 3D reconstruction. Both the positioning of the item and equipment can be seen in the Figure 3.1. It is essential that once image capturing commences that the object is not moved from its original position as this will produce errors during processing (Agisoft LLC 2011).

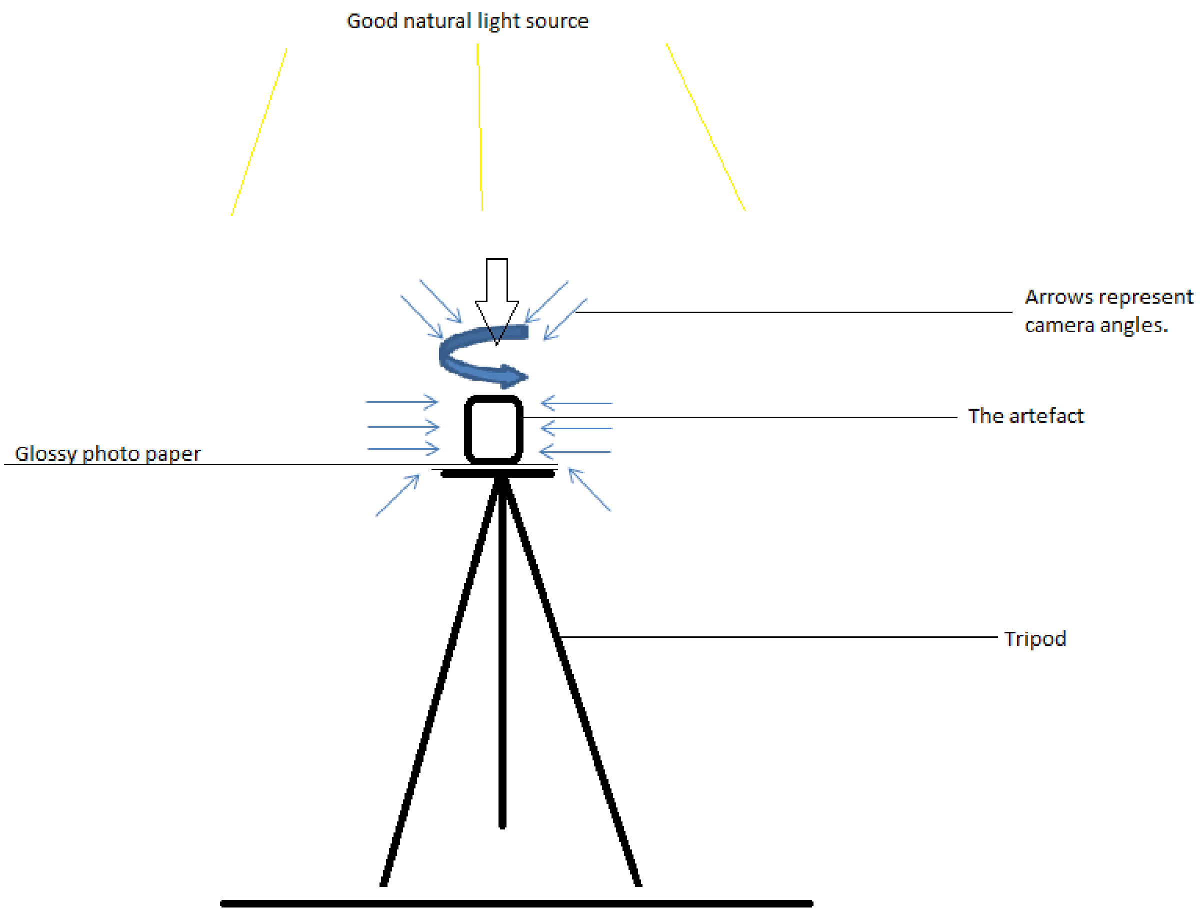


Figure 3.1 Ideal set up of the equipment (image created by author)

Set up of equipment and the 6 stages to image capturing:

Figure 3.2 displays the six stages of image capturing that must be followed to ensure accurate models are produced. Other processes were trialled, however, these alternatives produced insufficiently complete or accurate 3D models, often with only partial models being developed.

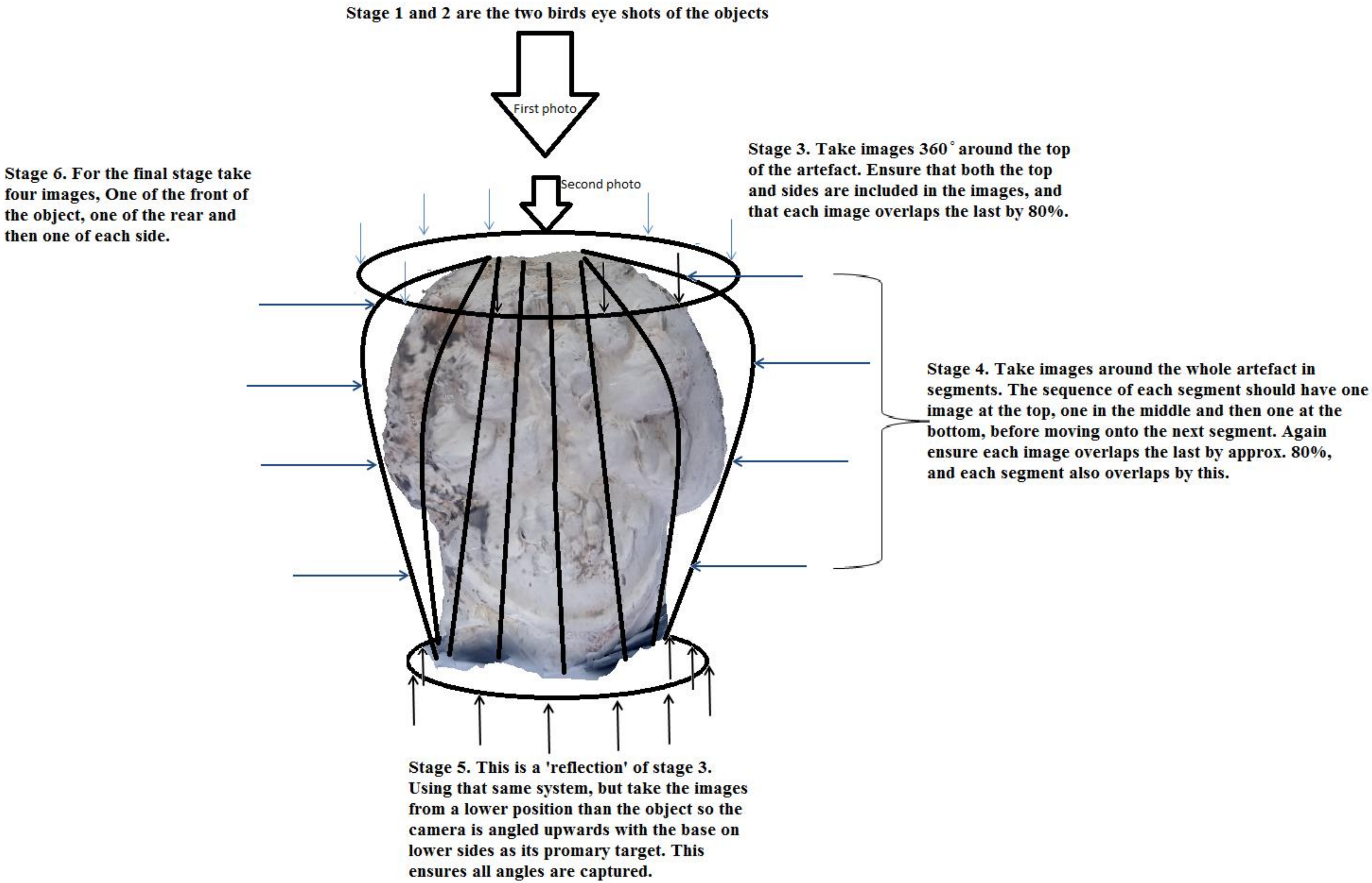


Figure 3.2 The 6 stages of image capturing for SfM 3D modelling (Diagram created by author) distance of the camera from the object is relative to the size of the object in each stage.

3.3.2 Laser Scanning Image Capturing Set up

For image processing using the NextEngine the methodology has stayed within the guidelines offered by this equipment's user manual. The only alterations that have been implemented are changes of the objects perceived shade. The software offers a categorisation choice of light, neutral or dark to describe an object's surface colour, adjusting the scanning process to provide improved scanning results. The second variation which has been allowed involves the number of scans used per object, due to the objects being of various sizes. Figure 3.3 displays the setup of this equipment. The chosen setup is the one specified within the NextEngine User Manual, since when alternative setups have been trialled they have usually produced insufficient scans, often with large areas of detail being lost.

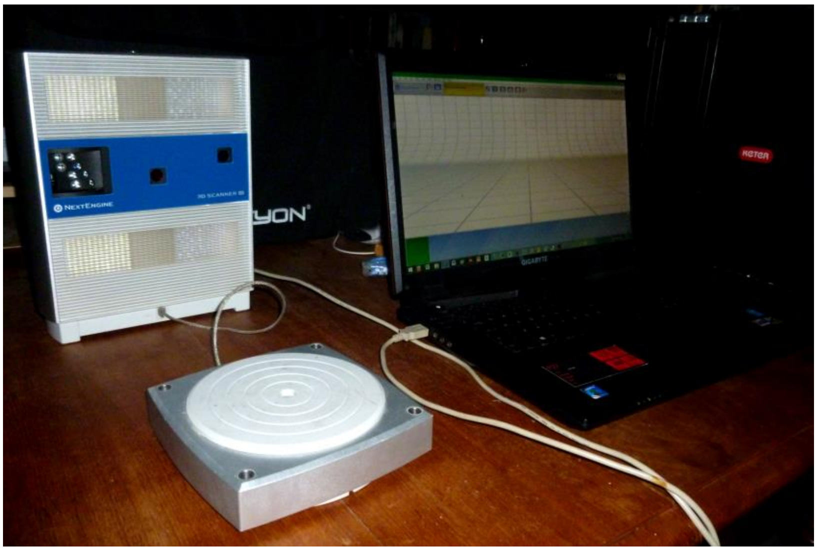


Figure 3.3 NextEngine Setup

3.3.3 Structured Light Scanning Image Capturing Set up

For the image processing using the Structured light scanner the methodology has followed the guidelines laid out by FlexScan, since these were the most suitable for the equipment and allowed it to work at optimum levels in comparison to other forms of setups. The process consisted of a range of set up instructions for the equipment (see Figures 3.4, 3.5 and 3.6 for equipment setup), followed by calibration of the equipment (Figure 3.7). FlexScan suggests that once the calibration images have been taken, the resultant calibration value should be 75% or above. Once the structured light scanner was set up and calibrated, 3D imaging could take place. This process involved replacing the calibration board with the object on the rotary table and taking a sequence of scans. Once the scanning was complete, using both the automatic and manual alignment functions on the FlexScan software the initial alignment stages were undertaken. The model was then finished by employing the fine alignment function.

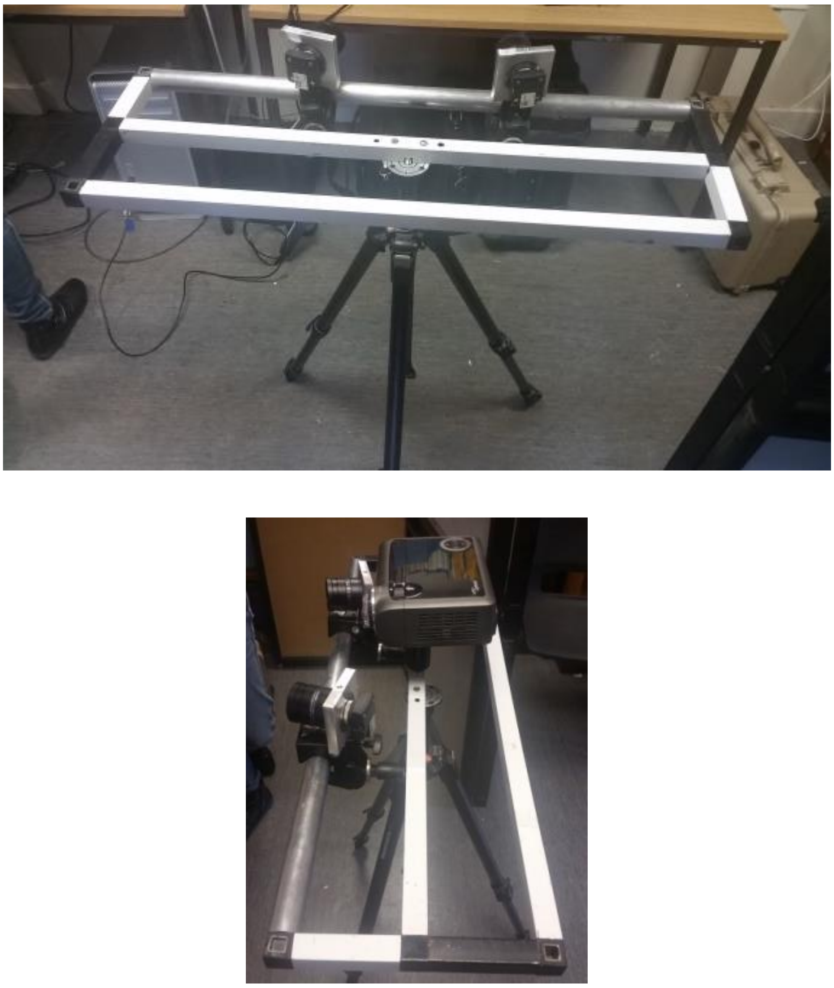


Figure 3.4 Set up of eyeU camera's and projectors on tripod and frame.

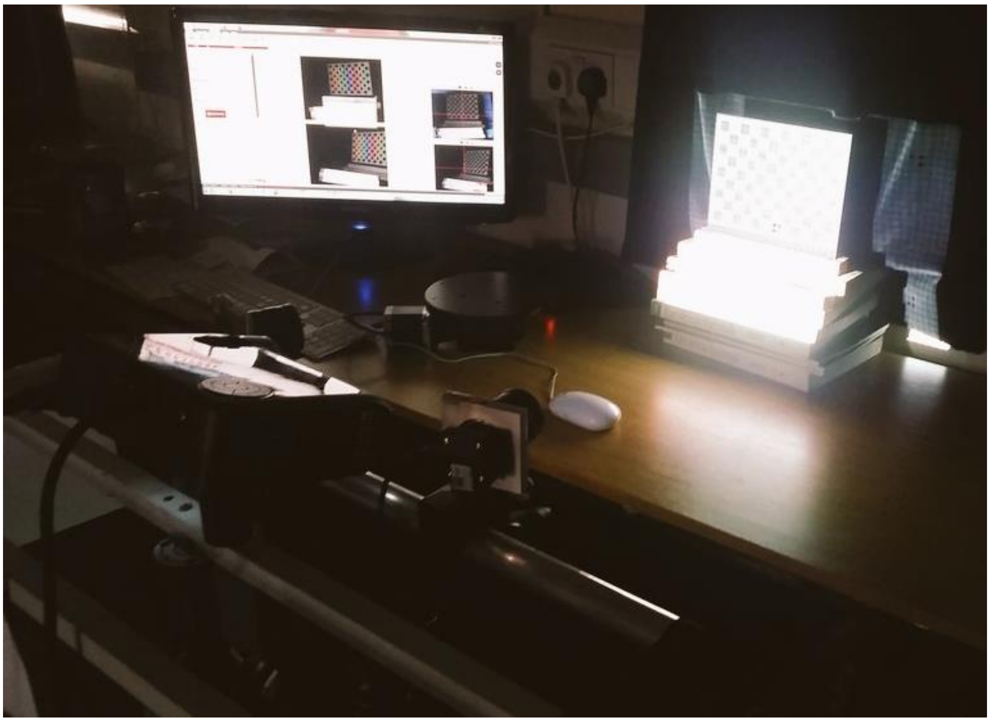


Figure 3.5 Image to display the Structured Light Set up during calibration.

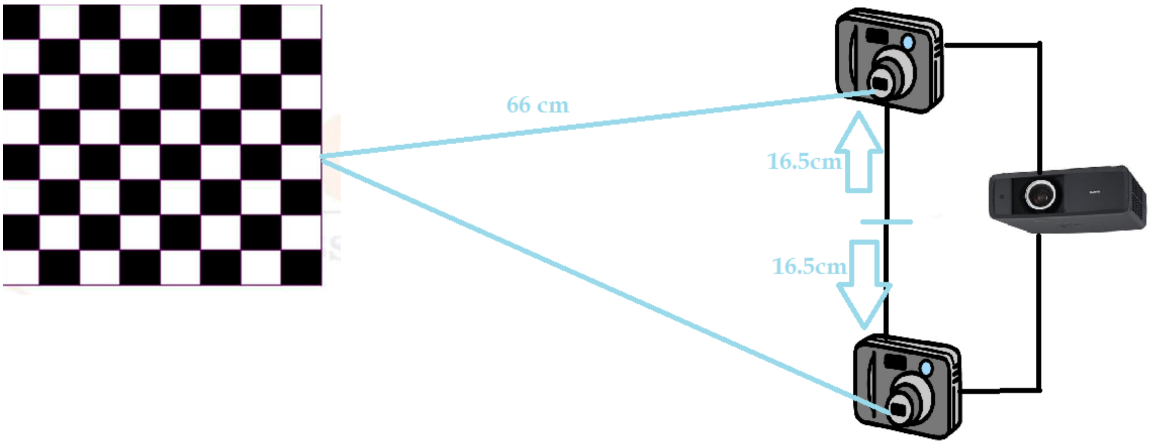


Figure 3.6 Displays the distances which should be present between the cameras and the calibration board.

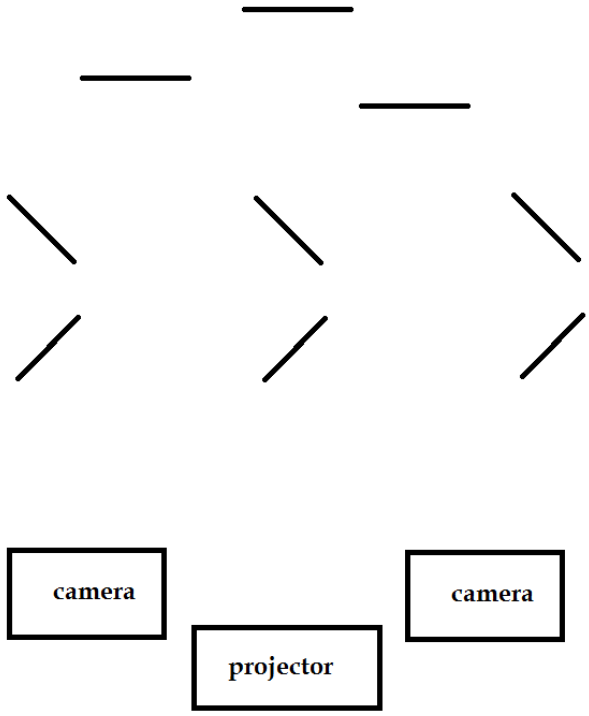


Figure 3.7 This diagram demonstrates the varying positions the calibration frame needs to be positioned in during each level of image calibration. Each of these board positions should be repeated on three levels, one at lowest height, one at medium height (also the height the artefact will be positioned at) and one at highest point, to give full calibration coverage).

3.4 The Simple Test Object Trials: methodology

Figure 3.8 displays the objects which will be employed within the initial accuracy test. The markings on the objects are there to both aid the SIFT algorithms used by the SfM as this software works at an optimum level on a surface which has variation upon it, as well as act as markers to ensure that all measurements are taken from the same points in the later comparison stages. Simultaneously, these were also removed for the

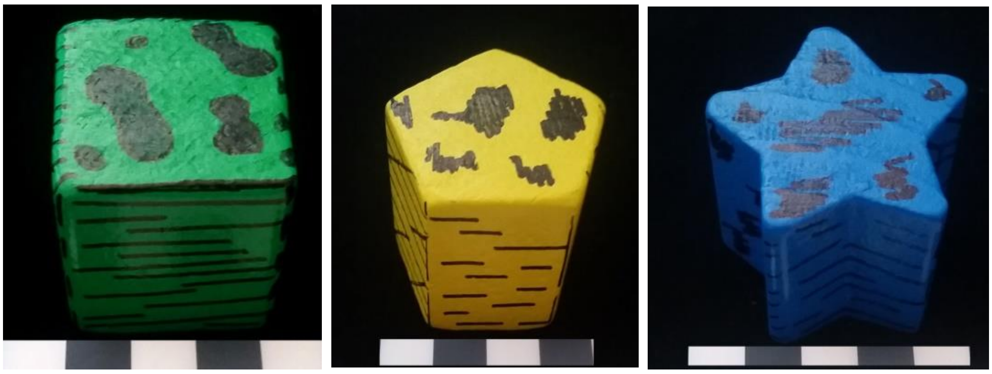


Figure 3.8 Images of the simple test objects to be used within the accuracy trials, a rectangular prism, a pentagon prism and a star prism.

Structured Light Scanner, as this scanner does not capture dark colouring, leaving the areas as voids. The methodology behind these accuracy trials involved 3D imaging each of the objects via differing 3D modelling methods. Following this, the results were firstly examined via their morphometries, employing MeshLab to measure the same points on each model, in comparison to measurements gathered from the actual objects. After it had been ascertained which 3D modelling method offered the most reliable metric replication to the original objects, the meshes were compared with each other, using the mesh with the most accurate measurements as the base data, to see the difference in quality between the differing 3D modelling methods. Additional notes concerning colour aesthetics will also be discussed following the accuracy results. What must be noted is that the purpose of these trials was to examine whether the accuracy of these different 3D methodologies are suitable for use in analysis within the field of archaeology, and artefact studies specifically. In particular, the examination of accuracy undertaken in this thesis focussed on the macro level, at a scale usual for traditional artefactual study.

An average error of maximum 1mm, which is approx. 2% of the size of the object, has been allowed in the first stage of accuracy trials. Any greater error than this affects the study of an object, even at a macro level, especially in connection to product and mould matching comparisons. An error of up to 1mm has been allowed due to the expected level of error which occurs with 3D reconstruction. Both structured light scanners and laser scanners anticipate a possible expected error, for example NextEngine states that their expected error is ±1.3mm when employed on objects at a macro level (NextEngine 2016). Though often SfM does not offer specifications on dimensional accuracy, it can be assumed that a level of error is to be expected.

3.4.1 Comparison Results

The following section presents a summary of results of the simple test object accuracy trials (Appendix 2 give full details of these 3D models and images of 3D measurements taken on the 3D models).

The below series of Tables and Figures display both the dimensions of the simple test objects being employed within these initial accuracy trials (Table 3.2 and Figure 3.9), and the results from the initial metric accuracy trials (Tables 3.3-5), as well as their partner images (Figures 3.10-12). It should be noted that these 3D models have only been aligned and excess background trimmed; there has been no editing in reference to the object mesh itself.

Furthermore, due to the slight shine present on the objects (especially when using the laser scanner and structured light scanner) they have had to be coated with a dusting of white powder. This reduced the glare present that interfered with some of the results and aided in gaining accurate metric results. Though powder has been added to the object within these trials to reduce this interference, it is important to note that researchers may not always be given the permission to add this extra layer of powder to artefacts, representing a further factor to consider when choosing 3D modelling technology for artefact studies of objects with a slight shine to their surface.

It must also be noted that the structured light scanner was unable to register the colour black, which meant that the black detail present on the objects was removed with alcohol for the structured light scanner accuracy trials. The structured light scanners inability to register the colour black is an immediate disadvantage for that methodology, however, in order to keep the broad testing spectrum established for these trials it was decided to still include the methodology. This was due to the fact that coloured scans are not always required and sometimes the morphometries of an object may be the only feature important to a research project.

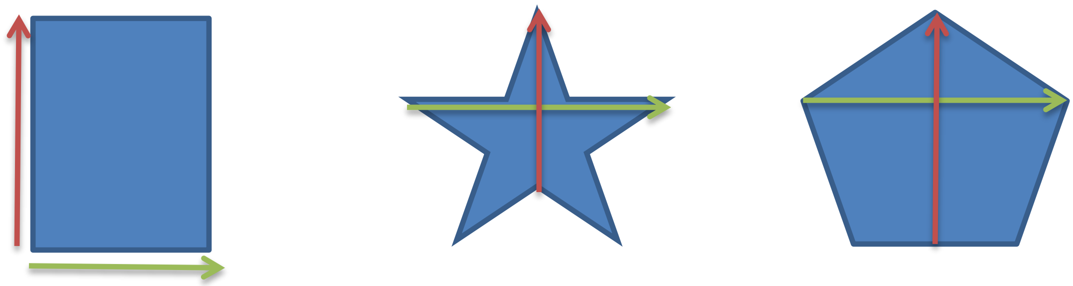


Figure 3.9 Diagrams displaying where the measurements were taken, the red arrow refers to the height of the object within table 3.2 and green arrow refers to the width of the object.

Table 3.2 The dimensions of the test objects

Object	Height/mm	Width/mm	Depth/mm
Rectangular Prism	36.89	32.43	32.43
Star Prism	36.61	43.41	37.65
Pentagonal Prism	37.8	38.94	38.94

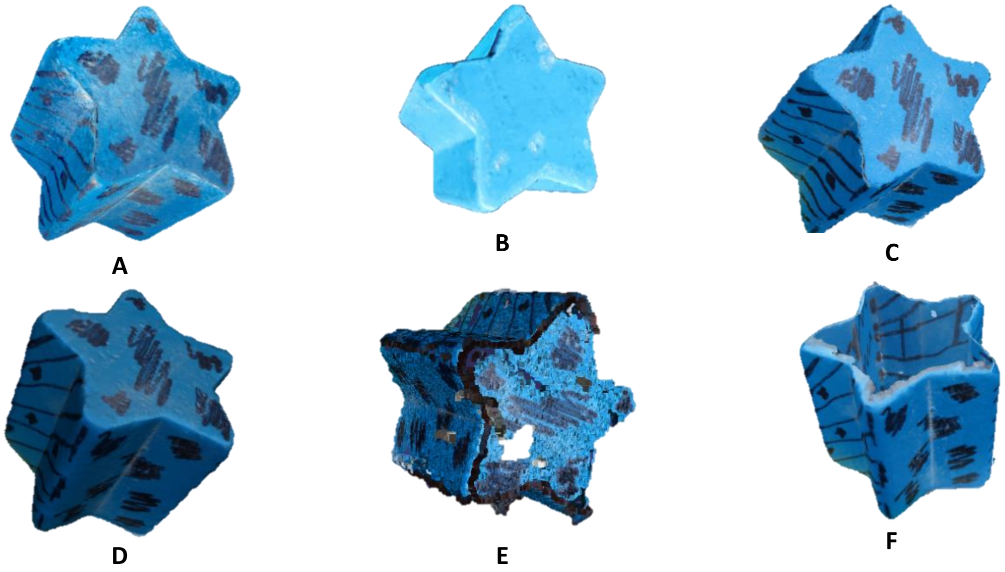


Figure 3.10 Star Prism 3D models. A) NextEngine Star. B) Structured Light Scanner. C) Agisoft Photoscan. D) Autodesk 123D Catch. E) Visual SfM. F) 3DF Zephyr Pro

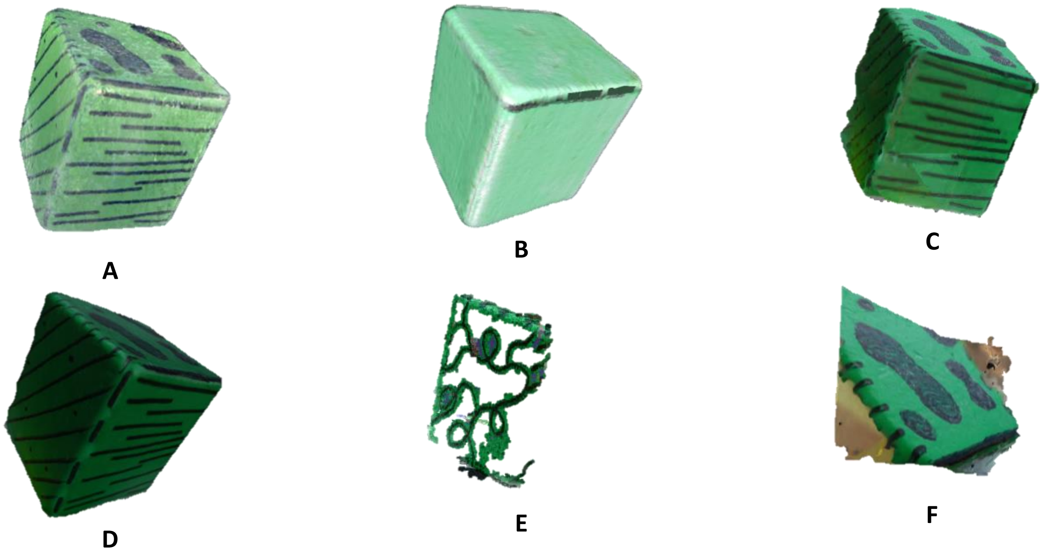


Figure 3.11 Rectangular Prism 3D models. A) NextEngine. B) Structured Light Scanner. C) Agisoft Photoscan. D) Autodesk 123D Catch. E) Visual SfM. F) Zephyr Pro.

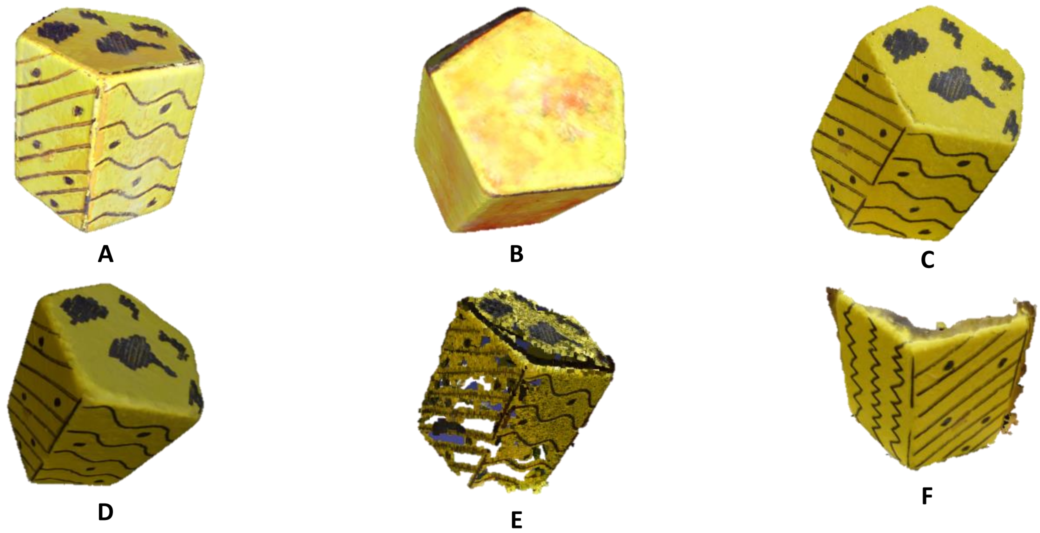


Figure 3.12 Pentagonal Prism 3D models. A) The Next Engine. B) The Structured Light Scanner. C) Agisoft. D) Autodesk 123D Catch. E) Visual SfM. F) Zephyr Pro.

Table 3.3 Star Prism results, results are all measured in MeshLab and 3D models shown in Figure 3.10. Colour comparisons are in relation to the original object (pictured in Figure 3.8)

3D Modelling method	Amount of Scans/ images	Approx. Time taken to scan and process	Results /mm	Data Size	Description
NextEngine	18 scans	18 scans took 48 mins. Total including processing 55 mins	H: 36.53 W: 43.22 D: 37.2	72,405KB .ply	Reasonable colour, however sometimes a little patchy, very exact on structure.
Structured Light Scanner	20 scans	25 mins for calibration. 10 mins for scanning and aligning. 35 mins total.	H: 31.9 W: 37.69 D: 32.26	3,805KB .ply	Poor colour quality. Good texture, a few holes present on the mesh along seams, and large dimensions errors appear throughout whole structure.
Agisoft Photoscan	56 images	5 mins for images, 46.30 mins for processing	H: 37.4 W: 44.16 D: 37.55	27,557KB .ply	Though the colour is good the image itself seems noisy with rough edges, and rough texture.
Autodesk 123D Catch	56 images	5 mins for images, 35 mins	H: 37.02 W: 42.56 D: 37.72	1,795KB .ply	Great colour and crisp image, with very good dimensions. The texture along the edges is slightly noisy.
VisualSFM	56 images	5 mins for images, 37.25mins for processing	H:38.91 W:46.23 D:41.00	23,044KB .ply	Low quality dense point cloud, with lots of noise and large gaps missing, colour is good though.
3DF Zephyr Pro	56 images	5 mins for images, 46 mins for processing	H: 37.14 W: 43.59 D: 38.55	27,058KB .ply	This software chose to only use 39 of the 56 images for the model processing.

Table 3.4 Rectangular Prism results, results are all measured in MeshLab and 3D models shown in Figure 3.11. Colour comparisons are in relation to the original object (pictured in Figure 3.8)

3D Modelling method	Amount of Scans/ images	Approx. Time taken to scan and process	Results /mm	Data size	Description
NextEngine	18 scans	18 scans took 48 mins. Total including processing 55 mins	H: 36.9 W: 32.2 D: 32.8	66,132 KB .ply	Low colour quality, slightly noisy mesh, however good dimensions.
Structured Light Scanner	21 scans	25 mins for calibration. 11 mins for scanning and aligning. 35 mins total.	H: 28.05 W: 27.87 D: 28.5	3,976 KB .ply	Poor colour quality, good texture, with a few holes in the mesh. However there does seem to be a slight size distortion.
Agisoft Photoscan	65 images	5 mins for taking images 32.43mins for processing	H: 39.68 W: 33.47 D: /	11,047 KB. ply	Great colour, distorted, noisy and holey mesh. Too distorted for depth measurement.
Autodesk 123D Catch	65 images	5 mins for images, 35 mins for processing	H: 37.82 W: 32.5 D:33.6	1,505 KB .ply	Great colour and structure, with a little bit of distortion around the edges of the rectangle.
VisualSFM	65 images	5 mins for images, 8.27 mins for processing	N/A as most of the model is not present.	5,524 KB .ply	Low quality dense cloud, very patchy with most of the of the model missing.
3DF Zephyr	65 images	5 mins for images	N/A as	27,140	Choose to only use 5 images out

Pro		13 mins for processing	most of the model is not present	KB .ply	of the 65 images. The majority of the model is incomplete with only ½ a side being produced.

Table 3.5 Pentagonal Prism results, results are all measured in MeshLab and 3D models shown in Figure 3.12. Colour comparisons are in relation to the original object (pictured in Figure 3.8)

3D Modelling method	Amount of Scans/images	Time taken	Results /mm	Data Size	Description
NextEngine	18 scans	49 mins to scan 6 mins to process	H: 38.21 W: 37.82 D: 38.08	66,924 KB .ply	Clear mesh, with some slight error where the black markings on the objects are seen (added texture is given) reasonable colour. Overall thought a nice quality model and mesh.
Structured Light Scanner	21 scans	25 minutes for calibration. 11 minutes for scanning and aligning. 35 mins total.	H: 32.07 W: 32.53 D: 33.34	4,642 KB .ply	Occasional holes in mesh, lightening of colour across entire object, with added random white patches.
Agisoft Photoscan	53 Images	36.08 mins	H: 37.32 W: 38.97 D: 39.41	26,567 KB .ply	Noisy mesh, good colour.
Autodesk 123D Catch	53 Images	30 mins	H: 37.35 W: 38.74 D:39.09	1,177 KB .ply	Clear precise mesh, good realistic colours, no holes, good detail.
VisualSFM	53 Images	43.30 mins	H: 37.91 W: 39.35 D: 39.64	16,964 KB .ply	Noisy mesh, with large spaces missing, colour reasonable.
3DF Zephyr Pro	53 Images	40 mins	N/A as only a partial model was produced.	27301 KB .ply	Thought the colour present was good, the software discarded all but 18 of the photo's during the sparse cloud build. The model it created was very partial, with only around a third of the object being present.

3.4.2 Conclusion to the Simple Test Object Comparisons

To summarise, the above results indicate that when the different approaches are compared there are some clear differences in the models that are created. SfM software such as Zephyr Pro and Visual SFM are clearly unreliable packages for producing good quality 3D models, with both these packages often failing to generate full models. The structured light scanner also provided poor results, which were so low that further trials were undergone on this equipment to ensure that it was not the initial calibration. As table 3.6 indicates, within each of these trials the structured light scanner ranged from a minimum of 3.95mm up to a maximum of 8.84 mm error when replicating the objects, with not a single dimension being the correct size. This demonstrated that even with separate calibrations the equipment was not suitable to employ for artefact 3D reconstruction.

Table 3.6 The margin of error seen within between the 3D models created by the Structured Light Scanner and those measurements taken from the actual objects. Trial 1 and 2. Trial 1 consisted of the following calibration levels: for the star: 77.1%; and for the rectangular and pentagonal prisms; 81%. For Trial 2 all three objects had a calibration value of 87.1%. The equipment recommends that you use 75% and above.

Object	Structured Light Scanner Trial 1 /mm	Structured Light Scanner Trial 2 /mm
Star		
Height	4.93	3.98
Width	5.72	5.23
Depth	5.39	5.25
Rectangular Prism		
Height	8.84	4.5657
Width	4.56	4.33
Pentagonal Prism		
Height	5.73	4.83
Width	6.42	3.95
Depth	5.60	5.78

As such, Agisoft's PhotoScan, Autodesk's 123D Catch, and the NextEngine were the three best 3D modelling methodologies in this trial. As Table 3.7 shows, 123D Catch and the NextEngine produced the most consistently clear data, both metrically and with the quality of image colour. Photoscan underperforming slightly in comparison, especially clear from the results on the rectangular prism. However, Agisoft did produce good quality models in texture, colour and dimensions in the other two trials. It is clear though that within this first stage of accuracy testing, 123D Catch and the NextEngine were the most reliable 3D methodologies to employ, although Agisoft will still be used in the artefact accuracy trials to explore the package's usability on actual artefacts. This would be particularly important given the necessity of an internet connection for 123D Catch, which may not always be possible in the field, meaning that Agisoft Photoscan (which does not require a constant internet source) will, in all likelihood, still have a place in archaeological artefact 3D modelling. However, Agisoft will only be promoted further for artefact 3D modelling if the results upon the archaeological trials are accurate enough.

Overall the results offered by the NextEngine, on average, provided the most accurate metrological results for the three simple test objects. The next stage of the accuracy testing was to see how much the meshes created by 123D Catch differed from those created by the NextEngine. This was established by comparing the meshes within CloudCompare, the results of which are presented in Figures 3.13-15.

Table 3.7 displaying the error differences in mm between the 3D images and the original objects

Object	NextEngine/mm	Agisoft PhotoScan /mm	Autodesk 123D catch /mm
Star			
Height	0.38	-0.49	-0.10
Width	0.19	0.75	0.847
Depth	0.45	0.1	-0.07
Rectangular Prism			
Height	-0.04	-1.88	-0.93
Width	0.72	-1.04	-0.07
Depth			
Pentagonal Prism			
Height	-0.02	0.48	0.45
Width	0.73	-0.025	0.18
Depth	0.86	-0.47	-0.47

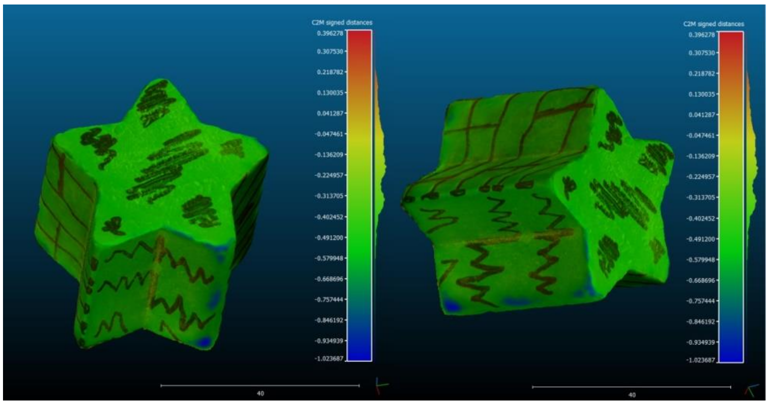


Figure 3.13 Results to show mesh differences between the NextEngine and the Autodesk star.

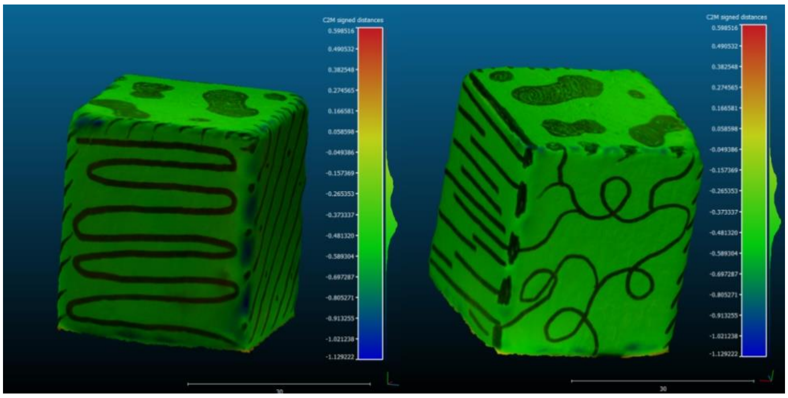


Figure 3.14 Results to show mesh differences between the NextEngine and Autodesk rectangle prisms.

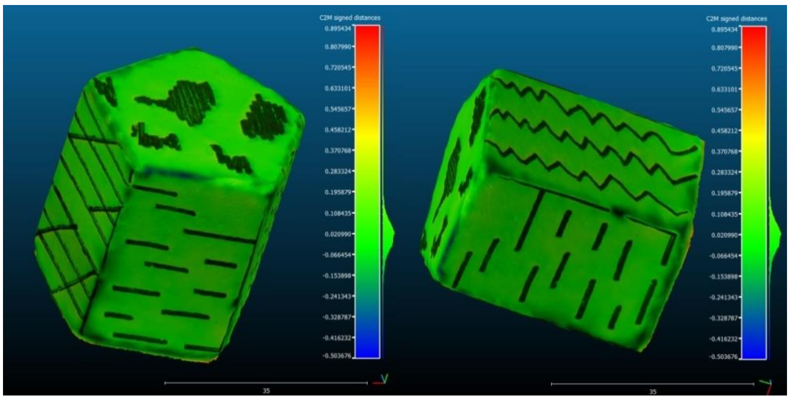


Figure 3.15 Results to show mesh differences between the NextEngine and the Autodesk pentagon.

The three mesh comparisons in Figures 3.13-3.15 demonstrate that, on average, the mesh difference between Autodesk 123D catch and the NextEngine ranges from 0.02 mm - 0.48mm. There are occasional peaks in mesh difference, displayed in blue upon the mesh comparisons, which reached a highest mesh difference of 1.13 mm^2. On average, therefore, these mesh comparisons demonstrate the high levels of accuracy capable by the 123D Catch package when compared with the more accurate results from the NextEngine. What should also be noted is that when looking specifically at the colour accuracy presented by these 3D models, the results offered by 123D catch are significantly superior to those offered by the NextEngine for these specific objects. The following sections will now examine how the NextEngine, Autodesk's 123D Catch, and Agisoft's Photoscan compare against each other when imaging archaeological artefacts.

3.5 The Archaeological Object Trials

These archaeological trials employed four different forms of material culture. The artefacts which were chosen consisted of three pipe clay figurines (Figure 3.16, chosen due to the particular research avenue of this thesis), a glass Anglo-Saxon counter (Figure 3.17, chosen due to the tricky nature usually experienced during 3D scanning of glass objects), and a carved stone hand and a piece of animal bone (Figures 3.17, as both masonry and bone commonly occur within archaeological assemblages and are likely subjects of 3D modelling in the future).

Figure 3.16 Post-Medieval pipe clay figurines, from left to right: a sheep LIVNP.2009.14.27, a female with inscription on plinth LIVNP.2009.14.10 and a cleric LIVNP.2009.14.12. All of these objects were found during canal dredging in Amsterdam. (All of these objects have been imaged by the author with permission from Dr. D.Higgins and Dr. S.White, Liverpool).

Figure 3.17 From top left to right: an Anglo-Saxon glass counter from Little Carlton, Lincolnshire (authors image, artefacts courtesy of Dr. H. Willmott) a medieval stone hand holding a lute, from Thornton Abbey, Lincolnshire (authors image courtesy of Dr. H. Willmott) and below, a piece of animal bone found on the Thames foreshore (author's image).

3.5.1 Methodology

For the NextEngine, the same approach which was applied in the simple test object imaging was re-applied during these trials. With the SfM software packages the only difference in methodology which occurred was that they were imaged in an office environment with good natural light sources, as opposed to outdoors as seen in the simple test object trials. Such a move enabled the SfM methods to be trialled in a second form of heritage environment, and helped to ensure that both indoor and outdoor environments provide suitable spaces to use SfM within. Apart from this one factor, the rest of the SfM methodology remains the same as previously effectively employed.

3.5.2 Results

The following sections present a summary of results of the archaeological object accuracy trials, whilst Appendix 2 gives full details of 3D models and images of 3D measurements taken on the 3D models.

LIVNP.2009.14.10

Figure 3.18 Diagram to display where measurements were taken upon LIVNP.2009.14.10

Table 3.8 Metric results of LIVNP.2009.14.10 3D models and some general comments

	Scans/ Image amount	Time taken/ min	Height /mm	Error difference /mm	Width/ mm	Error difference /mm	Comments
Object Actual Dimensions	/	/	50.69	/	26.29	/	/
NextEngine	18	47.5	50.04	0.65	26.11	0.18	Great mesh, terrible colour, cannot see the inscription
Agisoft Photoscan	62	41.33	50.12	0.57	25.91	0.38	Great colour and Mesh. Can see the inscription
Autodesk's 123D Catch Attempt 1	62	54	/	/	/	/	Unusable
Autodesk's 123D Catch Attempt 2	50	24	49.76	1.23	27.07	0.78	Colour is good, mesh too large.

As Table 3.8 demonstrates, both the NextEngine (Figure 3.19) and Agisoft's Photoscan (Figure 3.21) were within the previously discussed (section 3.4) 1mm maximum error allowed between actual object and 3D models. The highest errors which were seen were provided by Autodesk's 123D Catch. When using 62 images 123D's mesh was unusable (Figure 3.20). When reprocessed using a lower number of images (in this case 50 photos) the results, though an improvement on the initial attempt, still presented a higher error than the NextEngine and Agisoft PhotoScan results, with the object being produced 0.93mm taller than the original artefact. There was also a less than 1mm error within the base width of this 3D model in comparison to the original object.

The dimensional results within this example demonstrate that the NextEngine overall produced the most accurate 3D model of the pipe clay figurine, with Agisoft closely behind these results. When comparing the visual results of colour and artefact likeness (see Figures 3.36), Agisoft's results, however, appear the most superior. The object surface texture was reproduced closest to the original artefact and the inscription on the base was much clearer (Figure 3.22), especially in comparison to the colour results offered by the NextEngine which present a faded version of the object. This issue could be resolved by editing the lighting on the objects in secondary software, such as MeshLab, to create a clearer texture, however, for this primary stage of testing post-processing methods were not employed.

Figure 3.19 Screen Shots of the NextEngine's 3D model and mesh of LIVNP.2009.14.10

Figure 3.20 123D Catch, to the left 3D model of LIVNP.2009.14.10 with 62 images. The middle and right images display 3D model of LIVNP.2009.14.10 with 50 images.

Figure 3.21 Screen Shots of the Agisoft's 3D model and mesh of LIVNP.2009.14.10


A


B

Figure 3.22 A) Agisoft PhotoScan close up of inscription. B) A 2D photo of the inscription to show a contrast in clarity between a 3D representation of the image and a 2D representation.

LIVNP.2009.14.27

Figure 3.23 Diagram to display where measurements were taken upon LIVNP.2009.14.27

Table 3.9 Metric results of LIVNP.2009.14.27 3D models and some general comments.

	Scans/Image amount	Time taken	Height/mm	Error difference /mm	Width/mm	Error Difference /mm	Comments
Object Actual Dimensions	/	/	35.41	/	49.58	/	/
NextEngine	16	43.30mins	35.77	0.363	49.78	0.2	Great mesh, poor texture quality
Agisoft Photoscan	67	1.49hrs	36.3593	0.95	49.58	0.002	Good mesh, Great texture quality
Autodesk's 123D Catch	67	39mins	37.1913	1.78	49.83	0.25	Poor mesh, good texture quality

As Table 3.9 displays, once again the NextEngine and Agisoft's Photoscan present the most accurate metric results, with the NextEngine only slightly more accurate all round than Agisoft's results. The results displayed by Autodesk's 123D catch were again poorer in quality, and although the width was reproduced within the accuracy band of 1mm, the height measurement was 1.78mm too large. The texture results, which can be seen in Figures 3.24-26, display once again that although the NextEngine's mesh is a lot more precise with a reduction in noise in comparison to that offered by Agisoft's Photoscan, the textures are poorer. The texture and mesh presented by 123D Catch show a good colour composition within the texture, however, there appears to be a blurring of details present upon the mesh of LIVNP.2009.14.27.

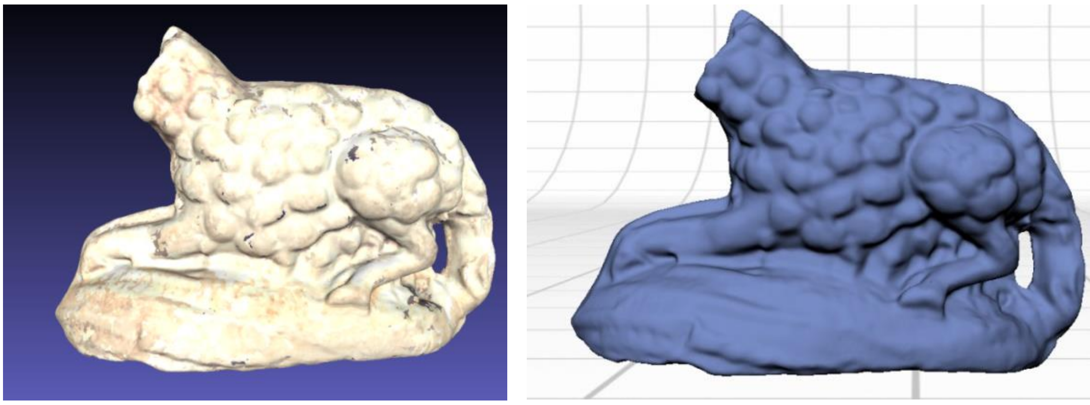


Figure 3.24 NextEngine textured 3D model and mesh of LIVNP.2009.14.27

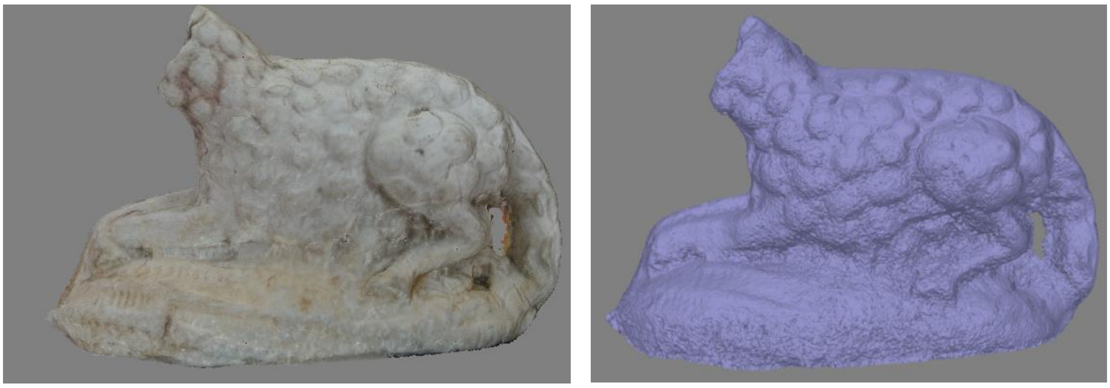


Figure 3.25 Agisoft's PhotoScan textured 3D model and mesh of LIVNP.2009.14.27

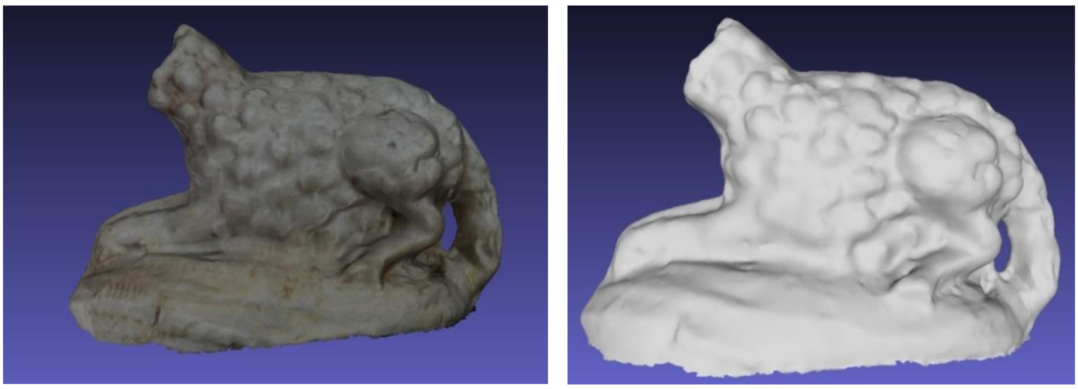


Figure 3.26 Autodesk's 123D Catch textured 3D model and mesh of LIVNP.2009.14.27

LIVNP.2009.14.12

Figure 3.27 Diagram to display where measurements were taken upon LIVNP.2009.14.12

Table 3.10 displays the results in relation to tests on LIVNP.2009.14.12. Again, the NextEngine demonstrated the highest level of metric accuracy, with both width and height results being around 0.08mm in difference from those measurements taken from the original figurine. The results displayed by Agisoft PhotoScan had a slightly higher error than those offered by the NextEngine, but were still below the 1mm error cap. 123D Catch's results, however, had a much higher error within the height of the object, presenting the figurine 1.32mm higher than the actual object.

Table 3.10 Metric results of LIVNP.2009.14.12 3D models and some general comments.

	Scans/ Image amount	Time taken	Height/ mm	Error difference /mm	Width/ mm	Error difference /mm	Comments
Object Actual Dimensions	**/**	**/**	**52.38**	**/**	**36.91**	**/**	**/**
NextEngine	18	57.1 mins	52.46	0.08	36.985 7	0.08	Good colour. Great mesh
Agisoft Photoscan	70	1.10.4 hrs.	52.6	0.22	36.445 3	0.47	Good colour. Great mesh
Autodesk's 123D Catch	70	24 mins	53.7	1.32	36.621 1	0.29	Good colour, slightly distorted mesh.

Figures 3.28-30 demonstrate that the meshes produced by the NextEngine and Agisoft show high detail, with Agisoft Photoscan providing the better texture quality. 123D Catch's mesh presents a distorted mesh with a reduction in detail across the whole figurine, and an exaggerated sloping base.

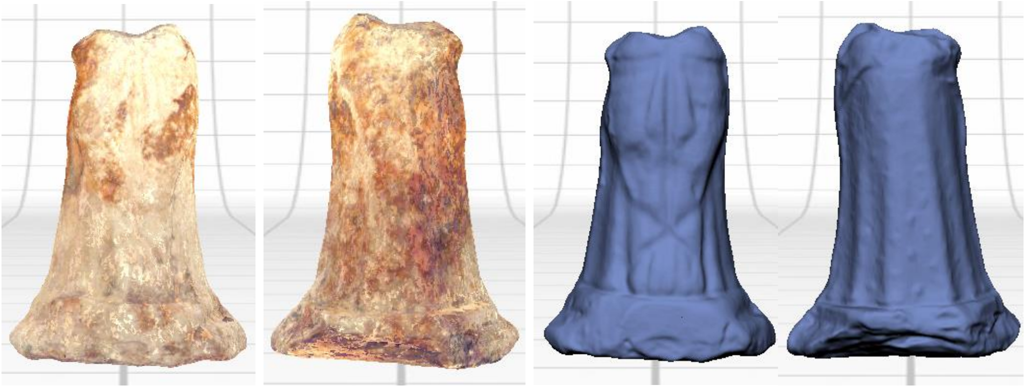


Figure 3.27 NextEngine textured 3D model and mesh of LIVNP.2009.14.12

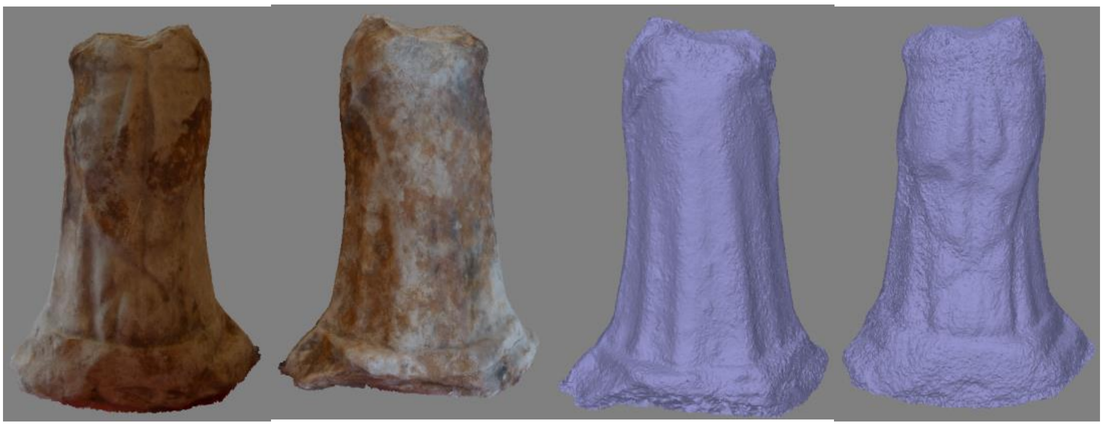


Figure 3.28 Agisoft's PhotoScan textured 3D model and mesh of LIVNP.2009.14.12

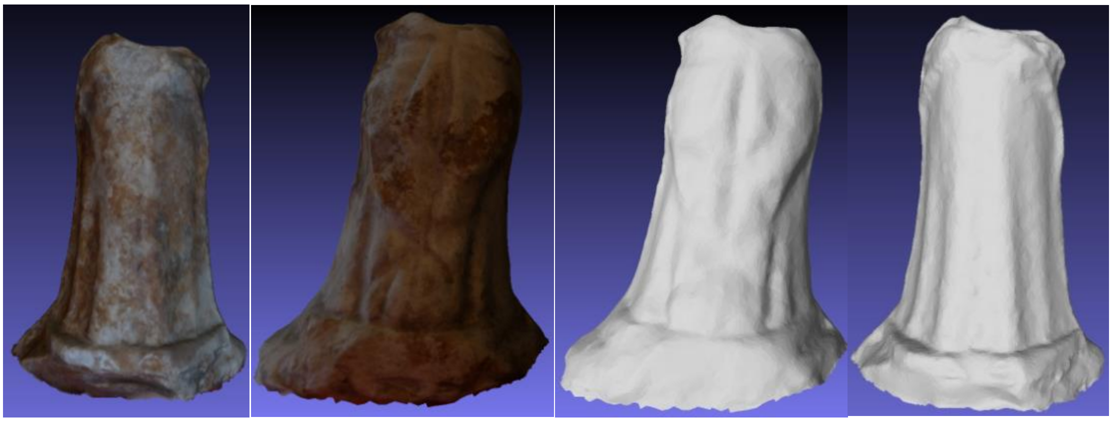


Figure 3.29 Autodesk's 123D Catch textured 3D model and mesh of LIVNP.2009.14.12

Anglo-Saxon Glass counter

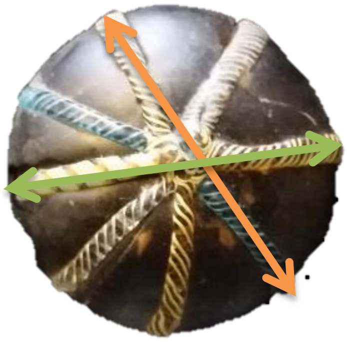


Figure 3.31 Diagram to display where measurements were taken upon the Anglo Saxon glass counter.

Table 3.11 Metric results of the Anglo Saxon glass counter models and some general comments.

	Scans/Image amount	Time taken	Height/mm	Error difference /mm	Width	Error difference /mm	Comments
Object Actual Dimensions	/	/	35.22	/	35.98	/	/
NextEngine	17 scans	46.5mins	35.08	0.145	35.27	0.63	Great mesh, low colour quality
Agisoft Photoscan	70	60.51	/	/	/	/	unusable
Autodesk's 123D Catch	70	33mins	34.5	0.72	34.88	1.02	Low mesh quality

Before the results are discussed, the importance of this trial should be noted. The material that the counter is produced from, coloured glass, though not as opaque as clear glass due to the pigmentations present within this artefact, still presents an issue for artefact 3D modelling. Due to the nature of the material noise interference is often experienced when attempting to 3D model glass objects, due to the refraction of either the lasers or lights employed within the capture/scanning recording process. This often results in either poor 3D models being produced or a complete inability to create a model at all. The following results demonstrate that even with the issues often presented when 3D scanning glass objects, the NextEngine still managed to produce an accurate model of the counter, with the mesh being both detailed (as can be seen in Figure 3.32) and metrically accurate. Both Agisoft's PhotoScan and 123D Catch failed to produce a usable model of the Anglo-Saxon counter, with both reconstructions presenting high levels of distortion (Figures 3.33-34).

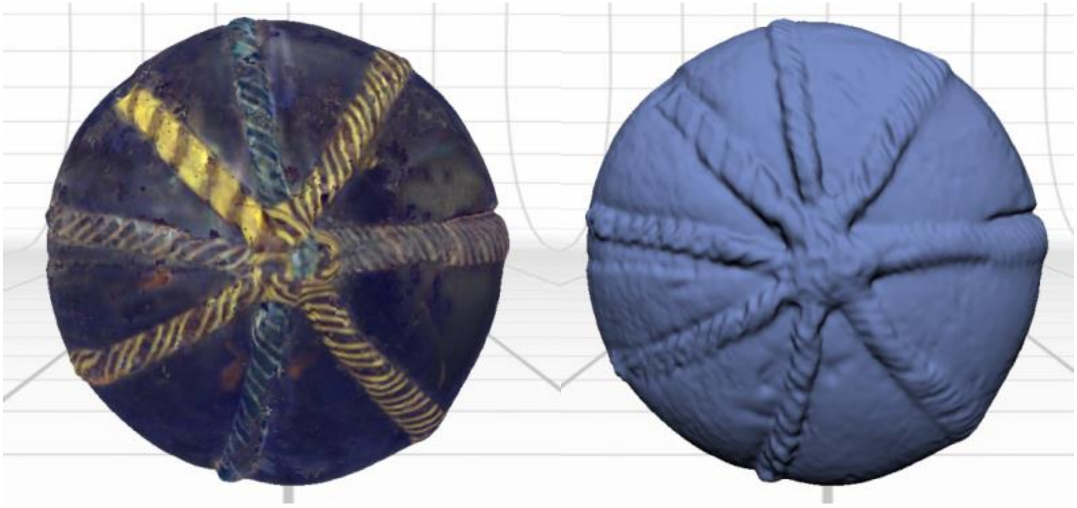


Figure 3.30 NextEngine textured 3D model and mesh of the Anglo-Saxon glass counter.

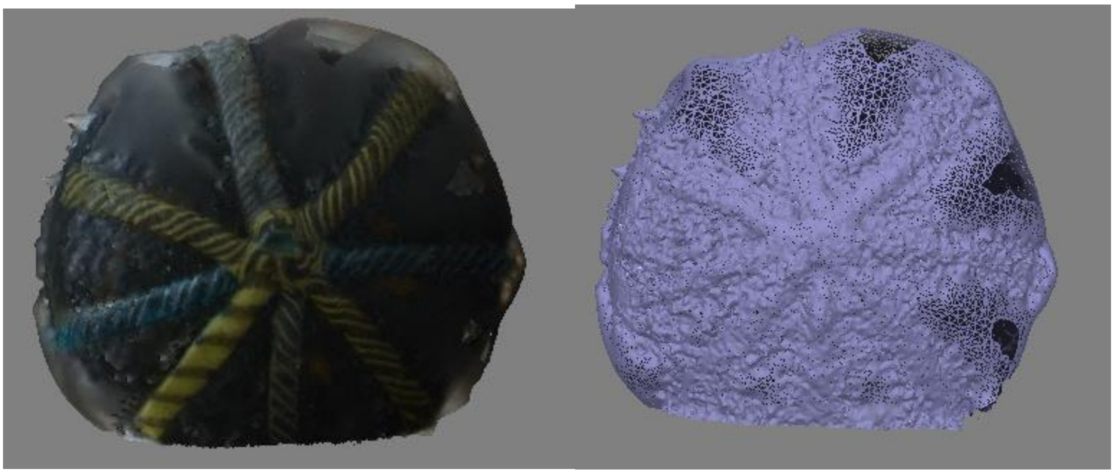


Figure 3.31 Agisoft's PhotoScan textured 3D model and mesh of the Anglo-Saxon glass counter.

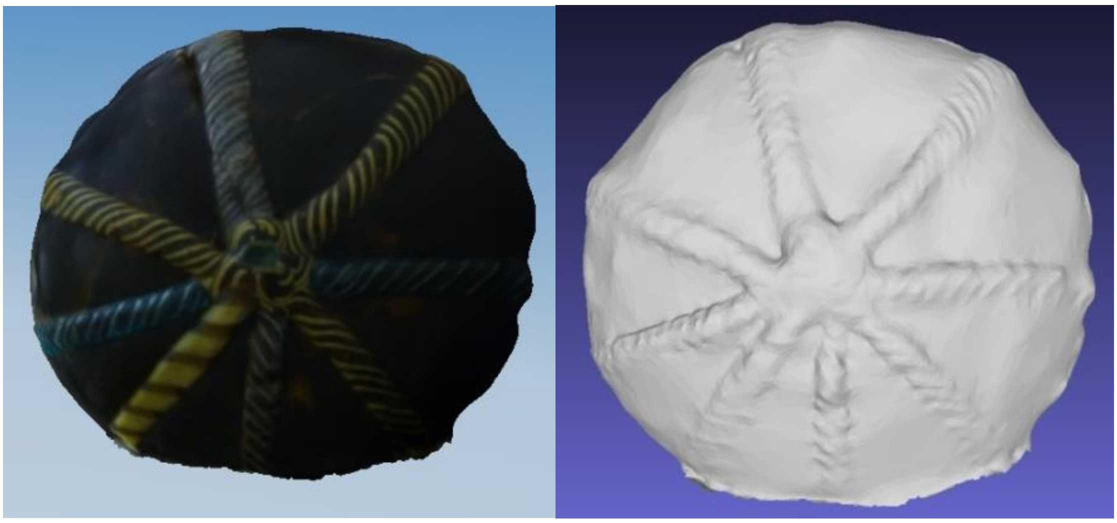


Figure 3.32 Autodesk's 123D Catch textured 3D model and mesh of the Anglo-Saxon glass counter.

Medieval Stone Hand

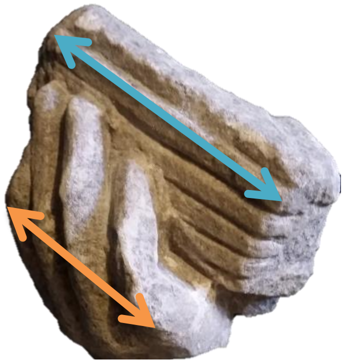


Figure 3.35 Display's where measurements were taken upon the medieval stone hand and lute.

Table 3.12 shows that all of the 3D modelling methods were able to reproduce the stone hand and lute well within the 1mm maximum error, with the NextEngine producing the slightly higher overall error. The meshes and texture for each of these 3D model replicas were also all produced at a high standard, with the texture upon the SfM examples being slightly more superior to that produced by the NextEngine. The NextEngine's mesh, however, was produced with a lower inclusion of noise in comparison to the SfM meshes (see Figures 3.36-38).

Table 3.12 Metric results of the Medieval stone hand and lyre models and some general comments.

	Scans/ Images amount	Time taken	Measurement 1 /mm	Error difference /mm	Measurement 2 /mm	Error /mm	Comments
Object Actual Dimensions	/	/	95.36	/	58.31	/	/
NextEngine	16 scans	48.4	95.1271	0.2329	59.0914	0.7814	Great mesh, slightly lower texture quality.
Agisoft Photoscan	67 images	2.45. 40 hours	95.2387	0.1213	58.5511	0.2411	Mesh is very good, however slight levels of noise seen. Great texture quality.
Autodesk's 123D Catch	67 images	24mins	95.18	0.18	57.941	0.369	Great mesh and texture quality.

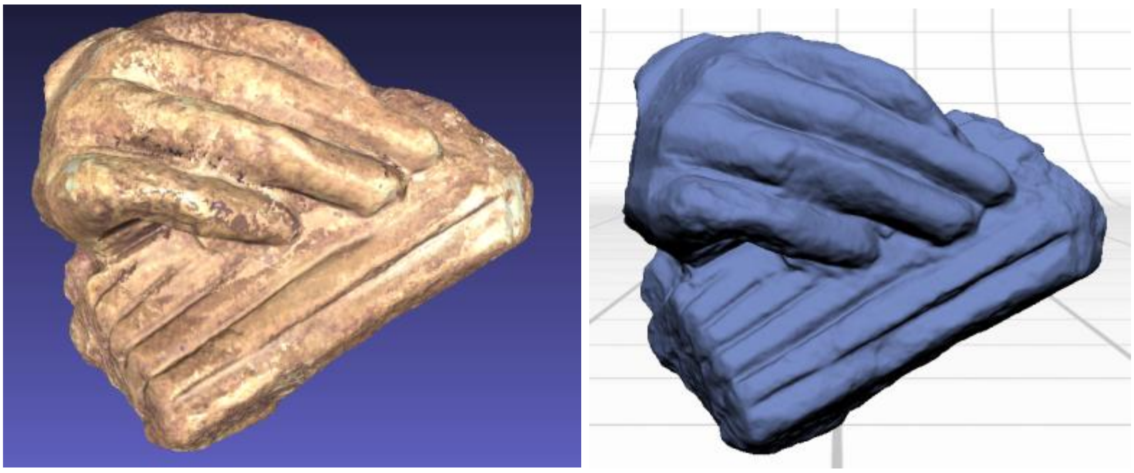


Figure 3.33 The NextEngine's textured 3D model and mesh of the medieval stone hand playing a lute

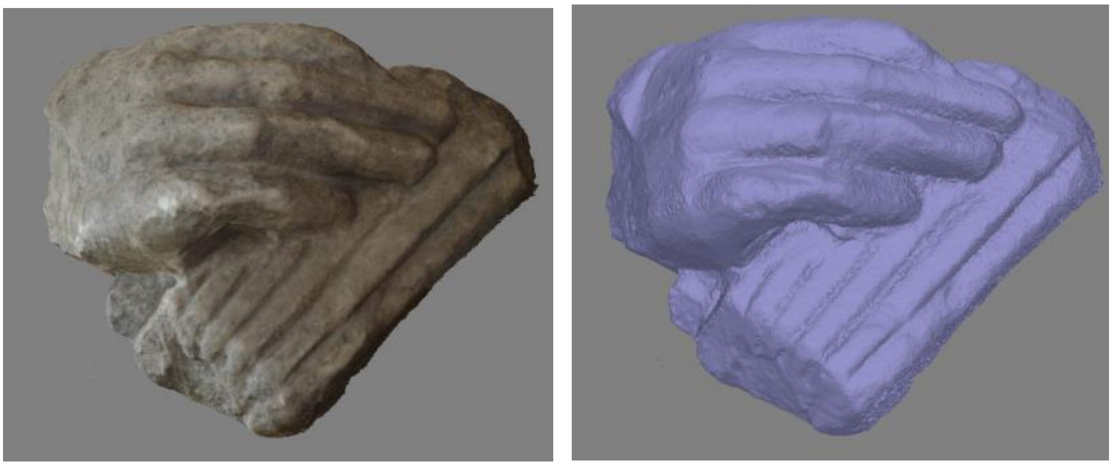


Figure 3.34 Agisoft's PhotoScan textured 3D model and mesh of the medieval stone hand playing a lute

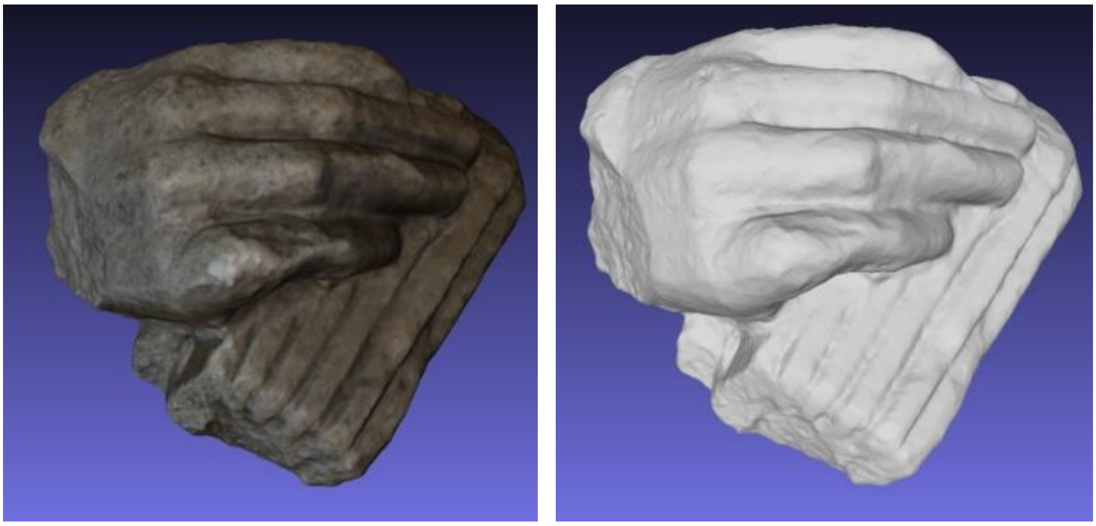


Figure 3.35 123D Catch's textured 3D model and mesh of the medieval stone hand playing a lute

Animal Bone

Figure 3.39 Diagram to display where measurements were taken upon the animal bone

The metric results offered in Table 3.13 show that both 123D Catch and the NextEngine are within the maximum of 1mm error, with the NextEngine's results being only slightly superior to that of 123D Catch. Both these results produced a higher level of accuracy in comparison to Agisoft's results (Figure 3.41), which was significantly over the margin of error allowance.

Table 3.13 Metric results of the animal bone models and some general comments

	Scans/Image amount	Time taken/mins	Height/mm	Error difference /mm	Width	Error difference /mm	Comments
Object Actual Dimensions	/	/	55.35	/	45.23	/	/
NextEngine	15 scans	41.10	55.39	0.04	45.24	0.01	Great mesh, usable texture.
Agisoft Photoscan	70	1 hour 42 mins 33 seconds	60.24	4.89	48.36	3.13	Low quality mesh and noisy texture.
Autodesk's 123D Catch	70	1 hour 11 minutes	55.4	0.04	45.88	0.65	Great quality mesh and texture.

Comparing the texture quality between the NextEngine and 123D Catch (Figures 3.40 and 3.42), it can be seen that 123D Catch demonstrates a higher quality of texture, though the mesh produced by the NextEngine offers much more micro details.

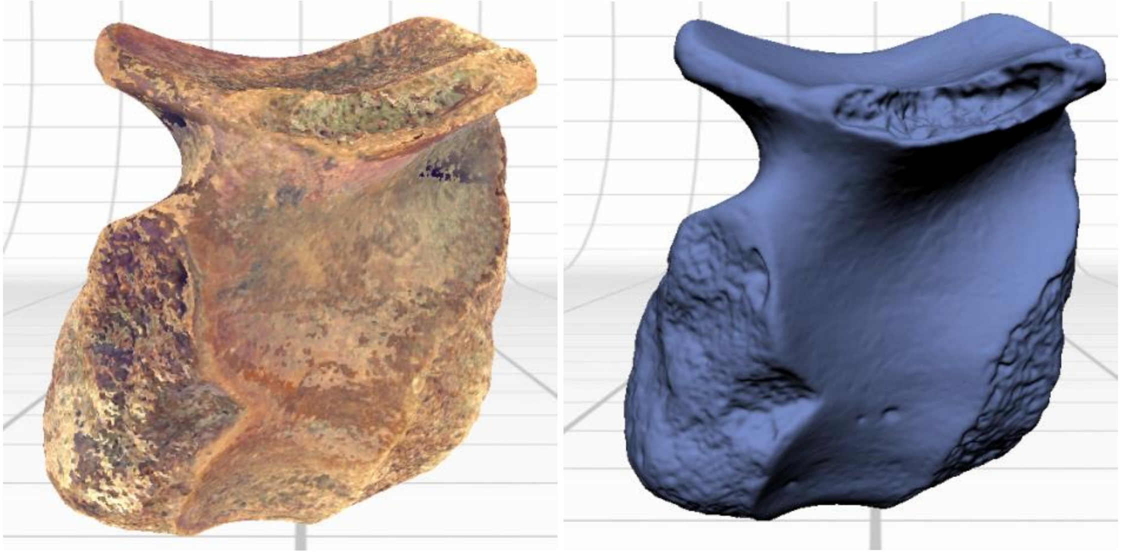


Figure 3.36 The NextEngine's textured 3D model and Mesh of the animal bone

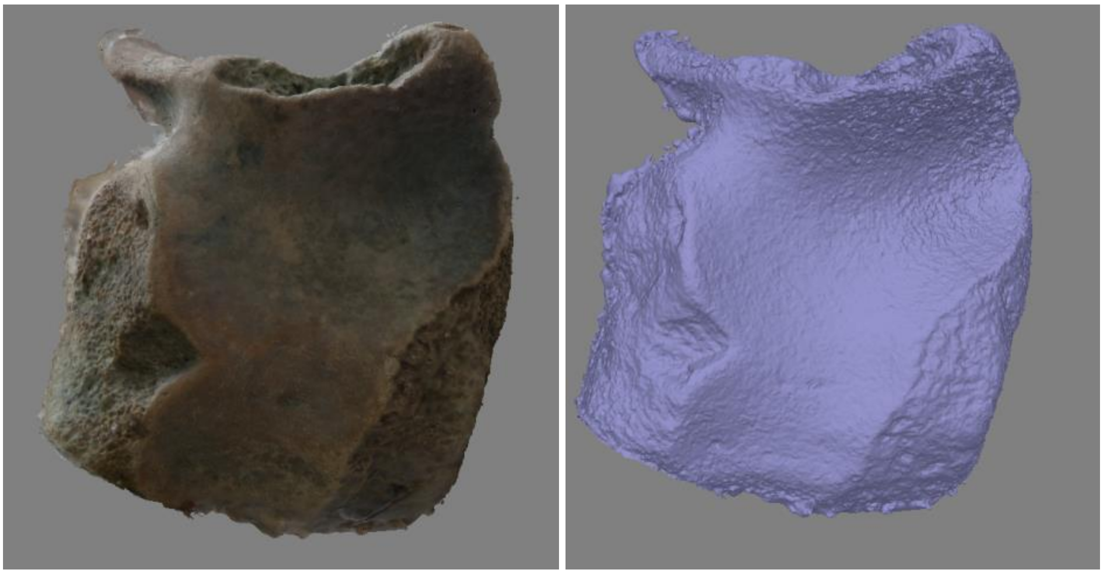


Figure 3.37 Agisoft's PhotoScan textured 3D model and Mesh of the animal bone

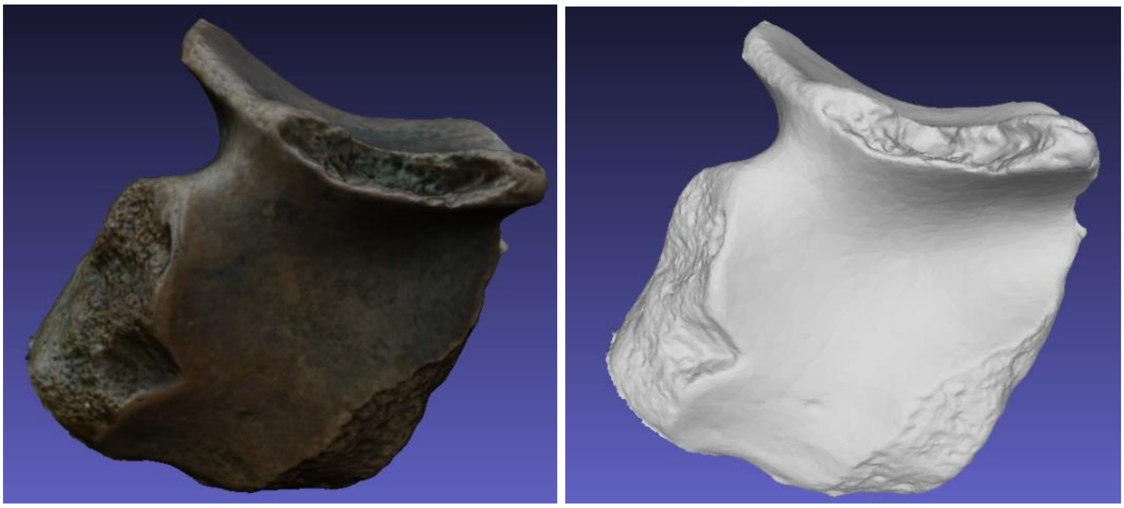


Figure 3.38 123D Catch's textured 3D model and Mesh of the animal bone

3.6 Chapter Summary

Looking collectively at the above series of accuracy examinations, the NextEngine has been shown, on average, to offer the superior metric and mesh results. However, the texture on the objects presented by the NextEngine does not offer the highest quality. It is obvious that the SfM methods offer a much higher quality of texture mapping on the artefact replicas than the NextEngine. When looking specifically at the SfM software results within the artefact object trials, Agisoft's PhotoScan can be seen to produce results with a closer accuracy more consistently in comparison to Autodesk's 123D Catch results, a change from what was previously seen within the results in the simple test object trials. This may be due to the variation in texture and colours upon artefacts, making it easier for Agisoft's software to 3D model the objects with a higher level of accuracy. Agisoft produced a very high level of metric, texture, and mesh quality on four of the six objects. Where the software seemed to struggle was upon the Anglo-Saxon glass counter, which was unsurprising due to the nature of the material, and with the animal bone, which was slightly surprising considering how well the software had processed the pipe clay figurines which are of a similar colour to the animal bone. However, where Agisoft's PhotoScan failed 123D Catch was able to produce an accurate replica with good texture of the animal bone.

In conclusion, what these results demonstrate is that the SfM software were able to cope with most of the artefacts utilised within this trial and produce 3D models that, with a few exceptions, were accurate to less than 1mm and produced clear and usable textures and surface details. There were erratic results also noted on occasion, and this does clarify that SfM can, in some circumstances, be an unpredictable method. Such instances were swiftly noticed, either through the low quality of the mesh or via a quick measurement comparison. This clearly highlights that such actions should be utilised to quality assure all 3D artefact models as part of any project that wishes to use such items as *surrogates.* Nonetheless, the consistent results presented by Agisoft upon the pipe clay figurines meant that it was an appropriate tool to use for the 3D modelling of those, or similar styled, artefacts. As the mesh comparisons in Figure 3.43 show there was only a 0.15 - 0.66mm^2 difference between the NextEngine's and Agisoft's mesh results seen within the LIVNP.2009.14.10 trial. These initial trials demonstrate that although the NextEngine does produce more accurate results, the low level of differentiation between the meshes should not have presented any issues when employing SfM techniques within artefact 3D modelling. This will be discussed in more detail in later chapters, but it should be stated at this point that while SfM approaches do show some level of potential in wider artefact analysis studies the technique, across the board, does not currently produce results of consistent accuracy. This will be clearly highlighted in Chapter 7 when investigating mould generations and comparison between figurines, leading to the conclusion that SfM is not suitable for standalone analysis but can have a role in more preliminary or multi-technique studies, especially when considering textures. Before this thesis goes into more detail about the analysis carried out on pipe clay figurine mould generations, Chapter 4 will examine the archaeological and iconographical themes of the pipe clay figurines found in London, and Chapter 5 will examine the evidence from the English Colonies.

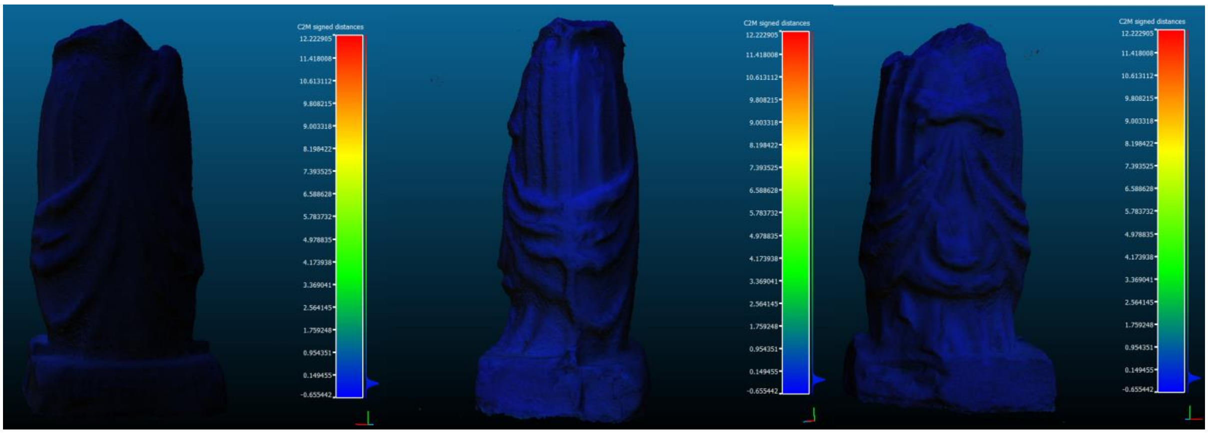


Figure 3.39 Mesh Comparison of LIVNP.2009.14.10 models, created by the NextEngine and PhotoScan. Mesh displays that on average there is between 0.15 - -0.66mm^2 difference in meshes. The red indicates some noise in the background which has not been edited out, but which is not on the actual figurine itself.

Chapter 4

London’s Post-Medieval Pipe Clay Figurines

This chapter will provide an analysis of the 121 figurines which have thus far been recorded from excavations within London. The figurines will be divided into their subject groups which consists of: royal memorabilia, religious iconography, adult knickknacks, and children’s toys. Alongside an examination of the individual figurines the contemporary importance and meaning behind specific iconographic qualities will be considered, as will their position within the market of luxury goods. An investigation into the distribution of the figurines across London will follow on from this commentary, including discussion concerning the specific contexts and wider area they were found within. For this latter discussion only those figurines which have sufficient data to conclude a firm provenance will be employed. By examining the figurines in this manner, combining iconographical analysis with geographical considerations, a deeper understanding of the functionality of these figurines within their specific social contexts will be possible. This investigation will then be widened to the rest of the UK to provide an initial study of this wider data set.

4.1 Royal Memorabilia

Royal commemorative figures, which may have been circulated during such occasions as coronations or employed as patriotic effigies, come in a range of styles. These include full-length monarchs, as seen in Figures 4.1 and 4.2, which are common examples of royal pipe clay figurines during the 15th – 17th centuries, to queens seated upon horses (Figure 4.7). These figurines may have been based upon state controlled images of the monarchy, such as Robert Walton’s *Set of Kings* (Figure 4.3), to ensure that they were portrayed as standardised ideals, and this form of image production was a practical way in which to reinforce monarchical authority. Of further interest and consideration is that portrayals of royals, such as those seen in Walton’s *Set of Kings*, were produced after the English Civil Wars, towards the end of the Commonwealth period and into the Restoration period after 1660. Consequently, this royal imagery may have been produced both to feed a consumer market that had a growing support for the return of the king, alongside helping to soften the views of those who were yet to be in full support of the return of the monarchy, in either case aiding popular backing for the future Charles II.

Figure 4.1 King Figurine from Blackfriars underpass, Greater London (Author's images, courtesy of The British Museum, GM181.1969.25134)

Figure 4.2 King figurine, Cannon Street, London. (Author's images, courtesy of Museum of London. 1887,0307)

Figure 4.3 Portraits, from top left to right Charles I, Charles II, James II when Duke of York, on lower line, Henry Duke of Gloucester, and the Duke of Albemarle; a sixth oval with 'A perpetual Almanacs', a ship and a tree. Engraving 1660-70 Robert Walton (Walton 1660, Image from ©Trustees of the British Museum.)

Commemorative royal imagery flourished across the ceramic and prints industries during the late 16th to 18th centuries (Figure 4.4, 4.5 and 4.6), and many of the same images were recycled through these different media. The reusing of the same body form and stance was common, with only slight alterations affecting the accessories depicted upon the figurines. However, this frequently makes it difficult to identify specifically which royal figure is being presented in the figurine. Nonetheless, monarchs identified in this study include: Henry VIII, Elizabeth I, Charles I, Charles II, and William III. To date in London one queen and ten definite kingly figurines and two potential kingly figurines have been recovered, although looking further afield three kings have been recovered elsewhere in England, one in Ireland, and two in America, specifically Maryland (see Appendix 1 for full details of these figurines). The king figurines recovered from Maryland are discussed in further detail in Chapter 5.

Figure 4.4 A depiction of Charles I on a tin glazed earth ware dish. London. 1653. C.71-1998 (Image from © Victoria and Albert Museum, London 2019)

Figure 4.5 Terracotta model of King William III. Made by John Nost the Elder ca.1695 (Image © Victoria and Albert Museum, London 2019)

Figure 4.6 Jug with portrait of William III, ca. 1689-1702 (Image from © Victoria and Albert Museum, London 2019)

Examining these king figurines’ stylistic attributes collectively, it seems that all but one was based upon the same standardised portrait. It also seems that some of these king figurines may have come from the same mould, a theory which will be explored in more detail in Chapter 7 when comparing 3D digital copies of these king figurines via 3D model matching software.

The queen mounted on a horse (Figure 4.7) may represent Queen Elizabeth I, as it was often noted that she preferred to ride upon horseback rather than by carriage. Many of these equestrian excursions were discussed within Nichols (1823) writings (Nichols 1823, 78, 91, 93, 132, 152, 159, 160, 163, 184, 225, 246, 267, 420, 492, 493, 514, 540, 596 and 620) these works illustrated the Queens reign from a collection of ‘*original manuscripts, scarce pamphlets, corporation records, parochial* registers’. Representations of Elizabeth I on horseback were produced in a variety of prints, (see Figures 4.8 and 4.9), and these further depict the elaborately trimmed dress, high ruff, hair piece, and ornamental saddle cloth, fashions characteristic of her. The increase in popularity of the image of the self-styled Virgin Queen might have come in response to the cultural void that had been left by the suppression of the Marian cult following the Reformation. Therefore, these depictions of the Virgin Queen would have directly replaced images of the Virgin Mary, who had been a popular iconographical motif across Europe in the preceding centuries, (see section 4.2.a for more detail). Such an iconographical shift would have been officially sanctioned to enhance royal authority and the Protestant religion in England during a period of considerable change.

Figure 4.7 Queen (Elizabeth) figurine. Bankside, City of London. (Author's images, courtesy of The British Museum, 17681)

Figure 4.8 A print of Queen Elizabeth I from 1612 made by Renold Elstrack and published by John Sudbury and George Humble. (Image from ©Trustees of the British Museum. Catalogue nos 1854,1113.117, 30/01/2017)

Figure 4.9 A print of Queen Elizabeth I from 1659 published by Robert Walton, number 23 in his Kings and Queens set. (Image from ©Trustees of the British Museum. Catalogue numbers 1870,0514.2919)

Another potential form of royal commemorative memorabilia were figurines of heraldic lions (Figure 4.10 and 4.11), which were moulded both lying down and standing rampant. To date in London six lions have been recovered, however two further pipe clay lion figurines have been found in Exeter (refer to appendix 1) and further examples have been recovered from Germany and the Netherlands (personal comm. R. Stam and Figure 4.12-13).

Some of these figurines retain vestiges of paint or pigments upon them, as shown on the lion in Figure 4.10, which has the remains of red paint on his paw and tail tip, and there is also a band running around the stomach of this lion, potentially a belt.

Figurines of lions were frequently employed by monarchs, both as a symbol of power but also as a symbolic representation of Britain. The first recorded use was by, and in relation to, Richard I and the lion continued to serve as an heraldic representation on the English coat of arms (Fox-Davies 2007, 172-190). It is entirely possible that producers of lion figurines had a broad consumer market in view, with individuals who wished to display public support for both the monarchy and their country by employing these as ornaments, or with children who may have used them as toys.

Generally what can be seen to be presented amongst the pipe clay figurines which depict royal iconography are highly standardised portraits of Kings, with specific poses and items being included within their representations. In relation to depictions of Queens, Elizabeth I appears to be the most clearly represented female monarch. Finally, concerning the lion figurines, these come in two main forms, laying down and rampant, possibly providing an allegory of English royal power.

Figure 4.10 To the left, the lion with band found on Queen's Street, London. To the right, a close up of the lions tale depicting the paint remains on the figurine (Authors images, courtesy of MoL. 20309)

Figure 4.11 Seated Lion in two halves. (Authors image, courtesy of London Archaeological Archive and Research Collection, NHU.481.50)

Figure 4.12 Lion, Holland (Image from Personal comm. R. Stam)

Figure 4.13 Lion, Holland (Image from Personal comm. R. Stam)

4.2 Religious Iconography

A large range of religious memorabilia has also been recovered from London, many of the figurines can be seen to be based upon ecclesiastical prototypes such as carved altar pieces and statues, as demonstrated with Figures 4.14 and 4.15 (Gaimster 2003, 124). The low cost and fast production of these figurines was ideal for the popular iconographic repertoire of the Roman Catholic faith (Gaimster 2003, 124), and a range of scenes concentrating on and around Christ, the Virgin Mary, and the Cult of the Saints has been discovered. These figurines might have been produced to satisfy a range of spiritual functions: as a form of protective charm for both individuals and the household (Tomasz 1998, 53); to be assimilated within house altars (Neu-Kock. 1988, 40); for display in ornamental biblical scenes; to be used as souvenirs for pilgrimages (František 2010, 226-231); and given as gifts during religious holidays (Borkowski 2004, 212). Alongside these standardised religious figurines, there has been the occasional finely detailed larger pipe clay figurines discovered. The presence of these objects suggests that these figurines were not just produced for the masses but also produced on commission for a more wealthy clientele (Higgins 2007, 684).

Figure 4.14 Standing Madonna and Child, A. Maitani. c.1330 Wood with Poly Chrome. Perugia, National Art Gallery of Umbria. (Image from Plazzotta et al. 2006, pl 2)

Figure 4.15 Madonna and Child. Billingsgate, City of London (Private collection, image from Timeline 2011)

4.2.a Madonna and Child

Madonna and child statuettes are one of the most well documented forms of religious pipe clay figurines, and reflect the prestigious position of the Marian cult within Europe. This cult, as mentioned in Chapter 1, had grown in strength across Europe, but declined in popularity following the Reformation (Johnson 2007, 364). The cultural gap this left in England was later filled by images of the 'Virgin Queen' who filled the void within the public's sentiment (see section 4.1 for discussion). In London there have been seven Madonna and Child statuettes so far recovered (Figure 4.17 and 4.18), and one mould fragment (Figure 4.16). All seven follow a similar template, although the clothing and side to which the child is cradled varies. The religious iconography present

Figure 4.16 Inverted Image of the Madonna and Child clay mould. Found in Greater London. (Author's image, courtesy of LAARC. LIG88)

Figure 4.17 Madonna and Child figurine. (Author's Image, courtesy of The British Museum 1856,0701.1652)

Figure 4.18 Crowned Madonna and Child, London. (Author's Image, courtesy of The British Museum 1855,0512.17)

in the London sample portrays similar themes to those seen within Germany and the Netherlands, and with a similar amount of significant difference in stylistic qualities. That being said, the larger corpus recovered from Germany and the Low Countries holds a wider range of Marian forms, such as Mary enthroned or the Madonna with crescent moon and rosette, styles which, so far, have not been recovered from UK assemblages.

4.2.b Christ as a Babe

Depictions of Christ were another popular motif in the late 15th to 18th centuries, and like the figures of the Madonna, depictions of Christ came in a range of forms. Within the London assemblage the image of Christ as a babe/child was present, often depicted naked or in a loincloth and holding a symbolic item, such a dove or goldfinch (see Figure 4.19), and occasionally with an olive branch (Figure 4.20). Outside of London, an example of a Christ within a cradle or basket has also been recovered in County Durham (Figure 4.21).

Depictions of Christ as a baby are thought to have had particular associations with female worship, where frequently the image of spiritual rocking and cradling the child was employed by nuns and in women's convents, as discussed in Chapter 1 (Neu-Kock 1988, 22). Specific documented examples of the imagery being employed within pipe clay figurine production are known from in and around Nuremburg, and Sister Katerina Lemmel, a Brigettine nun residing at Maria Mia (80km south of Nuremburg), discussed some of these in early 16th-century correspondence (Lemmel *et al.* 2009, 83). The Brigettines jointly followed the Rule of Saint Augustine and Saint Brigetta, the latter of which was devoted to the Order of the Holy Saviour and dedicated to the Virgin Mary (Lemmel *et al.* 2009, 73). Within one of Katerina's letters is a discussion of

Figure 4.19 Christ with a dove (Author's Image, Courtesy of The British Museum OA.9366)

Figure 4.20 Christ with dove and olive branch. Lambeth Road, London (Authors Image, Courtesy of LAARC)

Figure 4.21 Christ in a basket/cradle, Easington (Image from PAS DUR-069221)

an array of gifts sent to her by her sister-in-law to help with the care of Sister Magdalena Furter. The gifts are described as "*Baby Jesus with his sack full of blessings*'' (Lemmel *et al.* 2009, 239), and this likely refers to a figurine of the Christ Child given to an individual alongside a bag of devotional items. Given the changing religious nature of England at this time, and the Dissolution of the nunneries in the 1530s, this and similar practices may have transferred to a more personal and direct relationship with Christ-as-Child across secular society, with the figurines serving as a physical focus for a personal spiritual relationship with God.

This style of gift giving, though it was not restricted to nuns, and the broad spread of these figurines may suggest that these were a common form of holiday gift, specifically on New Year's Day, offered to friends and neighbours as a symbol of good health and well wishing. This concept is supported by artistic renditions in print, moulds, and paintings of the Christ Child playing or standing with ribbons containing slogan of New Year's greetings (see Figure 4.22) and well wishes (Neu-Kock 1988,22).

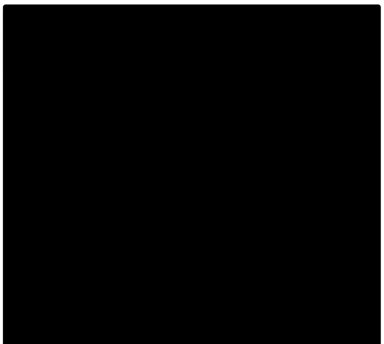


Figure 4.22 Wood cut displaying a New Year's greeting in a ribbon, and the Christ child wearing paternoster beads and holding a dove. (From Heitz, Neujahrswunsche des xv. Jarhunderst, in, Lemmel et al. 2009, figure 133, 245)

The Christ Child may also have represented an affiliation with the Nativity, direct examples can be seen in figurines from Westerwald, Germany (Figure 4.23). They may have been part of a larger nativity scene displayed during advent created from pipe clay figurines. In London, other possible nativity figurines have also been recorded (Figure 4.24), and these include cows and a praying Virgin Mary. As these figures have not been discovered within the context of the nativity scene, it can only been speculated that this may have been their function, or one of their possible functions. Another suggestion for the cow figurines is that they may have been a child's toy, or even as part of a recreation of Noah's ark, along with other animal figurines that have been recovered such as sheep, a range of birds including peacocks and swans, and lions (See appendix 1). Ultimately, it is possible that the cow figurines may have been produced to cater for a wide variety of functions, allowing for pipe clay figurine manufacturers to gain a maximum profit from the consumer market with only one product.

Figure 4.23 Pipe clay figurine Nativity arrangement. Westerwalds, Germany (from personal communications with Ruud Stam, 2014)

Figure 4.24 A pipe clay cow and praying woman, potentially the Virgin Mary (Image from Timeline 2013)

4.2.c The Passion of Christ

Adult depictions of Christ (Figure 4.25) were also being produced during these periods. Contemporary pipe clay examples have been found in the Rhineland and Poland (Kowalczyk 2013), whilst wooden examples have been noted within Wales. These depictions were often located above the rood in churches, such as the wooden examples located at the church of Mochre, made in the 16th century, and another at the Church of St Michael, Kemeys Inferior, Monmouthshire. Both these wooden examples had been removed from their visible positions the churches and concealed, rather than destroyed, during the Reformation (Redknap 2008, 2-3). It is clear that pipe clay examples of depictions of Christ were also placed above the rood, for example, at the Church of the Holy Flesh in Wroclaw (Kowalczyk 2013). The Passion of Christ figurines may have also been used as ornaments/charms, or used within either smaller or larger biblical scenes (Figure 4.26-4.28), acting in a similar manner to the previously discussed Marian figurines as items of personal devotion.

The story of the Passion of Chris was a teaching which was presented frequently in Martin Luther's sermons, serving as a focus for arguing for reform (Saak 2017, 34 and 287), and offering the most perfect example for living the Christian life. It is therefore not unexpected that the vast majority of Passion of Christ figurines recovered date to the late 15th and early 16th centuries, a period when the popularity of this imagery had increased. This imagery replaced previously popular religious imagery, such as the Cult of the Saints and the Virgin Mary, which had reduced in popularity due to their condemnation by Martin Luther and his urge for religious imagery to instruct rather than perpetuate a false theology (Koerner 2004, 28).

Figure 4.25 Christ on crucifix. From Haydon Street, London. Late 15th century (MOLA 1990)

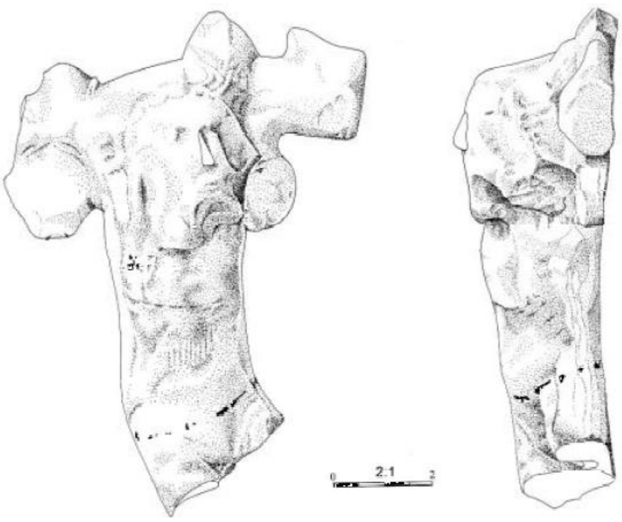


Figure 4.26 A thief being crucified next to Christ. Found at Carmarthen Greyfriars, Wales. 15th-16th century, 28.5cm in width (Image from Redknap 1997, 51 with permission From © National Museum Of Wales)

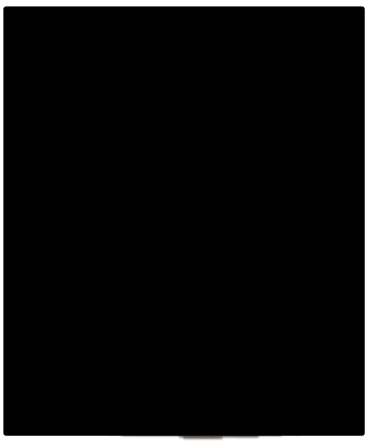


Figure 4.27 crucifixion of Christ in Pipe Clay, Amsterdam, 1475-1525. (Ostkamp 2012 figure 9.15, 118)

Figure 4.28 Anonymous Artist, Lamentation, dotted print, in the Gdansk Library of the Academy of Science glued to the inside cover of Sermones aurei de Sanctis, Nuremberg, Antonius Koberger, 1478 (Figure 37, Deluga 1995)

4.2.d The Cockerel on a Column

The cockerel figurine (Figure 4.29 and 4.30), which currently is the most common pipe clay religious figurine from London contexts (a current total of 17), may represent a variety of symbolic motifs. The first association is to the Denial and Repentance of Saint Peter, whereby Saint Peter would deny Christ three times before the Cockerel crowed. This was a subject which was popular in pre-Reformation art, but was seen less frequently after 1525 in north-west Europe (Callisen 1939, 161). The image of the cockerel is an oft-repeated subject within Christian art, with its roots in the decoration of early Christian sarcophagi. Although the exact composition of the imagery is not perfectly copied across varying medias the imagery of the cockerel on the *cippus* or a column (and less commonly a tree) are central to a number of works (see Figures 4.31-4.33 for examples). The continual reoccurrence of this imagery through different periods demonstrates the long-term association this iconography had with biblical narratives.

Figure 4.29 fragmented cockerel on a stand. (Authors image, courtesy of MoL 5176)

Figure 4.30 Cockerel on a stand. (Authors image, courtesy of MoL NN21231)

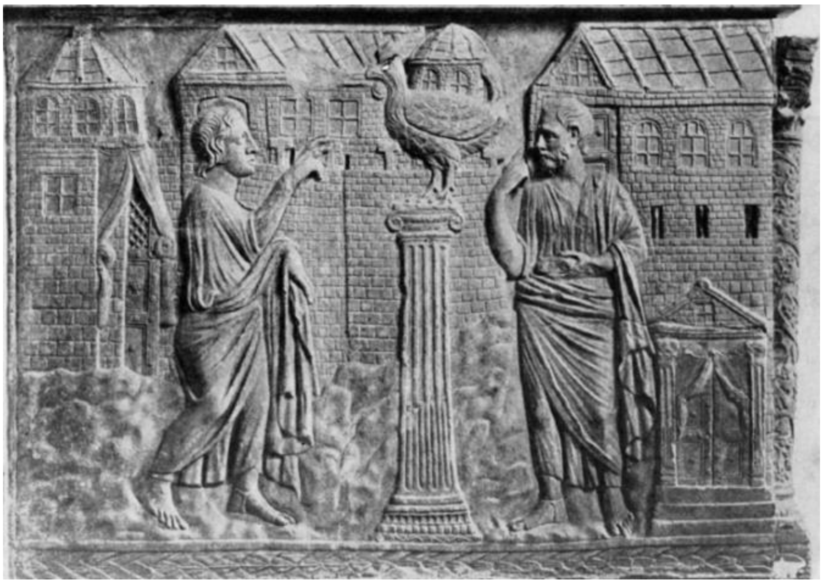


Figure 4.31 St Peter denouncing Christ on a sarcophagus displaying a cockerel on top of the central column (Callisen 1939, Fig 2, 163 artwork in the public domain; photographer unknown)

Figure 4.32 Ravenna, S. A'pollinare Nuovo: Mosaic, with a cockerel on a column in the centre of the image (Callisen 1939 Fig 12, 171 artwork in the public domain; photographer unknown)

Figure 4.33 Florence, Museo Nazionale: Ivory detail, with cockerel atop a column in the centre of the piece (Callisen 1939, Fig 4, 164 artwork in the public domain; photographer unknown)

The second biblical association of the cockerel, or rooster, is it’s use as a representation of Christ as The Man of Sorrows. Within depictions of this narrative the cockerel is often located on a column, representing the bird of betrayal at sunrise (Figure 4.34). Examples of this imagery can be found across various art media, including elegant jewellery pieces (Figure 4.35). Though this image was popular in an array of media prior to the late 16th and early 17th centuries, the image declined in popularity thereafter in the north west of Europe (Gaimster 2003, 130). A further interpretation for the prevalence of cockerel imagery, especially within a wider protestant audience, is that it may relate to a Lutheran evangelical polemic from the 16th century. In this polemic the cockerel represents a preacher on a tower, and it is from this same tradition that the popular use of the cockerel on weather vanes is derived, symbolising turning into the wind to stand against disorder.

Due to the varied manner in which the cockerel was used as a symbolic religious motif in the later medieval and early post-medieval periods it is difficult to establish the specific use or meaning associated with any specific depiction. However, what may be suggested is that it's use as an iconographical motif was pivotal within Christian art, both Catholic and Protestant. Cockerels standing both atop a column or on their own frequently reoccur in a range of media, including medals (Figure 4.36), prints (Figure 4.38), and pipe clay figurine (Figure 4.37). It can also be surmised that the use of the cockerel for various symbolic associations within Christian practice could also overlap or merge, making the cockerel an adaptive and context-responsive form of imagery. In Jan Steen's 1665-1668 painting *The Feast of Saint Nicholas* a pipe clay cockerel figurine can be seen within the bucket of gifts belonging to a young girl, alongside what appears to be a cleric figurine, whilst she also clutches a figure of John the Baptist to her chest (Figure 4.39). Though a painting representing domestic life, the painting also reflects the nature of giving and the typical messages associated with this particular religious holiday during the 17th century, and the inclusion of pipe clay figurines, and particularly the specific imagery utilised and their association together, should not be merely viewed as a coincidence.

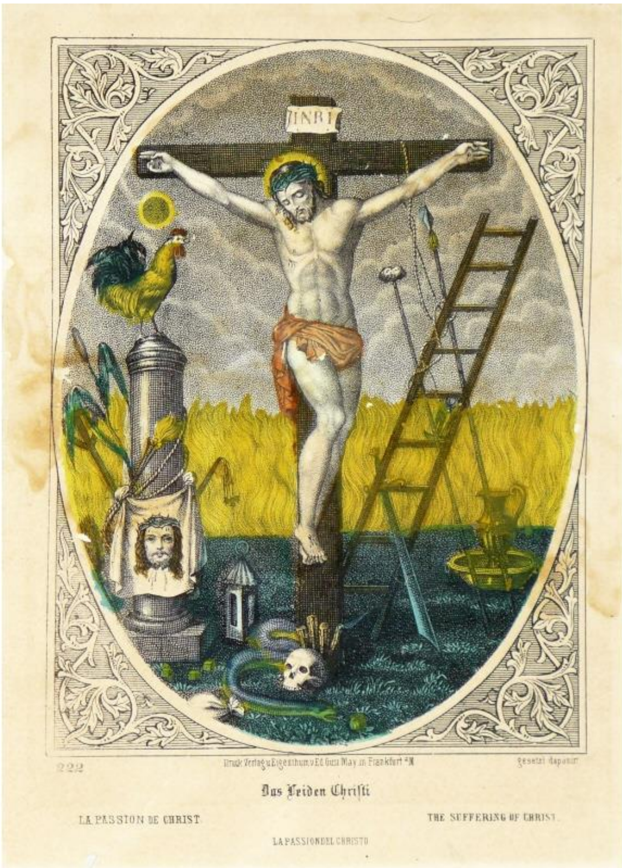


Figure 4.34 The suffering of Christ .Wandbild, Nr. 222 E. G. May, Verleger 1864 – 1877 N (33 R) 545/2009 Sammlung: Museum Europäischer Kulturen(© Photo: Museum Europäischer Kulturen der Staatlichen Museen zu Berlin - Preußischer Kulturbesitz)

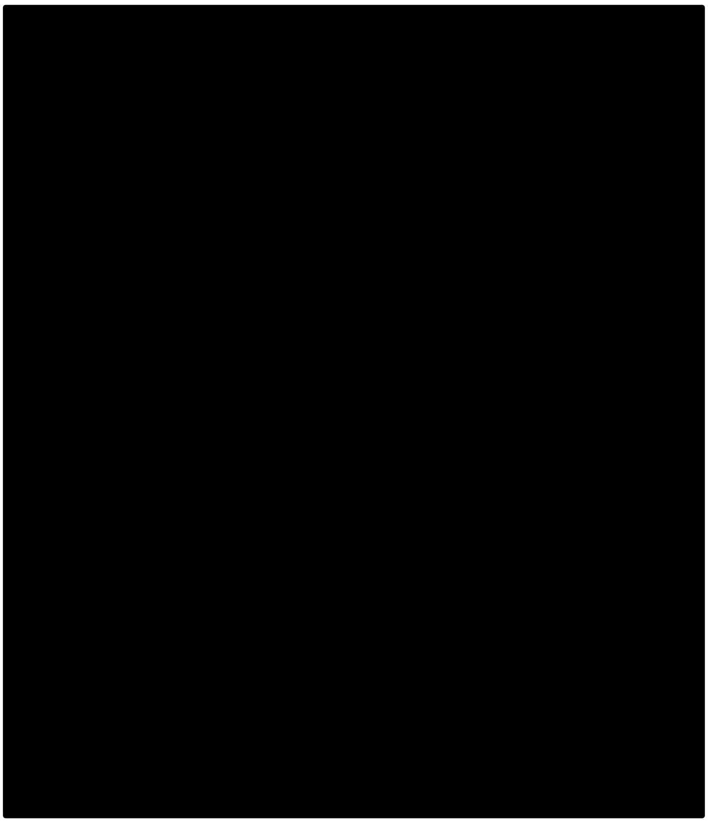


Figure 4.35 Pendant, Christ a Man of Sorrows with cockerel on a column to the left, 1590. Gold, enamel and pearl (Image by M. Fernandez from the Kunstgewerbemuseum, Berlin)

Figure 4.36 Silver medal. 1679, (obverse) Wheatsheaf with crossed sword, orb and crown on top. (reverse) Cockerel standing on orb to left in field, Netherlands. (Image from ©Trustees of the British Museum. M.1918, accessed 01/02/2017)

Figure 4.37 Two pipe clay figurine forms depicting Christ riding on a cockerel, Zeeland. (Van Den Dorpel 2013 figure 29, 59)

Figure 4.38 Study for a print by Johann Ulrich, Mary the Virgin of Sorrows adoring a reliquary of the Holy Blood, with a crowing cockerel lower left, 1700. Germany (Image from ©Trustees of the British Museum. 2009,7076.1AN703551001, accessed 01/02/2017)

Figure 4.39 Isolation of the little Girl carrying the bucket of treats, from The Feast of Saint Nicholas. (Painting by Jan Steen, 1665-1668, held in the Rijksmuseum, Public Domain, accessed 01/02/2017).

Similarly, the specific rendition of the cockerel atop a ringed column also occurs in a series of 18th-century, circa 1740-80, moulded tobacco clay pipes which have been recovered along the Thames foreshore, close to Black Friars Bridge in London (Figures 4.40-4.42). This group of post-medieval tobacco clay pipes all have the same cockerel imagery on the front of the pipe bowl and have the same makers stamp on each of the pipe spurs, in the form of an 'S' (see Figures 4.40-4.41). There are six further pipes from unknown provenances that have similar imagery, again the cockerel is on the front of the pipe bowl (Figure 4.42a), and these pipes are also thought to date to the 18th century. These six pipes are also finely embossed with the Waterman’s Arms with the motto ‘At A Command Of Our Superiors’. Cheminant (1981, 126) notes that the cockerel on the front of the pipe bowl is similar to a church spire, “resembling a minaret, with a cockerel perched on top”. Three further examples of this type have also been recovered. The first is a cockerel upon a GR bowl and, similar to the previously mentioned ‘cockerel pipes’, also has the letter ‘S’ on the right hand side of the spur. The other two are the same design upon a variant of the Hanoverian bowl, but with no initial (Figure 4.42b) (Cheminant 1981, 126).

Figure 4.40 Close up of Tobacco Clay Pipe with cockerel imagery, London. (With thanks to R. Carey for the image)

Figure 4.41 Range of Cockerel Tobacco Clay Pipes from London (With thanks to R. Carey for the image)

Figure 4.42 A) To the Left Watermen's Arms pipe embossed with a cockerel on a column; and B) To the right a variant on the Hanoverian bowl, embossed again with a cockerel on a column. (Cheminant 1981 figures 14 -15, 119-120)

Another possible function of these cockerel figurines could be associated with the game cockshy, an interpretation which has also been suggested for finds of lead alloy cockerels of a similar date (Forsyth and Egan 2005, 239). The tradition of cock shies may have come from Shrove Tuesday frivolities, whereby stones or cudgels were thrown at living cockerels which were either tethered or buried up to their heads in the ground (Figure 4.43), a sport which continued to the 19th century (Forsyth and Egan 2005, 239). However, though the imagery of a cockerel draws a parallel between the lead alloy and the pipe clay figurines, there are significant differences. The lead alloy figurines are only of decorated on one of their sides and stand upon a square base, both of which are often crude in nature (see Figure 4.44 for an example) (Forsyth and Egan 2005. 239). In contrast the pipe clay cockerel is often more detailed in structure, with the cockerel moulded in three dimensions. Furthermore, remains of paint are present on some pipe clay examples, denoting that at least some were further elaborated with additional decorative elements. Finally, the pipe clay cockerels sit atop a detailed column structure rather than being placed upon a crude base like the lead alloy examples. Consequently, if pipe clay figurines were used as cock shies they appear to have been more elaborate examples that may have been for more affluent consumers. Unfortunately, it is not clear at this point whether there was a connection between the pipe clay figurines and this game.

Figure 4.43 Men playing a game of Cockshy. Anonymous engraving of the 1683/4 Frost Fair on the Thames. (With permission from Forsyth and Egan 2005 fig 7.2, 7.1)

Figure 4.44 Two different cock shy designs made from lead alloy from 18th century London, no further information given (With permission from Forsyth and Egan 2005 fig 7.1 and7.3, 240)

4.2.e Saints

Depictions of saints were another popular set of figurines produced during the 16th to 18th centuries, and examples have been recovered from both the UK and mainland Europe. Such saintly figurines may have been used as a form of personal protective charm, either carried on an individual, given as a gift, or placed in a household to invoke the saint's protection. Contemporary archaeological evidence of these saint figurines can be seen in a convent church in the Netherlands. A figurine of Saint Lawrence was discovered behind several layers of lime and close to the roof. It has been suggested that the figurine was chosen specifically due to the method of his martyrdom. Lawrence was burned on a giant gridiron, and as such the figurine could have been placed in the wall of the convent in the hope that it would prevent the building from being damaged by fire (Ostkamp 2001, 215).

Saints recovered from London include St Catherine, represented with her wheel (Figure 4.45) (Neu-Kock 1988, 23), Saint Dorothy with her basket (Figure 4.46), Saint Barbara holding a tower (Figure 4.47), and finally the evangelist Saint Mark with his symbolic lion and part of the inscription *'de lions'* (figure 4.48). Of interest is the strong preference for female saints amongst this assemblage. These female saintly figurines, taken alongside those previously discussed as representing the Virgin Mary, may relate to, and be based upon, panelled altarpieces and woodcut prints popular in Central Europe during the 15th century (see Figure 4.50-4.54). The panels and prints often consisted of the Madonna in the centre surrounded by four, or more, virgins, with

Saints Dorothy, Catherine, Barbara, and Margaret being the most popular (Kowalczyk 2013).

Figure 4.45 St Catherine and Wheel. City of London. (Author's image courtesy of The British Museum's 1854.0814.8)

Figure 4.46 St. Dorothy with basket (Author's Image, Courtesy of MoL.4972)

Figure 4.47 Saint Barbara with Tower, Dorset Rise, London (Author's Image, Courtesy of LAARC)

Figure 4.48 Saint Mark. Greater London, (Author's Image, Courtesy of LAARC ALA884174)

[redacted]

Figure 4.49 High altar in the Church of Saint Mary, Zwickau, Saxony. Mary surrounded by eight female saints. By 'Master of the Zwickau High Altar', 1479 (Figure 28 from Kahsnitz 2006, 25)

These clay figurines may have offered consumers a more affordable method to replicate gothic altarpieces within their own homes. Jean Froissart's *Chroniques of France et d'Anglettere* (Figure 4.52) depicts an example of one of these figurines adorning a private home, where it is placed above the chimney hood. The placement of figurines in conjunction with the chimney is further confirmed by import records, one of which stated that on the 18th February 1679, Joseph Floyd bought 'a prele [parcel] of toyes over chimney piece' (cited in Mercer 1998, 292). Discussion on the etymology of 'toyes' can be found later on in this chapter, however the term 'toye' does not always reflect a child's play object, but can also present itself as a household 'buwbble' or 'trinket' (Forsyth and Egan 2005, 33).

Figure 4.50 Saint Mark with lion drawing, 16th century (Image from ©Trustees of the British Museum. T,12.45, AN403155001 accessed 01/02/2017)

Figure 4.51 16 female saints 1500-1526, Germany, woodcut print by Hans Wechtlin (Image from ©Trustees of the British Museum. E,8.176, accessed 01/02/2017)

Figure 4.52 Detail of a miniature of burning costumes of the 'hommes sauvages', displaying a figurine on the chimney hood, *Jean Froissart's Chroniques, Vol. 4, Netherlands, c. 1480, (© British Library Board Royal MS 18 E II, f. 206r. Biggs 2013 accessed 21/06/2017)*

4.2.f Angels

There have been a number of angel compositions which have been recovered from London, including an angel holding a chalice (Figure 4.53), and two cupid-style angels, one which has the remains of wings and a potential bow across his back (Figure 4.54), and another where only the fragment of his head remains (Figure 4.54). These differ from angel compositions recovered on mainland Europe, where popular examples include the Angel of Annunciation, often detailed with a dress, staff, band, and specific hand gestures such as signs of benediction. Other popular forms of iconography recovered from Germany and the Low Countries also include angels with instruments of torture, winged angels, cupids, and angels with instruments (Neu-Kock 1988, 22). Whilst some of the London assemblage includes forms found on the continent, the larger corpus of angelic pipe clay iconographic material in Germany and the Low Countries appears not to have been popular in England.

Figure 4.53 Angel, found at London Wall (Author's image, courtesy of MoL. A3886)

Figure 4.54 Front and back of a Cupid or an Angel. Aldgate, building VII, Greater London (Image from Weinstein 1984, 122-4 © Society for Post-Medieval Archaeology, reprinted by permission of Taylor & Francis Ltd.)

Figure 4.55 Cherub head. Aldgate, London. (Author's image, courtesy of MoL. A23836)

This difference in iconographic imagery in pipe clay assemblages may be explained by Germany’s continuation of its traditional artistic roots and elements of the gothic style. This style incorporated angels within scenes depicting the Virgin Mary, a theme that continued in popularity into the early post-medieval period. There was a transformation in the depiction across German art through the reformation, however, with angels being presented as the companions of the infant Christ or as bickering advice givers. This change in their depiction served to humanise their personas, in a similar method to how Christ came to be viewed more as a man rather than the son of God. Depictions of the crucifixion incorporated angels with chalices who collected Jesus’s blood, representing the offer of hope for man’s salvation. This transition can be seen in the works of artists such as Cranach the Elder and Durer, as well as in privately commissioned paintings, sculptures and carvings (NGA 2017, 1-10).

4.2.g Clerics

Male clerical figurines were also common throughout mainland Europe, and nine examples have been found in London (Figure 4.56 and 4.57). It has been suggested they may represent the Bishop Saints, due to the presence of maniples (Figure 4.58) and tabard with a cruciform emblem embossed on to it (Figure 4.59). The specific identity of these individuals is difficult to establish due to their standardised and generic clerical appearance. Grimm (2012, 46) and Neu Kock (1988, 32) have suggested that some may represent Saint Nicholas of Myra, the patron saint of children, seafarers, and merchants (Keller 2005 460-2; Farmer 1978, 292-293). Further suggestions for their identity include the 14 Holy Helpers, who were venerated within the Roman Catholic church for their effectiveness against disease (Grimm and Kaszab-Olschewski 2012, 45). The image of the 14 Holy Helpers was frequently produced in several media including paintings, stained glass windows, wood cuttings, and sculpture (Figure 4.60), as well as in varying forms of ceramic figurines (Figure 4.61). As a result, these pipe clay figurines may once again have represented a cheaper alternative for individuals to purchase in order to replicate ecclesiastical imagery within their own homes.

Figure 4.56 Ecclesiastical male. London Wall. (Image from London Museum 1940, Pl. XCI, No. 1)

Figure 4.57 Cleric with maniples, Lower Thames Street (Authors Image, courtesy of MoL)

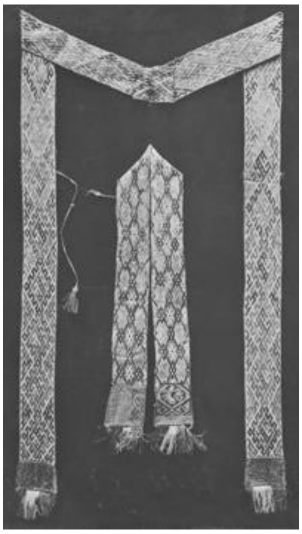


Figure 4.58 A set of maniples from the late 14th century, German (image from © Victoria and Albert Museum, London online collection 1262-1864, accessed 02/02/17)

Figure 4.59 cleric with tabard embossed with a cross from Fosters Lane, London, (authors image, courtesy of LAARC)

Figure 4.60 Woodcarving by Tilman Riemenschneider of the Fourteen Holy Helpers, 1520-30, held within the Mainfränkisches Museum, Wüzburg, Germany

*Figure 4.61 Staffordshire made Salt glazed stoneware Cleric, 1740.
(Image from from © Victoria and Albert Museum, online collection, C. 26-1938, accessed 2/2/17)*

4.3 Adult Knickknacks

Another category of pipe clay figurine recovered from London can be interpreted as knickknacks marketed towards adult consumers. This selection of ornaments may have been created for both the more refined and unabashed consumer market, with items ranging from classical figures, personalised consorts, nobles and gentry to humorous figurines, such as the nude urinating male (Figure 4.62), or the coquettish female who lifts her drapery for the onlooker (Figure 4.63). This wide selection of imagery is also represented on the continent, including the more lewd figurines, such as the courtesans recovered from Cologne (Neu-Kock 1988, 32). These figurines fall within a large network of mischievous adult ornaments, all of which present a brazen lust for life and symbolise activities which took place within public houses, communal bath houses, or brothels. In Cologne further figurines depicting naked boys busy with jugs, couples in bath tubs, and musicians have been found, all of which may belong to this stylistic context (Neu-Kock 1988, 29).

The figurine shown in figure 4.64 could be representative of two differing iconographical themes, both of which are similar in form. The first is it may present classical influence, something also with the cupid-style figurines discussed in the previous section on angels. Here the classical reference may be a representation of Bacchus, the god of wine and fertility (Figure 4.64), who holds an array of pinecones, fruit, grains, and flowers. The inclusion of classical gods and cupids was a frequent occurrence in the ceramic arts (Allergretto 2011, 3), and similar and near-identical copies of the Bacchus figurine have been found across Europe, with notable quantities appearing in Antwerp (Geyskens 2002) and Amsterdam. The second suggestion, which is also sourced from a classical

Figure 4.62 Male urinating. Greater London. (Author's image. Courtesy of MOLA. BGX05.101.842)

Figure 4.63 Courtesan with pipes Greater London (Authors Image, courtesy of the British Museum, M.592)

Figure 4.64 Naked male holding a bouquet of flowers and grapes, potentially a representation of Bacchus. Front and back. (Author's image, courtesy of MoL. NN21909)

influence, is the Green Man or Green Guardian, whose foliage and vegetation imagery is symbolically associated with the growth cycle, rebirth, and death. Representations of the Green Man appear frequently on church architecture, such as those found in St Jerome's Church in Llangwm, Monmouthshire, Rochester Tower, Lincoln Cathedral, Norwich Cathedral (Raglan 1939, Plate I), and the Rossyln Chapel in Scotland, which has over 100 Green Man carvings embedded within its architecture (Varner 2008, 59). The imagery of the Green Man was revived during the Renaissance, with the form appearing in carvings, manuscripts, metal working, and stained glass, the most notable example of this inclusion being in the Medici Chapel, Florence (Varner 2008, 65). While the meaning behind the exact symbolism may have transitioned over time, it is doubtful that the iconography became meaningless and instead became incorporated into wider Christian symbolism and ideology (as discussed by Varner 2008, 56-7). Interestingly, the rise in popularity of Green Man symbolism appears to be associated to after traumatic periods in history, for example, during the 14th and 15th centuries following from the Black Death (Varner 2008, 57), and may indicate the increase in the social need for fertility and reflections on life and death with the population as a whole.

Consorts, nobles, and both male and female gentry are also found amongst the pipe clay figurines. The precise purpose of these figurines is unknown, but they may have been used as household ornaments, children's toys, or an attempt, alongside the figurines of the monarchy, to replace the cult of the saints with an iconography that provided a representation of temporal authority (Gaimster 2015, 63). These figurines often display close attention to elaborate and fashionable details, such as the tipstaff seen in Figure 4.65, which was a symbol of an officer of the court. These gentry figurines came in a range of designs, with the tipstaff often being exchanged for either a pair of gloves or a hat. There is also a singular example of a possible personalised gentleman figurine (Figure 4.65), which wears a badge with the initials 'PB' engraved upon it just below his tipstaff. These might either refer to the initials of the maker of this figurine or the initials for the consumer, although if these were a maker's mark this example would be unique within the UK.

Figure 4.65 Male figure with tip-staff and badge with initials 'PB'. Aldgate, Greater London (Author's photo, permission from LAARC. 39.1262)

4.4 Children's Toys or Adult Trinkets?

The etymology of the term 'toy' is complex and confused, as can be seen from its many uses in the advert in Figure 4.66. In amongst this advert for a range of items such as: snuff boxes, razors and Shot-bags it also advertises a range of toy genres 'Silver Toys…Ivory Toys…all sorts of Toys for Children…Curiosities for Gentlemen and Ladies'. The term first appears in 1303 in a text produced by Robert of Brunne, but does not regularly appear within documents until the 16th century. The new gusto in the employment of the term 'toy', or as it may have appeared '*toye*' or '*toie*', may correlate with the general increase in personal affluence, therefore stimulating the market for a vast range of novel frivolities (Forsyth and Egan 2005, 32). The term 'toy' initially was considered to signify idle fancies, such as an ornament, and within Cotgrave's *Dictionary of the French and English Tongues*, published in 1611 and later revised in 1673, 'toys' were described as 'all kinds of superfluous trifles used, or usually bought by women', a 'trinket', and 'a paltry object' of no value (Forsyth and Egan 2005, 32).

In contemporary inventories or trade bills, sometimes the term 'child' or 'children' was prefixed to 'toy', 'knacks' (CLRO OC 360, 24 January 1666 in Forsyth and Egan 2005 32) or 'buwbbles' (CLRO MC1/228/101, September 1660, in Forsyth and Egan 2005 32) thereby providing a specific reference to children's play objects. The recorded context of their

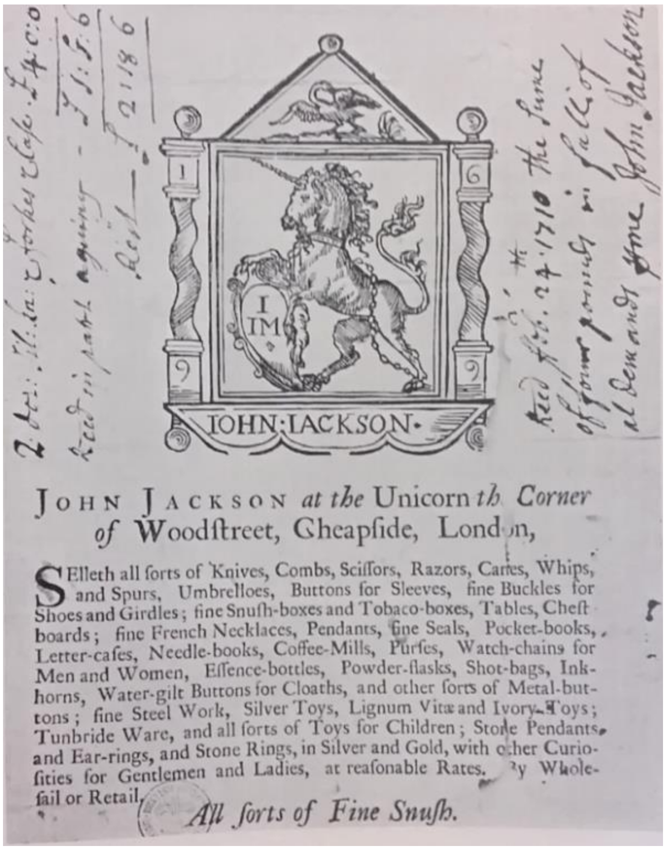


Figure 4.66 John Jackson1699 shop advert, items included 'Silver Toys…Ivory Toys…all sorts of Toys for Children…Curiosities for Gentlemen and Ladies'. (Cat.no.8.45 Image from ©Trustees of the British Museum. Heal Collection, in, Forsyth and Egan 2005, 33)

use can sometimes offer an indication as to who the 'toy' is deemed for, for example their presence in inventory lists for women's closets or dining rooms, as seen recorded in the inventory for Joseph Floyd on the 18 February 1679, 'a prele [parcel] of toyes over chimney piece.' (Mercer 1998, 292), where it can be assumed that these referred to an ornament or trinket, rather than a child's plaything (Forsyth and Egan 2005, 34). However, references to 'toyes in boxes' amongst imports on the ship *Trinitie Bull* into London for Frank Matthew on 13th November 1481 (PRO, E 122/194/25: Petty Customs Account 1480-1, no. 33: 1 box with toys valued at £7.3s 4d, in Forsyth and Egan 2005, 35) leaves an ambiguous question of whether these were intended for children or adults (Forsyth and Egan 2005, 34).

The figurines discussed below are presumed, due to contemporary artistic representations (see figures 4.67 and 4.68), to relate to items of child's play, rather than solely adult trinkets (4.69). Children's figurines included those of soldiers with muskets and knights on horses, (Figure 4.70 and 4.71), both of which also had similar counterparts in contemporary lead alloy soldiers and knights, the latter of which has an initial production date originating in the 1300s (Forsyth and Egan 2005, 60). The pipe clay horseman figurines had a constant base structure for the horse and body, with a range of differing styles and forms provided through changes of accessories to the model. Often a small perforation is present beneath the riders arm, which may have been where a small wooden lance would have been placed so that they could been used to create re-enactments of tournaments (Neu-Kock 1988, 32). This selection of male figurines, alongside the well adorned gentleman previously discussed in section 4.3 presents an interesting social commentary on what was socially expected from young males, both in fashionable attire as well as status and career prospects.

Figure 4.67 A detailed section of plate X from Matthäus Schwarz of Augsburg autobiographical costume book, 1509. Showing a sick little boy with nurse, who is trying to amuse him with toy knights on horseback (With permission from Forsyth and Egan 2005, fig. 36, 145)

Figure 4.68 A detailed section of an engraving which Jacob Cats used to illustrate the emblem 'Schoon voortgedaen is half vercocht' which depicts a market stall selling a range of toys, such as dolls, hobby horses and drums, 1632 (With permission from Forsyth and Egan 2005, 153, fig. 38)

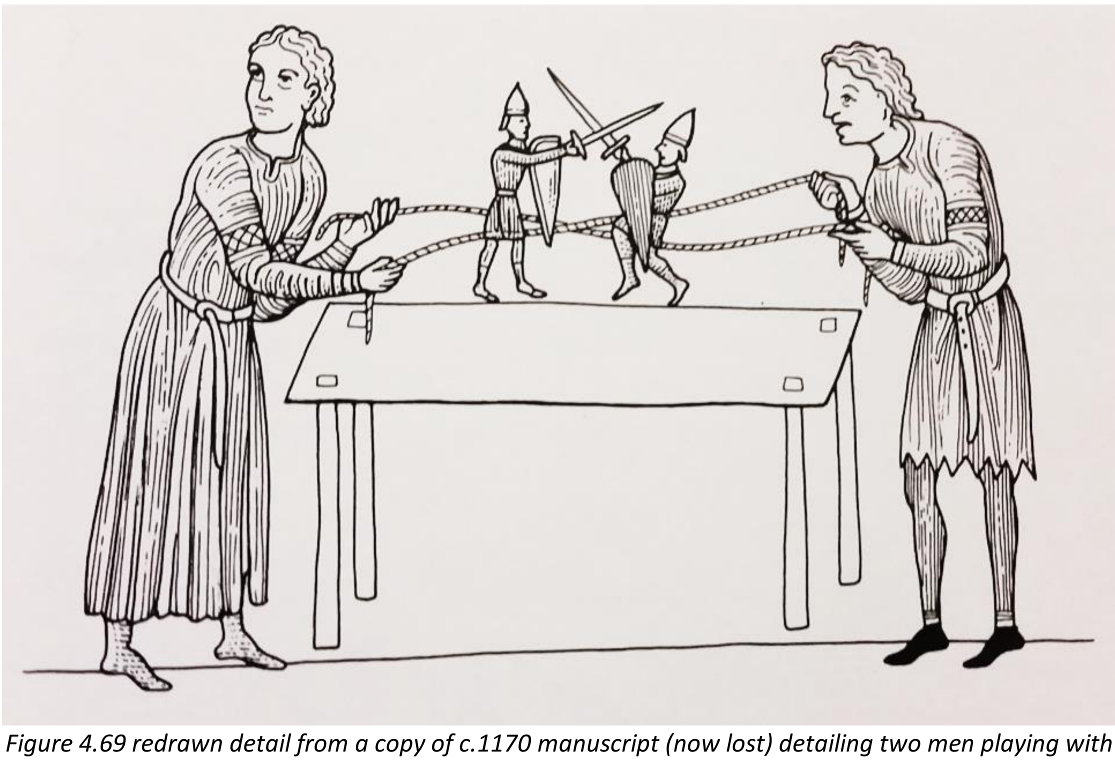


Figure 4.69 redrawn detail from a copy of c.1170 manuscript (now lost) detailing two men playing with puppet knights, an image which accompanied a Latin legend underlining the futility of those who waste time with vain pursuits. Entitled Hortus Deliciarum by Herrad von Landsberg of Strabourg (With permission from Forsyth and Egan 2005, fig 15, 61)

Figure 4.70 Soldier with musket, Eden Street, Greater London (Image courtesy of Steve Nelson and Pre-Construct Archaeology Ltd)

Figure 4.71 knight figurine. From London Wall (London Museum 1940, Pl.XCII, No. 3)

Such gender-targeted toy production, an issue still present within cotemporary toy manufacturing, is also reflected within those toys targeted for young ladies. These included well-adorned women (Figure 4.72 and 4.73), which were a popular product with a number of examples being discovered in London. Cruder examples of dolls are also known from the 16th century onwards with the introduction of lead alloy female figurines (Figure 4.74; Forsyth and Egan 2005, 152). The pipe clay figurines were provided with details that had clear similarities to the more expensive cloth dolls which are portrayed in post-medieval portraiture of children (Figures 4.75 and 4.76), but provided through a cheaper medium. In both these portraits the associated imagery of the doll, along with other items, presented an aspirational message of what was expected of young ladies. The girls within the paintings are holding items such as rings, grapes and pears, the ripe fruits a symbol of fertility. The ring displays the importance of the role of a wife, and the dolls are dressed as an image of what would be socially appropriate for these young girls to mimic in the future.

The gender-targeted pipe clay figurines fell within the ideological sphere of use as dolls more widely, but offering a more affordable alternative to high end toys. Within the group of pipe clay figurines there were still differences in quality, as indicated when the figurines in Figures 4.72 and 4.73 are compared. The presence or absence of paint, the quality of production, and the varying presence of accessories or decorative elements, for example, would all have played a role in differentiating between figurines of different quality, with the unpainted, plainer dolls presumably cheaper than the more elaborately decorated dolls. Furthermore these groups do not have to be mutually exclusive, and a range of production choices must have been made concerning how much extra effort to go to when decorating these items. The gentlemen and lady figurines also hold the potential to be both displayed and used as pairs, in a similar manner to the couple figurines from Breslauer Platz discussed in Chapter 1.6.11.

Figure 4.72 Front and rear of woman on a plinth. Found at London Wall (Author's Image, Courtesy of MoL. 4971)

Figure 4.73 Painted pipe clay figurine, female consort. (Authors photo with permission from Museum of London, 5036)

Figure 4.74 Female figurine, mid to late 16th century, lead alloy (With permission from Forsyth and Egan 2005, 154, fig 4.14).

[redacted]

Figure 4.75 Portrait of Three Young Girls, from the Circle of Robert Peake (fl. 1598-d. circa 1626) (Sotheby's 1988 figure 3, 19)

Figure 4.76 Christopher Anstey with his daughter.(Hoare 1775, © National Portrait Gallery, London 3084, Public Domain)

These figurines of gentlemen, soldiers, knights, and dolls present a vivid image of fashions during these centuries, and an additional social commentary on the expectation of the role of both women and men. For young males it was deemed appropriate to orientate their interests around war, soldiers, and the gentry, all perceived by contemporary society to be suitable aspirational concepts for young boys of different social strata. Parallel to this were toys orientated around the home and beauty, traits for young girls to aspire to. Furthermore, the presence of the cheaper class of pipe clay figurines displaying this imagery indicates that such aspirational motives were not just reserved for the wealthy, highlighting how all echelons of society willed their children to aspire to, or conform with, these social roles.

4.5 A Question of Luxury

One question that must be asked is where pipe clay figurines stood within the boundaries of luxuries or necessity. With one commodity fulfilling such a wide range of functions, from religious worship and political pomp to child's play and frivolous knick-knacks, where did these objects lie within the consumer scale? These figurines, alongside many other new and readily available commodities that began to appear, influenced shifts within the consumer markets targeted towards the middle and lower classes. Berg (1999, 65-6) has considered new commodities, such as pipe clay figurines, to have many similarities to traditional luxury wares, such as the previously discussed cloth dolls in section 4.4, the carved wooden altar pieces discussed in section 4.2, or sculptures discussed in 4.2.g. However, these items were produced from cheaper materials and marketed not towards the elite but to the social groups below them, including the new urban wealth found in traders, the lower gentry, and craftsmen, where these items were closely attuned to the aspirations for quality and individuality that such groups wished for (Berg 1999. 65). These objects therefore present a new insight into these social classes, from tradesmen to merchants, allowing researchers to examine how their fancies may differ from those of the rich.

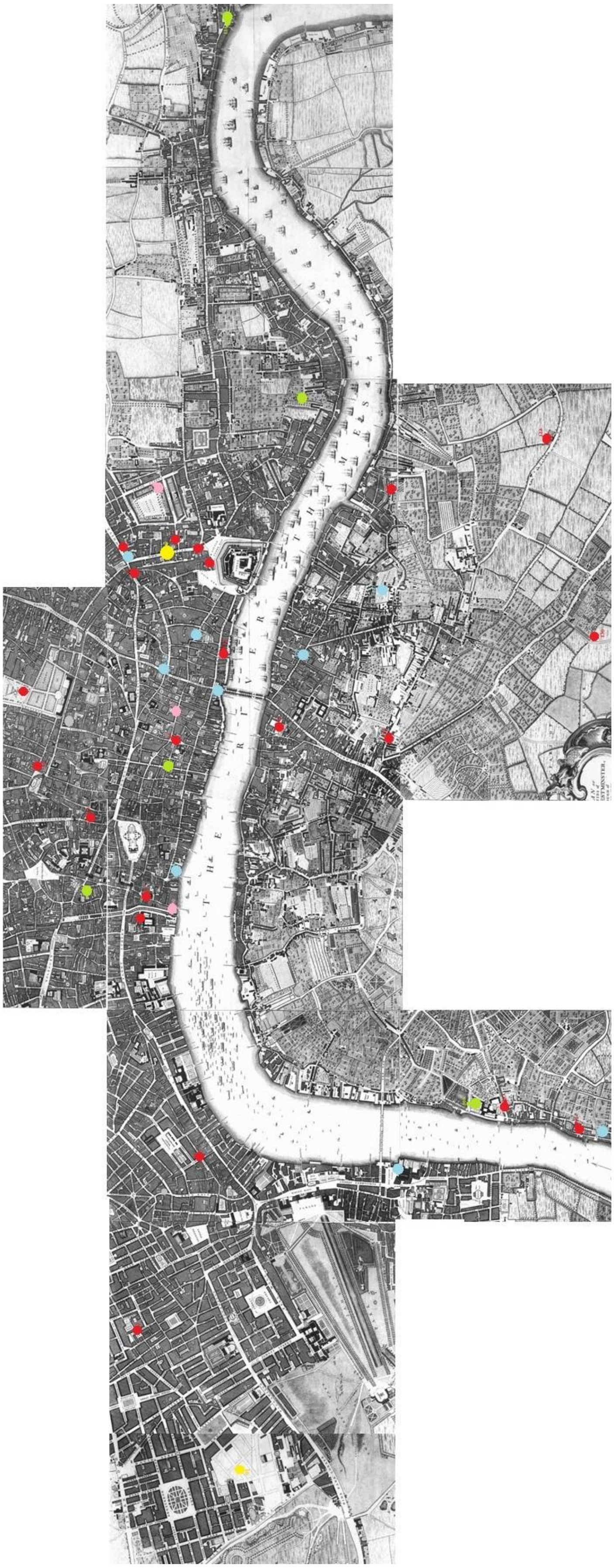
For the wealthy luxury objects representing the renaissance, honour, and pomp surrounded the elite domestic setting. These collections demonstrated the refinement of their owners, presenting them in a light of civility and good taste to those who saw or heard of the fine collections, with the goods themselves becoming markers of social hierarchy (Berg 1999, 66). The 'luxuries' under question within this thesis, the pipe clay figurines, should be viewed within their social context and not simply in terms of items made from a cheap material. These items were not necessities *per se*, unlike commodities such as food and clothing, but instead represent the ability to use wealth for expenditure on social display, providing individuals with an inexpensive means of mimicking elite luxury wares (Cissie Fairchilds, cited in, Berg 1999, 67). Seen in this light, and as objects in their own right, they were not merely cheap copies of unobtainable high status goods but, for some of the individuals purchasing them, luxury items themselves.

Therefore, this discussion of *relative* value shows that most of the pipe clay figurines were a form of desirable good within the social and religious arena that they operated. Their affordability provided a group of objects through which the social aspirations of a particular part of society could be expressed, and yet they were never so common as to have been possessed by the labouring classes (Berg 1999, 69). To further understand the position and value pipe clay figurines held to their contemporary audience, their context of use needs to be examined, alongside their symbolism and patterns of circulation, with the aim of defining more clearly their position within consumer scales, regardless of the materials and artistic prowess employed to create these objects (Berg 1999, 66).

4.6 Distribution and Context

Map 4.1 shows the distribution of 77 of the 121 figurines thus far known from London. The number of figurines present on the map is limited to those with specific location information, the map does not include those figurines which do not have these details available. The central location of these figurines reflects both the focal points of the 16th- to 18th-century consumer markets, and also may coincide with, if there are figurine workshops with England, the central city location of the pipe clay figurine workshops, in a similar fashion to those which have been located within Germany and the Low Countries. The suggestion that London's clay pipe industry was centrally located within the city is further confirmed when the archaeological evidence for workshops are noted, such as the Aldgate kiln site (see Thompson 1981). Both the simple nature of the production of these figurines and the location of the kiln sites makes it reasonable to assume that producers of these items were swift to respond to the contemporary social, political, and religious climates of the 16th – 18th centuries. It has also been suggested by Gaimster (2003, 132) that the distribution of secular and religious propaganda also infiltrated differing social echelons' domestic spheres, with figurines portraying messages on a range of political and religious matters understandable across the social divide. This seems to be corroborated when the distribution of these figurines are mapped onto Roques 1746 map of Georgian London (Map 4.2; see appendix 4 for magnified segments of the map). As can be seen by the colour-coded markers, these figurines were found on a range of sites, not just restricted to one social class or organization. Find spots for the figurines include royal and wealthy locations, mercantile abodes, and slum areas, and include both religious and secular contexts.

Map 4.1 Map displaying the distribution of 77 of the 121 figurines so far known in London. Top image displays general figurine distribution across Greater London, lower image displays a close up of those figurines found in Central London. (Map created by Author, using Palladio v1.2.4)



Key

Red – Religious figurines

Yellow – Toy Figurines

Green – Animal Figurines

Pink –Royal Figurines

Blue – Secular Figurines

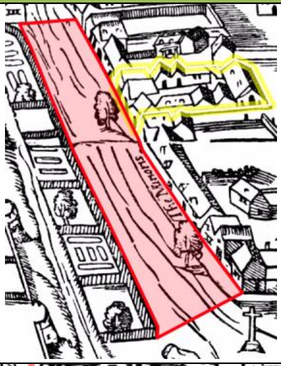
Map 4.2 Brief overview of figurine distribution on Roque’s 1746 map(Adapted map created by Author on John Roques 1746 Map of London [Public Domain]) .

An important element to understanding the nature of these figurines requires contextualisation within their final context of deposition. This, however, presents a significant issue for the current dataset, since only 21 out of the 121 London pipe clay figurines surviving for modern analysis can be can be assigned to a specific archaeological context, and that total only increases to 26 in total if the rest of the UK is included. Of the remaining figurines 19 have been recovered from the Thames foreshore, and whilst these demonstrate the styles of figurines circulating in London during the 16th – 18th centuries, specific contextual discussions cannot be presented for this group. A further 20 figurines have been donated to museums, often with only vague data concerning provenance, whilst 61 have been recovered during excavations within London but provided with limited details of their physical provenance due to minimal detail offered within the context sheets and excavation report. As a result, the following discussion will concentrate on the 26 figurines recovered in London and the rest of the UK which offer detail contextualised data, before expanding this examination into a brief discussion on those further 61 figurines found within London were some limited or generalised contextual data is available. The tables below present a summary of the 21 figurines found within detailed context, separated into the various context themes; Table 4.1 displays figurines connected to religious contexts, Table 4.2 presents figurines from wealthy/adult knickknack assemblages, Table 4.3 displays figurines which may be connected to public houses, and finally Table 4.4 presents figurine groups which may be connected to market places.

The most immediate conclusion from this overview suggests that in many cases there is a link between the iconography of a figurine and the function of the context from which it was recovered. For example, of the figurines which were recovered from religious contexts, Table 4.1, subject matters included: one Christ figurine, one Christ scene figurine, depicting one of the thieves crucified next to Christ, three clerics, one saint and one unknown cloaked figurine.

Figurines which have been assigned to secular contexts are presented in Table 4.2, including examples of personalised or finely detailed figurines, such as the Aldgate male and the green glazed lady from Baynards Castle. The Aldgate male figurine displayed personalised elements in the form of an individual's initials on a breast badge. This personalised figurine was recovered from a domestic, mercantile context which also included a wealthy assortment of imported accessories such as elephant ivory and tortoise shell, along with a rich assortment of food waste which included peacock, turkey, swan, and goose. An assemblage from Bishopsgate, London, consisted of a unique example within London of four different pipe clay figurines recovered within the same context. The cellar in Trench 18, consisted of a domestic assemblage which contained 24 different ceramic figurines, four of which were the formerly mentioned pipe clay figurines. The figurine assemblage has a date range from the late 16th century to the early 19th century, and may represent the remains of an individual's

Table 4.1Figurines recovered from religious contexts, with five from London and one from Wales.

Figurine	Site and Archaeological Context	Reference	Map
Crucifixion of Christ, Late 15th century Haydon St, London ID 94 NGR TQ33708105	During excavations within a two-roomed medieval structure a Christ figurine was recovered. The site was once the locations of the Abbey of St Mary Clare (highlighted in yellow on the map), which became the parish of the Holy Trinity Minories, 1539-1899. The two-roomed medieval structure lay within the late 13th century Franciscan Abbey. The land highlighted in red represents the Minories, land associated with the Abbey.	(Redknap 1997, 52), (MOLA 1990), (Agas Map 1561, with permission from London Metropolitan Archives, City of London SC/GL/AGA/00 Jenstad 2017)	
Cleric 1580-1670 Foster Lane ID 121 NGR TQ 32201 81320	The excavation area, highlighted in yellow, is the location of the Church of St Vedast. The site dates back to the 12th century and the church was later restored by Christopher Wren after the great fire in 1666. This site is dedicated to the French saint, with the original medieval church here being founded by the Flemish community in London in the late 12th century. The figurine was found in a brick cess pit on this site.	(LAARC 2017a), (Agas Map 1561, with permission from London Metropolitan Archives, City of London SC/GL/AGA/00 Jenstad 2017)	
Cleric 16th century Apothecaries Hall, London ID 125 NGR: TQ3173081030	This figurine was recovered from a basement context from the Apothecaries Hall site on Blackfriars. The site was originally the site of the Dominican Blackfriars Friary, but the site was purchased by The Society of the Apothecaries in 1630, with the buildings then being destroyed by the great fire in 1666.	(LAARC 2017b), (Agas Map 1561, with permission from London Metropolitan Archives, City of London SC/GL/AGA/00 Jenstad 2017)	

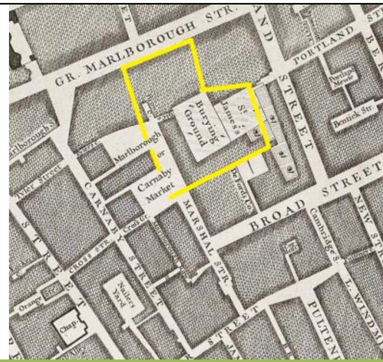
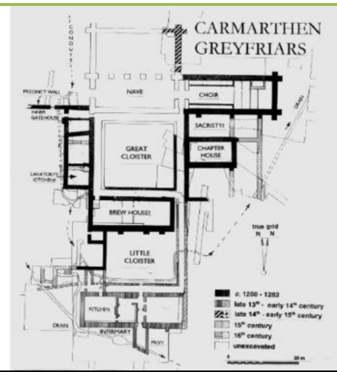
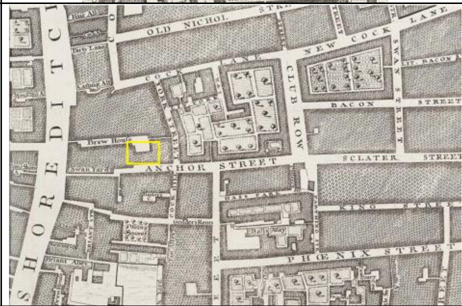
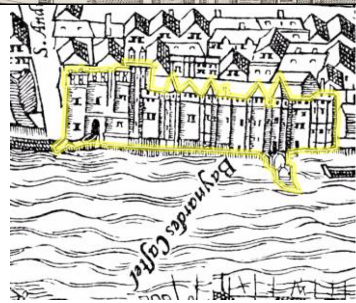
Cleric Late 16th – late 17th century Marshall street ID 13 NGR: TQ29338107	A largely rural area until the 17th century. The area where the excavation took place formed part of the Mercer’s Company during the 16th century. Afterwards the land was owned by the crown until late 17th century. Though no firm context can be connected with this figurine, it should be noted that the Mercers company practised collective religious worship, and each guild adopted their own patron saint.	(LAARC 2017c) (Sheppard 1963, 196) (Rocque's 1746 Map, 2013, Public Domain)	
Female, saint 17th century St Mary Overy(ie) ID 45 NGR TQ 32711 80312	This figurine was recovered from the St Mary Overy(ie) refectory crypt, Southwark. This church dates back to the 12th century, with continual use from there on.	(Personal contact with The British Museum 2016) (Walford 1878b) (Agas Map 1561, with permission from London Metropolitan Archives, City of London SC/GL/AGA/00 Jenstad 2017)	
Thief on a Crucifix, and cloaked figurine fragment 15th-16th century Carmarthen Greyfriars, Wales ID 163 and 164 NGR SN 41073 19991	One of the thieves crucified next to Christ figurine: context: SF.4051. C2. [930] layer of destruction dating the demolition of building 1324 in the post-suppression period, 16th century. Cloaked figurine: SF.3826. C1.[521]. Slate layer probably representing collapsed material from a possible pentice roof over the eastern Cloister alley, 16th century.	(Map from Redknap 1997 with permission From © National Museum Of Wales) (James and Brennan 1998, 2)	

Table 4.2 Secular Context

Figurine	Site and Archaeological Context	Reference	Map
Man with tip staff and cherub from Aldgate, London 1700-1720 ID 1 NGR: TQ3367081200	The Man with Tip Staff was recovered from building VII, within the cellar of what is assumed to be a wealthier residence in this section of Aldgate due to other related finds; rings, tortoiseshell fans, elephant ivory, and fine glass ware. Food waste included swan, peacock, goose, turkey, veal, and fowl. There was also a coin from the Netherlands found. The surrounding houses were trade/residential and seem poor. The cherub was recorded as unstratified.	(Weinstein 1984, 122-4) (Rocque's 1746 Map, 2013, Public Domain)	
Swan mid-18th C Urinating male mid-18th C, Lady late 17th C, Male with gloves 1820-50 Bishopsgate, London. ID 4, 5, 6 and 48 NGR: TQ 33540 82300	Within the cellar of Trench 18, 24 different ceramic figurines in contexts dated from late 17th century to 19th century were discovered. These ceramic assemblages were found among usual domestic assemblage of ceramics which included a combination of local wares, wider English wares and imported wares.	(Pearce and Birchenough 2008, 55) (Rocque's 1746 Map, 2013, Public Doman)	
Glazed Lady 16th -17th century ID 124 NGR: TQ3194080920	'Excavations revealed part of the North wing of the medieval Baynard's Castle, including the north gate and gate tower, the frontages of medieval houses between the medieval castle and the East Watergate dock; part of the north wing of the 16th-century addition to the castle; the cobbled entrance to the castle from Thames Street; and evidence for Thames Street before the Great Fire of 1666, such as its construction and narrow width. '	(LAARC 2017d) (LAARC 2017e) (Agas Map 1561, with permission from London Metropolitan Archives, City of London SC/GL/AGA/00 Jenstad 2017)	

King 1465-1522 Brandon House/ Suffolk Place, Borough High Street, Southwark ID 100 NGR TQ3241 7980	This site was once the residence of the Brandon family and was in their hands from 1465. Charles Brandon remodeled the house between1518-1522, although by 1562 the house style had fallen out of favour and was demolished and replaced with small tenements which became known as the Mint.		[redacted]
Lady $16^{th-17th}$ century Norwich castle ID 151 NGR TG 23186 08543	Female figure in flowing dress, decorated with stars figurine from Norwich recovered from a general post-medieval context.	(Ayers 1985,44)	
Sexless nude Picton Castle, Pembrokshire 18^{th} century ID 167 NGR SN 00811 13441	The figurine in a in a flower border of the stately home, along with some fragments of late 18th century wine bottles, although the date may be later.		
King 17thC Southampton, Canute's Palace Site ID 143 NGR SU 41952 11001	The figurine was recovered in 1959 from a pit north of "Canute's Palace", which is a merchant home in Southampton. It was found within a rectangular 182.88 cm pit which contained mainly early 18^{th} century items, with occasional 16^{th} and 17^{th} century items as well.	(Platt and Coleman-Smith 1975, 276)	

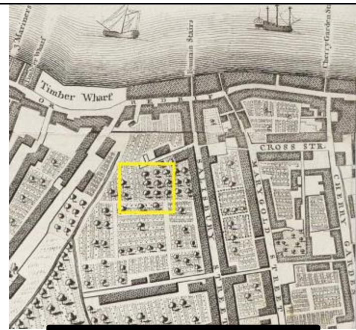
collection of ceramic figurines. There are also two examples of King figurines within Table 4.2 which have been recovered from higher status contexts, Brandon House and the Canute Palace. Once again this category shows an unsurprising correlation between the social contexts of the figurines and their iconography.

The iconography of figurines found associated with public houses, Table 4.3, is as striking as those which were found in relation to those from religious contexts. A figurine of an alluring female wafting her fan was recovered from the Ship and Ball tavern, and the male figure riding on a beer barrel was from the King's Arms public house. These bawdier styles of figurine are similar to those recovered in Germany and the Low Countries, which represented scenes common to the bath house, such as flirtatious women and scenes of drinking.

Finally, Table 4.4 shows those figurines which have been recovered from public spaces that may have served as markets or other locations where they may have been sold. Some public locations, with or without association with market areas, alongside the eclectic range of figurines which are recovered from these sites, may suggest the figurines belonging to a supplier with a range of items as opposed to an individual's personal collection. This suggestion is bolstered further as these figurines, though found in the same area, are not recovered from the same context, in comparison to the collection of figurines discussed previously which had been recovered as a group in the same context from a mercantile abode.

When considering context of use, a number of observations concerning the different types of figurines can be made. First, there appears to be a direct link between the figurines' iconography and the function of the site from which they were recovered. However, due to the small sample size of the contextualised assemblage it cannot be assumed that each of these iconographic representations was restricted to a single type of site alone; it does not intrinsically designate a form of iconography to one specific group, but allows for the concept of a fluid movement of iconographical repertoire between social groups. This concept of a transferring of iconography between social groups is further explored in Chapter 5, when the figurines which have been recovered from the British colonies in the New World will be discussed.

Table 4.3 figurines from taverns/public house assemblages.

Figurine	Site and Archaeological Context	Reference	Map
Female with fan, Old Ship and Ball Tavern, Southwark 17th century ID113 NGR TQ 33642 79660	The assemblage the figurine was found with suggests that of a pub, indicated by the corpus of drinking vessels, pipe fragments, eating implements and serving dishes, drinking glasses and bottles.	(personal communication with J. Pearce 2016)	
Cock on a column Cherry Garden's site, Bermondsey Wall East, Southwark 18TH century ID 123 NGR TQ34507968	The figurine was found in a brick lined pit abundant in pottery, roof tile, bone, glass, oyster, iron, brick, leather scraps, and domestic debris, particularly tableware and kitchen waste. Mr. J. Larwood, in his "History of Sign-boards, tells that after the Restoration this house [little Salisbury House] became a tavern; and discusses how Sam Pepys, on Sunday, April 14, 1667, took his wife and her maids there to give them a day's pleasure. Cherry Garden itself, the site of which is now covered by a street bearing that name, was a place of public resort in the days of the Stuarts. It is mentioned by Pepys in his "Diary," 15th June, 1664: "To Greenwich, and so to the Cherry Garden, and thence by water, singing finely, to the bridge, and there landed Edward Walford.”	(Rocque's 1746 Map, 2013, Public Domain) (Walford 1878a) (Larwood and Hotten 1875)	 [redacted]
Man on Beer Barrel 38-46 Albert	The south end of Trench 1, where this figurine was found can be identified as the Kings Arms (33 Princes Street), a public house known to exist from the manorial survey of 1785 and closed in 1869. Its construction date was probably slightly earlier the date of the manorial	(LAARC 1987) (LAARC 1988)	

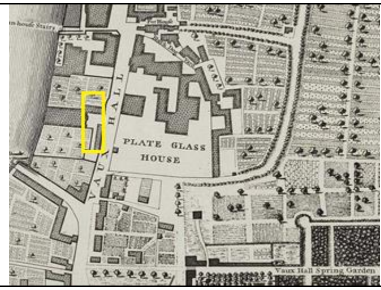
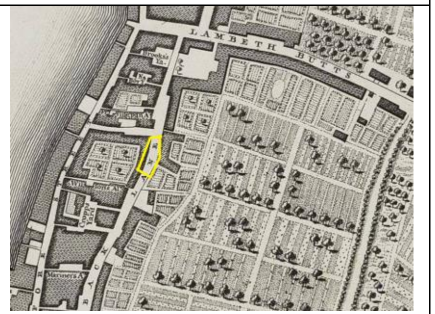
Embankment, Lambeth, London, England 18th C ID 126 NGR TQ30437835	survey. Behind the pub there was also a pottery, John Wisker who owns the Kings Arms also owns the pottery as shown in tax collections, with this information and the use of Rocque's map they indicated that the pottery was behind the public house in 1746. With the potter's name of 1788 being known George Moss. There was also a second pottery a few doors away on Princes Street.	(Dyson 1998, 157) (Rocque's 1746 Map, 2013, Public Domain)	

Table 4.4 potential market place assemblages and production assemblages

Figurine	Site and Archaeological Context	Reference	Map
Lady, King, Two Soldiers with muskets, Late 17th century 76 Eden Street, Kingston, London ID 95, 96, 99, 106 NGR TQ18186921	This area was established for boat building, tanning, milling, brewing, and river barge traffic. It was a flourishing market town that was helped further by Charles I who forebade any holding of markets in a seven-mile radius.	(LAARC 2017f)	
St Mark of Lions 1800-60 19 Albert Embankment, London ID 18 NGR TQ30547862	This site used to be called the Back Lane. Clay, charcoal, and other materials for the potteries in Fore Street and High Street (formerly Back Lane) and for the Vauxhall glasshouse were brought by water and the finished products were transported in the same way. Important shopping area.	(Girardon *et al.* 1988) (Gaimster and Weinstein 1989, 60) (Dyson 1998, 124) (Rocque's 1746 Map, 2013, Public Domain)	
Lion Bartholomew Street, Exeter Late 17th C ID 145 NGR SX 91632 92402	Kiln waste site - This came from a kiln waste site, around 17kg of pipe fragments were also found. The Bartholomew Street west site lies within the small parish of All Hallows-on-the-Walls. The only pipe manufactory known in this parish was that of the Burges family. Earliest reference to the family is in 1691 when William Burges becomes a Freeman of the City.	(Allan 1984)	

4.7 Chapter Summary

These figurines, which were quick to mass produce and whose iconography was adaptable, were the prefect medium to supply consumer demand in a range of areas. From commemorating monarchs and replicating church altars within the home, to providing children from all social backgrounds with the same gendered stereotyped toys that are often presented within wealthy portraits, these figurines appear to have penetrated all social spheres. Furthermore, it is apparent that these figurines catered to more explicit political and religious sentiments, with controversial symbolism, such as the cockerel imagery, the oak leaf (discussed in the following chapter), and the Virgin Mary, being present within this medium. The period when pipe clay figurines were at their most prolific in England was during a period containing significant social, political, and religious tension and change, including the Reformation, the Civil War, and the Restoration. As such, pipe clay figurines represent an avenue for observing the way in which these wider events disrupted, transformed, or were subverted within contemporary everyday art and artefacts. These figurines are important examples of personal objects, with a key aspect of these figurines being their slight stature. These small objects could be carried on a person discreetly, or hidden away during periods of political and religious persecution, and in many cases could represent several different elements of life. For example, a saintly figurine could serve as a focus of worship, be representative of the local parish church, a memento of travel, be representative of the patron saint of a guild, or a combination of these and more.

Pipe clay figurines were adaptable material culture for a wide variety of contemporary social issues. Their manner of production was relatively cheap and convenient for other professions, and they maintained a robust physical nature over other materials used for similar forms, such as lead or cloth. In light of these benefits it is unsurprising that these items were taken to the New World. Figurines which have been recovered within the New World will be discussed in the following chapter, since they will help to further bolster the understanding and contextualisation of figurines which have been recovered within London. A comparative examination also provides further understanding on their functionality and role within social contexts.

Chapter 5

Clay in the Colonies

With the gradual expansion of the English, French and Dutch colonies into America and The Caribbean, it is of little surprise that the range of domestic artefacts which have been recovered from these colonies show parallels to contemporary English and Dutch material culture. Pipe clay figurines, although not common within the colonies, are still present in certain areas. In total, nine colonies so far provide evidence for this material culture being transported across the Atlantic to a new home in North America and Jamaica (see Map 5.1). These figurines present an insight into the choices made by those who travelled across the Atlantic, whether due to economic opportunity or for freedom of worship, about what unessential items to take with them. As one such item, understanding the pipe clay figurines that are present is an important facet of this colonial life and may present a different image of worth that these figurines may have held to an individual. This chapter will first discuss the distribution and context of figurines which have so far been located in North America, before examining figurines found within the Caribbean.

So far the figurines that have been recorded in North America have been located along the East Coast; this is to be expected as there was no European colonization within the interior of America during the 16th to 18th centuries. Most of the domestic artefacts which have been recovered from colonists reaching the East Coast consist of practical items for day-to-day activities in these early English colonies. These consist of items such as pipes for smoking, pottery for eating, and glass for drinking. Rarely are items with low essential value for maintaining basic needs or widespread practices recovered, so the presence of nonessential pipe clay figurines are unusual. Their presence offers an interesting insight into how these new colonies connected to the broader popular religious and contemporary political trends which were circulating across Europe (Hurry and Grulich 2015, 1).

5.1.1 The Charles Gift Site at Patuxent River Naval Air Station's, Maryland

The Charles Gift site, also known as the Eltonhead Manor (Hornum *et al.* 2001, 47), (18ST704), was part of a 17th-century colony located on southern Maryland's western shore along the Patuxent River. Maryland itself was founded by the Calvert family, after being granted to them by Charles I as a proprietary colony in 1634. Five years after the founding, a Jesuit mission known as the Conception Hundred, or Mattapanient Hundred, was established at Cedar Point, land which was also granted to them by King Charles I. Initially this mission consisted of 21 inhabitants, but by 1642, this had grown to around 40. However, once Charles Calvert became the sole

Map 5.1 Map of the east coast of America and the northwest of the Caribbean. Red points show the sites where pipe clay figurines have so far been located in America, these include: the Charles Gift Site at St Mary's City, Maryland, the Duvall Middle Plantation in Maryland, St John's Site in Maryland, Van Sweringen in Maryland, New town in Jamestown, Virginia, Jamestown in Virginia, Mount Vernon in Washington D.C., Chaney's Hill in Anne Arundel County, Permaquid in Maine, Leonard Calvert Site in St Mary's City and the Drummond Plantation in Maryland.
(Map created by Author, using Palladio v1.2.4)

individual responsible for granting manorial parcels, the Jesuit inhabitants retroceded Mattapanient to the Calvert proprietary (Pogue 1983, 17-19). William Eltonhead then patented 2,000 acres of this land in 1648. After his execution in 1655 in the aftermath of the Battle of the Severn, and his wife's death in 1659, the land was shared amongst their four chosen heirs, one of whom was Thomas Taylor, Jane Eltonhead's son. Thomas disposed of the Eltonhead lands with a total of 600 acres being sold to Charles Calvert, the Third Lord Baltimore, in 1668 (Hornum *et al*. 2001, 48).

Henry Sewall, who emigrated to Maryland in 1661, was an early Secretary and Councillor of the Province of Maryland, a Judge of the Prerogative Court and in 1663 became Lord of Mattapani Manor and was granted the property and lands. These were then re-granted to his widow Jane in 1665 after his death. Two years later Jane married Charles Calvert who then appropriated the Mattapany property in the name of the proprietary. In 1668 Jane Sewall was awarded a patent of 2,000 acres of the Mattapany property, with the proviso that on her death this patent was to be passed to her son Nicholas Sewall. Within the patent, the land is referred to as '*the Mannor of Charles' Gift'* thereby converting the once named Eltonhead Manor into the Charles' Gift site (Hornum *et al*. 2001, 49). The Charles Gift Site was then past to Major Nicholas Sewall by his stepfather Charles Calvert, Lord Baltimore, and when Nicholas came of age, in 1675, Nicholas built his first home there.

Nicholas Sewall was a dedicated member of the Governor's Council and Deputy Governor, and achieved high positions and power within Maryland. It was this power which also ensured his association with severe difficulties within the area. The primary cause of Sewall's problems was the tentative relationship between the Roman Catholic Calvert's and the remaining Protestant population within the province. These disputes climaxed during confrontations between the popularly elected Maryland Assembly, which contained predominantly Protestant members, and the proprietor and his small but influential council to which Nicholas Sewall had been appointed the head. The Assembly charged the Calvert's with capricious political tactics that had attempted to limit the Assemblies power, and with excluding Protestants from holding positions of responsibility within the provincial government (Walsh and Fox 1974, 22). Charles Calvert took this issue back to England in 1684, where he aimed to defend his proprietary interests there, and while he was away, he named his nine-year-old son as proprietor in his absence. As the child was so young Charles specified that the Council should act as Government. However, the ejection of King James II and the ascension of the Protestant Monarchs William and Mary bolstered the Protestant opposition to the Catholics proprietary claims in Maryland.

As political tensions rose between the Catholic acting-Government and the Protestant Assembly, actions were taken by both parties to consolidate power: Council members appropriated arms and ammunition from the colony, efficiently disarming the general populace and arming themselves; and the Assembly further organized themselves, including appointing John Coode as their military leader. Newly organized and with better management of their power, the Assembly cornered the Council members in the garrison at Mattapany in July 1689. It is unsurprising that even though the Council members were offered surrender terms many chose to flee instead, including Nicholas Sewall, who in October 1689 fled to Virginia (Hornum *et al*. 2001, 50). Virginia was a common destination for many Roman Catholics fleeing issues, leading to a significant and notable Roman Catholic settlement towards the mid-seventeenth century. Nicholas Sewall returned to the Charles Gift Site on a number of occasions during his exile, during which visits he was accused and charged, alongside three of his companions, with the murder of a local Protestant revenue collector, which led to him fleeing once more to Virginia. Nicholas petitioned for clemency from the King, eventually gaining it on the second petition, and returned to the Charles Gift site, where he eventually died in 1737 (Hurry and Grulich 2015, 3).

Two fragments of a pipe clay English King figurine (Figure 5.1) were discovered in an extraction pit at the Charles Gift Site (the location of which is circled green in the site plan in Figure 5.2). The extraction pit was initially used for clay extraction for the construction of Nicholas Sewall's second house on the site. Once this structure was built, and the pit no longer required, it was then backfilled with the refuse from Sewall's first home on this site. The refuse in the pit shows that the former home was a timber structured building, and given that timber buildings of this date and region usually had a lifespan of 20 years before falling into disrepair due to termites, this narrows the date of the building to approximately 1675-1695 (Hurry and Grulich 2015, 3). This is further reinforced with the survival of dated window leads from the burrow pit feature that indicate a *terminus post quem* of 1682 and by the absence of specific ceramics, which taken together suggest the most likely date for this activity to be in the two decades before 1700. It is also of interest to note that these dates also fall within the period of Nicholas Sewall's occupation and struggle against the Protestant Assembly (Hurry and Grulich 2015, 3).

Figure 5.1 Front and back of kingly figurine found at the Charles Gift Site, Maryland. (Author's Image, with permission from the Station Patuxent River, St Mary's County, Maryland)

[redacted]

Figure 5.2 Site Plan of Nicholas Sewalls primary and secondary homes and clay extraction pit. (Plan adapted from Hornum et al. 2001, 177 figure 55)

Due to the lack of a surviving head for this figurine it is difficult to identify which of the kings it represents. That being said, because of the strong Catholic faith held by the Sewall family during this period, James II is a particularly inviting consideration for this particular figurine. A coin of James II with a hole drilled through it for use as a pendant (Figure 5.3) was found at George Brent's Woodstock Plantation in Virginia, where Nicholas took refuge when in exile and to whom Nicholas's sister had married, suggesting further links between Sewall and the Catholic royal image. A further suggestion that might be made is that this statuette was not only that of James II, but also that it had been purposefully broken in July 1689, during the Protestant uprising and the ransacking of Nicholas Sewall's home (Hornum *et al*. 2001, 170-173), although there is no direct evidence to support this.

The figurine is similar in form to 18 other known kingly figurines (see Table 5.1) which have been found across England, Ireland, the Netherlands and other locations in North America (Hurry and Grulich 2015, 4). Presently these figurines are thought (by Hurry and Grulich 2015; Hume 2001 and Grulich n.d.) to represent Charles I, Charles II, or James II. However, as these figurines are often found with no heads, combined with a lack of contemporary literature concerning these items, the precise king that these figurines represent can only be hypothesised. Such suggestions are based on the artefacts' context dates, and via broader comparisons of material culture in which kingly images are incorporated, such as commemorative dishes and other forms of commemorative ceramics.

These kingly figurines had the potential to make political statements during times of religious and political struggles within England and the colonies; for example, it is possible that displaying these kings, and by extension affiliation with the monarchy, may have been considered an act of sedition during the Cromwellian Republic. If such severe reactions were felt towards these kingly figurines, two things must be considered: first those who displayed the figurines in their homes must have felt incredibly strongly towards the monarchy, risking themselves to promote what they believed in. Second, if these figurines were condemned heavily by some, the lack of surviving heads on these figurines may not just be due to natural degradation of the objects but possibly the purposeful beheading of an image of the king, reflecting contemporary actions against Charles I. It may be assumed that not all those who looked upon these figurines did so with such scorn. Instead, relief and agreement may have been felt by onlookers, with the figurines providing a subtle manner of symbolising a series of opinions and values for others to observe and interact around (Hurry and Grulich 2015, 5). Furthermore a less alluring option must be considered as well, that these objects may have presented little more than *curios* that have naturally degraded over time and were eventually thrown out, with no ulterior motives involved.

Figure 5.3 James II coin pendant, from site 44ST130, Virginia (Image from Hornum et al. 2001, 174 Figure 44)

Table 5.1 List of kingly figurines and their locations.

Regal Figurine Reference	Location	Figurine height (cm)	Date
British Museum 1854,1130.43	White Chapel, London, England, UK	6.3 (no head)	17^{th} C
British Museum 1856,0701.1656	-	9.9 (no head)	17^{th} C
British Museum 1856,0701.1657	Thames foreshore, London, UK	7.62 (complete)	17^{th} C
British Museum 56, 0701, 1659 s13	Thames foreshore, London, UK	2.9 (Feet and base)	17^{th} C
Charles Gift	Maryland	14.8 (Missing head and lower legs)	17^{th} C
Charles Gift (fragment and have no picture)	Maryland		17^{th} C
Mareen Duvall	Maryland	4.45 (legs and base)	1670-1690
MOL A9188	England	9.7 (No Head or lower legs)	17^{th} C
MOL 21848	Moorfield, UK	7.16 (No Head or lower legs)	/
MOL GM181.1969.25134	Blackfriars, London, , UK	13.7 (No Head or lower legs)	17^{th} C
MOLA PPL11.1216.3113	Point Pleasant, London, UK	11.9 (no head)	/
Norwich	Pottergate, England, UK	5.1 (Legs and base)	1690-1730
Old Salem Toy Museum	Netherlands	7.62	/
PCA TBF10.173	Eden Street, London, UK	Complete, no measurements available	/
S'-hertogenbbosch	Netherlands	7.62	/
Southampton	Canute's Palace site, England, UK	12.7 (missing head)	17^{th} – 18^{th} C
Un-armoured king (Pers. Comm. with Steve Nelson)	Spring House, Ewell, Surrey, UK	7.11 (No Head or lower legs)	1700-1730
Waterfords Corporation C/60791233	Bakehouse Lane, Ireland	(no head), no measurements available	17^{th} C

5.1.2 St John's Site in St Mary's City

Excavations at St John's site (18ST1-23 and Figure 5.4) in St Mary's City, Maryland, began in the 1970s. This 17^{th}-century site was one of the first excavations in Chesapeake and concentrated upon artefact scatters recovered within plough soils. The site itself was built in 1638 by John Lewgar, and followed an English hall and parlour house design, otherwise referred to as a Lobby Entrance house (Miller 2006, 2). John Lewgar was the colony's first government administrator and owned one of the

Figure 5.4 The foundations of the St John's site (Image from Miller 2006, 1 with permission from Miller and ©Historic St. Mary's City)

first and busiest tobacco plantations in Maryland (Miller 2006, 1). Later Charles Calvert moved to St John's and subsequently became the Governor and third Lord Baltimore. He and his wife Jane Sewall relocated themselves to her plantations, known as Mattapany, 10 miles north at the mouth of Patuxent River, making them neighbours to the Charles Gift site (Hurry and Grulich 2015, 1). St John's remained under the ownership of the Calvert's throughout the 17th century, with a suggested abandonment date of *c*. 1715.

The site contains remains of a great house, alongside evidence for modifications, such as a detached quarter, a separated kitchen, and extensive fence systems dividing the land around the house into a range of activity areas (Hurry and Grulich 2015, 2). At this site the head of a pipe clay cherub was discovered in two pieces (Figure 5.5). This head would have most probably belonged to a free-standing Cherub, similar to the one found in Aldgate, London (now lost, although pictures of this figurine are still in existence). The break of the figurine followed the path of the mould seam, therefore a fused 3D reconstruction of this figurine was possible and can be seen in Figure 5.6. The back of the cherub head was recovered in 1974 within a layer of plough soil, whilst the face was recovered from backfill in 2004. Unfortunately, due to a lack of sealed archaeological contexts, the fragments can only be approximately dated. Although exact ownership of this figurine cannot be ascertained, consideration must be given to the fact that despite being an affordable product usually interpreted as belonging to servants or slaves, they could instead also be possessions of members of the main household, as has been suggested elsewhere (for example, George Washington's home in Mount Vernon, discussed in Section 5.1.6). The differing statuses of possible owners and their relative wealth would provide some information on the sentimentality behind these figurines, and provide evidence for a heightened sense of worth in comparison to their commercial properties. Furthermore, their presence within an area where art for pleasures sake was not widespread during the 17th-century, and with seldom mention of objects of art being present within probate inventories, their occurrence here becomes even more interesting.

Figure 5.5 Front fragment and back fragment of cherub head (Authors image's, with permission from Historic St Mary's City)

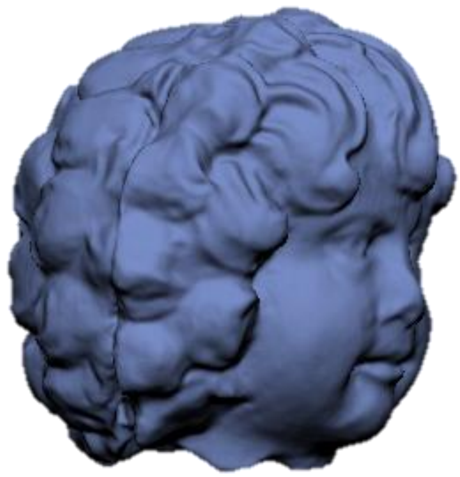


Figure 5.6 a fused 3D scan of the two halves fused together. (Authors 3D scan, with permission from Historic St Mary's City)

This figurine, along with others figurines recovered from North America (discussed in more detail below), brings into focus two separate theories. The first concerns the evolution of the joining between low-cost, mass production crafts with the use of, predominantly Catholic, religious figures, a movement which holds roots within the medieval period and demonstrates a gradual shift from church altar to home, partly due to religious scrutiny being experienced by many during this period. The second notion considers the developments in contemporary popular artistic styles, in this particular example the neoclassical movements, reproduced in a more affordable mass medium to cater for a more significant economic market. Both of these present the beginnings of two interesting questions which will be examined and discussed in more detail later in this thesis. These points are also relevant connections to Charles Calvert, an Oxford-educated man who would have been exposed to the latest continental fashions and highly aware of the neoclassical movement while simultaneously raised

Catholic by his Father, Cecil Calvert 2nd Baron of Baltimore (Hurry and Grulich 2015, 2-3).

5.1.3 The Van Sweringen Site

Although there was a strong concentration of English settlers in Maryland, other nationalities were also present. Excavations at the Sweringen house, Maryland (Figure 5.7 and 5.8), began in the 1970s, revealing the 1670s house of Garrett Van Sweringen, an immigrant from the Dutch Colony of Delaware, with a mission to reinvigorate the Dutch colony of New Amstel, on the Delaware Bay. This trip did not come without peril, especially after Sweringen was shipwrecked and lost most of his possessions (Hurry and Grulich 2015, 6). Sweringen then moved to Maryland after losing his fortune when the English captured the Dutch colonies in 1664. Concurrent with his move to Maryland was the building of what was to be the Council Chambers, a single story, two-bedroom building constructed by William Smith at the request of the Assembly. This building remained empty until around 1678 when Sweringen occupied, repaired, and expanded the structure, making it into a private house for lodgers during meeting times of the Provincial Court or Assembly (Hurry pers.comm.,). The structure was frequently used for the governor's council meetings and as a public records office throughout the 1680s and 1690s. Eventually, Sweringen was appointed to alderman of St Mary's City and a Sheriff of St Mary's County by Cecil Calvert.

As Swerigen's capital grew stronger so did his trade links, reaching from North America to England, Jamaica, and Ireland. During his lifetime in North America Sweringen married twice, the first time to Barbara, a lady native of Flanders, and after her death he married a 17-year-old English girl, Mary Smith, in total fathering ten children with these two wives. After Sweringen's death in 1698 the property, which in the inventory at his death consisted of 1,500 acres of farmland, St. Elizabeth's Manor, and four African slaves, passed to his son Joseph, then to William Deacon, Joseph's widows' new husband. A dated William Deacon glass bottle seal suggests the site was abandoned around 1750, when William moved to his own home at Rosecroft Point (Nancy. n.d. 1-3).

Figure 5.7 Van Sweringen site during excavation (Image Courtesy of Historic St. Mary's City, Hurry and Grulich 2015, 6)

Figure 5.8 Reconstruction of the Van Sweringen House (author's image)

Among the thousands of artefacts recovered from this site were two figurines. Unfortunately, both figurines were from plough soil contexts, so the depositional history may only be attributed to the general period when the site had been occupied. The first are two fragments from a Madonna statuette (Figure 5.9), which, like the cherub mentioned previously, also broke along its moulded seam line. One of the fragments shows the face of the Madonna with crown and headdress and the second shows the back of her head and crown. This fragment is very similar to other examples found in the UK (LAARC, LIG88, 9, 17; The British Museum 1854,0814.9 and 1855,0512.17; ID 3, 26 and 27 respectively in Appendix 1), Utrecht (Central Museum, Inventory Number 1856, Table 8.2), and Maryland (Figure 5.16).

This Madonna figurine, as well as other finds from the site, such as the copper alloy religious medal which depicts the Blessed Aloysius Gonzaga upon it, suggest that Sweringen may have been Catholic and public about his religious choosing. Furthermore, it is tempting to postulate that this figurine may have found its way into the soil after the ceremonial burial of damaged, blessed, religious objects; a procedure, although not detailed in canon law, still a tradition carried out enabling individuals to dispose of broken religious items (Hurry and Grulich 2015, 6). This, however, may be a fanciful idea, and the figurine may have just been discarded after it had been broken, with there being no significant meaning behind either the breaking of the object or the disposal of it.

In addition to the Madonna figurine, another pipe clay figurine fragment was also recovered (Figure 5.10). This fragment of a pair of legs appears to have a leaf attached to the back of the calves. It has been suggested that this fragment could represent Eve, with the leaf being that of a fig (Hurry and Grulich 2015, 7); however the figure also appears to be wearing clothes as seen on the detail above the leaf. Furthermore, parallel examples of this piece occur at the Duvall and Mount Vernon sites, both of which are discussed below (see Figure 5.11 and 5.12). The legs and leaf of both these examples belong to ‘gentlemen’ statues and both offer the same trouser trim and leaf design as that seen on the figurine from the Sweringen site. The oak leaf itself could signify a range of meanings from location related symbolism, with many countries and regions using oak leaves as part of their emblem, such as Germany or Derry in Ireland. The oak leaf was also employed as a political symbol by the Jacobite’s, who frequently employed this imagery in their artwork (Figure 5.13), medallions (Figure 5.14) and on glassware for societies such as the Cycle Club (Glasses and Relation 1921a). Finally, however, there are also a significant amount of classical references to oak leaves, possibly meaning that this motif was a fragment of a more decorative, secular object with touches of neoclassical designs upon it.

Figure 5.9 Madonna statue fragments, (front 1.94 in / 4.96 cm , back 1.29 in / 3.28 cm) 18ST1-19-297C/AA and 18ST1-19-332H/AA (Authors image, with permission from Historic St Mary's City)

Figure 5.10 Gentleman statue with oak leaf. (.69 in / 1.75 cm tall) 18 ST1-19-259/AA (Image Courtesy of Historic St. Mary's City, Hurry and Grulich 2015, 7)

Figure 5.11 A male figurine with acorn leaf from Mount St Vernon. (Image belongs to the author courtesy of George Washington's Mount Vernon)

Figure 5.12 A figurine from the Duvall Plantation. (Image from Doepkins 1991)

Figure 5.13 Portrait of Prince Charles II with oak leaf to the right of the image, British Museum Collection (Figure 11 from Glasses and Relation *1921)*

Figure 5.14 The Oak Medal of Charles II (Figure D from British Numismatic Journal vol. V p.251 in Glasses and Relation 1921, 260)

5.1.4 The Mareen Duvall Middle Plantation, Annapolis, Maryland

Mareen Duvall was a French Huguenot who had lived in Brittany, but who emigrated to Maryland due to the French governments' oppression of Huguenots. During his years in Maryland Duvall rose from an indentured servant to carpenter, and finally gentleman reaching his economic heights as a plantation merchant. By the time of his death Duvall owned around 3,000 acres of land and an estate worth £1,400 (see Doepkens 1991 for more details). There was a range of figurines discovered on the

Duvall Plantation. These consisted of the fragments of a pipe clay king (object 7 in Figure 5.15), one complete Madonna figurine (Figure 5.16), a Madonna with 'battered midsection', and a partial gentleman figurine (Figure 5.17), which once again has an oak leaf placed at the rear of his legs. Six further figurine fragments were also recovered (Figure 5.15), and these consisted of: a lady's headdress, an elbow with pleats, a potential back of cupid head with ringlets, upper body fragment of a lady, another arm with pleats, and an epaulet. All the pipe clay figurine fragments were recovered from contexts dating to between 1670-1690 (Doepkens 1991, 150). The symbolism of the assemblage could be argued to demonstrate a Catholic predisposition, with the presence of two Madonnas, one with Child. The assemblage could also reflect a potential supporter of Charles II, given the remains of a kingly figurine dated to 1670-90, and, hypothetically, having a possible Jacobite association, if the oak leaf is to be taken to signify that category of symbolism. If true, this may argue that this assemblage may not be directly related to Mareen Duvall, a French Huguenot and protestant.

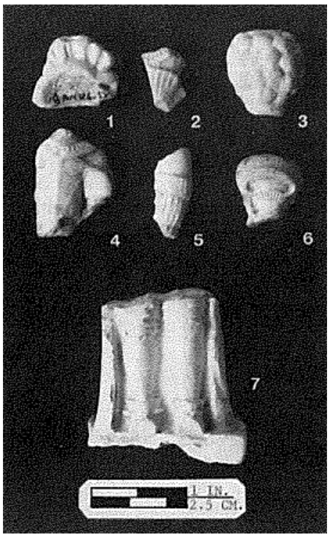


Figure 5.15 Seven of the ten pipe clay figurine fragments found on the Duvall. (Doepkens 1991)

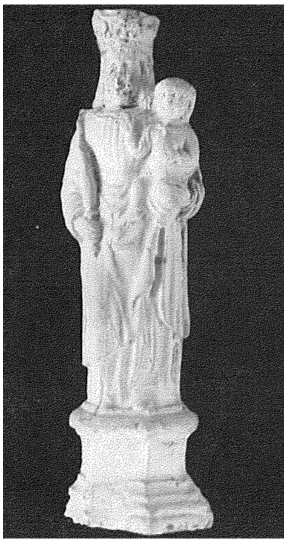


Figure 5.16 Complete Madonna and Child. (Doepkens 1991)

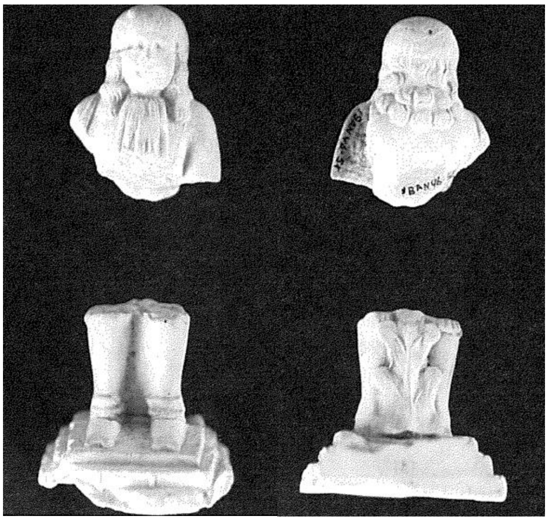


Figure 5.17 Front and rear of Gentleman with oak leaf symbol figurine. (Doepkens 1991)

While this assemblage of pipe clay figurines is the largest recovered in America there is very little data available to assess the collection, making it difficult to draw conclusions. These figurines belong within a private collection with admission no longer allowed. This issue is compounded by the limited contextual records associated with them, mainly limited to a single report covering the private amateur excavations carried out on the site (Doepkens 1991). There is no mention of the figurines in the Inventory of Duvall's estate (Doepkens 1991 23-31), which may suggest that these figurines were not in his ownership. In the patent records of land ownership it states that in 1664 Duvall received his land grant to the Middle Plantation, of which 250 acres belonged to John Ewen, 50 acres belonged to Thomas Parsons, and 300 acres belonged to Andrew Skinner (Doepkens 1991, 3-5). Both Ewen and Parsons died in 1664, the year of Duvall's land grant (Heritage-Consulting 2003; Ancestry Family Trees 2018). Furthermore, Duvall was married three times, but there are no records concerning who the first wife was, and only the first name of the second wife is known, Susan. More information is known about his third wife, Mary Stanton, who survived Duvall and later married Colonel Henry Ridgely. Duvall resided at the Middle Plantation site with his family, and it is there that he died in 1694, possibly being buried in one of the 39 unmarked graves from this period which have also been discovered during excavations on the site (Doepkens 1991, 16). With the land being previously divided into three ownerships and then the later corpus of individuals whom resided on this site, the individual who possessed these figurines will remain unknown, and the true significance of these figurines, whether as baubles, religious or political symbolism, or children's toys, undetermined.

5.1.5 James Fort and New Towne

Settled by the English in 1607, James Fort and the later New Towne combine to offer an extensive and diverse range of material culture (Straube 2013, 263). The fort itself (see Figure 5.18 for reconstruction) remained the nucleus of the colony into the 1620s and within it were the domiciles of the first governors, as well as other amenities such as the first church, storehouses, and wells (Straube 2013, 263). After the 1620s, New Towne, to the east, began expanding, as the population from the fort spread. With such a dense concentration of activity, it is unsurprising that around 2 million artefacts have been recovered from the fort site alone. The artefacts that have been recovered from both the fort and New Towne not only help to further our understanding of this colony and its position in the Atlantic world context but also helps to reveal more about early 17th-century England, and specifically London. This colony was established, administered, and funded by the Virginia Company as an entrepreneurial investment under a charter from James I, and was predominantly supplied by London merchants and populated by people from London (Straube 2013, 265). Initially, the colony consisted of 300 men, many of whom were gentlemen and shareholders who paid for their transport as well as their families and servants. Individuals with essential skills related to resource extraction were required at James Fort, with little initial intention to transport anything 'unessential' to the new colony. These labourers and specialists had their transport subsidized by the Company and it was presumed that resources such as food could be bartered from the indigenous Powhatan rather than have farmers transported over from England (Straube 2013, 265).

John Smith's condemning statement concerning the lack of preparation for provisions offers us an insight into the specific tradesmen who were sought after and taken to the new colony. His views on the causes of the siege of the town by the Powhatan during famine in 1609, places blame upon the need to turn a quick profit demonstrated '*by sending . . . so many Refiners, Gold-smiths, Jewellers, Lapidaries, Stone-cutters, Tobacco pipe-makers, Imbroderers, Perfumers, Silk men with all their appurtenances*' (Smith 1986a, 272) and with ignorance towards the needs of basic survival. Abundant quantities of tobacco pipe fragments were found in the fort's earliest contexts, and there was a documented presence of clay pipe makers in the fledgling colony logged in official records, for example Robert Cotton, a tobacco pipe maker who arrived in Jamestown in April 1608 (Smith 1986b, 162). Importantly for this thesis, there was clear presence of tobacco clay pipe makers from the earliest contexts of the fort, and these individuals may have been responsible for the manufacture or use of the figurine recovered from James Fort and the ceramic mould from New Towne.

Excavations at James Fort produced the pipe clay head of a lady wearing a 15th-century horned hat (Figure 5.19, Straube 2011, 67). This fragment was contained within a context dated between 1607-1610 and was part of a single deposit within a ditch associated with the western Bulwark of the Fort (personal communication with Bassett 2016). During excavations on the site of New Towne a ceramic mould of a soldier figurine was found (Figure 5.20). This small mould suggests that not only were individuals importing or emigrating to America with these figurines, but they were also attempting to produce their own pipe clay figurines once the colony was established. The mould itself was found in refuse pit 2 (see Figure 5.21), next to feature 17. This refuse pit was clearly dated to the 18th century through the associated ceramics and mid-18th-century wine bottles, while the pipe stems mostly dated to 1700-1750. The refuse pit was located at the nucleus of 20 houses (Cotter 1994, 151). Both the soldier mould and the lady's head may indicate the presence of children at the initial stages of colonisation in America.

Figure 5.18 Reconstruction of the James Fort site (With permission fromn Straube 2013. 264, Figure 1)

Figure 5.19 Lady in Horned Hat, head.
(With permission from Straube 2011, 67)

Figure 5.20 Ceramic soldier mould (Authors Image, with thanks to the NPS, Jamestown, Virginia, USA)

Figure 5.21 Archaeological Base Map of the Site of James Towne, the green circle indicates refuse pit 2. (Adapted from the US Department of the Interior, NPS, Colonial National Historical Park Map)

5.1.6 The Washington Residence at Mount Vernon

Excavations at George Washington's plantation at Mount Vernon revealed two further pipe clay figurines discovered in the South Grove midden. These two figurines (Figures 5.22 and 5.24) are of a female in country attire standing with a dog or a lamb next to her, and of a gentleman with staff and hat, once again with the remains of an oak leaf on the rear of his legs. The crude nature of design on the female figurine may suggest that this figure was a toy rather than a household ornament, with noticeable mould lines still seen running along the edges of the figurine. The gentleman is of slightly better quality, and could thus have served as either a child play toy or a mantelpiece ornament. The figurines were found within phase 1 of the south grove midden, dated to 1735-1758 by associated finds. This phase holds the earliest group of finds within the midden, and represents episodes of cleaning directly related to the main household, particularly around the death of Lawrence Washington, George Washington's older half-brother. These episodes were proposed due to the significant degree of matching ceramic sets found in this phase of the midden.

It cannot be known for sure for whom these figurines were produced for, whether one of the many children who were associated with both Lawrence Washington and George Washington, or whether these figurines were household ornaments. However, it is clear that these figurines were directly related to the leading household members. The resident slave quarters were located much further to the north of this estate (see Figure 5.25 square 6) where their refuse pits were uncovered in an area separate from those of the main households. Significantly, invoices have survived which demonstrate that George Washington was importing toys from London for his children (Figure 5.27 and 5.28), although what toys these were is unknown. However, the correlation of toys on site and importation receipts does provide some context for the presence of these figurines, and may tie their use to the children on site.

Figure 5.22 Lady with dog, front and rear (Author's Images with thanks to the Mount Vernon Archaeology Department)

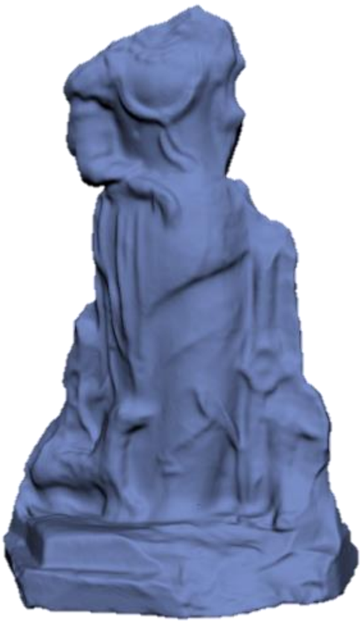


Figure 5.23 3D model of the front of the lady (Author's 3D model with thanks to the Mount Vernon Archaeology Department)

Figure 5.24 Front and rear of Gentleman with staff and hat, with Oak leaf on the rear of his legs (Author's Images with thanks to the Mount Vernon Archaeology Department)

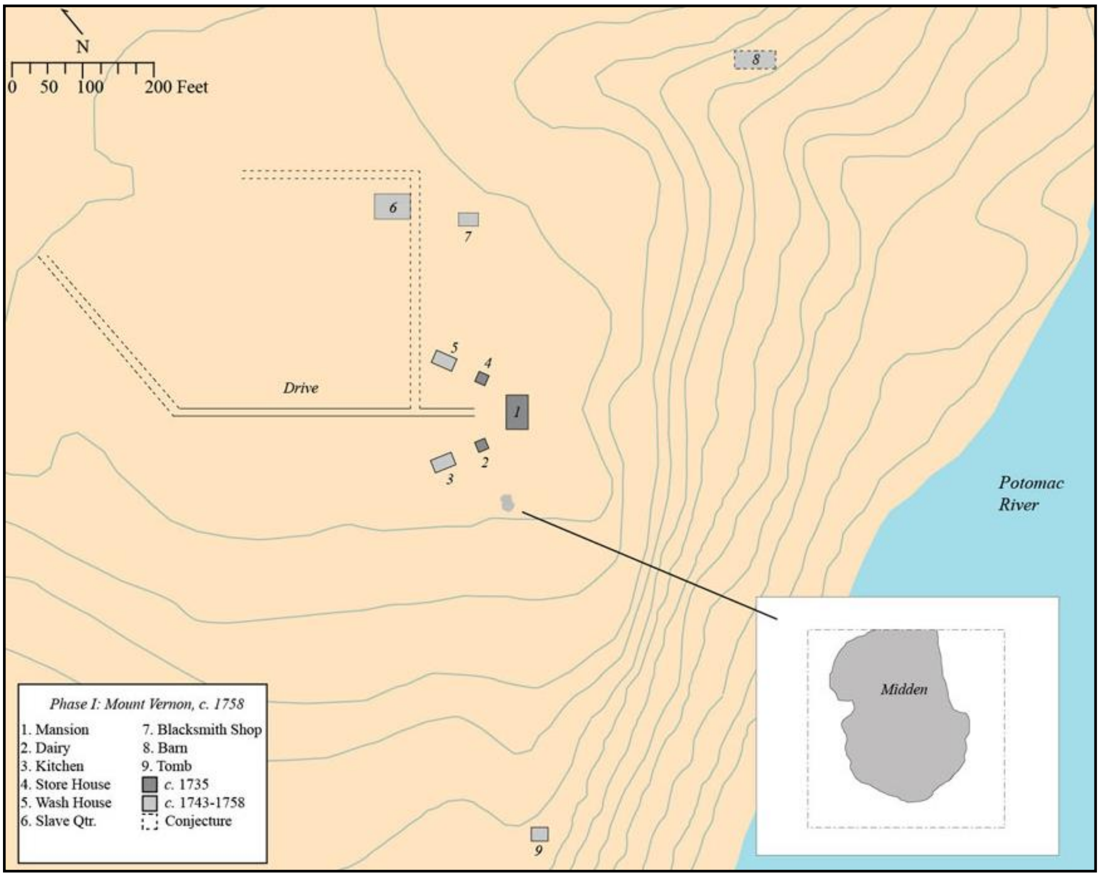


Figure 5.25 A Site map to display the location of the midden and also the slave quarters, marked nos6. (Map provided with Permission from Mount Vernon Archaeology Department, mountvernonmidden.org/hpages/chronology.html 2013)

Figure 5.26 Image of George Washington's Home taken in a NE direction, the midden was located in this grassy area. (Author's image)

[redacted]

Figure 5.27 Invoice from R. Cary & Co. Showing Purchase for Patsy Custis from London toy Store Unwin & Wigglesworth ‘from Unwin & Wrigglesworth— ‘3 Neat Tunbridge Toys 1/’
(R. Cary & Co. 1760, courtesy of The Library of Congress, Washington, DC, accessed 21.12.15 15.53)

[redacted]

Figure 5.28 Invoice from R. Cary & Co. Showing Purchase for Jacky Custis from London toy Store Unwin & Wigglesworth (R. Cary & Co. 1760, courtesy of The Library of Congress, Washington, DC, accessed 21.12.15 15.53)

5.1.7 Chaney’s Hills Site, Anne Arundel County

The Chaney Hills Site, which was 100 acres in size (Doliante 2004, 105), is located in Riva along Flat Creek, a tributary of the South River in Anne Arundel County. Richard and Charity Chaney founded the site in *c*.1658. Richard Chaney was an Anglican Englishman born in St Johns, London, where he was also baptized. He later emigrated to Maryland in 1658 and appears on the Passenger and Immigration Lists Index (Gibb 1997, 46). He was later buried in All Hallows Parish Church cemetery, part of the Anglican Church after it was established as the formal church of the Province of Maryland through an Act of the General Assembly (Ridout VI 1969). In Richard Chaney’s will it makes mention that he had three daughters, three sons, and at least one female servant, who is mentioned in his probate inventory, and thus it can be assumed that there was a minimum of around nine residents at the site (Maryland Archaeological Conservation Lab 2014a). After Richard's death in 1686, John Gray purchased the property for ten thousand pounds (weight) of tobacco in 1707 (Doliante 2004, 108), though archaeological evidence suggests that John never took up residence at the site (Luckenbach 2004).

At the site two footprints of mid-17th-century earthfast structures were found, alongside an assemblage of artefacts typical for sites from this period in Chesapeake. The material included: Borderware, North Devon graffito slipware, sprig-molded blue and manganese-decorated Rhenish stoneware, English brown stoneware, Rhenish brown stoneware, and lead-back tin-glazed Delftware (Maryland Archaeological Conservation Lab 2014b). The assemblage also included five pipe clay figurine fragments, all of which were dated to the mid to late 17th century. Although two of these fragments are too small to be positively identified, of the other three fragments (Figure 5.29 and 5.30), two were part of the same figurine, both displaying gentleman imagery. Within the archaeological assemblage, a large collection of tobacco clay pipe fragments were also recovered, 1,689 in total. While many of these fragments display no makers marks, those that are present indicate manufacturers from England, particularly Bristol and Chester, and include pipes attributed to Llewellin Evans, Henry Artus, and James Fox. The analysis of the pipes recovered on this site, reinforced by existing archival records and other ceramics that were also part of the assemblage, support the theory that Chaney's Hills was occupied from its founding in 1658 until just before Richard Chaney's death in 1684 (Callage *et al.* 1999, 32). This places the ceramic figurines recovered on this site during this period of occupation as well.

Figure 5.29 These two fragments of the same figurine, long coated gentlemen, the fragment to the left displays the rear of the lower half of this gentleman from hips to knees, and the right fragment shows the front of the gentlemen, again from the hips to knees. (Author's images, with thanks to Historic Londontowne's archaeological laboratories)

Figure 5.30 The fragment on the right displays the rear of a male's head. The fragments are dated to the mid to late 17thC. (Author's images, with thanks to Historic Londontowne's archaeological laboratories)

Little more can be discussed about the figurines, their use, and who owned them, nor whether they were of brought by the family upon first settling the site or imported later, like the tobacco clay pipes. While similar figurines of gentlemen have displayed oak leaves on their lower quarters to the rear, there is no oak leaf present on this figurine. This is either due to a lack of survival or this aspect of iconography having never been present on this figurine. The tip of the oak leaves are often very prominent immediately after the figures coat tails, with the leaf tip often being placed between the coat tails, as seen in figure 5.24. If the oak leaf symbol is representative of Jacobite sympathies, as suggested in 5.1.4, it seems likely that this symbolism may have been present upon this gentleman figurine. It should also be remembered that the inclusion of an oak leaf was not a prerequisite of this style of figurine, as seen by the male figurine with a tip staff recovered from Aldgate, London (appendix 1, ID 1).

5.1.8 Port Royal, Jamaica

Port Royal, Jamaica, is an example of a British settlement established outside of North America that also included pipe clay figurines amongst their assemblages. Established in 1655, Port Royal swiftly grew in size to become a centre for privateers and buccaneers, with a correlating adjustment to amenities that better catered for a consumer market which had a taste for the lavish living (Hume 1986, 6). The site was also impacted by a series of natural disasters, causing the settlers to rebuild large areas of the fort and site several times. This constant pattern of natural disasters followed by rebuilding presents an interesting but complicated array of archaeological strata. An effort to further understand this stratigraphy was made by Hume in 1967 when he excavated a 5ftx5ft test pit (Figure 5.31) in the SW corner of a walled dockyard, in an area that had previously been occupied by an 18th-century stable (Hume 1986, 8). Evidence of a fire prior to the construction of the stables was discovered within this test pit. The fire which had caused the previous building to collapse had burnt the roof tiles so fiercely they had re-melted *in situ,* unintentionally creating a protective seal to the stratum beneath it. Beneath the roof tiles survived an array of heavily burnt ceramic finds. Due to how heavily vitrified the ceramics were, identification of the wares in many cases was impossible. However, a few easily recognisable artefacts include part of a small apothecary's delftware ointment pot, English delftware plates, mugs, English brown stoneware, and a fragment of a Gentleman pipe clay figurine (Figure 5.32) (Hume 1986, 8-10). Records which discuss this fire, though not detailed, indicate that it occurred on the 9th January 1702/3 due to carelessness within a warehouse, and it consumed 'all ye Town, and left not one house of it standing… especially merchants are ruin'd' (Hume 1986, 12). There is little else known about the context of the pipe clay figurine, but once again the presence of this figurine indicates the prevalent spread of these items across the Americas.

[redacted]

Figure 5.31A location, plan, and section of the 1967 test pit (Hume 1986, Figure 2 and 2a, 9-10)

[redacted]

Figure 5.32 The pipe clay figurine which was discovered within the test pit (Hume 1986, Figure 2 and 2a, 9-10)

5.1.9 Miscellaneous Models

The sections above discuss the figurines for which detailed contexts and archaeological reports were available. There is a selection of further figurines from America which have not been mentioned thus far, due to a lack of detailed information and publication on these figurines. These figurines include a 17th-century horse figurine discovered on the Drummond Plantation (M. Outlaw, pers.comm), a fragment of the head of the Madonna and child recovered within plough zone excavations at the birthplace of George Washington in Westmoreland County, Virginia (Chester Harris, National Park Service, pers.comm), and several figurines which have been found within Virginia, Rhode Island, and at Fort Ouiatenon in Indiana (Hurry and Grulich 2015, 1). Unfortunately, other than these limited descriptions more details on these figurines are currently not available.

5.2 Chapter Summary

The presence of these pipe clay figurines, cheap, unessential items of limited practical importance, within the English colonies demonstrate the figurines underlying significance they held for their owners. The often high-status nature of the contexts in which these figurines were found reveals the potential worth and respectability of the objects, located within gentrified households, from wealthy landowners and merchants to politicians and statesmen. Unfortunately, in all cases there was no way to tie the individual figurines to a specific owner, whether the owner of the property, the children of the main household, servants, or slaves, but in some cases it was possible to tie it to a particular building or group living on the property. For example, at the Washington residence at Mount Vernon (section 5.1.6) it was clear the figurines belonged to members of the main household, since they were discovered amongst the refuse of the main house, not the slave refuse pits.

By examining figurines from London in conjunction with those recovered from the English colonies a more comprehensive understanding of the figurines distribution can be ascertained. What is most clearly seen is an appearance of these figurines across the social spheres. Often the figurine’s imagery was pertinent to the context in which it was found, for example saintly depictions and representations of Christ and the Virgin Mary were found in homes owned by Catholics, or their areas of worship. Kingly figurines seem to have a connection with the households of elites and local statesmen, whist the more generic figurines, such as small gentlemen and ladies, were found within households where children are known to have resided. These figurines coupled with their context therefore give us a glimpse into the daily lives of their contemporary audience.

Close examination of these figurines combined with 3D modelling and computer-generated distribution mapping will allow an increased understanding of their symbolic roles, functions, and social topography (Gaimster 2015, 63). Such work also provides some evidence for the development on their distribution routes from original production site to final deposition. A methodological and analytical critique of these methods can be found in Chapter 6, which will then lead into Chapter 7 where these methods will be applied to the pipe clay figurines included within this thesis. These approaches allow for further understanding in the similarities and differences in consumer’s desires between countries, as well as enable the identification of figurine generations and families. By understanding the level of similarity of both details but also exact manufacturing will increase the visibility of the trade and movement of figurines from areas of production to markets and houses around the Atlantic. Ultimately, this will help with ascertaining any contextual trends in their manufacturing, trade, and use in Britain and the colonies.

Chapter 6

A Critique & Contribution to Current Product and Mould Comparison Analysis

Within the history of moulded artefact studies there have been many attempts to produce precise methodologies to interpret mould and product lineage and relationships, an approach known as mould generation analysis. The process and purpose of mould generation analysis is to assess moulds and/or their sequential products via a series of measurements and visual examinations to comprehend the moulds/products lineage. The study aims to create mould and/or product ancestry from the archetype, which is the first generation of a mould through each proceeding stage. These stages vary between the production of moulded products, or sequential moulds. As items are produced, they become further removed from the archetype and reduce in size as the lineage grows. It is these slight size variations which can be used to analyse mould generations. Mould/product anomalies and scarring can further aid this study. A defective mould, which marks its products with a unique 'scar', acts as a signature and aids researchers in product and mould matching. Chart 6.1 lays out a hypothetical sequence of mould and figurine generations.

The master mould is rarely directly used during production; instead the master mould is used to make a series of copy moulds. These replicas are then repeatedly copied and it is this generation of moulds which, for the example of this thesis, are used in figurine manufacturing directly. Overall this is an economically cheaper method as it ensures the master moulds are preserved, and avoids the re-employment of mould carvers to reproduce the original master mould design. Methods which are employed archaeologically during object generation analysis currently consist of visual side by side comparisons assisted by specific feature measurements using callipers. When side by side comparisons are not permissible, sketches and scaled photos are employed. Currently, there are no standardised computer-based comparisons of moulded objects applied within these studies. An example of this form of study can be seen in Nicholls (1952), who employed it to study mould generations on Greek mould-made terracotta from the archaic periods is presented (Nicholls 1952, 217). Other studies include Willmott (2000), whose study examines post medieval Lion Glass stems generations; Friederich and Conijn (1967), who attempted to produce a clear generational timeline based on stylistic analysis of pipe clay figurines (Van Den Dorpel 2013, 22) Marianne Stern (1995) who created a large corpus of materials detailing methodologies connected with moulded glass bottle generations; and Lledó (1997), study which analysed a large corpus of fragmented glass vessels recovered from the seabed from the Serçe Limani shipwreck. All these studies produced methodologies for analysing mould and product generations, and they will be discussed in more detail within section 6.1.

Following on from these reviews a new methodology for mould generation analysis will be presented. This method will offer more metrically accurate results concerning generational analysis and figurine pairing. It will also provide a statistical analysis of metric errors that arise due to variables occurring within the manufacturing and archaeological processes, such as firing and erosion that cause surface variations between objects. Following the exploration of errors, the results for matching a range of pipe clay figurines, using both SfM and the NextEngine will be presented, and the accuracy of results discussed.

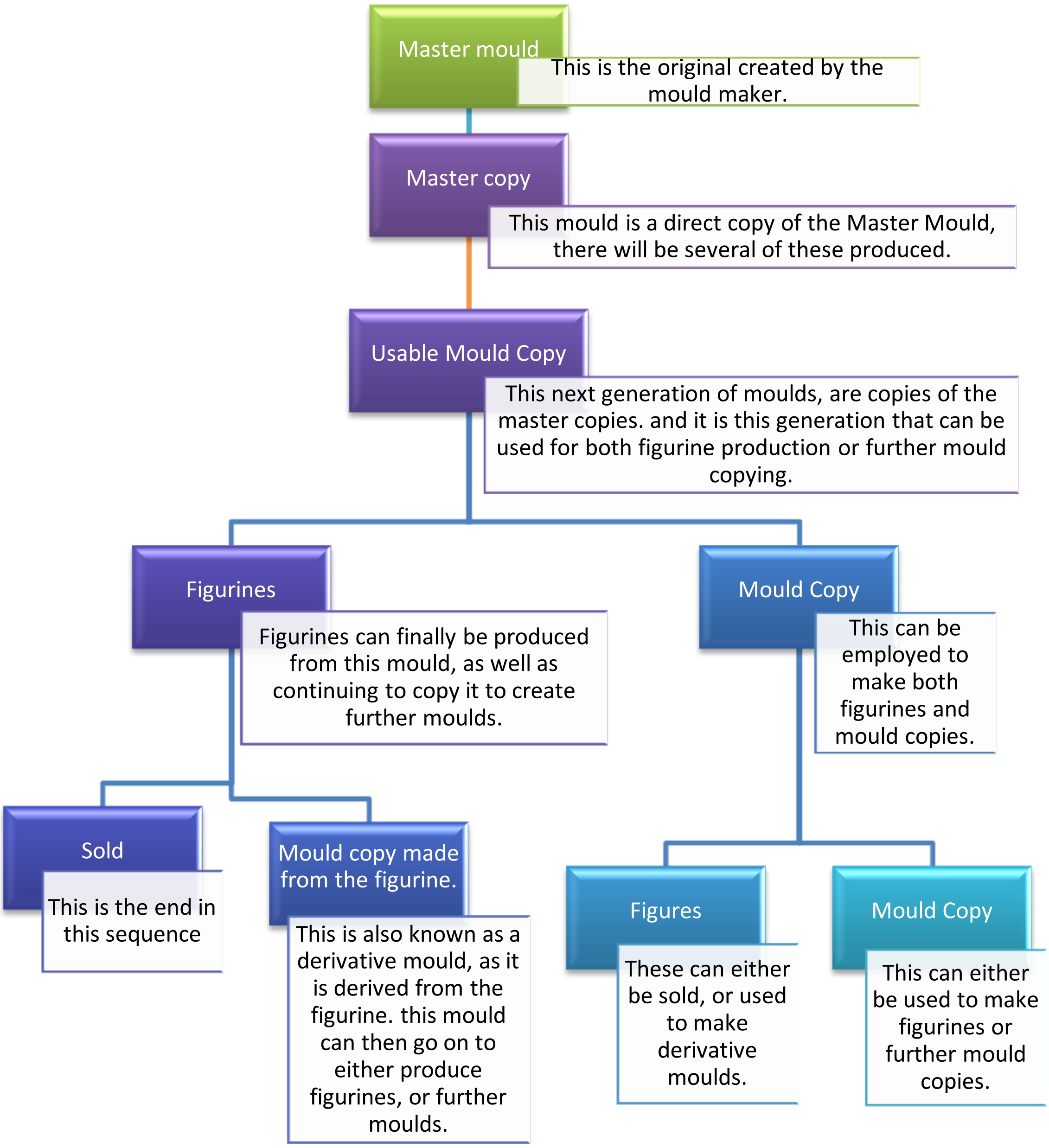


Chart 6.1 Demonstrating sequence of mould generation (in blue) and mould derivative production (in purple).

6.1 Critique of past methodologies

Within this section a pattern will emerge from each of the discussed projects. Throughout all of their methodologies, there is a consistent reliance upon the *Typen der, figürlichen Terrakotten* method produced by Winter (1903). The basis of Winter's methodology converts the concept of a 'type' into a form of unit. Specific classification for the 'type' is not easy to define as there has been little consistency in its use. The general concept of a type refers to a number of moulded artefacts displaying a strong resemblance to one another in their general external appearance and shape. This unit was adapted to present and discuss the development of an object's motifs and history in a similar manner to an equation. An early example of this style research which builds on Winter's (1903) concepts is a project by Eisen (1927). Eisen presented his work on the ''Temple Series'', which designated vessel type classification via the vessel's representation within the friezes in a temple. Eisen used the imagery to then denote specific stylistic groups of vessels from archaeological contexts (Eisen 1927,233-248). While this project was developed nearly 100 years ago, the methodology and premise for Eisen's analysis are still being used to assist further research.

The above method of product analysis, with its focus upon the concept of type, is still frequently employed within the discipline today. Unfortunately, it has undergone little development or refinement, resulting in an inconsistent application. While this form of research can be used to understand groupings of objects, to a degree, e.g. when a mould presents a distinct feature/scar, which is then passed onto the object, the methodology remains restricted. It focusses upon the gathering of metric data, often without clear levels of accuracy, which are then utilised to create static and definitive conclusions on object comparisons. These conclusions can be lacking in both subtler metric evaluations and the application of statistical metric errors which can directly affect objects, such as shrinkage or contortion during firing. These points were explored in further detail within Nicholls (1952) paper 'Type, Group and Series: A Reconsideration of Some Coroplastic Fundamentals', which examined and critiqued a series of studies and methodologies related to the analysis and grouping of Hellenistic mould-made terracottas. Nicholls condemned Winter's methodology due to its analytical reliance based solely on visual comparison, potentially with the employment of callipers and scales. These issues have been compounded by a lack of consistency in practise, such as no specific metric parameters being implemented during the process of examination, and has led to lack of adaptation, improvement, and advancement within this methodology (Nicholls 1952, 217).

Friederich and Conijn (1967) built upon Winter's (1903) and Eisen's (1927) original methodologies when they attempted to create a system of figurine matching and dating via stylistic comparisons between pipe clay figurines collected from Germany and the Low Countries. Their methodology consisted of establishing links between the figurines' gestures, accessories, and stylistic qualities to determine a date of production, as well as separating out different production groups. This latter point refers to the original location of figurine production. Table 6.1 and 6.2 provide examples of their sequencing categories for both the saint figurines and the Christ child.

When these methodologies were applied to excavated figurine production sites both in Utrecht, at the Toolsteeg gate, and in Konstanz, Germany, a confused and imprecise chronology was produced; the varying pipe clay figurines present within the assemblages of these two production sites created a divergent dating pattern. For example, in Utrecht, a relief which displayed the coronation of Mary dated to 1400-1425 was recovered from the same layer as a relief of a fainting Mary dated to 1460-1480 and a crucifixion of Christ which dated to 1475-1525. However, the whole context layer was dated to the 14th century, as suggested by other associated items. In Konstanz, the figurine production waste was recovered from one layer and, using the described stylistic methods, was dated to 1420-1440. Within this same context layer, the remaining material culture recovered was dated to the first half of the 16th century. Consequently, this demonstrates how Friederich and Conijn's (1967) strict stylistic dating framework cannot be applied to production site assemblages since it seems clearer that figurine production was not structured by the application of rigid stylistic elements. Rather than there being a definitive stage whereby one mould design surpasses its predecessor, the pipe clay figurine production process involved the long-term use of the same mould design over several centuries, alongside the gradual addition of further mould designs and choices concurrent to the previous designs. This process makes it difficult to grant specific iconographic details to certain periods but rather indicates a more gradual and overlapping process of iconographic

Date	**Stylistic references**
Before 1350	The heads of the statues usually covered by a veil, cap or hood, and their hair is no longer than shoulder length.
After 1350	The veil is combined with a crown and then disappears, leaving only the crown. The hair is longer often past their shoulders.
Before 1475	The garment of the neck is straight or arcuate
After 1475	The garment of the neck is square trapezoidal, or V-shaped
After 1500	The crown disappears, and the neck garment is round

Table 6.1 Stylistic dating for saint figurines (summarised from Van Den Dorpel 2013, 22)

Date	Stylistic references
Before 1350	The Christ Child is usually carried on the left arm
After 1350	The Christ Child is usually carried on the right arm
1425	The pleats on the robes become sharper
1500	Christ Child is in a more reclining position

Table 6.2 Stylistic dating for Virgin Mary and Christ Child figurines (Summarised from Van Den Dorpel 2013, 22)

transformation. For example, it has been previously thought that pre-1350 Mary usually held Christ on the left arm, then from 1350-1500 on the right arm, and after 1500 Christ was held in a reclining position (Van Den Dorpel 2013, 22). However, in reality what is present on excavated examples is that each of these styles seems to occur simultaneously.

Looking beyond pipe clay figurines, Willmott's (2000) work on classifying moulded glass lion mask stems from London provides a useful discussion concerning moulded artefact matching and registering examples of mould generations. Willmott's methodology for stem grouping involved the creation of silicon moulds for the lion glass stems which were under examination, coupled with both a series of feature measurements and the noting of finer details on the stems, such as the spacing of the decorative gadroons present on almost all variations of this type of stem. Willmott's results suggested that 85% of these stems fitted into just seven groups, titled A – G (Figure 6.1). Importantly, it was noted that those which had been designated to group A were not uniform in their execution. The stems appear distorted due to poor workmanship during the removal of the still warm glass stems from their moulds, or through the subsequent attachment of their feet and bowls when the glass was still relatively plastic. Though Willmott states that by 'careful examination of the upper gadrooning and the spatial relationship of features it is possible to group with some degree of certainty those belonging to A', he later also discusses the issues which arise during attempts to measure the distorted stems, and states how it made any 'exact measurement of size impossible' (Willmott 2000, 390-1). Continuing from the discussion of identifying different types of stems, the problems of variables within the data collection stages were also debated in this study. These included an absence of information connected to object provenance and complications that arose from the possibility of mould generations producing slightly distorted copies of products over time, resulting in conclusions that can only be speculative (Willmott 2000, 391). While the conclusions drawn in this study cannot be substantiated for certain, they still identify some possible production groupings within this material, as well as highlight the importance of trying to identify related products.

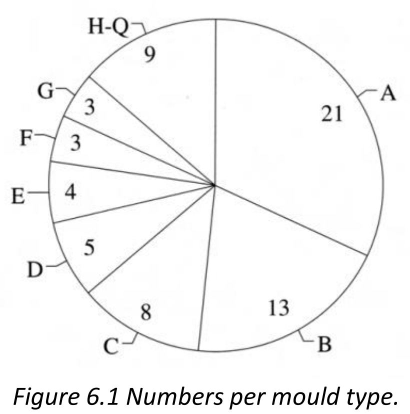


Figure 6.1 Numbers per mould type.
(With Permission from Willmott 2000, figure 4, 391)

A further example of object and mould matching of glass can be seen in the examination of the cargo from the Serçe Limani shipwreck (Lledó 1997). Here a similar methodology to Willmott (2000) was employed to attempt to catalogue a large corpus of highly fragmented glass vessels recovered from the seabed. In the case of these specific glass vessels the process employed in their production involved blowing a small gather of glass into a patterned one-piece mould to impress the design. Once the glass assumed the decorative form, the bubble was reheated and re-blown to expand the glass further into the desired vessel shape. This process allowed for the cheap and rapid reproduction of the same decorative designs on a variety of different vessels, although it produced a distortion of design due to the reheating and enlargement of the vessels (Lledó 1997, 44).

With the Serçe Limani glass, the overall aims were to try to catalogue these varying vessels into mould groupings. This was attempted by examining and comparing the decoration on the vessels both through the individual fragments themselves and by creating composite vessel reconstructions by superimposing the drawings of the fragments on top of each other (Lledó 1997, 45). For example, those vessels catalogued as coming from Mould 1 were designated via their patterns which:

‘*consists of a central, five-pointed star, with circular dimples between its points, surrounded by concentric circles. The first of these circles has 17 dimples, the second has 25 dimples, and the third and fourth have 30 dimples each. The dimples of the first three circles, or bands, are circular, while those of the fourth circle are rhomboid’* (Lledó 1997, 45).

One bowl with flared sides and base ring, one bowl with nearly vertical sides and a rounded bottom, one shallow bowl, and two basket bowls were designated to the same mould (Lledó 1997, 45). This method was reapplied to a variety of vessels, finally designating 28 different vessels into 11 specific moulds (Lledó 1997, 54). Within the analysis, it was also stated that the amount of decoration might vary on an object depending on its size, therefore smaller objects could have less concentric rings due to their shorter height (Lledó 1997, 55). Lledó’s study had to consider a broad range of variables which directly affected the metric composition of the vessels, meaning that the project’s evaluation and attribution of different vessels to specific moulds was far from certain. A better approach may have been to follow a similar presentational format to Willmott’s (2000), where, if it was not permissible to gather exact measurements or to securely tie a fragment to a specific mould, it was made clear that discussions and conclusions were speculative rather than absolute. Vessel groupings should also have been assigned to a mould family, allowing suitable flexibility to the subjective data gathered. This would have created a more flexible method allowing for any metric issues which can arise, such as the use of mould generations. Overall, the above projects display an over-reliance on Winter's (1903) methodologies, focussing too heavily on visual comparisons with often limited metric analyses of the objects. As previously stated, this style of research can be successfully employed to comprehend object groupings to a certain degree. However, the methodology is restricted due to its deficient employment of metric data and is only capable of producing static conclusions on mould and product comparisons, which lack thorough metric evaluations and the application of statistical metric errors.

To create a more robust methodology that provides a means of accurately analysing and comparing the morphologies of artefacts this project employed digital morphometrics, an approach that has recently seen more widespread use within 3D artefact analysis. This methodology provides a visual representation of object comparisons, allowing individuals to read clearly the (±0.5mm) metric comparison between two individual objects, or between an object and a mould. Furthermore, this new methodology's accuracy has been refined by a statistical analysis of the effect of shrinkage upon the final clay pipe figurine, both during the drying and baking stages. This was achieved via a comparison of unfired figurines against fired ones. A statistical analysis of the metric variability between freshly made and fired figurines, produced from both the same mould and on the same day, was also carried out. These examinations help to generate a unit of error expected to arise naturally between figurines that are produced from the same mould. They also allow for a more precise calculation of error tolerance between figurines by visually demonstrating not only the differing effects of shrinkage which will occur between figurines, but also the minor changes that occur to objects during removal from a mould and post seam scraping. These statistical examinations and methodologies are discussed in the following sections in more detail. By analysing these areas of error in a more in-depth manner provides a better understanding of moulded object relationships, mould generation, and derivative production. The latter of these processes involves the use of an existing object as a prototype for the production of further moulds.

6.2 Metric Variabilities

The metric variability tests aim to produce and present a clearer representation of data which will demonstrate the effects of firing upon moulded artefacts. It will also examine how the overall production process can cause variabilities between figurines produced from the same mould in the same firing conditions. This investigation will be carried out using a controlled dataset which has been provided by Dr D. Higgins (Figure 6.2). This dataset consists of one unfired pipe clay elephant, and three fired pipe clay elephants, which have been moulded in a metal mould and fired at a temperature of around 1050˚C. These figurines have remained unpainted and their surface presents a minimal amount of features and decoration. As such, these elephants would present a challenging comparison for more traditional approaches involving feature measurements with callipers, the focus of most previous research on mould-made

Figure 6.2 Above a mould half used to make the figurines, below an example of the fired elephant (Author's images, with thanks to Dr. David Higgins for creating the specimens)

artefacts, due to a lack of surface features and reference points that make their form a more homogenous structure.

6.2.1 Methodology

To carry out the metric variability analysis the three fired pipe clay figurine elephants (labelled models A, B, and C), and the unfired elephant figurine, were 3D scanned using the NextEngine laser scanner (Figure 6.3). Table 6.3 gives a summary of the NextEngine data and appendix 5 contains the 3D models relating to this chapter.

Once the 3D models were processed, the surface areas of the models were first recorded using the NextEngine software. This comparison allowed an immediate comprehension of the different surface areas seen between the fired versus unfired figurines. The results of these surface area measurements showed that on average a total surface area reduction of 12.59mm² is experienced during the firing processes.

These results, however, only give a general overview of the metric variations between the fired and unfired figurine. To achieve a more exact analysis of surface area differences the meshes were then compared against each other using CloudCompare. The settings of the workflow employed in CloudCompare consisted of a point sample limit set to 900,000, during both alignment and comparison of models. This was to ensure that the maximum points produced within the figurine 3D point clouds were all included within alignment and comparison. In this scenario model B had the highest level of points, consisting of 840,776 faces. The results from the CloudCompare comparisons are represented in millimetres (mm) with a summary of these results displayed in Table 6.4 and are discussed in more detail within the following sections.

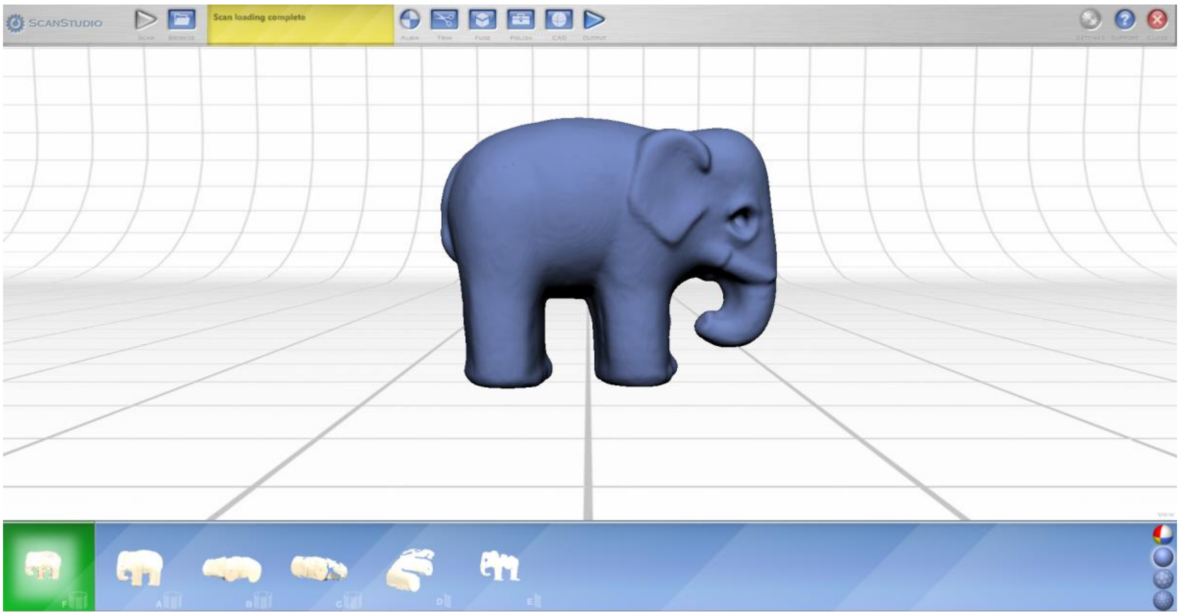


Figure 6.3 NextEngine scanning results example.

	Amount of scans	Faces	Vertices	Surface Area/mm²
Unfired	19	715,638	421,807	126.57
A	16	636,192	391,998	113.97
B	19	840,776	520,780	113.45
C	15	714,403	423,979	114.5
Mould half 1	5	167,963	92,547	
Mould half 2	9	352,704	178,142	

Table 6.3 Summary of NextEngine data.

	Unfired	A	B	C
Unfired	/	/	/	/
A	94% smaller by 0.63, peak reduction 1.52 RMS = 0.63 Mean distance = 0.57 STD = 0.37	/	/	/
B	97% smaller by 0.66, peak reduction 1.49 RMS = 0.63 Mean distance = 0.58 STD = 0.24	54% of B is smaller than A, by -0.25-0.05. Total size variations range between -0.25– 0.2. RMS = 0.22 Mean distance = 0.04 STD = 0.27	/	/
C	96.7% being smaller by 0.64, peak reduction 1.26 RMS = 0.57 Mean distance = 0.54 STD = 0.23	53% of C is larger than A, by -0.14 - 0.14. lowest peak reaching -1.3 and the highest reaching 1.6 RMS = 0.22 Mean distance = 0.02 STD = 0.3	62% of C's surface is larger than B's by 0.02-0.6 RMS = 0.18 Mean distance = 0.04 STD = 0.13	/
Mould Half 1	53% of the unfired figurine is between 0-0.8. 16% is 0.8-1.6 smaller. 13% is between 0.8-1.6 RMS 0.9 Mean distance = 0.25 STD = 0.58	68% of A is smaller. 48% of which is smaller by 0-1.2 and 20% is smaller by 1.2-2.37. RMS 0.77 Mean distance = 0.4 STD = 0.9	75% of B is smaller. 62% is 0-1.2 smaller. 17% is 1.2-2.5 smaller. RMS = 0.55 Mean distance= 0.5 STD = 0.76	66% of C is smaller. 40% is 0-1.2 smaller. 16% is 1.2-2.86 smaller. RMS = 0.58 Mean distance= 0.21 STD = 0.85
Mould Half 2	65% of the figurine is between 0-1.1 smaller. 10% is 1.5-1.7 smaller RMS 0.49 Mean distance = -0.32 STD = 0.6	75% of A is smaller. With 65% being 0-1.6 smaller and 10% 1.6-2.9 smaller. RMS = 0.74 Mean distance= 0.56 STD=0.7	70% of B is smaller. 52% is 0-0.1 smaller. 18% is 4.1 smaller RMS = 0.52 Mean distance= 0.38 STD = 0.88	74% of C is smaller. With 52% being smaller by 0-1.2. 22% is smaller by 1.2-2.77 RMS = 0.65 Mean distance = 0.53 STD = 0.73

Table 6.4 Summary of comparison results, all results in mm^2

6.2.2 Unfired vs fired

The first set of metric data analysed offered a comparison between freshly fired pipe clay figurines and unfired figurines. This direct comparison provided an understanding of the reduction of size experienced during the firing of an object. Before examining the comparisons, Figure 6.4 offers a brief explanation of what is included within each of the following comparison figures.

Figure 6.5A shows that 94% of the faces on A's 3D surface area are smaller than the unfired figurine faces with a peak reduction of $0.63mm^2$ displayed. Figure 6.5B demonstrates that there is a minimal difference within the histogram results when the base data is switched from the unfired figurine to Model A, with the results then represented on the Unfired figurine. The small difference which has arisen within the histogram has been caused by a change in the faces chosen on the 3D models during the mesh comparisons, as this is automatically generated by CloudCompare. Overall,

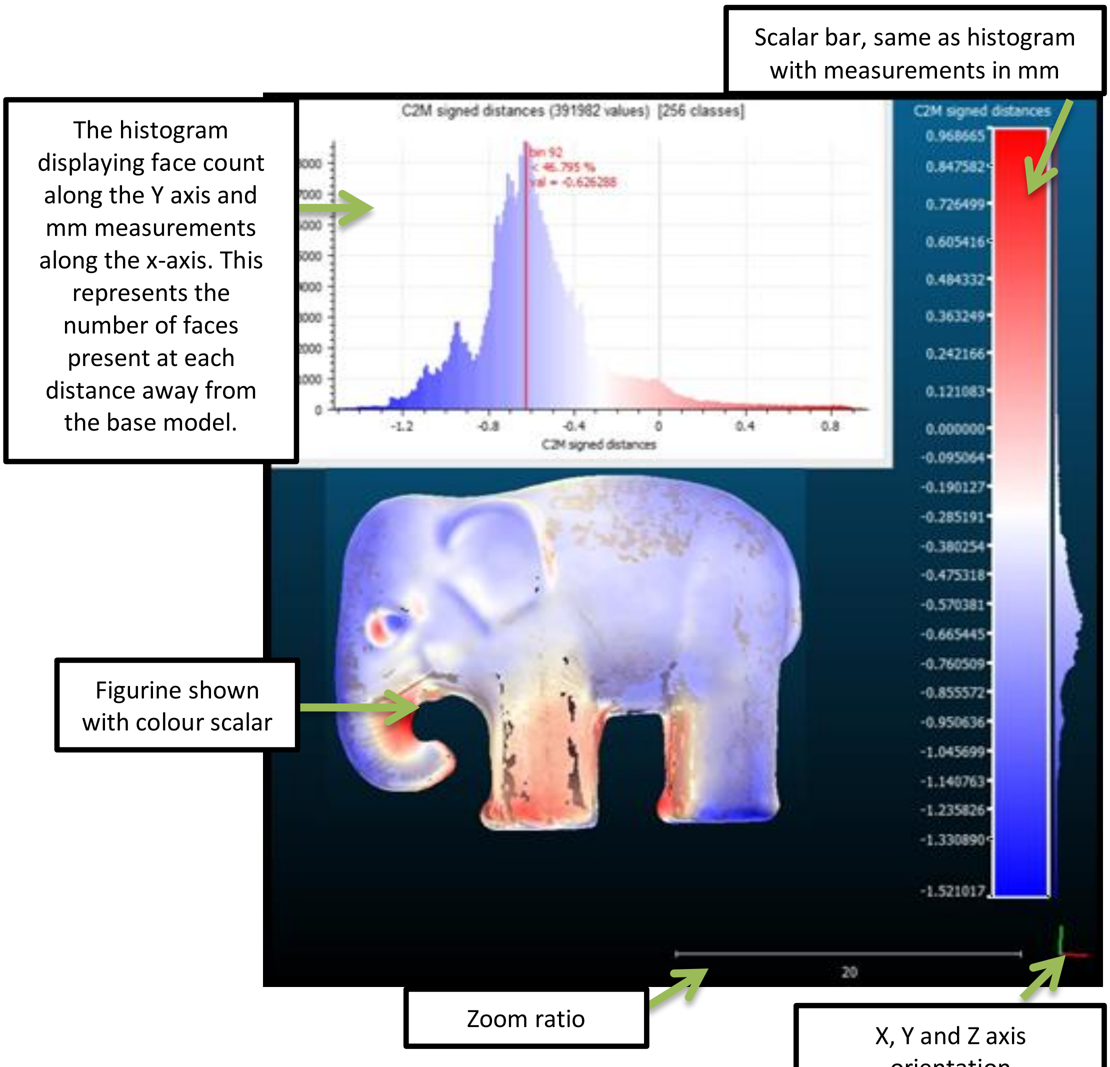


Figure 6.4 Overview of data shown in comparison screenshots

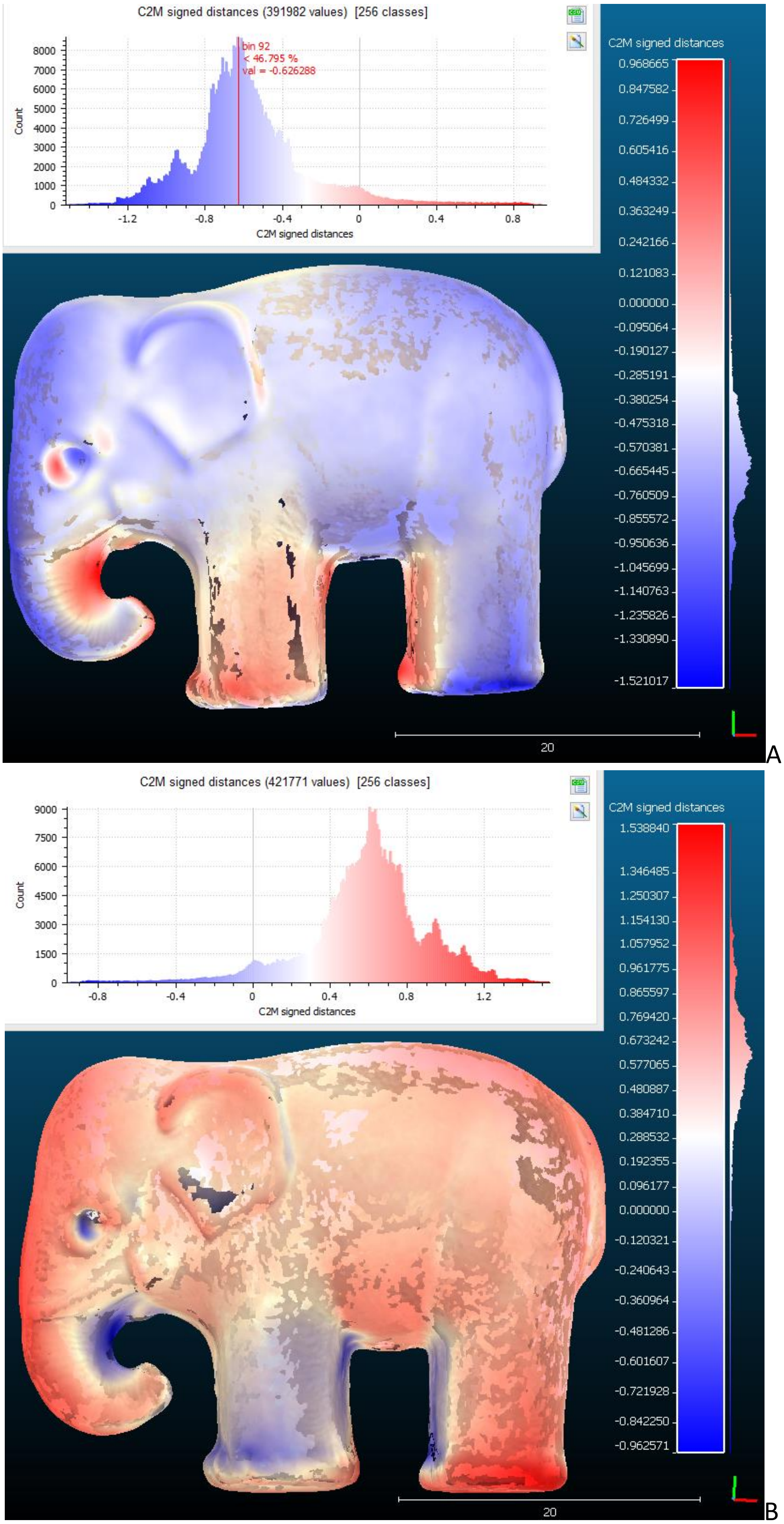


Figure 6.5 A) Model A vs Unfired model, with the colour scalar represented on Model A. B) Model A vs Unfired model, with the colour scalar represented on the Unfired Model.

however, the two histograms display inverted representations of each other, a result which was expected to be seen. As this was an expected result, inverted representation of figurine results will not be displayed throughout each comparison.

Model B (Figure 6.6) in comparison to the unfired figurine shows that 97% of the faces on B's surface area were smaller than the unfired figurine, with a peak reduction of 0.66mm² seen. Finally, model C (Figure 6.7), in comparison to the unfired figurine, demonstrated that 96.7% of the faces on C's surface area were smaller than the unfired figurines, with a peak reduction of 0.64mm².

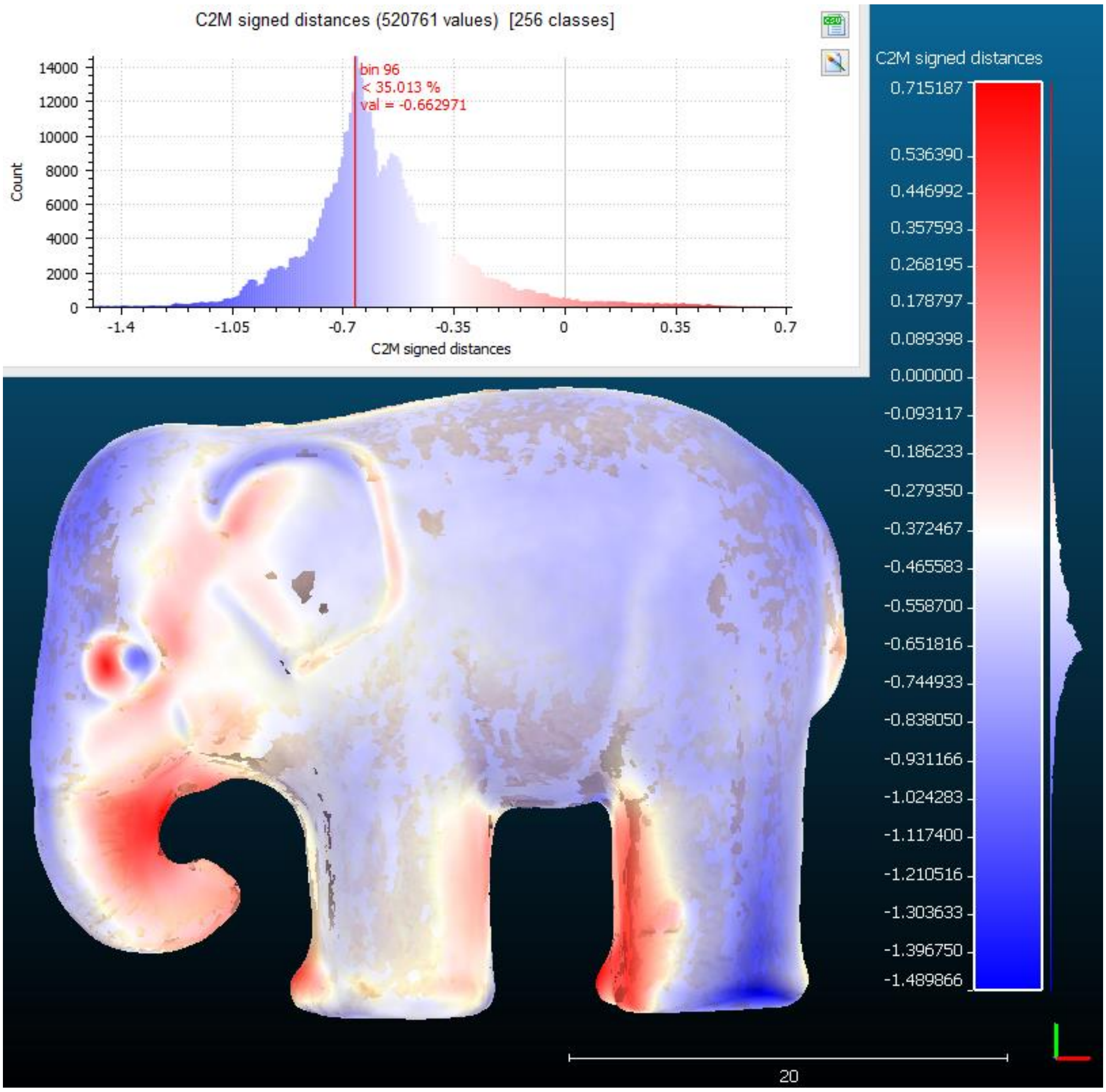


Figure 6.6 B vs Unfired model, with the colour scalar represented on Model B.

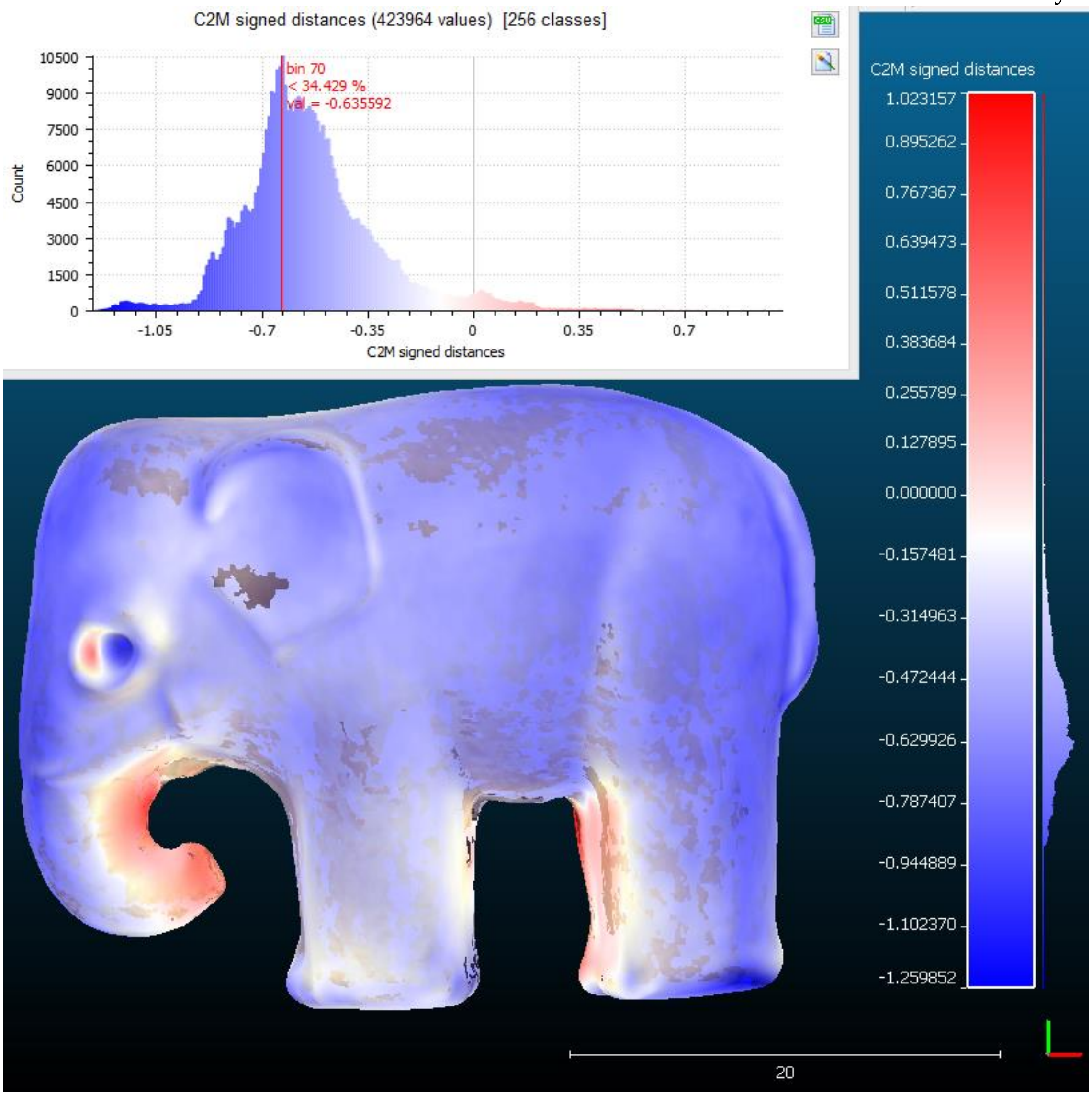


Figure 6.7 C vs unfired model, with the colour scalar represented on Model C.

Overall, the comparisons between the fired and unfired figurines demonstrated that on average there was a total surface area reduction of 12.6mm², with an average of 95.9% of the figurines specific areas showing a reduction of 0.6mm². When looking at the histograms, a general reduction in surface area on the figurines is clearly displayed amongst the comparisons. Each of the histograms (with the exception of 6.5B) display a skewed left distribution of points which form a distinct single mode, with a few points distributed along a large range creating a long-tailed spread. The points which fall within the red section of the 'long tails' are noticeable clustered around the figurines extremities, eye sockets and seams. These size fluctuations are due to these areas receiving inconsistent levels of stress, such as areas that have been exposed to seam scraping, and extra manipulation during pressing or mould extraction. These size fluctuations show minor erratic peaks between each of the models, however, their location is consistent. As such, whilst the measurements within these areas have to be disregarded, they do not pose an issue to the overall analysis for model matching.

6.2.3 Fired vs fired

The next stage of metric comparison analysis compared the fired figurines with each other in CloudCompare, using the same parameters as outlined above. The NextEngine had already signified between a 0.5-1mm² difference between these three fired elephant figurines (Table 6.3), and the results from CloudCompare below confirm these results in more detail. In the overall surface area comparison between models A and B (Figure 6.8), 54% of B's faces which were compared to A's were shown to present a smaller surface area value. Within the colour scalar comparison between A and C (Figure 6.9) the results showed that 53% of model C's faces present a larger area value than A's faces. Figure 6.10 displays the comparison between model C and B, with the colour scalar results displayed on C. This comparison shows that 62% of C's faces present a larger area value than B's. Once again this is unsurprising since the NextEngine's surface area results informed that C's surface area was 1.05mm² larger than B's.

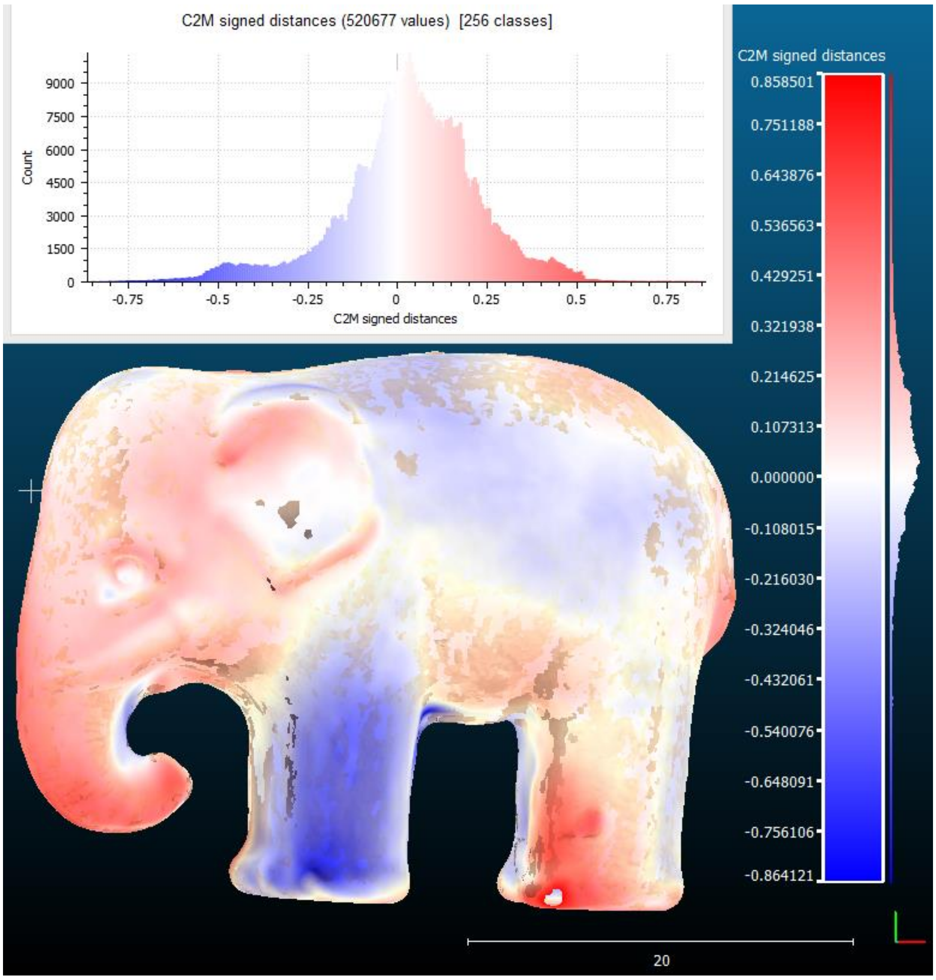


Figure 6.8 A vs B, displaying comparison on model B.

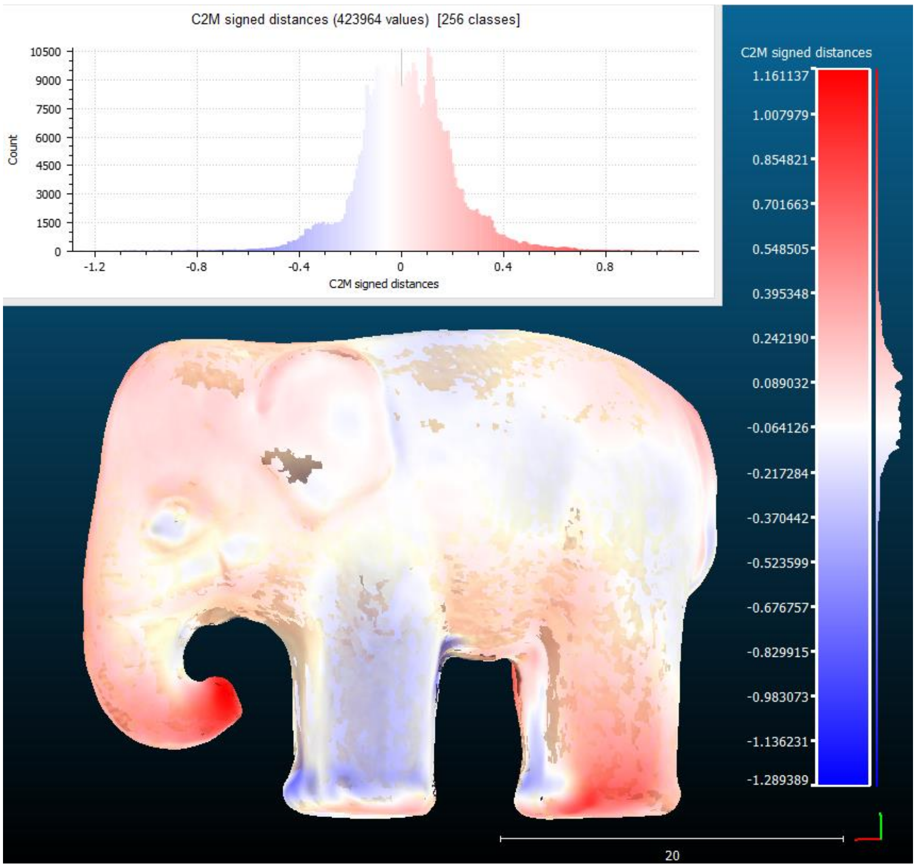


Figure 6.9 Shows model A vs C, with the results displayed on model C

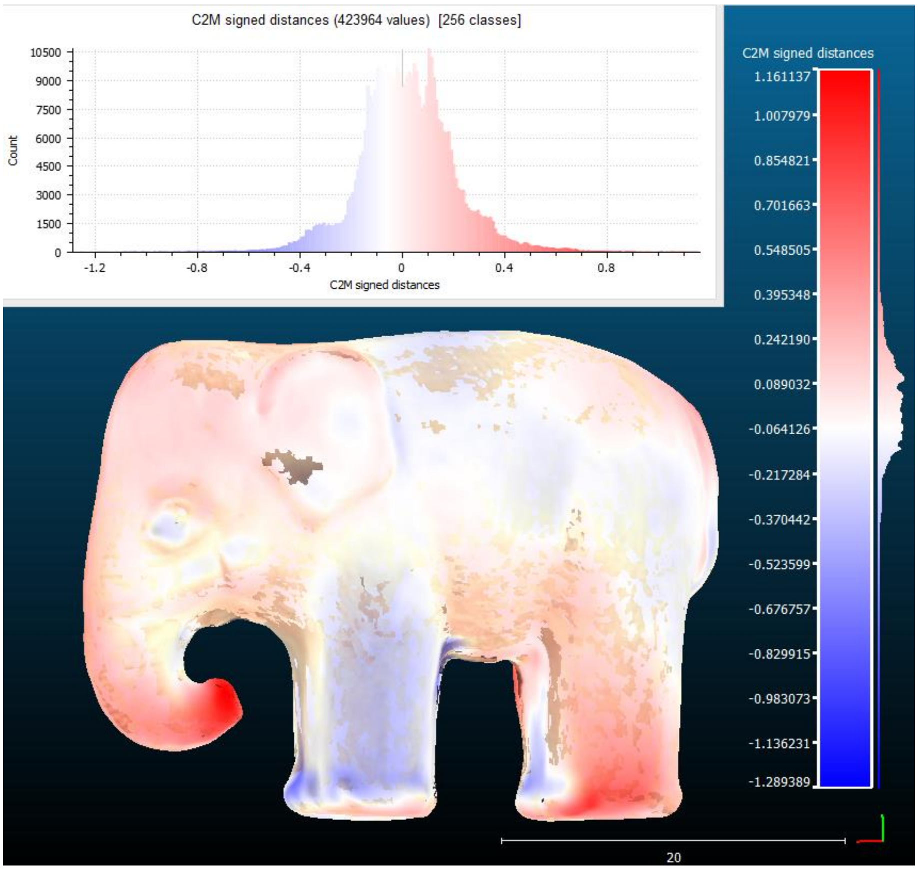


Figure 6.10 Shows model B vs C, with the results displayed on model C

Figure 6.11 displays the histograms from the fired comparisons, with their upper and lower quartiles indicated by a green line, and the x-axis values indicated beneath these. These histograms display that most of the comparison pair values are close to 0. This is to be expected since each of these figurines has been produced from the same mould and fired in the same conditions. However, as the upper and lower quartiles indicate there is also approximately a 0.5mm range either side of the 0 marker of comparison representing the value difference between the pair of 3D models. This value does not include what can be presumed to be noise within the 3D models, represented by those values which appear in the 'long tails' of the histograms.

6.2.4 Fired and unfired vs mould halves

The final section of this controlled figurine and mould comparison consisted of comparisons between the fired and unfired figurines against the two separate mould halves. Within this section the methodology is the same as previously employed, however, to be able to compare the mould halves directly with the models, each of the mould halves has been inverted. Figures 6.11 – 6.18 demonstrate what is to be expected, that there is a slight reduction in figurine size between the unfired figurines and both mould halves, with this size difference then increasing substantially when comparing the fired figurines with the mould halves, post shrinkage. Of note, is in some areas where the comparison results have indicated that the figurine has increased in size, this is of course not due to an actual increase, more a fluctuation and deviation in position from the figurines original stance. These figurine alterations may have been caused by object contraction during shrinkage and/or during figurine extraction from its mould.

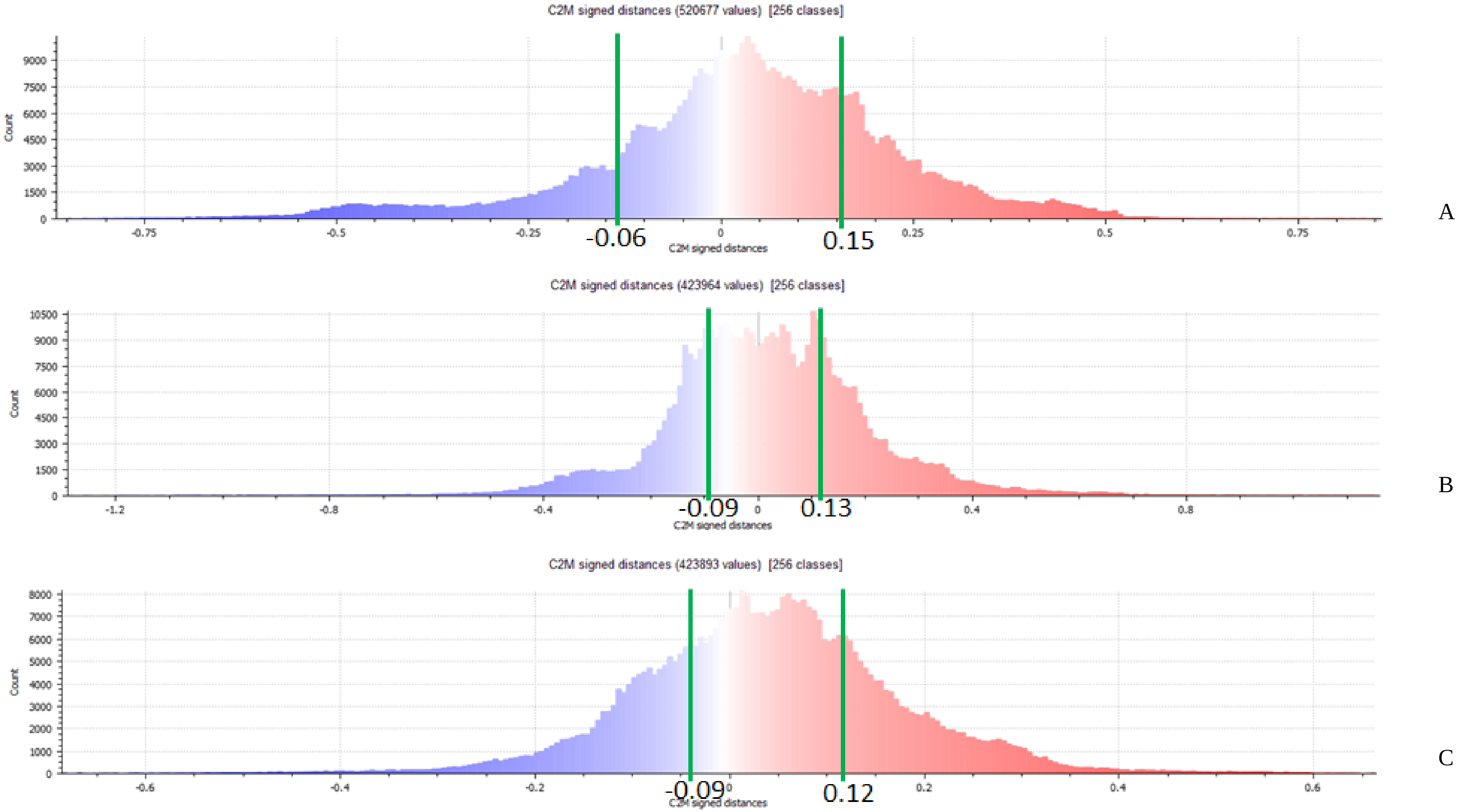


Figure 6.11 Close up of Histograms with their upper and lower quartiles displayed.

A) A vs B histogram.
B) A vs C histogram.
C) C vs B histogram.

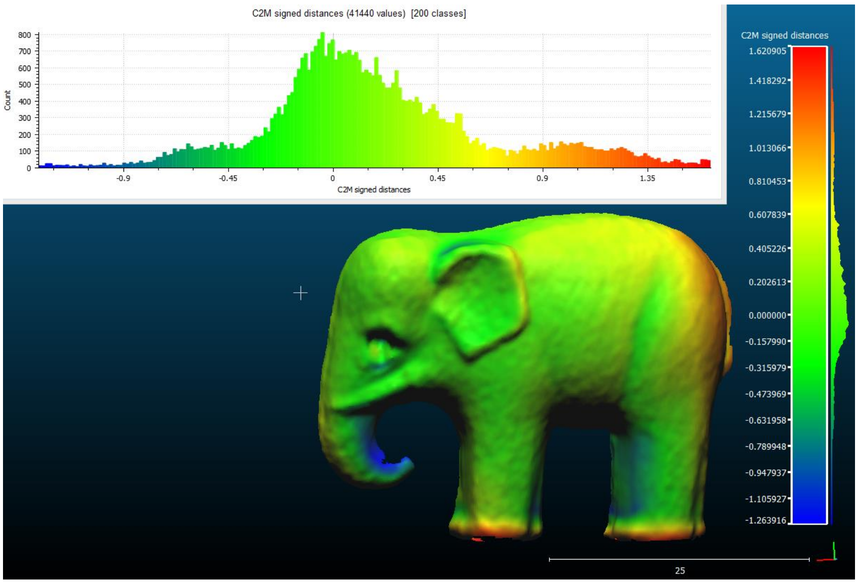


Figure 6.12 Unfired vs mould half 1

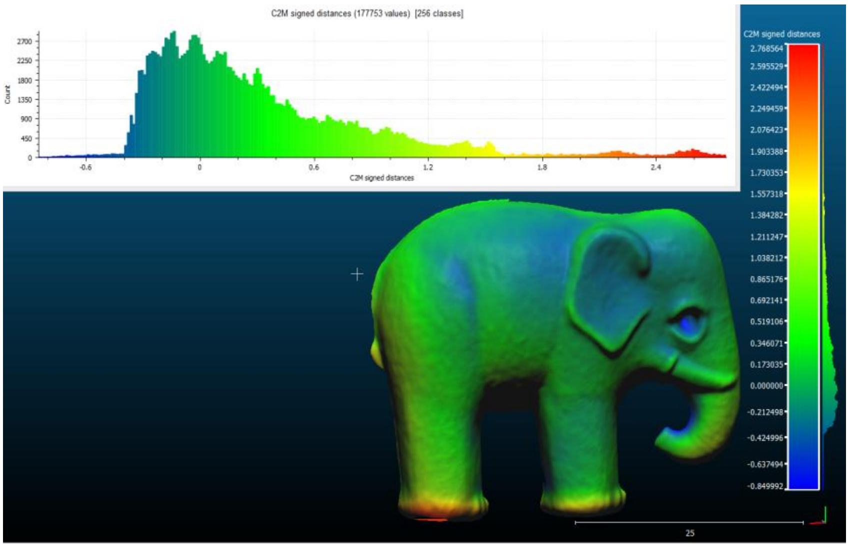


Figure 6.13 Unfired vs mould 2

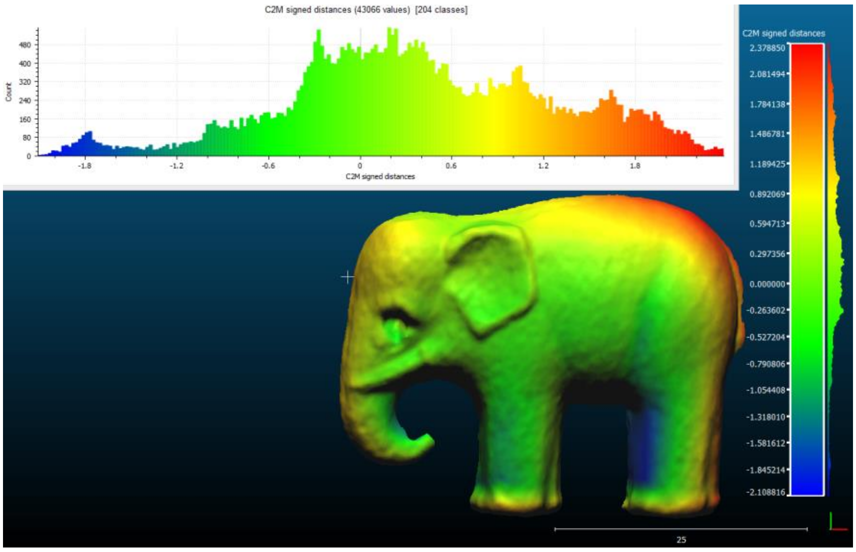


Figure 6.14 Mould half 1 vs A

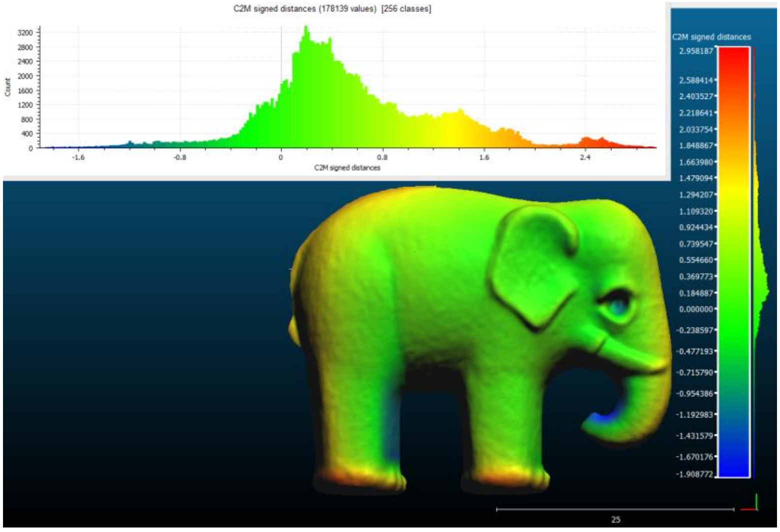


Figure 6.15 Mould half 2 vs A

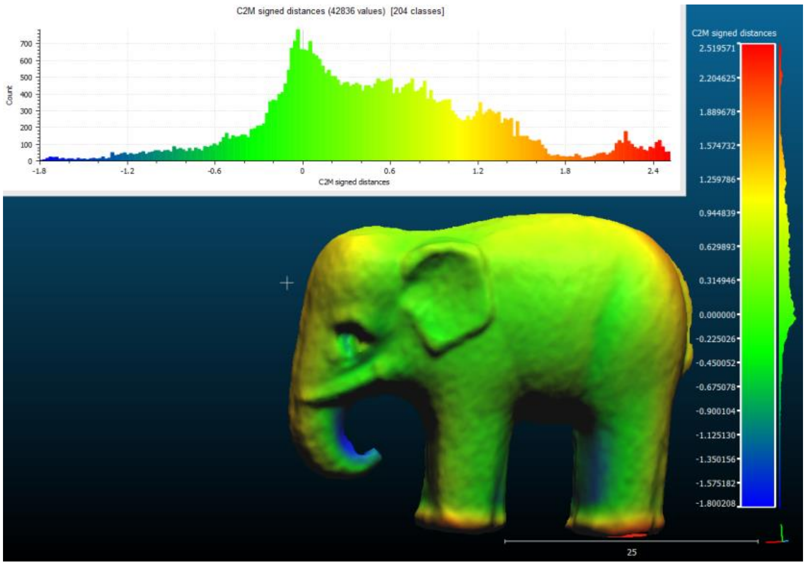


Figure 6.16 Mould half 1 vs B

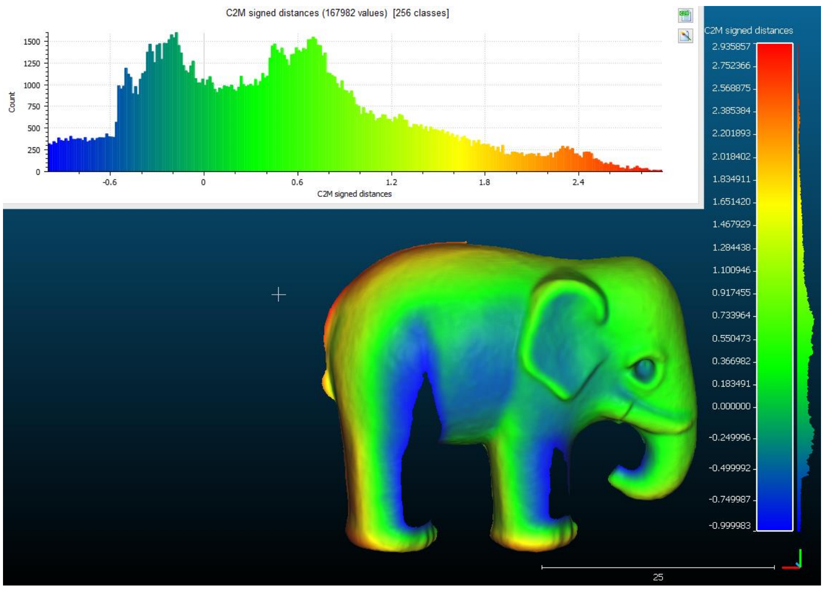


Figure 6.17 Mould half 2 vs b

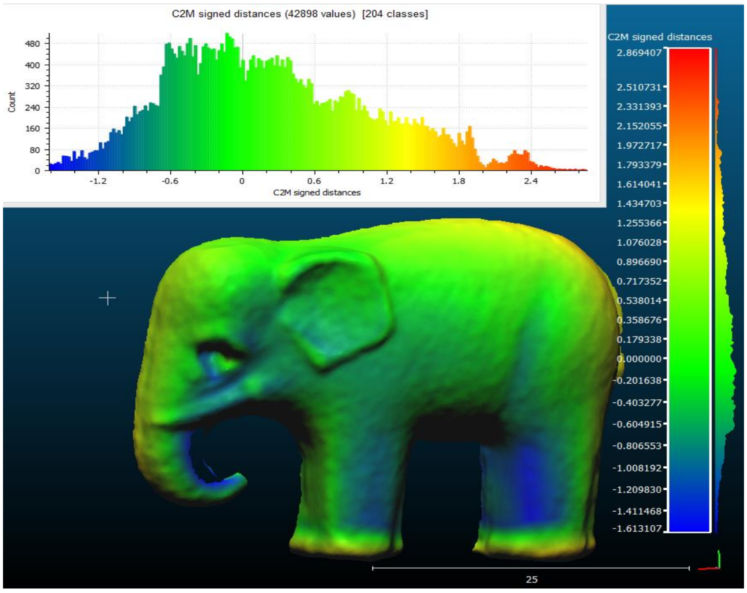


Figure 6.18 Mould half 1 vs C

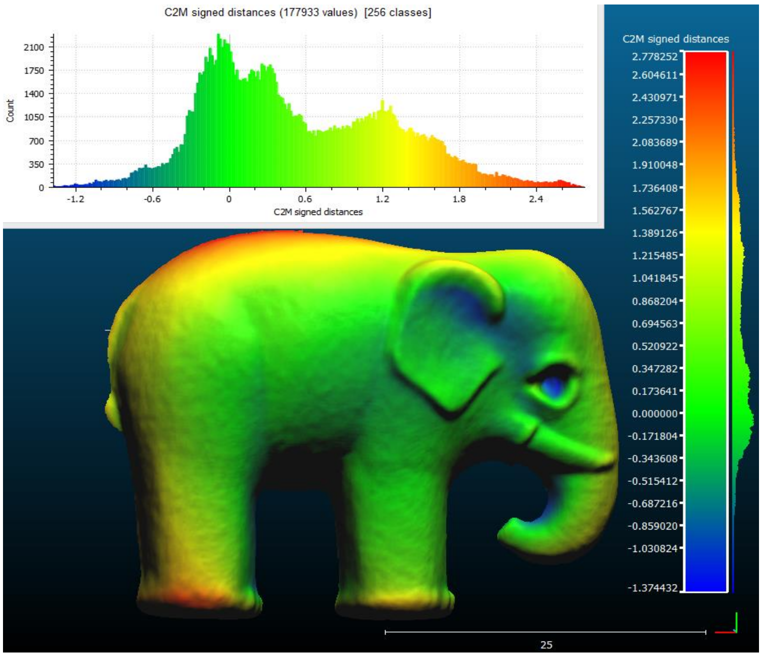


Figure 6.19 Mould half 2 vs C

6.3 Methodology Discussion and Summary

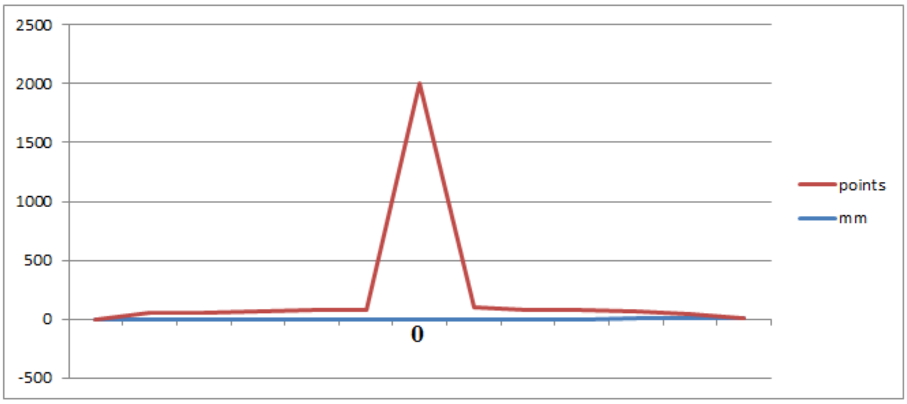
The previous discussion has demonstrated that the laser scanner can highlight parameters through which it is possible to define it as 'highly probable' that two objects might be made from the same mould generation. This is due to its ability to clearly map metric similarities and differences between two objects and display these results both on a colour scalar comparison model and histogram. The results showed that there is, on average, an initial 12.6mm² overall surface value difference between an unfired and fired elephant figurines. The comparisons between the figurines and the mould halves demonstrate an expected fluctuation in size variation between each comparison, with a greater fluctuation seen between the fired figurines and mould halves, in comparison to the unfired figurines and mould halves. Furthermore, due to the inevitable shift in elephant limbs due to contraction during the firing process the colour scalar has indicated increased size regions (in red) on the figurines. However, this is slightly misleading, as this is actually indicating a shift in features from their original locations to their newly fired contracted locations rather than an increase in size.

Overall, these mould comparisons demonstrate the two stages of surface area losses which have taken place during the production processes. The first, and smaller scale, reduction in size was experienced on the removal of the unfired figurine from the mould halves, and the second stage then takes place during firing, when shrinkage due to water loss from the figurine occurs. It was also clearly shown that the effect and rate of shrinkage on the figurines were not universal, and the value ranges over 1mm variability on the overall surface area, with the majority of specific areas concentrating on an average size difference of 0.63mm², and an average peak difference at 1.46mm². These tests have also highlighted that even if one object is made in the same mould as another there will still be specific, idiosyncratic differences between them which relate to specific and individual firing conditions and their interaction with the mould, both on implanting and removal. The results above display how the overall surface area could vary by 0.5-1mm² between each of the figurines, with on average the majority of area-specific variabilities measuring between 0.14mm² to 0.26mm², and an average surface variability peak measuring up to 0.7mm² in variation between figurines.

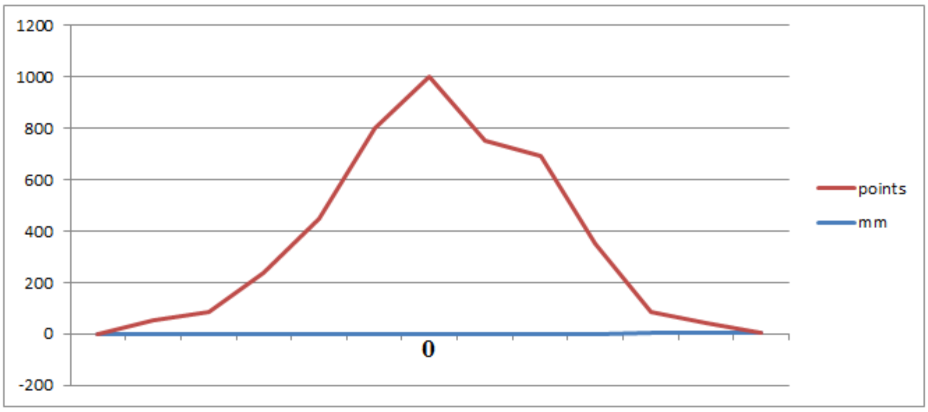
When examining the metric variabilities shown on the histograms between these fired figurines, it is worth noting that these differences are confined, in the vast majority, to a very select band either side of the 0 marker. This, though, excludes those areas most susceptible to damage, movement, or modification by firing, mould removal, or seam trimming, such as the extremities. This highlights that accurately matching figure generations of moulds is possible through the use of error parameters. These parameters consist of compared fired figurines having no more than a 0.5mm-1mm² overall surface area difference, they should present a histogram which orientates around the 0 marker, and the majority of fluctuations should fall within 1mm either side of the figurine surface area. In addition to this, a tolerance for archaeological erosion on figurines must also be taken into consideration, however, this should not alter or shift the appearance of the histogram peaks. The level of tolerance that should be permitted on top of the error parameter already calculated has currently no set value due to the difficulty in assessing erosion rates. For example, ceramic figurines up to 16,000 years old have been recovered within archaeological contexts with their form remaining at a very high preservation (Vandiver and Vasil'ev 2002, 421-431). Their resilience and longevity within the ground reflect the resistance of ceramics to biological and chemical degradation processes (Kibblewhite *et al.* 2015, 250). These degradation processes can be affected both by the materials used in ceramic production and firing temperatures. For example, objects that are fired at a higher temperature, such as the pipe clay figurines, present a stronger and less porous structure than those fired at lower temperatures (Kibblewhite *et al.* 2015, 250). Furthermore, the specific construct of the soil the artefact is deposited in will also affect the figurines erosional rate, for example, dry clay soil is more resistant to deformation and will better protect the deposited objects in contrast to wet, strongly alkaline or sandy soils which are more likely to promote artefact shattering (Kibblewhite *et al.* 2015, 250).

Recent research carried out by Kibblewhite (see Kibblewhite *et al*. 2015 for full details) has attempted to define preservation categories for materials and tried to display these degradation rates in linear relationships. This analysis summarised that no meaningful timescale could be assigned to ceramics due to their endurance in the soil. With this comprehension of figurine durability within the soil due to their material, core thickness, firing process and short periods in which they have been buried or submerged (a maximum of 500 years and a minimum of 200 years), only an extra 1mm tolerance will be included on the figurines select surface area variability rate allowing then fired figurines to have an overall surface area difference of up to 2mm variation and fluctuation of up to 2mm either side of the 0 marker on the histogram. These parameter markers will enable an even more effective methodology at identifying identical images across different mould generations. However, due to this wider set of error parameters, it may not be possible to explicitly match an object or object group with a specific singular mould. There are two possible exceptions where multiple objects could match to a specific mould. First, if there were any individual abnormalities, errors, or marks present which were specific to a singular mould. The second exception would be if the figurines under comparison display a smaller fluctuation than the parameters discussed above, though considering these parameters were created via modern primary data, it is highly unlikely that archaeological samples which have gone through additional erosion within their contexts would present examples of these reduced parameters.

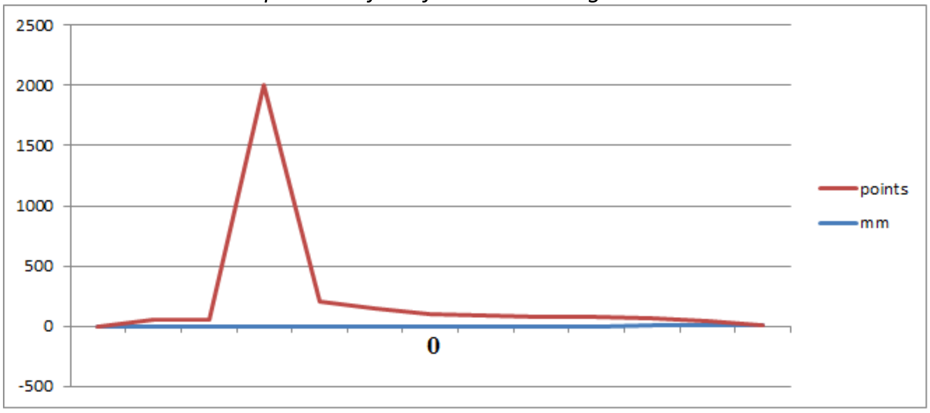
Finally, this analysis also provides information for hypothetical expectations of histogram structure for a range of different figurine comparison scenarios. Shown in Graphs 6.1 and 6.2 are the different spreads expected to appear on a graph when figurines from the same mould or mould generation are compared. Graphs 6.3 and 6.4 demonstrate the likely results from later and earlier generations of moulds. The values within these two latter graphs will display an increase or decrease in value every time a figurine is moved down or up the generation scale. Therefore, the peaks in the graph will move left or right from the 0 marker, and the distance from 0 will depend upon the closeness in the relationship between the two figurines which are being compared.



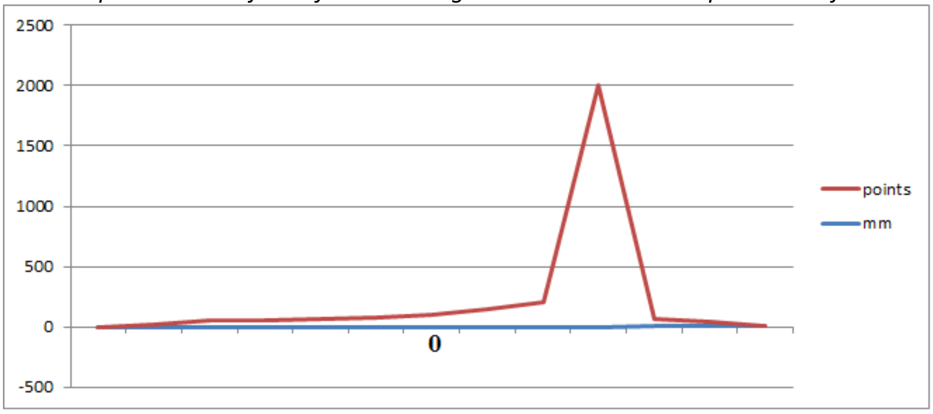
Graph 6.1 Objects produced from the same mould



Graph 6.2 Objects from the same generation.



Graph 6.3 One object is from a later generation than its comparative object.



Graph 6.4 One object is from an earlier generation than its comparative object.

For example, comparing a figurine one or two generations later than the original would move the peak slightly to the left of 0, but several generations might see a more substantial shift. When considered together, model generational analysis depends on a nuanced appreciation for the nature of the variables, requiring the combined utilisation of overall differences, the histograms, and noting where specific differences occur to create a convincing argument for related figurines.

There is one major caveat on this discussion which is the potential problem of extreme over-firing, for example, Higgins (1987, 57-60) demonstrates that during the production of two pipes, which are produced from the same mould, one of the pipes is overfired. The resultant size difference calculated between these pipes was 8%. A second batch of pipes, which was produced also using this same mould, was also overfired. Once again the size difference was calculated between the over fired pipes and the correctly fired pipe. The normal fired stem measured 195mm in length, but the over fired pipes stem measured 185mm. The bowl heights were also compared the pipe which was fired at normal temperatures measured 40.8mm and the overfired pipe measured 38.7mm, a difference of around 5%.

Therefore the dataset that this thesis has utilised will fall into one of three scenarios. Firstly, that this material is not affected by this issue; secondly, that the material may have been affected by over firing on a smaller scale, but this effect is covered by the error parameters produced and would only result in suggested generational differences between comparisons of one generation, which has usually been a tentative suggestion anyway. Thirdly, the material does include one or more figurines that have been significantly over fired. This third scenario could lead to one of these figurines being from a very early generation which has been over fired, being compared with a significantly later generation. There are several factors arguing against the third scenario impacting this study. From a historical perspective we have no evidence to suggest that production of pipe clay figurines found in the UK and America would have produced enough generations to create such large differentiations in figurine sizes that a 5-8% over firing reduction would match a later generation, as discussed in Chapter 4. When discussing production, such cases have been noted as being rare in materials subject to this problem of extreme over-firing. Lastly, from a 3D comparison perspective such an over-firing would also be highly unlikely to produce the same feature details which would match as exactly to a later generation. This third point about figurine feature details will be mitigated by the fact that this form of study examines those details closely for clear matches. As such, cases where these details are similar but don’t match would already be considered to not come from the same mould or closely related moulds.

Taking these points into consideration, whilst issues of over-firing, be it extreme or slight, may impact on the results it is suggested that these are likely to be of minimal impact on the overall study and would fall within the error parameters set out above.

Any extreme cases of shrinkage caused by over-firing will be identified during the detailed comparisons.

The methodologies and parameters concluded within this chapter will be tested on an archaeological sample within Chapter 7. Six separate groups of post medieval pipe clay figurines from London, UK, and Maryland, USA, were utilised for comparison. These figurines were selected due to visual similarities noted during data collection, leading to the supposition that they may have been created from the same or related moulds. As such, they have served as a pilot study for the approaches advocated in this thesis, as well as providing added context for the figurines themselves.

Chapter 7

Figurine Matching Case Study: London's Post-Medieval Pipe Clay Figurines

The methodology and parameters for figurine matching, formulated and discussed in the previous chapter, will now be applied to the London pipe clay figurine dataset. The following archaeological material will be examined by the comparison methodology, consisting of potentially matching pipe clay figurines from London and the Americas. Table 7.1 lists which figurines have been compared, with ID numbers relating to Appendix 1 where more details can be found for each figurine. Many of these figurines are held by different museums and archaeological stores, meaning direct physical comparison has not been possible due to restriction on material movement between research sites. This is a common issue which arises during the study of archaeological materials, one which traditionally has been countered via compiling rigorous notes, measurements and 2D images (both via photography and sketching) of the artefacts. While these methods have still been employed within this research, they have been aided with the ability to create 3D replicas of the objects, immediately allowing for a closer direct comparison when the actuality of this activity is not permissible.

Figurine 1	Figurine 2	Figurine 3
Blackfriars King GM181.1969 (ID 50)	Charles Gift Site King (ID 170)	/
Cockerel A5176 (ID 57)	Cockerel 4973b (ID 76)	Cockerel A19159 (ID 74)
Whitechapel King 1854,1130.43 (ID 31)	Thames King 1856,0701.1657 (ID 32)	/
Dorothy with a basket 1854,1130.45 (ID 23)	Dorothy with a basket 1854,1130.46 (ID 24)	Dorothy with a basket 4972 (ID 51)
Man in a hat 1854,1130.47 (ID 40)	Man in a hat 4975 (ID 65)	/
King 1854,1130.44 (ID 25)	King 17681 (ID 69)	/

Table 7.1 Figurine comparison list

7.1.1 Charles Gift Site King Compared to London Blackfriars King, NextEngine

The Charles Gift Site king and the king recovered from Blackfriars in London (Figure 7.1) have already received a certain level of attention from Hurry and Grulich (see Hurry and Grulich 2015), where it was noted that these two figurine are of similar appearance and stature. Their study of the two kings relied on measurements and 2D images in which to compare the figurines, as they may not be brought together for direct comparison. On visiting each figurine individually, though there are noticeable differences between the states of preservation between these figurines, it was immediately apparent that both figurines are extremely similar. Consequently, it seemed pertinent to investigate the potential relationship that these figurines may share via 3D comparison. Before this took place, however, it was worth marking visually on the figurines where large peaks of metric variation would arise due to the variable rates of erosion and damage affecting each of these figurines (Figure 7.2). Marking these areas was important as these zones would be reflected within the results as areas of high differentiation and create peaks within the histograms. Following on from this initial erosional study the 3D comparison methodology discussed in the previous chapter was then employed. The face sample limit was set to 3 million to encompass all the points during fine alignment and the results are presented below.

Figure 7.3 presents the initial results from the comparison between the two 3D models of the figurines. The results are displayed on the Blackfriars king and show a broad metric interpretation of the figurines. They indicate large similarities between the two figurines; the histogram concentrates around the 0 marker with a slight inclination to the left. This initial interpretation thus demonstrates that a large portion of the surface

Figure 7.1 Charles Gift Site King (top two images) and London Blackfriars King (bottom two images) (author's Images courtesy of Historic St. Mary's City Archaeological Museum and Museum of London)

area of the London figurine is marginally smaller the American figurine, but the two figurines have a high similarity consistency which falls in the 2mm tolerance field outlined in Chapter 6. To interpret these results further a closer analysis was undertaken, using CloudCompare to only show those areas which were within 2mm either side of the 0 marker (Figure 7.4). As figure 7.4 shows, following the enforcement of the 2mm parameter the majority of the figurine has remained present. The areas which have been removed by the parameters or have remained as peaks continue to be those areas most affected by erosion or seam scraping. Overall 71% of the Blackfriars king's face values are smaller than the American figurine. The majority of which is reduced by 0.97mm, though there is graduation either side of this majority, rather than it representing a distinct peak. The regions which represent a clear

Figure 7.2 The Charles Gift Site (top) and Blackfriars (bottom) king figurines, with red circles highlighting areas of erosion that are likely to produce areas of difference in the analysis. Such areas include heavy erosion seen along the cloak edges, the crack in the middle section of the Charles Gift Site king's cloak, the neckline breaks, the sword breaks, the leg breaks and the break on the right arm of the Blackfriars king's arm.

fluctuation in size (shown in red) seem to be those areas where there are significant erosional and breaking differences between the two figurines as displayed previously on Figure 7.2.

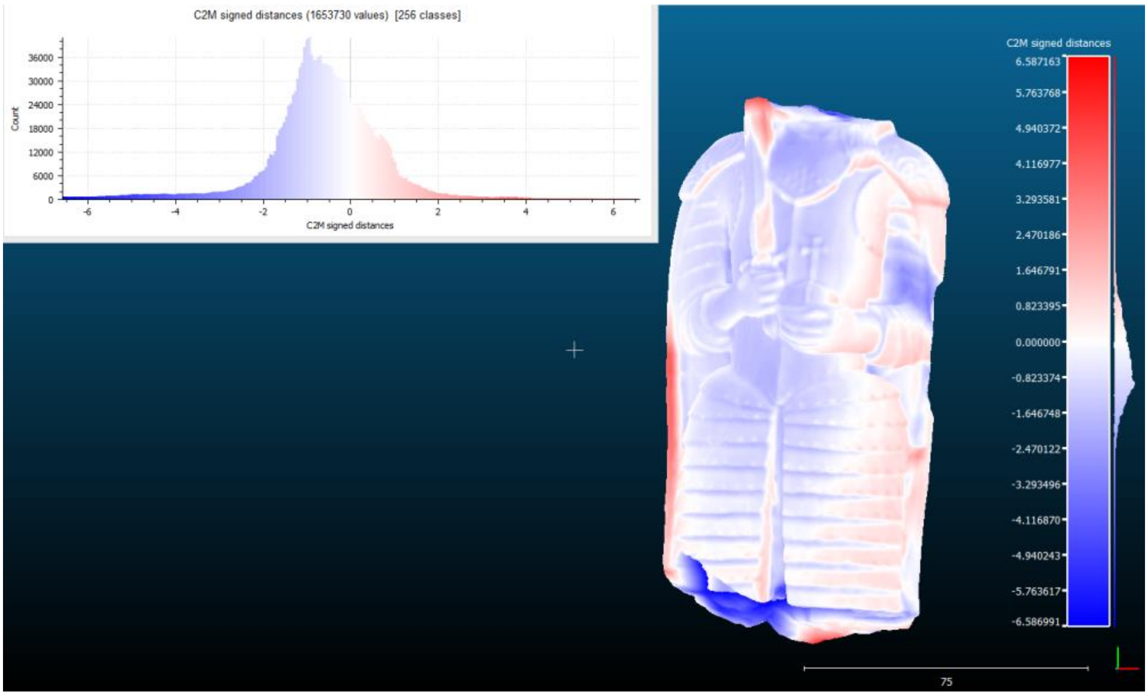


Figure 7.3 Results displaying the Blackfriars King with colour scalar in comparison to the Charles Gift Site King/mm

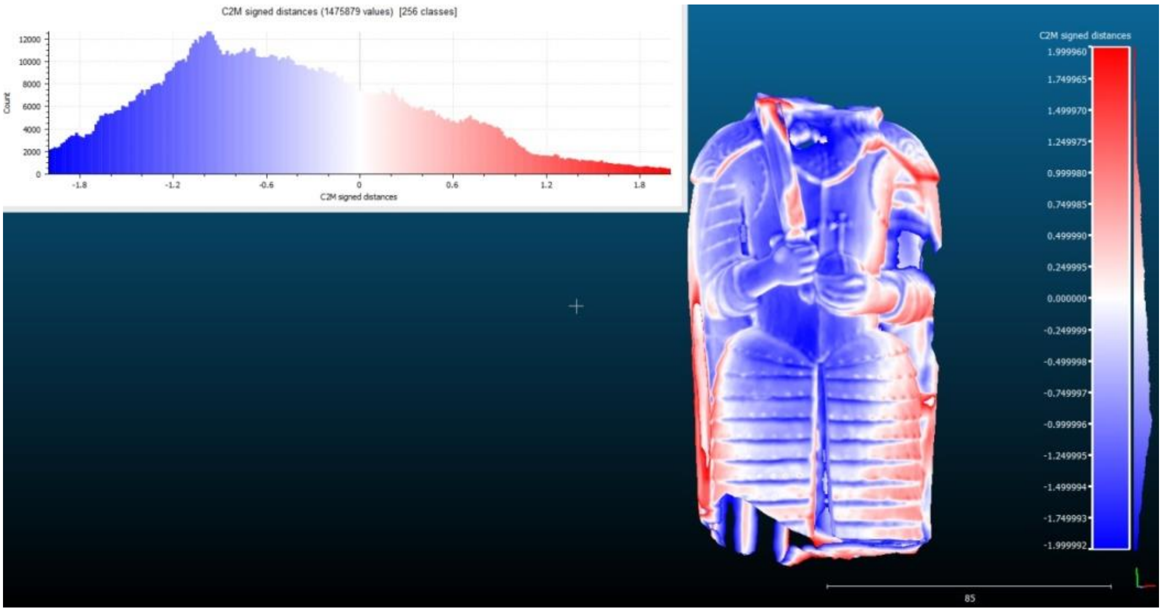


Figure 7.4 Blackfriars King compared to Charles Gift Site King, with 2mm parameters set in place.

What is of note is that specific features on the king such as rivets on the armour, elements of the sword and orb and cross, and the placement of the hands orientate around the 0 marker, with many of these being represented in white indicating very close matches. This demonstrates that although erosion and differing size variation factors such as shrinkage during firing and seam trimming may have affected the kings, both the figurines precise features are in identical locations. Furthermore, if even stricter metric parameters are emplaced, as shown on Figure 7.5, which displays a 1mm parameter and Figure 7.6 which displays a 0.5mm parameter, large areas of the figurines surface areas remain present. Specifically, 58.23% of the figurines overall face count falls into the 1mm parameter, and a total of 28.56% of the faces fall into the 0.5mm parameter. Of note, with the similarity parameter set to 0.5mm there are still significant elements of specific features that are displayed as outlines or points of detailed similarity between the two figurines, such as the sword, orb, and in particular the armour. For full details on the face count at each stage of figurine parameter adjustments see Table 7.2. Finally, Figure 7.7 displays those regions which fell outside the 2mm tolerance, clarifying that these correlate to the high erosion areas previously discussed. Some of the expected erosional points are not represented by the colour scalar due to their value remaining under the 2mm tolerance, such as the wearing on the lower half of the sword.

Overall, this 3D comparison indicates a highly probable example of figurines being from the same mould generation, with even a potential for these figurines having been generated from the same mould. For example this is indicated by the clear similarity in position and size of specific features, such as the rivets, the fact that 50% of the figurines surfaces were similar under 1mm to each other and that over 25% of the figurines surfaces were similar at 0.5mm and finally the make-up of the histogram which had a high concentration around the 0 marker. The employment of this 3D

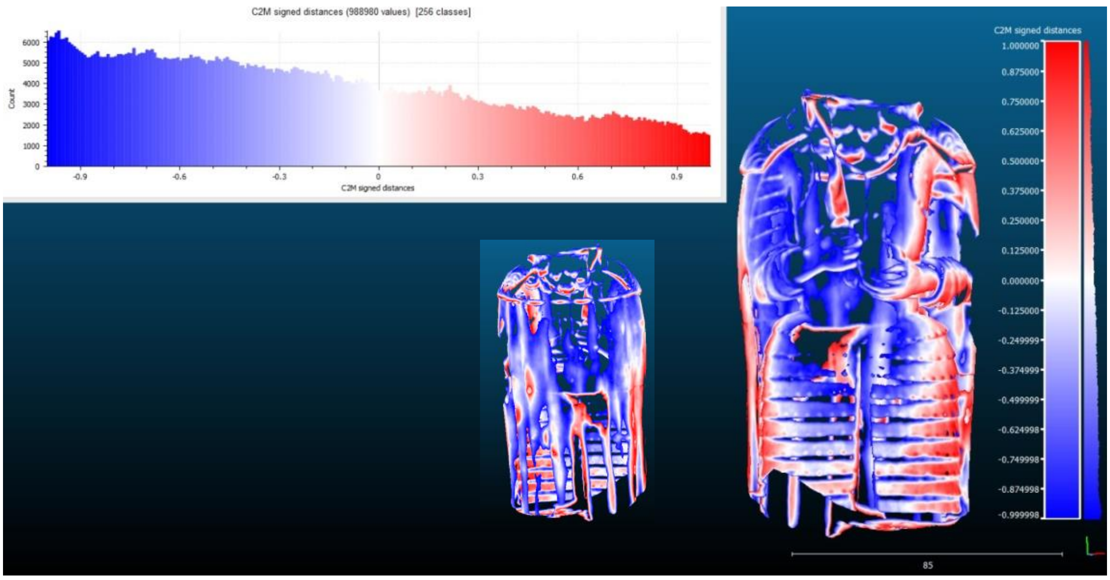


Figure 7.5 Blackfriars King front and rear compared to Charles Gift Site King, with 1mm parameters set in place.

methodology not only allows for a clear representation of the comparison, but also allows for a clear and focused dissemination of this data as well. This enables a more acute deconstruction of specific metric parameters between the figurines.

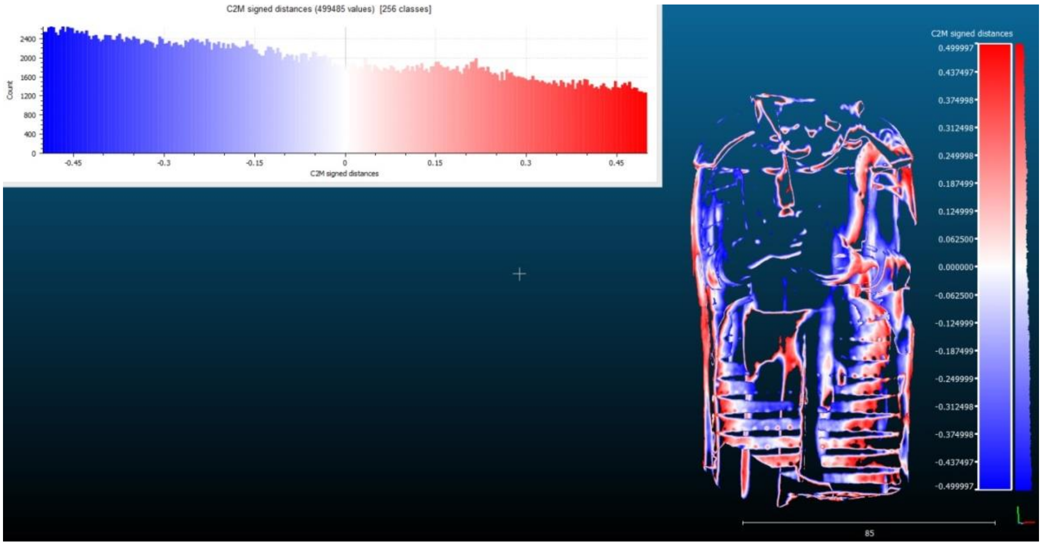


Figure 7.6 Blackfriars King compared to Charles Gift Site King, with 0.5mm parameters set in place

Mm parameter	Total number of faces present	Percentage of figurine
Full figurine	2,834,454	100%
3	2,674,046	94.3%
2	2,512,186	88.63%
1	1,650,284	58.23%
0.5	809,651	28.56%

Table 7.2 Different stages of figurine parameters, the affecting face count and the overall surface area percentage representation

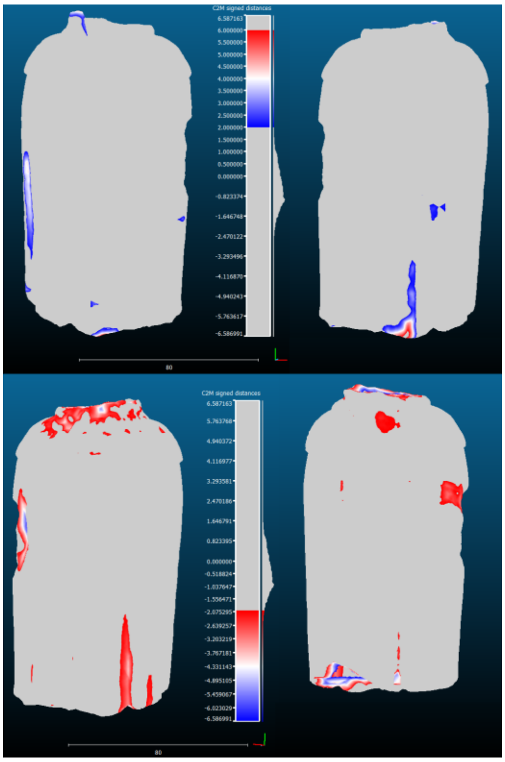


Figure 7.7 The pattern of regions which correlate with expected regions of metric variation due to erosion.

7.1.2 King Comparison Results Using SfM, Agisoft Photoscan

Although Chapter 3 made it clear that there are issues with using SfM software for 3D comparison methodologies, it is still of benefit to carry out a further case study looking at two figurines that do have close similarities. While it is hypothesised that the SfM software would provide less accurate morphometric data in comparison to the NextEngine, this still needs to be clarified. Carrying out this comparison would also clarify whether the quality of the data produced through SfM could still be high enough to provide the level of detail necessary for morphometric analysis and figurine comparison. Agisoft Photoscan was chosen as Autodesk123D Catch, although potentially slightly better (see Chapter 3), would not produce a useable model of the Blackfriars king. The models of the two kings were then processed through CloudCompare with the same parameters which were employed during the NextEngine CloudCompare comparison tests (figure 7.8 -7.11); this ensures a consistent procedure is carried out. The following results are displayed in meters as this is the set measurement within Agisoft, but represents the 3mm, 2mm, 1mm, and 0.5mm stages from above.

Examining the results which have been produced from the Agisoft comparisons of the king (Table 7.3), it can be quickly ascertained that they have produced significantly less similarity than the NextEngine. The models produced for the 1mm and in particular 0.5mm parameters (Figures 7.10 and 7.11) are of little use. Whilst 28.22% of the models' faces are still displayed with the 1mm parameter, this is less than half of the number of faces from the NextEngine data at the same point of analysis, and many details are lacking, such as the outline of the orb and the rivets on the tasset. The NextEngine results during these two stages indicated a much higher level of similarity between the two figurines, with a higher correlation in the models face counts. These results are to be expected, since the accuracy of this software does not reach the same macro scales of precision seen in the laser scanner, as discussed in the accuracy trials in Chapter 3. That being said, Photoscan does still produce some information at these levels, especially at 3mm and 2mm parameters, and it is interesting to see that some of the specific features are still outlined even at 0.5mm parameters, such as the tasset edging. However, it is within the 2mm parameter (Figure 7.9) where potential for employing SfM software may be seen. Within the 2mm parameter 73.28% of the models' compared faces remain, and features such as the sword, rivets, breastplate, and orb and cross are all represented within this parameter.

Therefore, while SfM cannot provide results down to the macroscopic levels that the laser scanner, it can still offer a suggestive comprehension of the models within the 2mm parameter bar.

For example, using the above king comparisons, it could not be suggested that these figurines were produced via the same mould. What could be suggested is that, due to the majority of model faces and specific feature details remaining within the 2mm parameter, the figurines are produced at least from the same generation of models. Furthermore, if one examines and compares the histograms (Figure 7.12) of each of the NextEngine parameters stages with the Photoscan parameter stages, it can be quickly seen that, although the values for the SfM tests dissipate around the 0 marker (an expected result due to the reduced accuracy of the software), the general shape of the Photoscan histograms mirrors those of the NextEngine. Therefore, while the direct visual comparison of the models may not produce an exact morphometric analysis of the model comparisons, the histogram shape can act as a suggestive placement for the models, with the same theoretical predictions discussed in section 7.2.5 also being applied to the SfM results. As such, these results indicate that SfM could be used to carry out the suggested 3D comparison methodology employed within this study as a quick and cheap technique offering researchers a suggestion of object comparison. These could provide initial targets of interest that could then be laser scanned for more detailed comparison concerning the nature of the similarity and the potential mould relationship. In this case an appreciation for the different behaviour of the likely SfM histograms (as represented in Figure 7.12) would need to made, and expectations about how the peaks would look adjusted accordingly.

Mm parameter	Total number of faces present	Percentage of figurine
Full figurine	3,523909	
3	3,065,589	86.99%
2	2,582,384	73.28%
1	994,319	28.22%
0.5	234,258	6.65%

Table 7.3 Different stages of the SfM approaches to the Charles Gift Site and Blackfriars figurine comparison parameters and the affecting face count and overall surface area percentage representation.

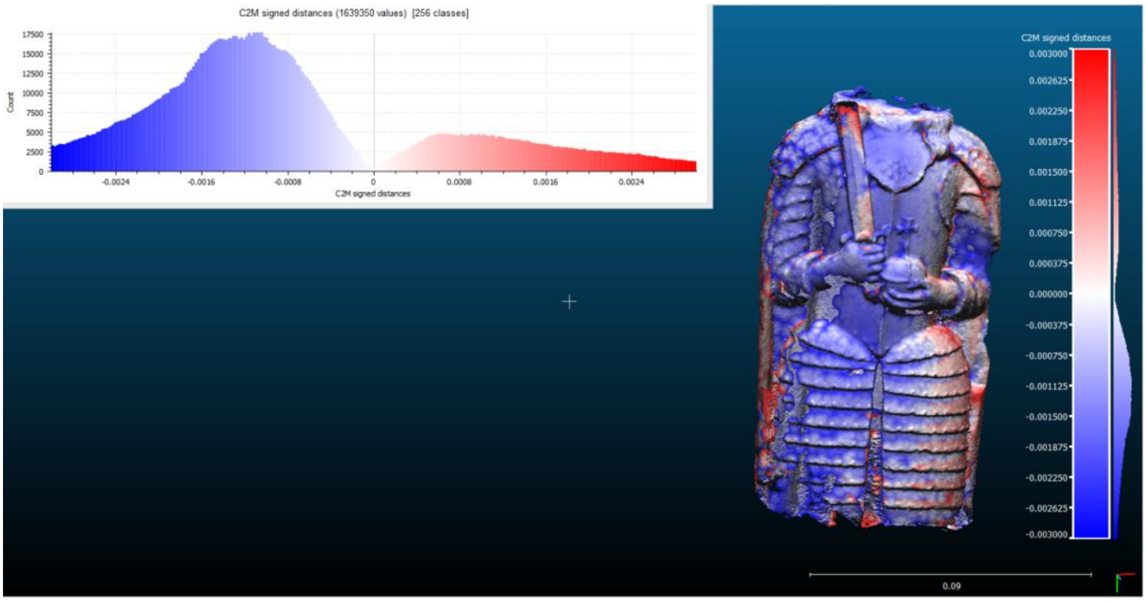


Figure 7.8 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.003m parameter set (3mm).

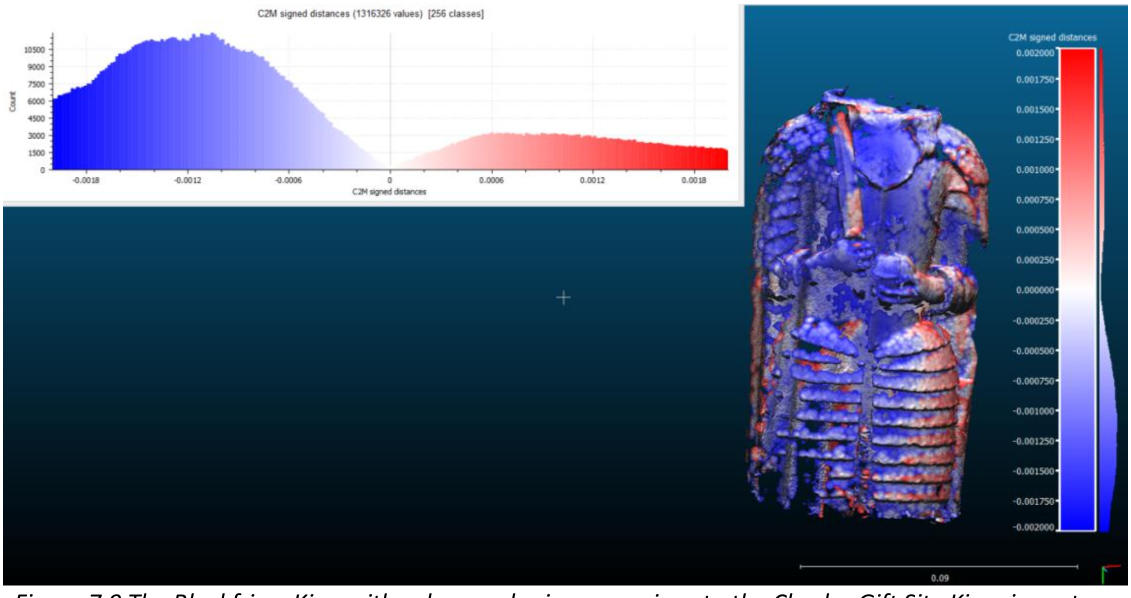


Figure 7.9 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.002m parameter set (2mm).

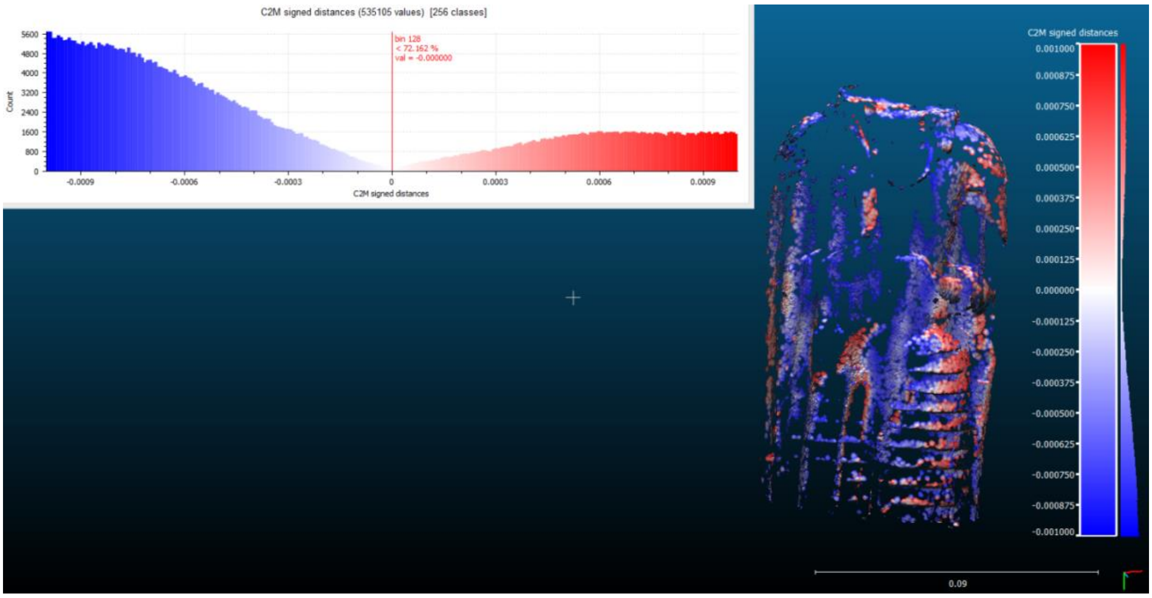


Figure 7.10 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.001m parameter set (1mm).

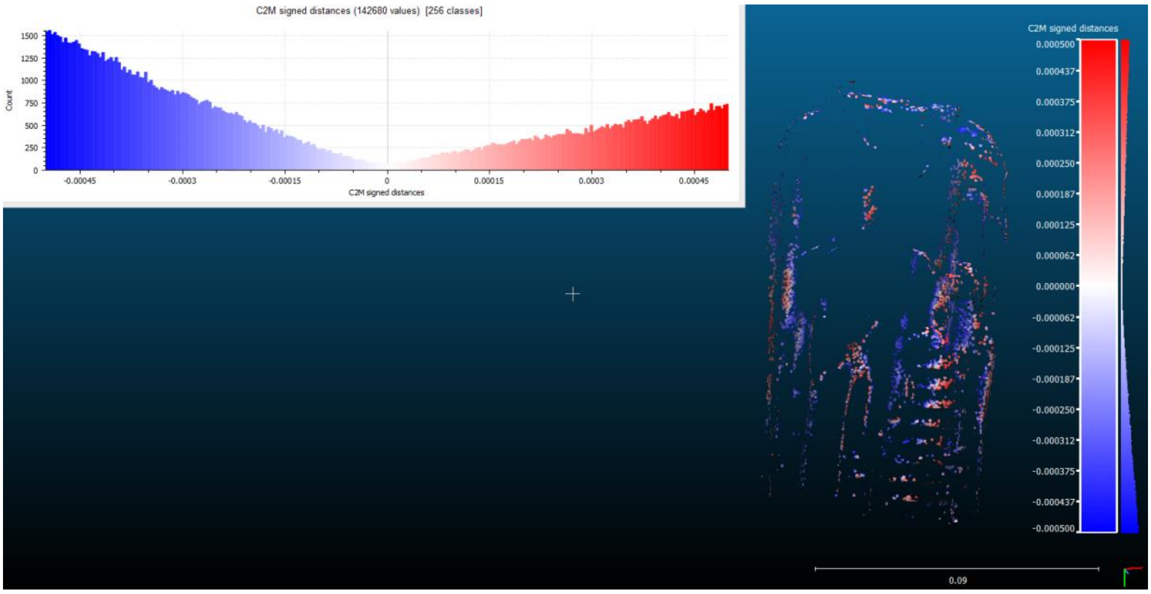


Figure 7.11 The Blackfriars King with colour scalar in comparison to the Charles Gift Site King, in meters, with a 0.0005m parameter set (0.5mm).

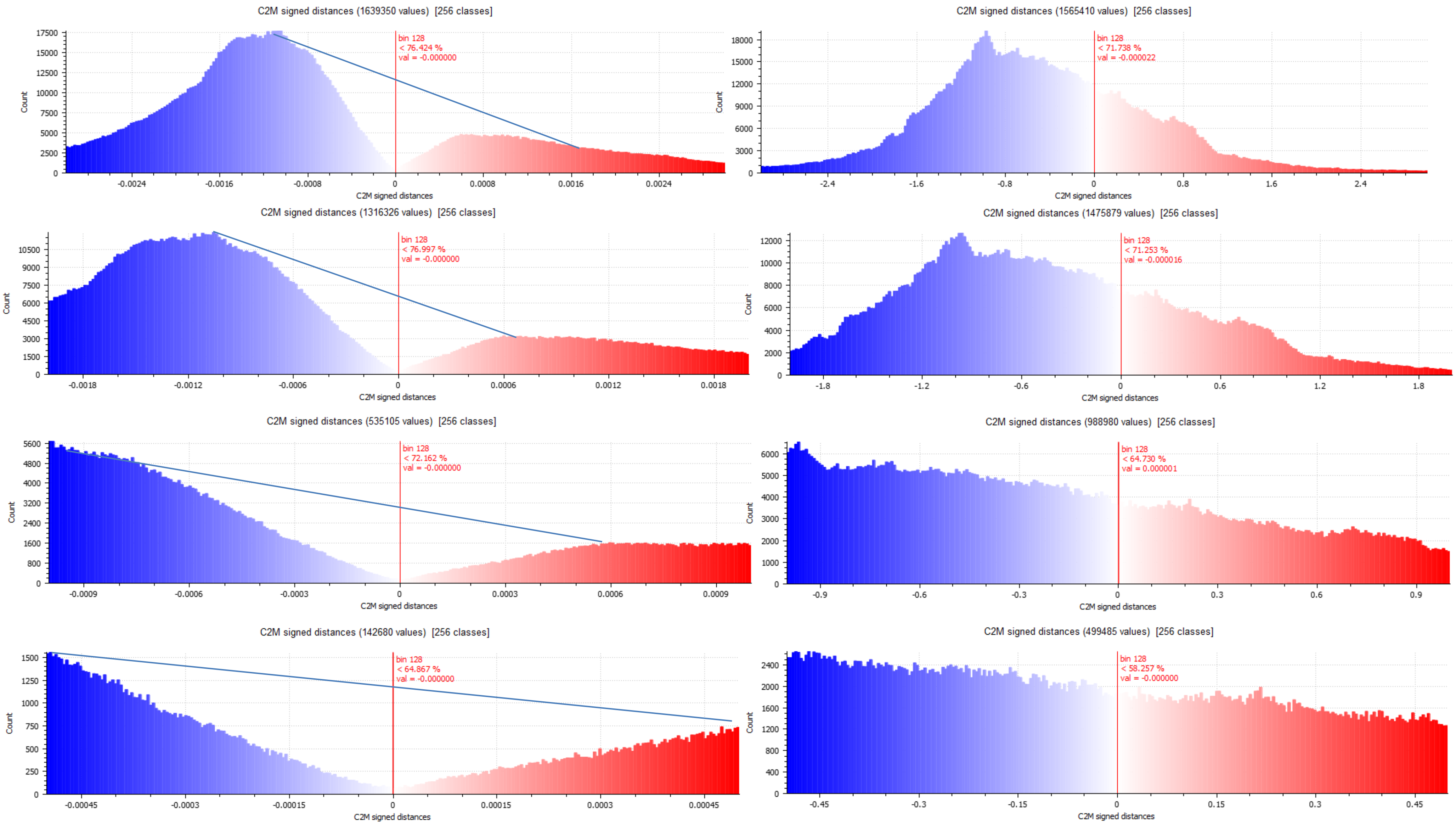


Figure 7.12 SfM histograms on the left side compare to the NextEngine Histograms on the right side.

7.1.3 Cockerels A5176, 4973b and a19159

The Museum of London holds nine fragmented cockerels on column, and three of these (Figure 7.13) look to be of very similar form. These similarities have been assessed using the usual visual comparison methods discussed earlier in Chapter 6. There are many post-production differences on their surfaces (Figure 7.14), such as colour caused by mineral leaching in the contexts they were deposited in, as well as the usual broken and worn features, which is especially apparent on 4973b. Nevertheless, despite these erosional differences there are still a lot of similarities between these three cockerels (Figure 7.15), including the flow of the feathers, the eye design, the wattle position, and their general sizes. These similarities are especially apparent when these three figurines were compared directly with each other in the Museum. Comparisons were carried out between A5176 and a19159 and between A5176 and 4973b, both used a 1,200,000 face sample limit during alignment, and between a19159 and 4973b used a 620,000 sample limit.

Figure 7.13 from left to right Cockerels A5176, a19159 and 4973b. (Author's images courtesy of the Museum of London)

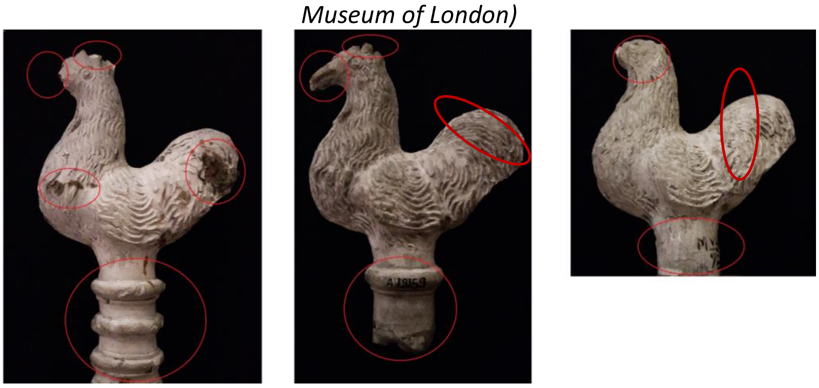


Figure 7.14 The post production differences between each of these cockerels, highlighted by red circles.

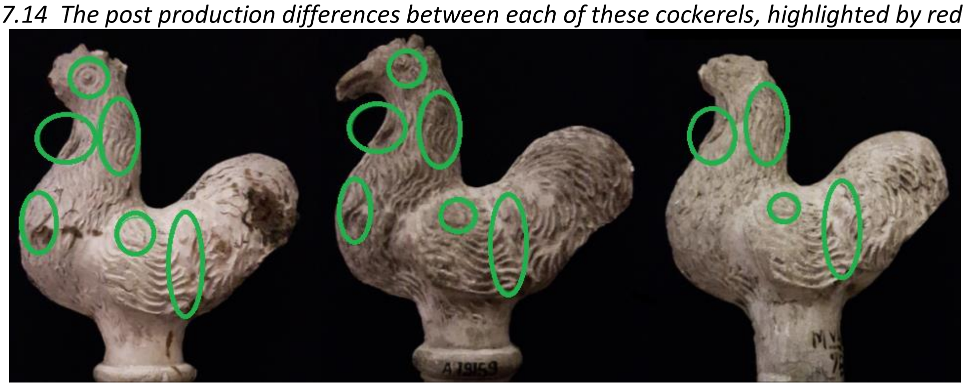


Figure 7.15 Structural similarities between the three cockerels, highlighted by green circles.

Cockerels A5176 Compared to a19159

The four levels of figurine comparison are summarised in Table 7.4 and Figures 7.16-7.19 (3mm parameter: Figure 7.16; 2mm parameter: Figure 7.17; 1mm parameter: Figure 7.18; and 0.5mm parameter: Figure 7.19). These show a significant level of structural similarities between the two cockerels, with 95.5% of their faces correlating with a maximum error of no more than 2mm (Figure 7.17). Considering that 58.36% of their faces also correlate at the parameter of 0.5mm, it seems likely that these figurines are from the same generation, possibly even from the same mould. This is further suggested by the peak of comparison value orientating at 0, similar to what was seen within the metric variability trials in Chapter 6, a result which was produced from figurines produced from the same mould.

mm Parameter	Total Number of faces present	Percentage of figurine
Full figurine	530,996	100%
3	519,167	97.77%
2	507,076	95.5%
1	453,354	85.38%
0.5	309,875	58.36%

Table 7.4 Different stages of figurines A5176 compared to a19159, parameters and the affecting face count and over all surface area percentage representation.

Cockerels A5176 Compared to 4973b

Comparisons involving Figurine 4973b were of particular interest, since the figurine had significant levels of erosion on all surfaces. Although there was a clear relationship between the two figurines (Table 7.5; Figure 7.20 for 3mm; Figure 7.21 for 2mm; Figure 7.22 for 1mm; and Figure 7.23 for 0.5mm parameters), the level of erosion and damage does appear to have impacted upon the overall comparison, most clearly indicated by the lack of a clear peak in the histograms. The level of similarity despite the damage, with 99.22% of their faces correlating at the 2mm parameter, and 49.48% at the 1mm parameter, indicates that erosion can be seen to dull trends present on

mm Parameter	Total Number of faces present	Percentage of figurine
Full figurine	608,502	100%
3	603,735	99.22%
2	531,566	87.36%
1	301,064	49.48%
0.5	147,492	24.24%

Table 7.5 Different stages of figurines A5176 compared to 4973b parameters and the affecting face count and over all surface area percentage representation.

the histograms but not to such a detrimental extent that a broader family relation within mould generation analysis cannot be undertaken. While in this scenario no clear assignment of generation could be reached, a broader family relationship can at least be indicated by the high correlation of face values seen.

Cockerels a19159 Compared to 4973b

The final two cockerels to be compared were a19159 with 4973b. The results from this comparison shown in Table 7.6 and Figures 7.24 - 7.27 display clearly that these two figurines do not come from the same generation of mould, as overall 74.15% of a19159 is smaller than 4973b. Many of the features remain in the same regions down to 1mm, however, with 68.56% of the surface areas still correlating within this parameter (Figure 7.26). This suggests that although these figurines are not from the same generation they may present an example of related moulds of different generations. Unfortunately, the exact nature of this relationship is not clear due to the extent of erosion experienced on 4973b.

Table 7.6 Different stages of figurines a19159 compared to 4973b parameters and the affecting face count and over all surface area percentage representation.

mm Parameter	Total Number of faces present	Percentage of figurine
Full figurine	530,996	100%
3mm	494,834	93.19%
2mm	473,928	89.25%
1mm	364,054	68.56%
0.5mm	174,396	32.84%

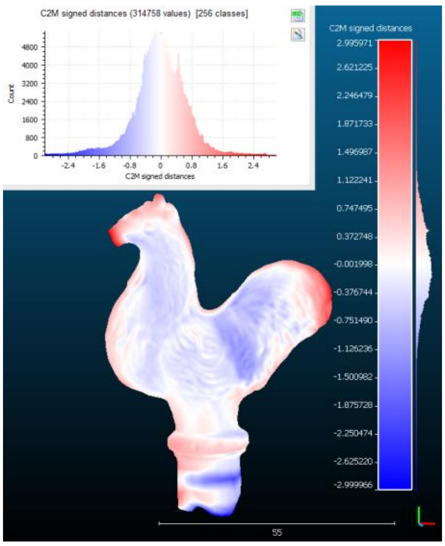


Figure 7.16 A5176 compared with a19159, results displayed on a19159, 3mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. High similarities seen in the main body, indicated by the large space of white and light blue.

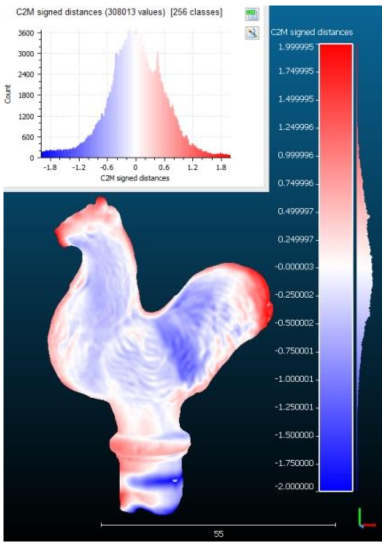


Figure 7.17 A5176 compared with a19159, results displayed on a19159, 2mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. High similarities seen in the main body, indicated by the large space of white and light blue.

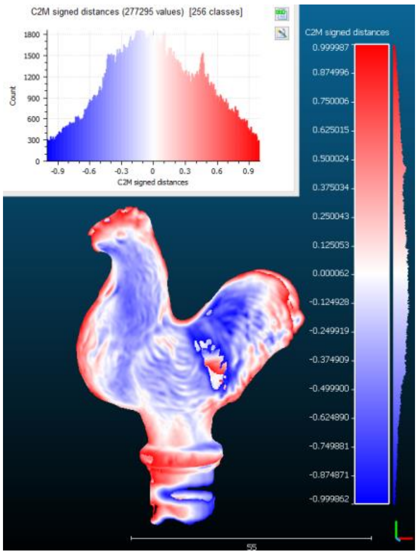


Figure 7.18 A5176 compared with a19159, results displayed on a19159, 1mm parameter. Significant difference along figurine seams, expected due to seam scrapping after moulding. Some areas are shown not to be in the 1mm parameter, however the majority of the figurine is still present.

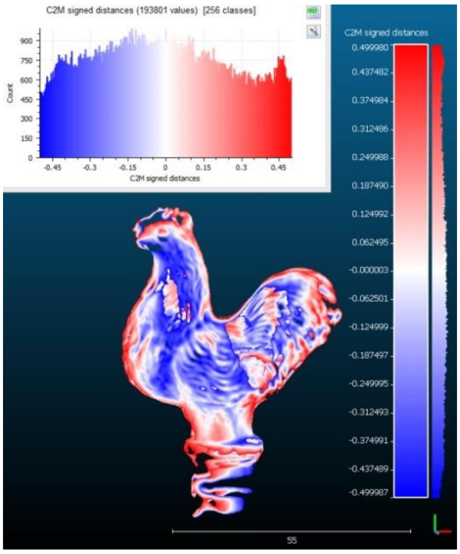


Figure 7.19 A5176 compared with a19159, results displayed on a19159, 0.5mm parameter. Significant difference along figurine seams, expected due to seam scrapping after moulding. Some areas are shown not to be in the 0.5mm parameter, however the majority of the figurine is still present.

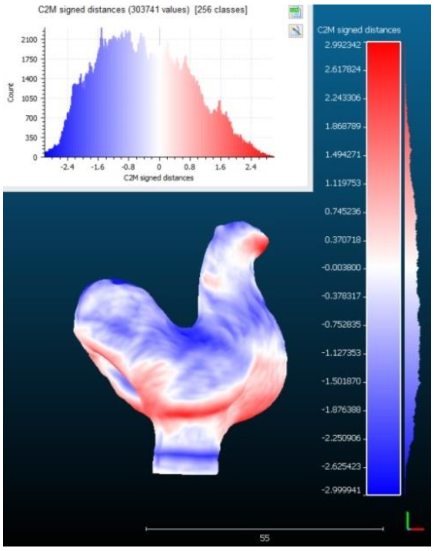


Figure 7.20 A5176 vs 4973b, results displayed on 4973b, 3mm parameter. Significant difference along the beak, tail base and wing base, indicated by the red colouring. A majority of a5176 is shown to be slightly reduced in size in comparison to 4973b, indicated by the large regions of blue.

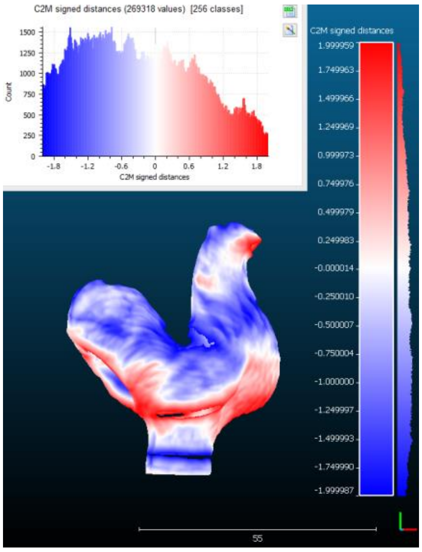


Figure 7.21 A5176 vs 4973b, results displayed on 4973b, 2mm parameter. Significant difference along the beak, tail base and wing base, indicated by the red colouring. A majority of a5176 is shown to be slightly reduced in size in comparison to 4973b, indicated by the large regions of blue.

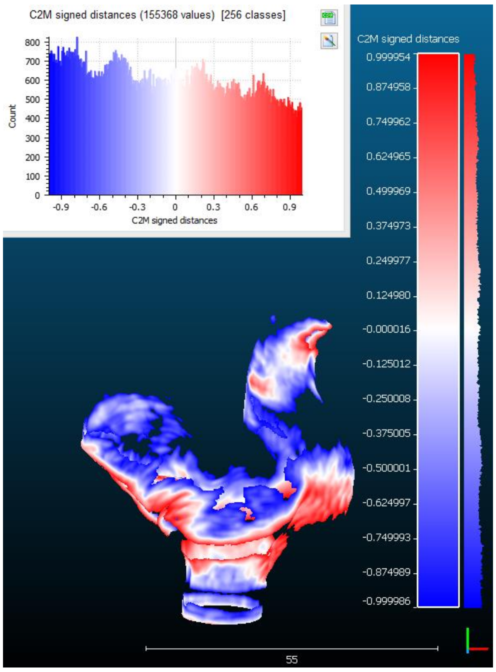


Figure 7.22 A5176 vs 4973b, results displayed on 4973b, 1mm parameter. 49.48% of the model comparison remains at the 1mm parameter, showing that there are still similarities present at this level between the figurines, with A5176 displayed as the slightly smaller figurine still.

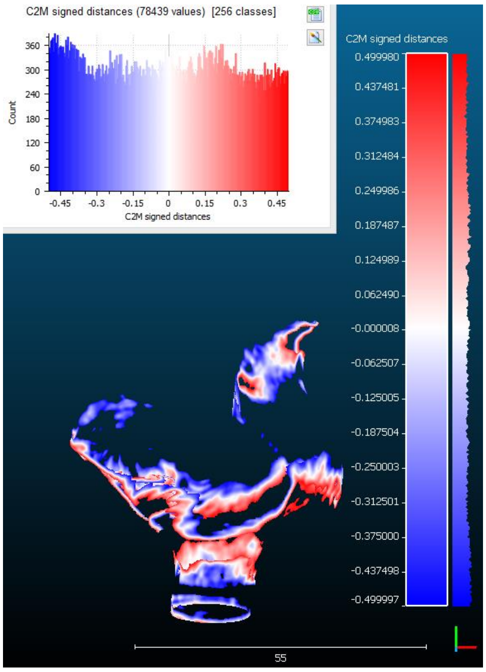


Figure 7.23 A5176 vs 4973b, results displayed on 4973b, 0.5mm parameter. 24.24% of the figurines are still shown to be present.

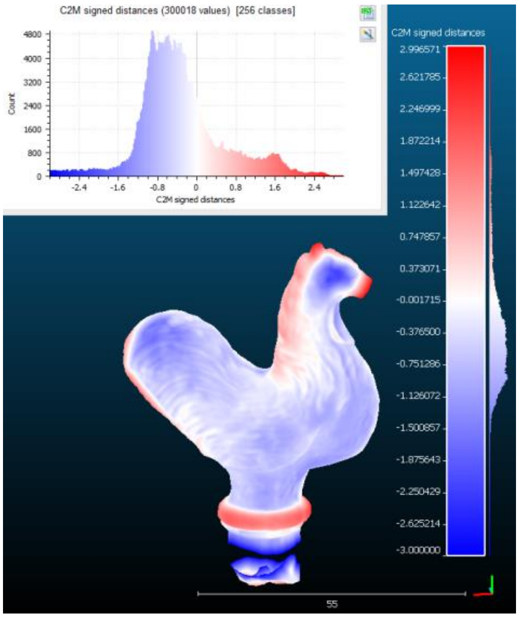


Figure 7.24 a19159 vs 4973b, results displayed on a19159, 3mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. A majority of a19159 is shown to be reduced in size in comparison to 4973b, indicated by the large regions of blue.

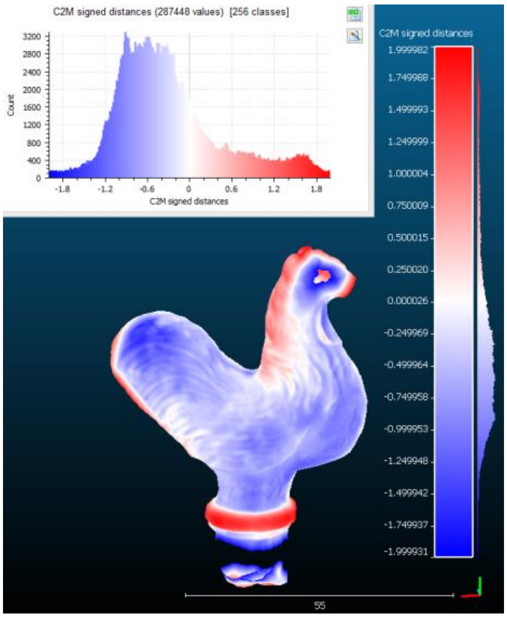


Figure 7.25 a19159 vs 4973b, results displayed on a19159, 2mm parameter. Significant difference along the beak, cockerel comb and tail tip, indicated by the red colouring. Some areas around the cockerel's eye are present within this parameter. A majority of a19159 is shown to be reduced in size in comparison to 4973b, indicated by the large regions of blue.

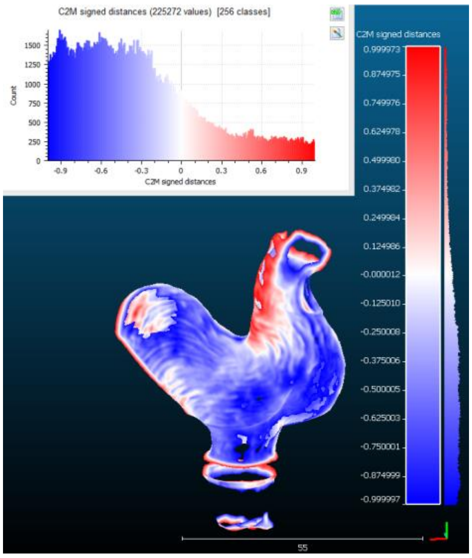


Figure 7.26 a19159 vs 4973b, results displayed on a19159, 1mm parameter. 68.56% of the model comparison remains at the 1mm parameter, showing that there are still similarities present at this level between the figurines, with a19159 displayed as the slightly smaller figurine still.

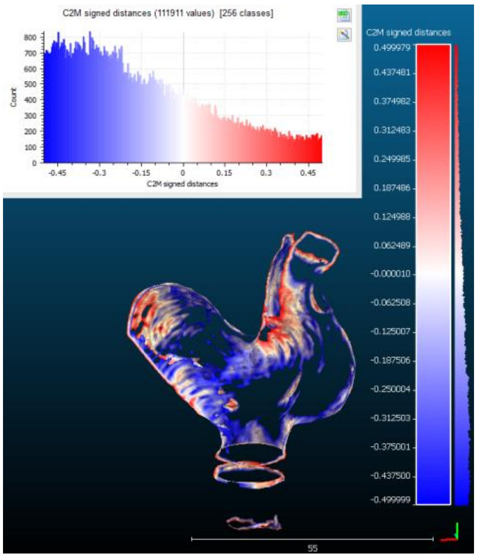


Figure 7.27 a19159 vs 4973b, results displayed on a19159 0.5mm parameter. 32.84% of the figurines are still shown to be present.

7.1.2.4 Discussion of Cockerels A5176, A19159 and 4973b

Through the comparison of the three cockerel figurines several points can be made. Firstly, there is a clear and strong relationship between A5176 and a19159. This relationship is displayed clearly both on the histogram's structure, which presents a central peak orientated on 0 with 'long tails' either side of this peak, the same structure seen in the fired elephant comparisons discussed in Chapter 6. This was also linked to a significant level of correlated faces even within the lowest parameter setting, with 58.36% of faces being present at 0.5mm parameter. Taken together, these points allow a conclusion that these figurines are clearly from the same mould generation, with high potential that they are also from the same mould, as shown in the suggested hypothetical sequence in Figure 7.28. Secondly, the high level of erosion and damage on Figurine 4973b dulled the histogram results, preventing a clear trend to be produced. Despite this, there was a high correlation of face counts seen within both of its comparisons, with 49.48% still present at 1mm when compared to A5176 and 48.16% remaining when compared to a19159. There was also a slight leftward preponderance to the histogram in both comparisons, although whether due to erosion or mould generation cannot be ascertained. As such, whilst no specific assignment of generation can be consigned, a general family relationship to the other figurines can be suggested.

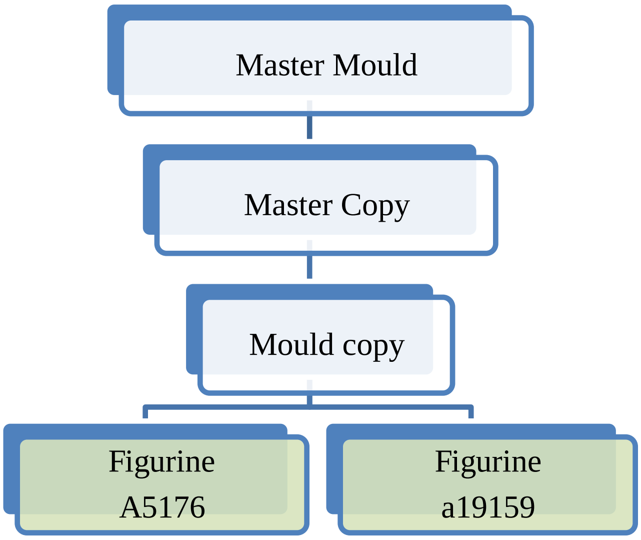


Figure 7.28 Hypothetical appearance of suggested mould generation, 4973b is not shown as no specific assignment of generation can be consigned.

7.1.4 Whitechapel King 1854,1130.43 and Thames King 1856,0701.1657

Both the Whitechapel King and Thames King (Figure 7.29) are held within the British Museum. The Whitechapel King is the figurine with a head, whilst the Thames King, recovered from the Thames foreshore, is the one without. Having been found on the foreshore, the Thames King has experienced a significant level of riverine erosion, possibly explaining the lack of a head, although accidental breakage or purposeful damage could still be considered. Despite the erosion the Thames King still has significant detail surviving, likely the result of the clay's resilient nature (Figure 7.30). As these figurines are both held within the British Museum, side by side analysis could occur, following the standard figurine recording and examination processes carried out on almost all the material included in this thesis, involving measurements, feature comparisons and examination. It was decided at this point that these figurines may be from the same generation or closely connected generations, as both the stature and design of the figurines were corresponding. The base, which was an element dependent upon the original mould and not attached after production (as seen by the mould lines), was the one feature of significant variability between the two figurines. Both bases also appear to have experienced high levels of alterations, via trimming and additional shaping. Once the visual comparison was completed the figurines were then 3D scanned and examined via the CloudCompare software. The results are displayed on the Thames King, which was headless, with the original face count consisting of 1,046,280 faces, which was the sample set for the comparison (a summary of the results can be seen within Table 7.7).

Figure 7.29 The top two images display the front and rear of the Whitechapel King, and the bottom two images display the front and rear of the Thames King (Author's images with thanks to the British Museum)

Figure 7.30 The top two images display the front and rear of the Whitechapel King, and the bottom two images display the front and rear of the Thames King, the erosional variation between the two figurines is indicated with the red circles. Significant areas of difference are seen on the neck break, sword pommel, damage to the top of the left thigh on the Thames King figurine, damage to the right of the Thames King's cloak, base damage, the crack along the Whitechapel King's left ankle and the curatorial ink on both the figurines.

The visual representations of the comparison are shown in Figures 7.31-7.34, and indicate that the Thames King is marginally smaller than the Whitechapel King. The smaller size may suggest that the Thames King was produced via a later generation mould of the Whitechapel King. On the other hand, specific features remain in constant positions between each of the figurines, suggesting that there is potential for the two figurines to have been produced from the same mould. When examining the figurine at the 0.5mm parameter it can be seen that even at this level many of the main features are still present, such as the tassets, cuisse, cloak folds, and greaves. Similar to the analysis of the Cockerels, the erosion damage to the Thames King may also explain why this figurine showed a slight reduction in size, meaning a suggestive conclusion that these figurines were from related moulds of either the same or slightly different generations.

Parameter	Faces	%	Comments
RMS 0.63 **STD** 0.6 **MEAN** -0.2			
Original model	1,045,934	100	/
3mm	1,046,280	99.97	66% of the Thames King is smaller. Fluctuations of size differences especially noted around the highly eroded regions, as expected.
2mm	1,041,948	99.59	Majority of features still present.
1mm	946,059	90.42	10% of the areas have been removed, especially seen on the top right hip, expected due to the erosional differences recorded in Figure 7.30.
0.5mm	578,609	55.30	Over half of the features still present at this level.

Table 7.7 Summary of Whitechapel compared to the Thames King comparison results. Results are in mm.

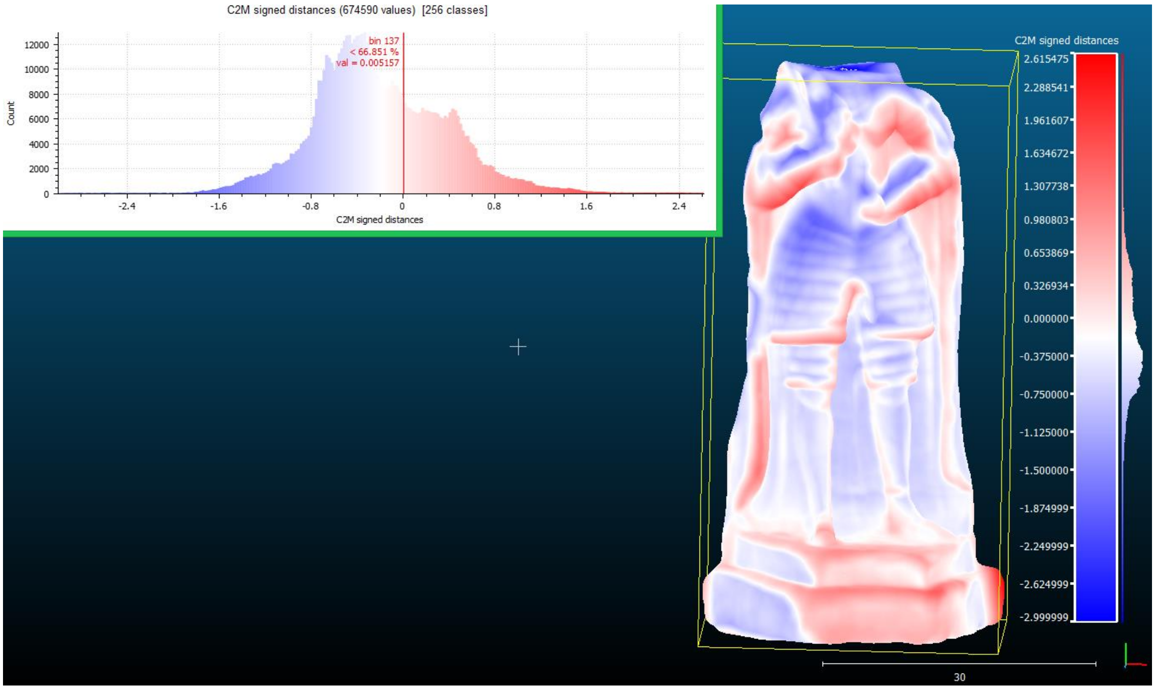


Figure 7.31 2.6 - -2.99mm parameter results, displayed on the Thames King. 66% of the Thames King is smaller, indicated by the blue regions. High areas of differentiation are shown to correspond with the regions marked out on Figure 7.30.

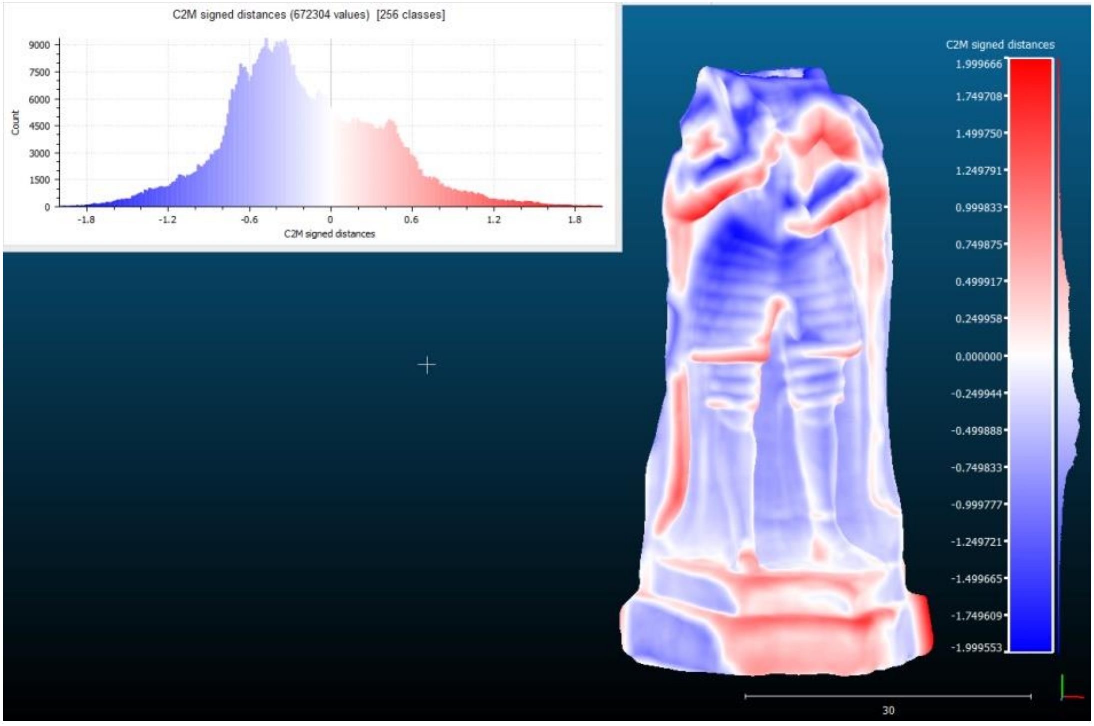


Figure 7.32 2mm parameter results, displayed on the Thames King. However 99.59% of the figurine features are present within the 2mm parameter.

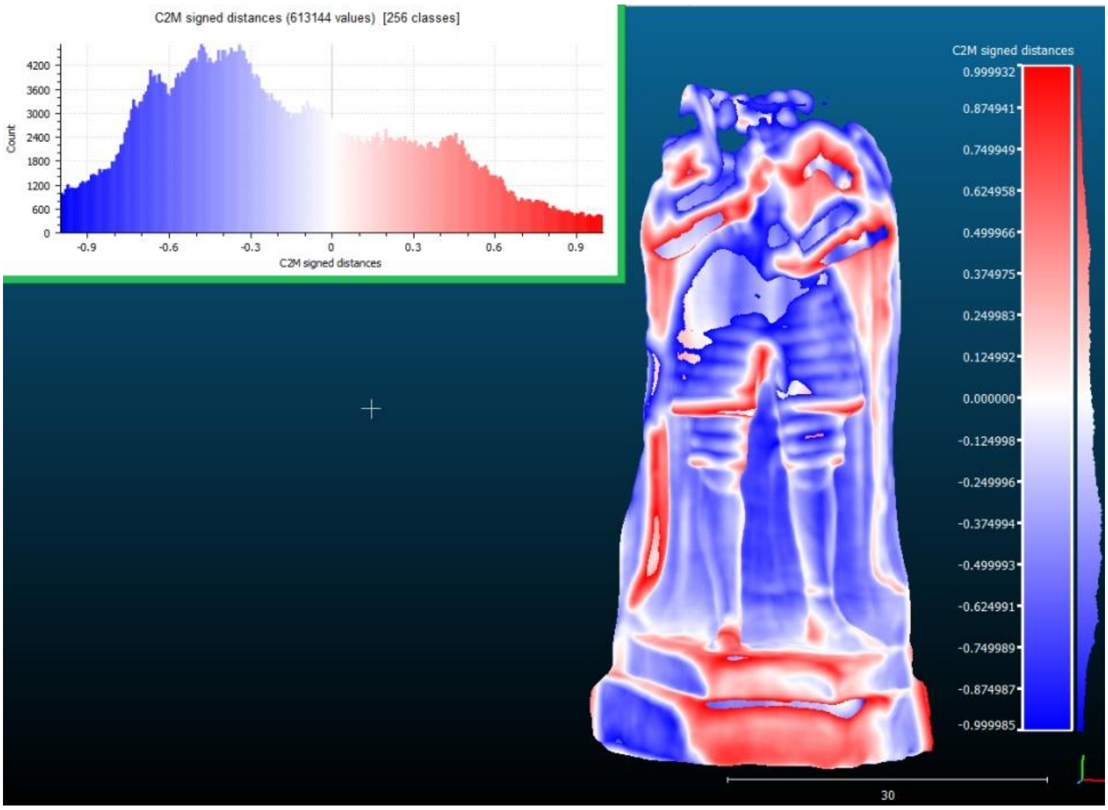


Figure 7.33 1mm parameter results, displayed on the Thames King, with 90.42% of the figurine faces still present at the 1mm parameter.

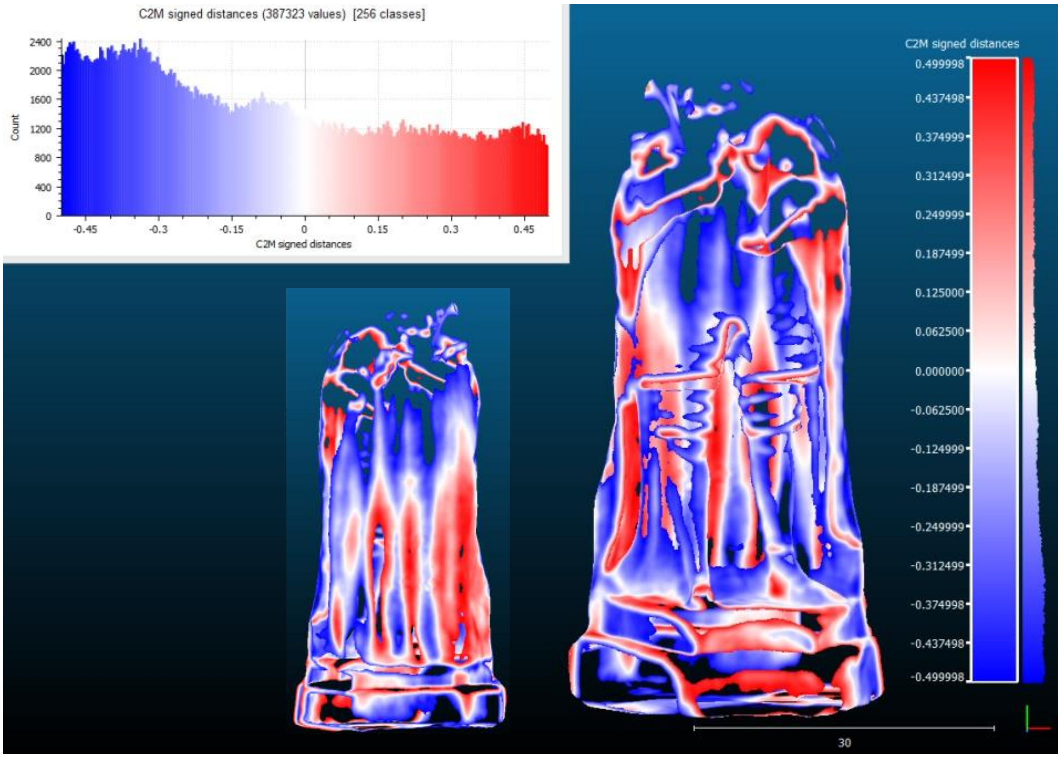


Figure 7.34 0.5mm parameter results, displayed on the Thames King, the image displays the rear of the comparison to the left and the front of the figurine comparison to the right. 55.30% of the model comparison remains at the 0.5mm parameter, showing that there are still large similarities present at this level between the figurines, with the Thames King still displayed as the slightly smaller figurine.

7.1.5 Dorothy Holding a Basket: 1854,1130.45; 1854,1130. 46 and 4972

The three figurines displayed in Figure 7.35 all potentially represent Saint Dorothy. The two from the British Museum were found on Cannon Street, and the figurine from the Museum of London has no specific provenance. The two British Museum figurines were visually compared to each other via a series of measurements and stylistic observations, leading to the conclusion that apart from the angle of the head, the two figurines were incredibly similar (Figure 7.36). This angle alteration may have occurred during extraction of these figurines from their moulds, especially due to the delicate size of the figurine. The other main factors affecting the comparison were caused by the museum sticker on the rear of both of the British Museum figurines, which were picked up during scanning and causing clear areas of difference when compared through CloudCompare. During the analysis these areas were noted in a similar manner to damage and erosion, and were taken into consideration when interpreting the results. The third figurine, which is held in the Museum of London, could not be compared physically next to the other two figurines. Similarities were noted during data collection through photographic images and measurement comparison, leading to the conclusion that this figurine had the potential for being either from the same mould or a closely related mould generation as the two figurines from the British Museum, although it also seems that the head of this figurine has experienced some angle shifting during mould extraction, as seen in Figure 7.36.

1854,1130.45 1854,1130.46 4972

Figure 7.35 from left to right front and back of figure 1854,1130.45, in the middle is the front and back of figurine 1854,1130.46 (author's images courtesy of The British Museum) and to the right is the front and back of figurine 4972 (authors image courtesy of the MoL)

Figure 7.36 Areas of likely variation on the models marked in red. Some is due to erosion and breakage, but significant parts of the left two figurines are affected by the museum stickers

After the visual comparison, figurines were then compared against each other using CloudCompare. The comparisons which involved the 4972 Dorothy were done in two parts due the break in the figurine. In each case the face count during figurine alignment was based on the figurine with the highest face value to ensure all faces were included during alignment. For a summary of results please see Tables 7.8 – 7.12.

Parameter	Faces	%	Comments
Dorothy 1854,1130.45 compared to 1854,1130.46 with results shown on 1854,1130.45. (Figures 7.37-40) **RMS = 0.25mm** **STD= 0.6mm** **Mean= 0.02mm**			
Original Model	531647	100	/
1mm	531647	100	Entire model remained. Areas of positive size difference on the front face are matched by a corresponding negative size difference on the rear and *vice versa*, though feature locations are displayed in white. Potential squashing of figurine? Though the circular area indicated in red on the rear of the figurines indicates the museum sticker not an actual size difference between figurines themselves.
0.5mm	510,309	96	Features which have the potential to be most affected by erosion, shrinkage and mould extraction shifting begin to be removed.
0.25mm	377149	71	High level of faces remaining, many features such as basket weave outline and clothing folds still represented in white
0.05mm	77200	14.5	Main outline and feature outlines remain.

Table 7.8 Different stages of figurine parameters and the affecting face count and overall surface area percentage representation. Dorothy 1854,1130.45 compared to 1854,1130.46 with results shown on 1854,1130.45.

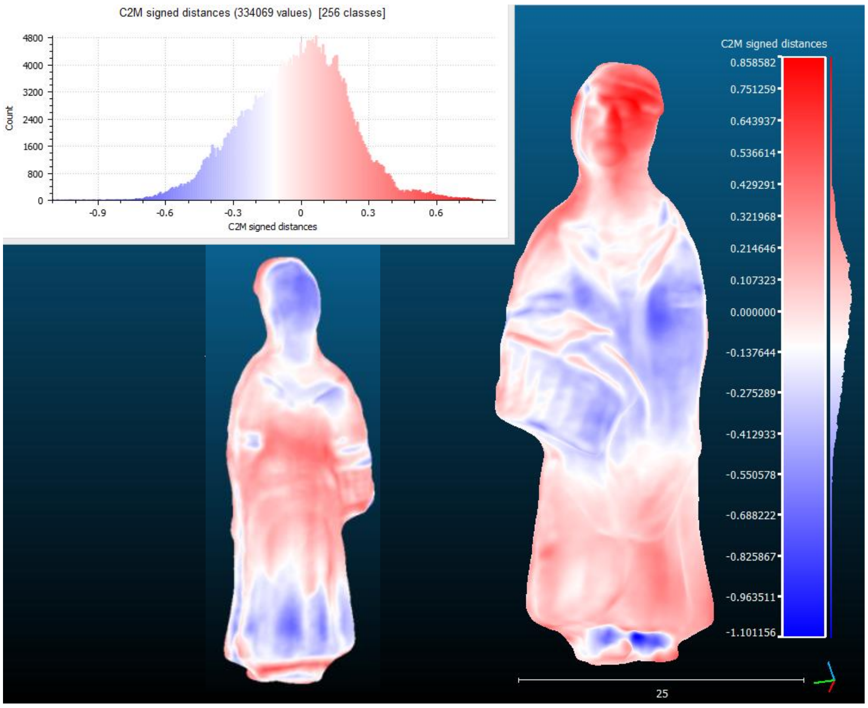


Figure 7.37 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46, 1mm parameter. To the left is the rear of the figurine, to the right is the front of the figurine. Note the circular area on the rear of the figurine, indicating the museum reference sticker rather than actual size variation on the figurines themselves.

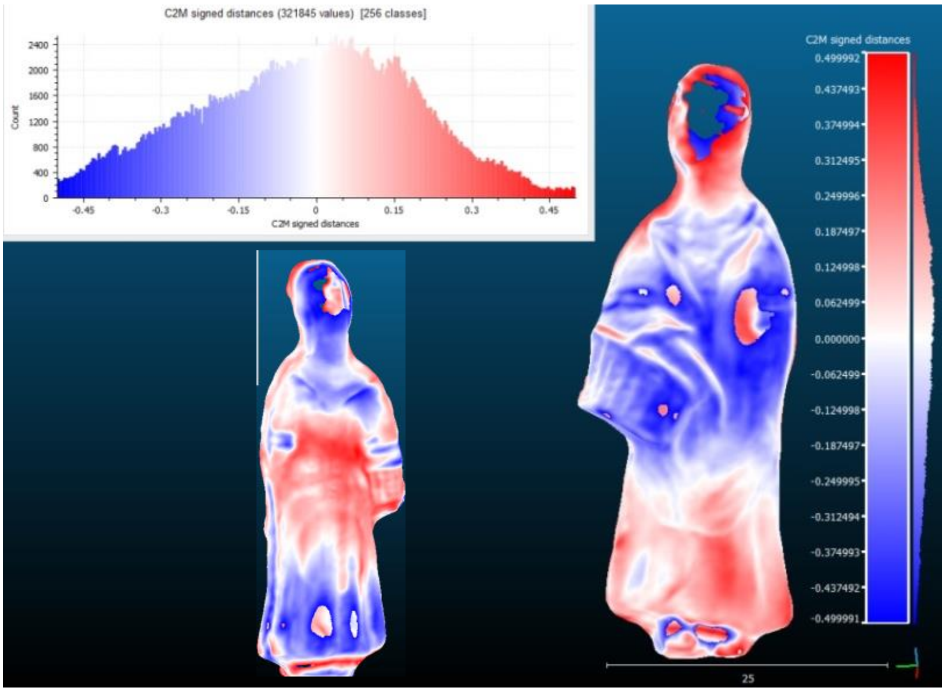


Figure 7.38 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46, 0.5mm parameter. Areas which begin to be removed are the features which have the potential to most highly affected by erosion, shrinkage and mould extraction, as expected.

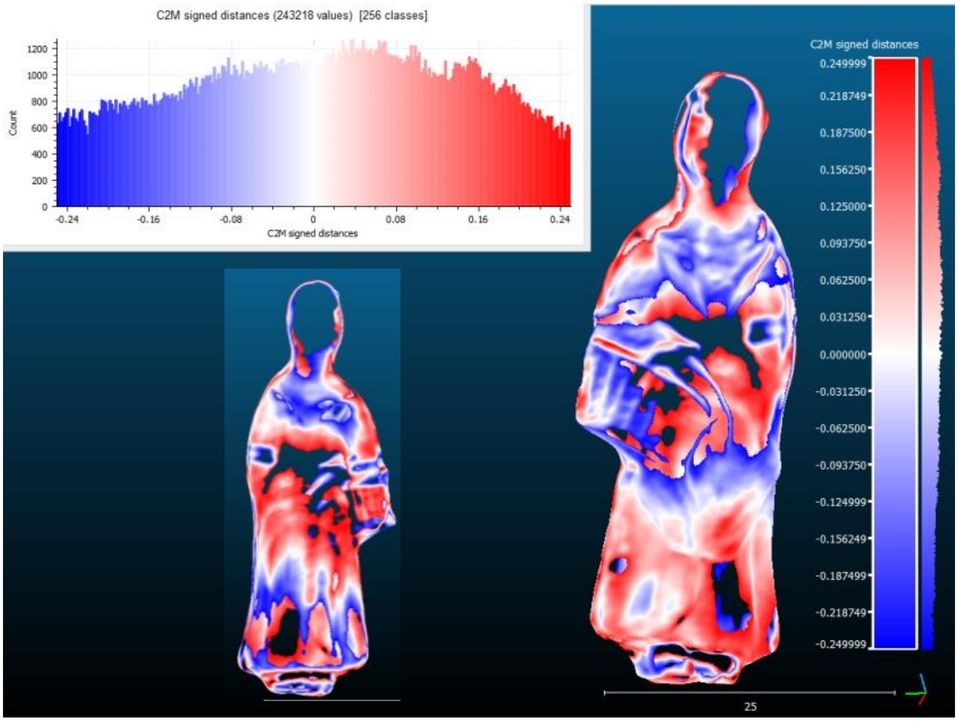


Figure 7.39 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46, 0.25mm parameter. High level of faces remain with many specific features such as the basket details still present.

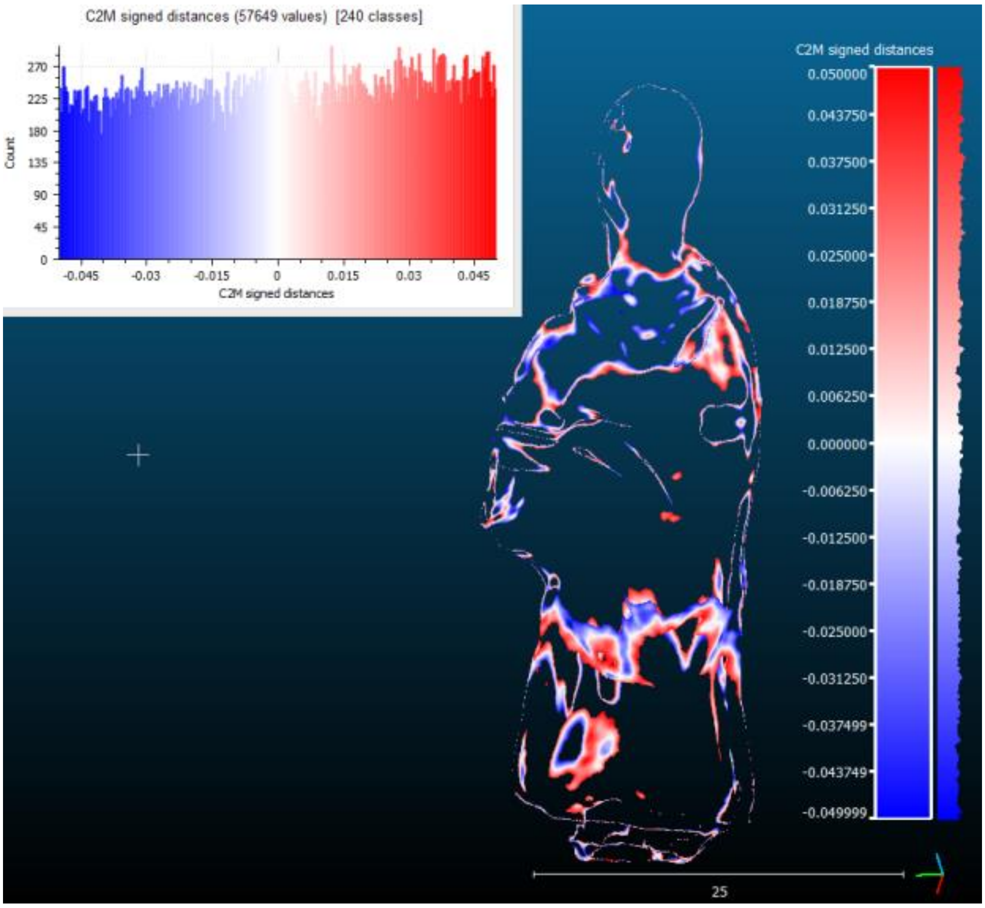


Figure 7.40 1854,1130.45 compared to 1854,1130.46. Results shown on 1854,1130.46. 0.05mm parameter, the main outline of the figurine is still present.

Parameter	Faces	%	Comments
Dorothy 1854,1130.46 vs 4972 with results shown on 4972 lower half (Figures 7.41-43) **RMS = 0.29mm** **STD= 0.4mm** **Mean= 0.1mm**			
Original Model	412,782	/	/
2mm	412,782	100	/
1mm	408,210	98.9	The areas which were removed at this level were the faces along the break (Figure 7.37). 75% of the remaining figurine is larger than the lower half of Dorothy 1854,1130.46.
0.5mm	408,210	98.9	The figurine is overall larger – apart from along the seams where it is smaller. However, the features such as the basket weave are still present in high detail.
0.25mm	389,317	94.3	The majority of the figurine is still present with a large proportion of this being 0.25mm larger than Dorothy 1854,1130.46.

Table 7.9 Different stages of figurine parameters and the affecting face count and overall surface area percentage representation. Dorothy 1854,1130.46 vs 4972 with results shown on 4972 lower half.

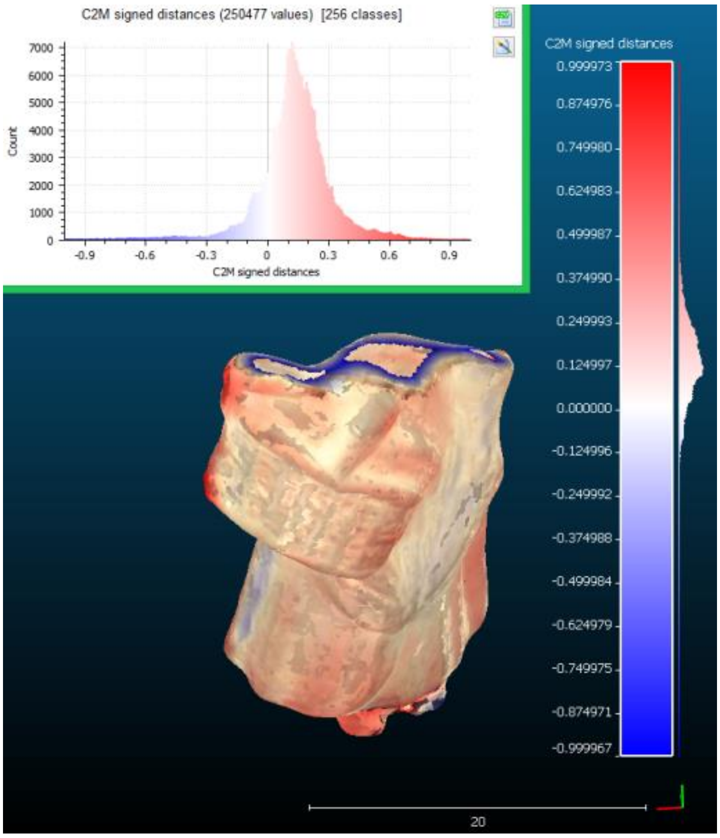


Figure 7.41 1854,1130.46 compared to 4972 with results shown on 4972 lower half, 1mm parameter, angle displays the removal of faces along the figurines breaks at this level.

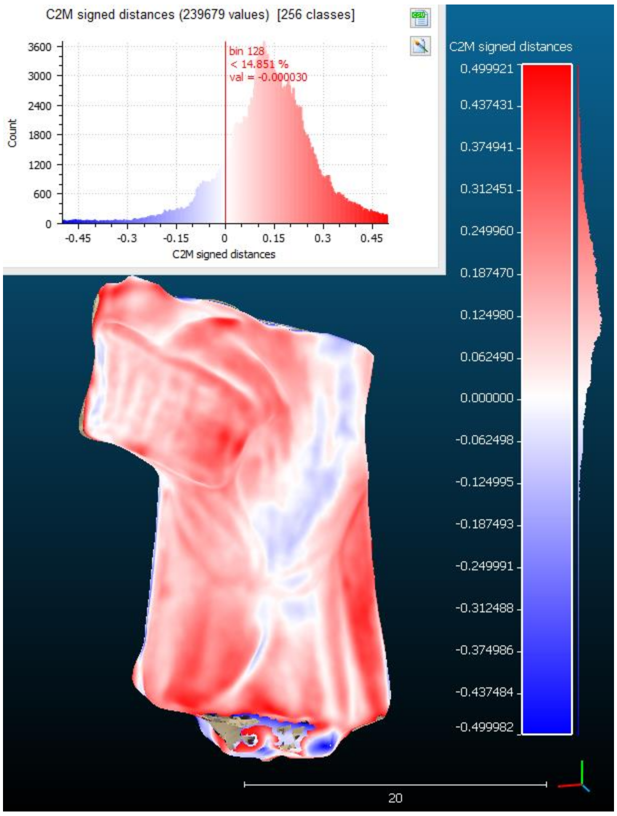


Figure 7.42 1854,1130.46 compared to 4972 with results shown on 4972 lower half, 0.5mm parameter. The texture has been removed on this image so the colour scalar can be seen clearer. Majority of figurine details still present, though 4972 is marginally larger than 1854,1130.46.

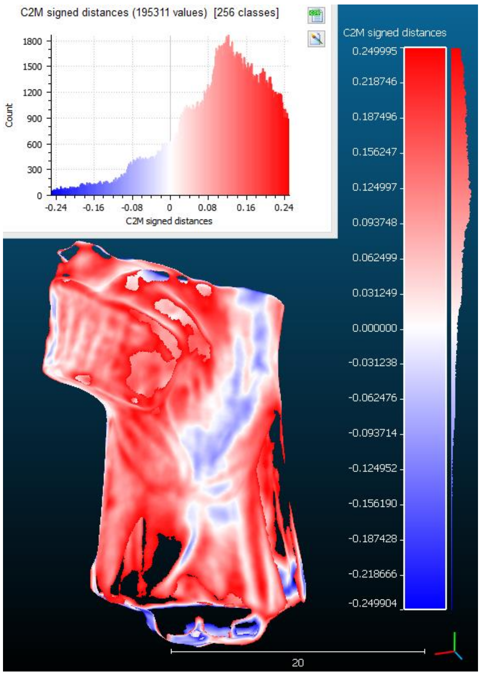


Figure 7.43 1854,1130.46 compared to 4972 with results shown on 4972 lower half, 0.25mm parameter. The majority of the figurine is still present, with a large proportion of 4972 0.25mm larger than Dorothy 1854,1130.46.

Parameter	Faces	%	Comments
Dorothy 1854,1130.45 vs 4972 with results shown on 4972 lower half (Figures 7.44-47) **RMS = 0.26mm** **STD= 0.42mm** **Mean= 0.08mm**			
Original Model	412,782	/	/
2mm	412,337	99.9%	Faces which were removed were those along the break.62% of 4972 is larger by up to 0.5mm.
1mm	408,494	99%	Though majority is slightly larger by up to 0.5mm, the features are represented in white which displaying matching features locations.
0.5mm	402,407	97.5%	Majority of features still present at this parameter.
0.25mm	336,661	81.6%	Overall lower half of MoL Dorothy seems marginally larger than Dorothy 12.

Table 7.10 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. Dorothy 1854,1130.45 vs 4972 with results shown on 4972 lower half.

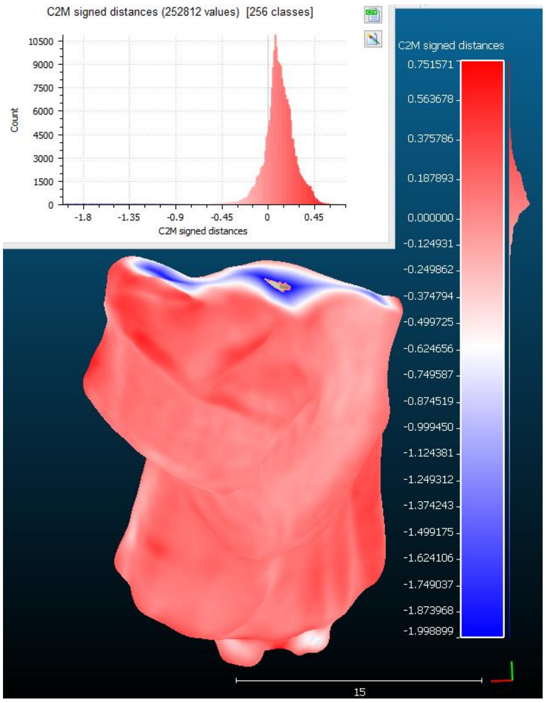


Figure 7.44 2mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy. Faces which were removed were those along the break.62% of 4972 is larger by up to 0.5mm.

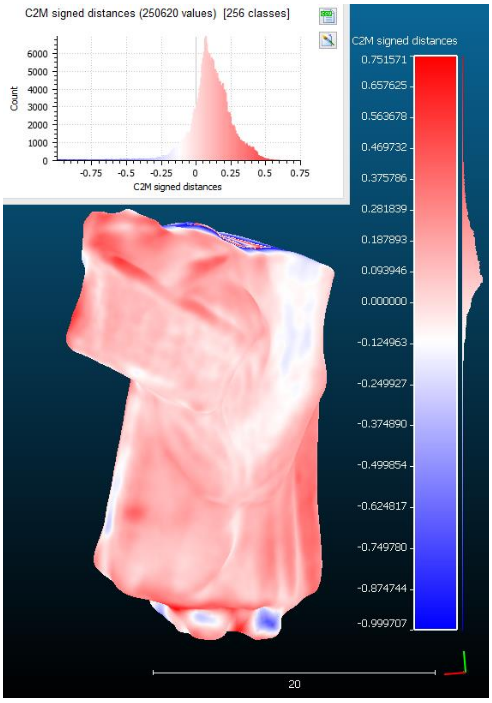


Figure 7.45 1mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy. Though majority is slightly larger by up to 0.5mm, the features are represented in white which displaying matching features locations.

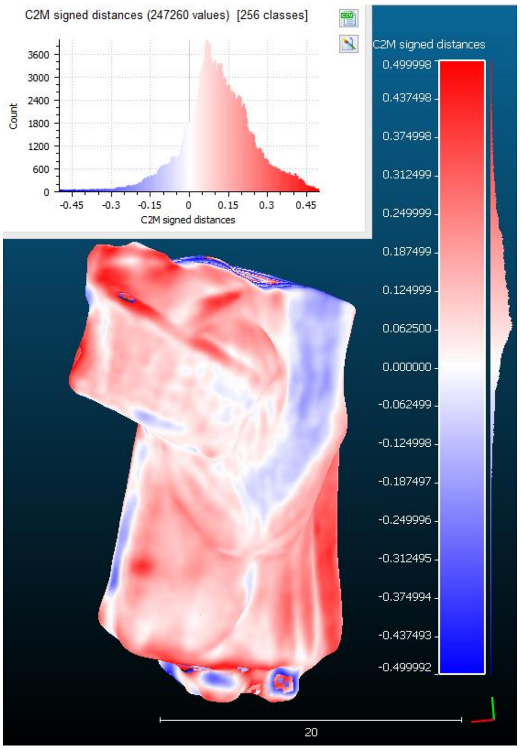


Figure 7.46 0.5mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy. Majority of features are still present at this parameter.

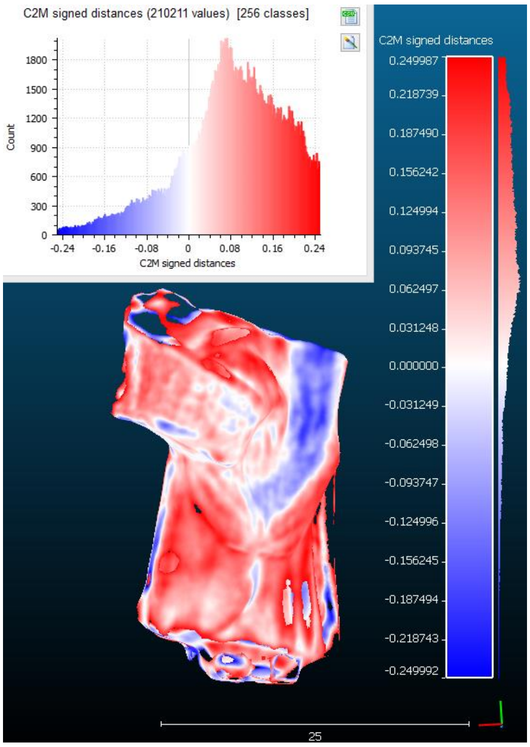


Figure 7.47 0.25mm parameter. Dorothy 1854,1130.45 compared to lower half of 4972 Dorothy

Parameter	Faces	%	Comments
Dorothy 1854,1130.46 vs 4972 with results shown on 4972 upper half (Figures 7.48-51) **RMS = 0.28mm** **STD= 0.45mm** **Mean= 0.09mm**			
Original Model	191,436	/	/
2mm	191,215	99.9%	Faces lost on break line. 87% of 4972 is larger by up to 0.5mm
1mm	188,052	98%	More faces lost along the break
0.5mm	184,107	96.2%	90% of the remaining faces are larger on 4972 than Dorothy 1854,1130.46.
0.25mm	166,366	87%	

Table 7.11 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. Dorothy 1854,1130.46 vs 4972 with results shown on 4972 upper half.

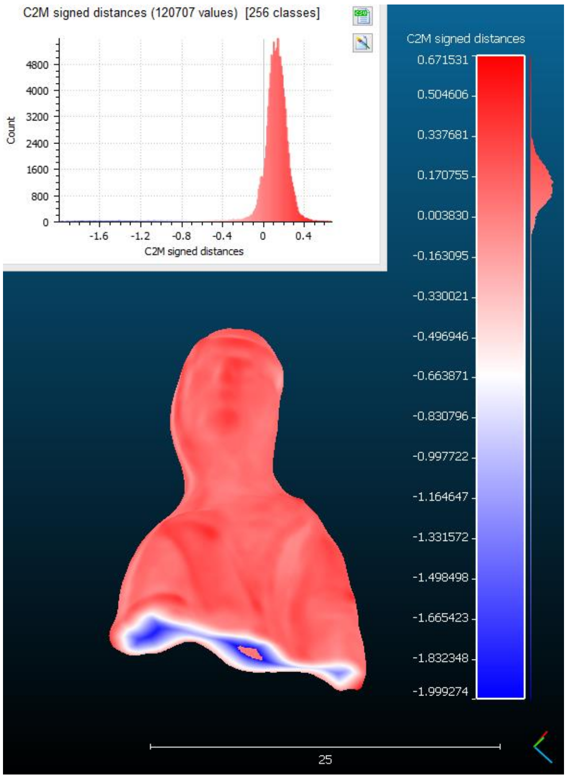


Figure 7.48 the 2mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. Faces lost along break line. 87% of 4972 is larger by up to 0.5mm.

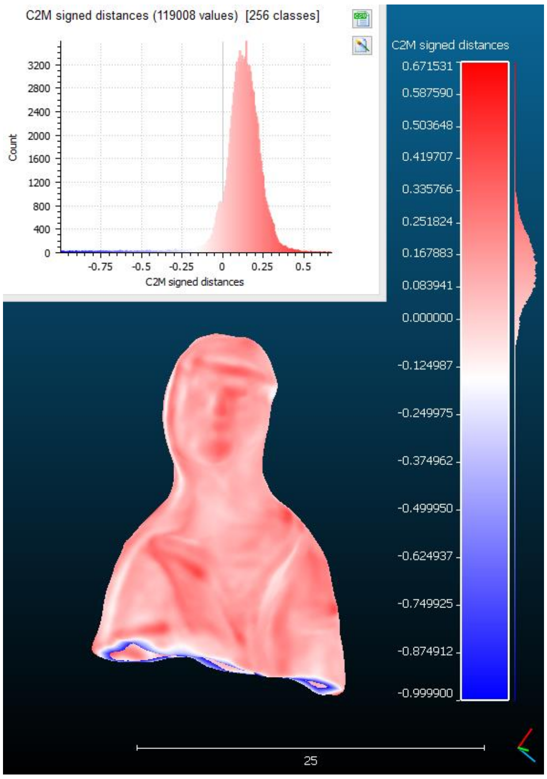


Figure 7.49 1mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. 2% of the faces have now been removed, these are concentrated along the break line of the figurine.

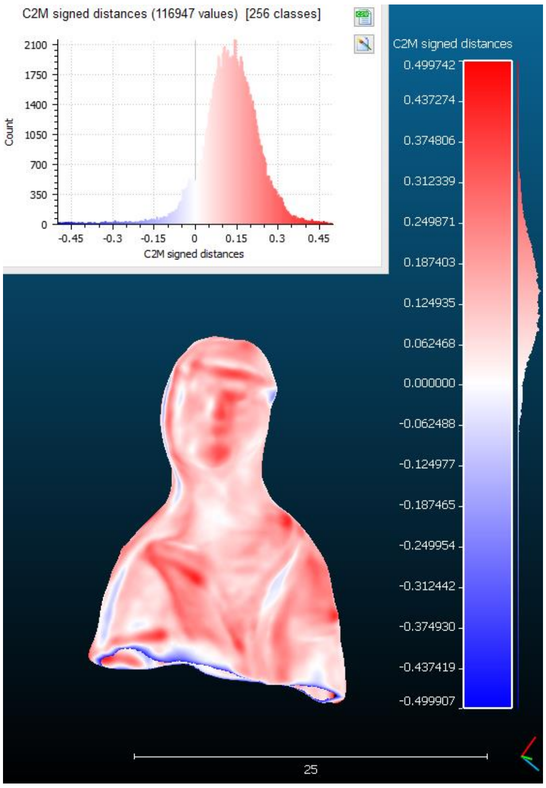


Figure 7.50 0.5mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. 90% of the remaining faces are larger on 4972 than Dorothy 1854,1130.46.

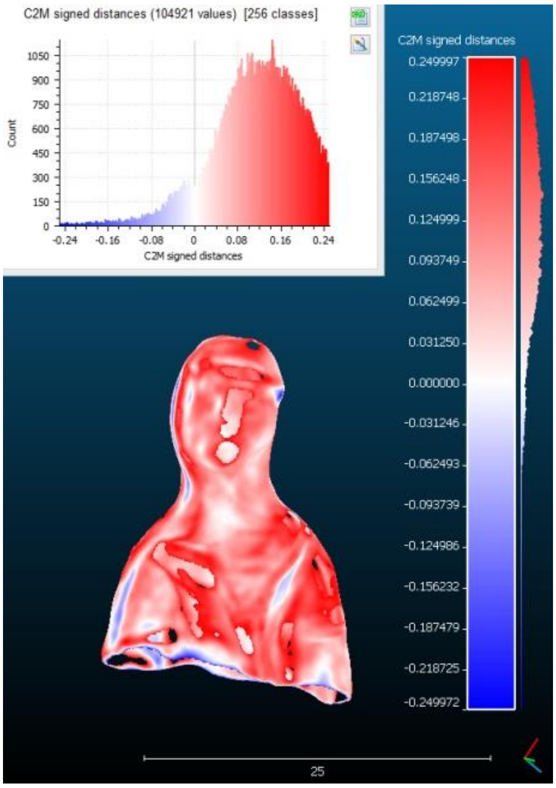


Figure 7.51 0.25mm parameter. Dorothy 1854,1130.46 compared to 4972 upper half. 87% of the faces are still present.

Parameter	Faces	%	Comments
Dorothy 1854,1130.45 vs 4972 with results shown on 4972 upper half (7.52-55) **RMS = 0.3mm** **STD= 0.47mm** **Mean= 0.06mm**			
Original Model	191,436	100	/
2mm	191,150	99.9%	Faces lost along the break. 65% of the 4972 figurine is larger by up to 0.5mm
1mm	187,525	98%	Faces lost due to whole of the break line being removed.
0.5mm	182,942	95.6%	Majority of features still present.
0.25mm	156,540	81.7%	The main area affected by feature removal at this parameter is seen within the figurines facial features.

Table 7.12 Different stages of figurine parameters and the affecting face count and overall surface area percentage representation. Dorothy 1854,1130.45 vs 4972 with results shown on 4972 upper half.

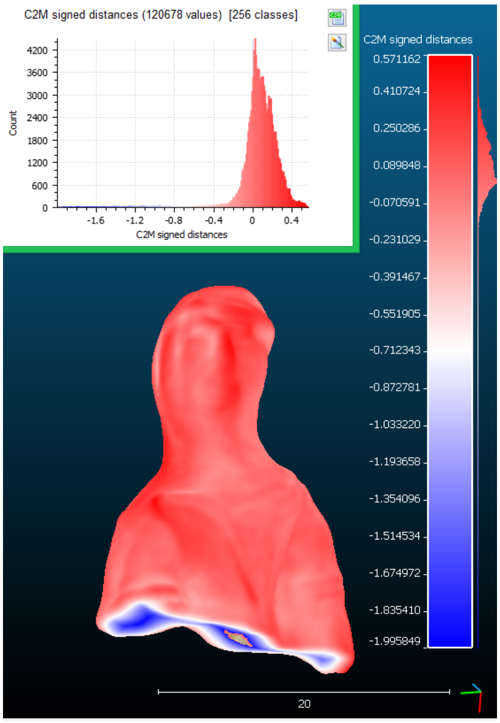


Figure 7.52 2mm parameter. Dorothy 1854,1130.45 compared to 4972 upper half. Faces lost along the break. 65% of the 4972 figurine is larger by up to 0.5mm.

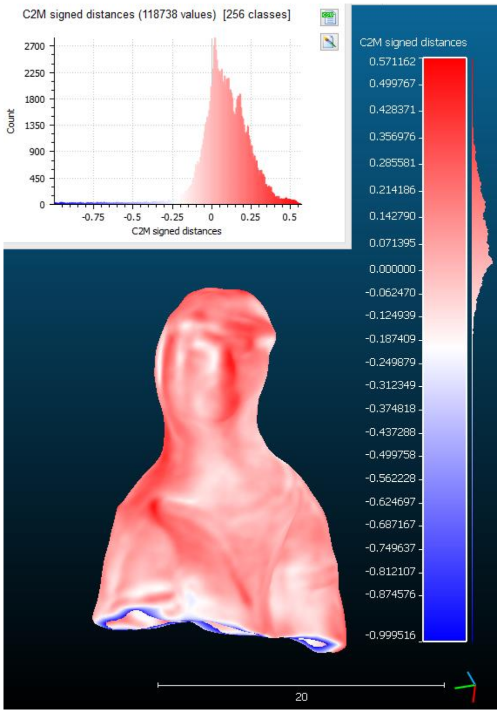


Figure 7.53 1mm parameter. Dorothy 1854,1130.45 compared to 4972 upper half. Faces lost due to whole of the break line being removed.

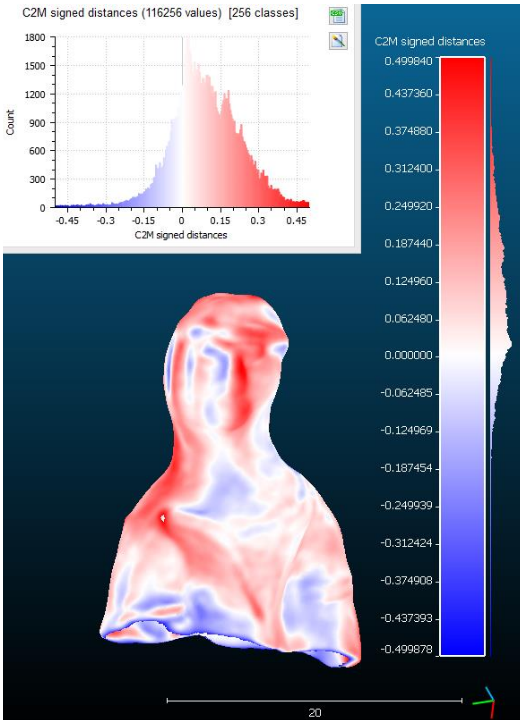


Figure 7.54 0.5mm parameter. Dorothy 1854,1130.45 compared to 4972 upper half.

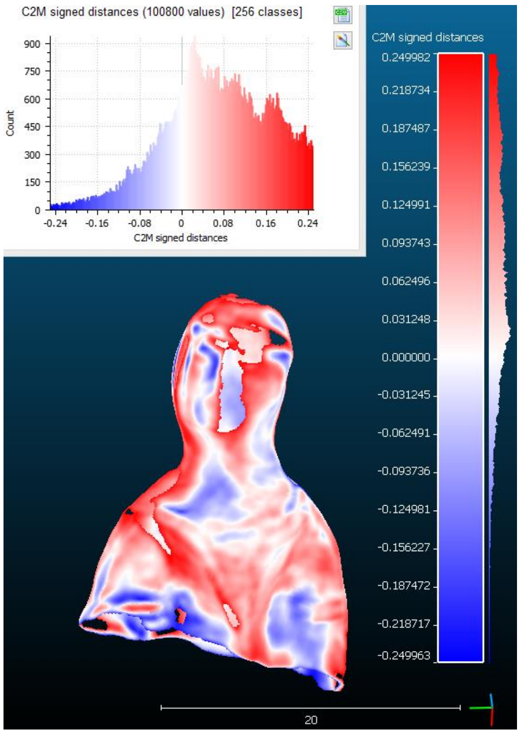


Figure 7.55 0.25mm parameter. Dorothy 1854,1130.45 compared to 4972upper half. The main area affected by feature removal at this parameter is seen within the figurines facial features.

The results indicate that figurine 4972 from the Museum of London is up to 0.5mm larger than the two figurines held in The British Museum. Due to the close relation of feature placement but different general overall size of figurine 4972, it is suggested here that figurine 4972 was created from an earlier mould generation to figurines 1854,1130.45 and 1854,1130.46, but still in the same mould family tree as the other two figurines. The two Dorothy's from the British Museum both display manipulation to the figurines which could have occurred during figurine removal from the mould. Despite this, examining the specific feature placement within the comparisons shown in Figures 7.37- 7.40, and the small millimetre difference parameters utilised (with just over 14% comparable faces at 0.05mm difference), it can be noted that the features are represented in white throughout, suggesting that these figurines came from the same generation of moulds, and a case could be made for them being produced in either the same mould or a very closely related mould. Figure 7.56 demonstrates a suggestive family order of the above compared figurines, with figurine 4972 produced from an earlier generation and Dorothy 1854,1130.46 and 1854,1130.45 are likely to come from the same generation, but potentially not from the same mould.

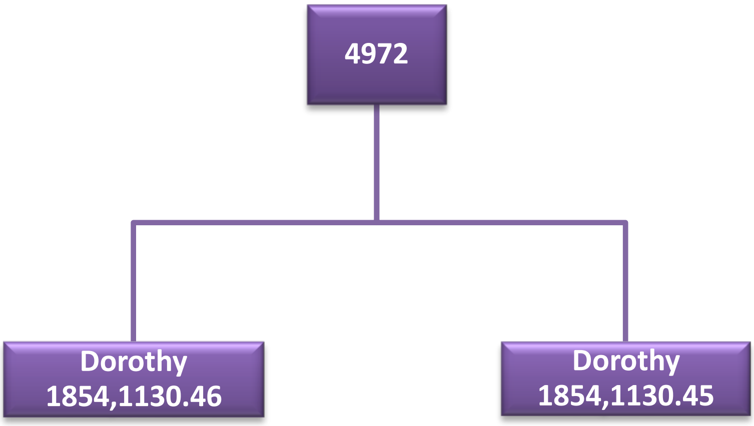


Figure 7.56 Hypothetical family order of the 3 compared Dorothy figurines.

7.1.6 Man in Hat 1854,1130.47 Compared to 4975

The two figurines shown in Figure 7.57 are two low quality male figurines, both demonstrating a rushed production process with poor seam smoothing. Furthermore, due to their small size, both have received damage around the neck. The figurine which is held at the Museum of London (Figurine 4975) has had its head glued back on to his body and while the crack on the British Museum figurine has not travelled all the way through the neck there is a definite fissure. Both of these issues will cause potential peaks to arise within the figurine comparisons. These cracks and repairs may also alter the alignment of the heads of the figurines as well, so a slight margin of error should also be incorporated. Further stress markers which will be flagged up on the comparison images are displayed in Figure 7.58.

Figure 7.57 left two images display man 4975 (Museum of London) and the right two images display man 1854,1130.47 (British Museum).

Figure 7.58 Top two images display man 4975 (Museum of London) and the bottom two images display man 1854,1130.47 (British Museum). The red circles indicate areas of erosional scarring.

The results shown in Table 7.13 and figures 7.59-7.62 demonstrate a possible example of figurines from the same family but different generations of moulds. There appears to be a constant reduction in size between the two figurines seen at each level. This is demonstrated by the fact that figurine 4975 had 300,000 less faces than figurine 1854,1130.47, as well as the structure of the structure of the histogram, which had a concentration to the negative (left) side of 0. Combined with specific feature placement represented in white, which indicates a position orientated around the 0mm marker, show suggestive results that man 4975 displays a later generation of figurine 1854,1130.47.

Parameter	Faces	%	Comments
1854,1130.47 Compared to 4975, results shown on man 4975. **RMS = 0.3mm** **STD= 0.45mm** **Mean= 0.05mm**			
Original Model	320,034	100	/
2mm	320,034	100	52% of 4975 is smaller, so preliminary results suggest that the 4975 man is from a later generation. Though some specific features are highlighted white, such as the buttons, showing minimal movement between figurines features. 20% is highlighted red – this looks like movement from mould removal issues.
1mm	312,664	97.7	Around 5% of the features are in the exact same locations.
0.5mm	283,194	88.5	Majority of features which have been removed in this parameter are concentrated around the figurines face, expected due to this region being highly affected my removal from the mould.
0.25mm	193,841	60.5	A majority of the faces are still present at this parameter.

Table 7.13 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation. 1854,1130.47 Compared to 4975, results shown on man 4975.

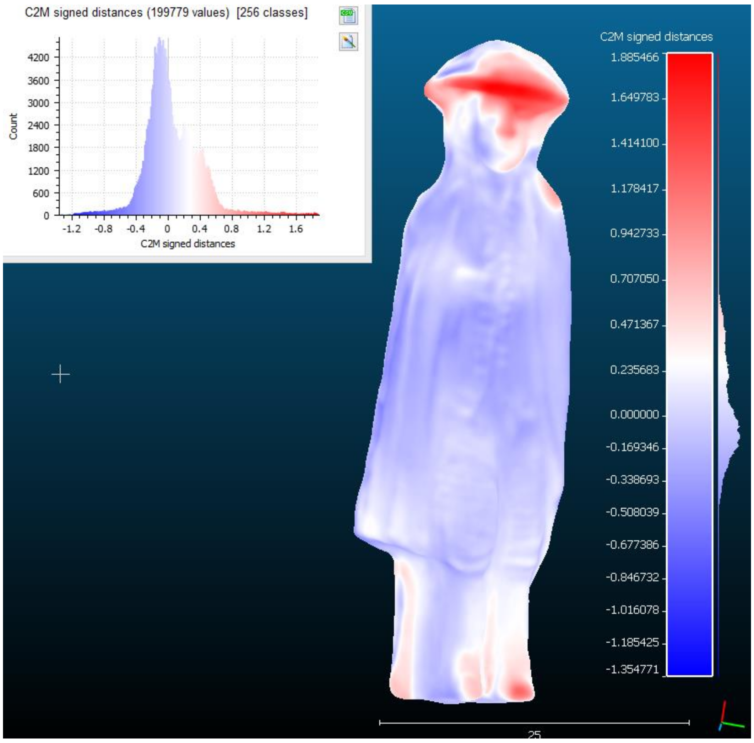


Figure 7.59 2mm parameter, with results shown on man 4975. 52% of 4975 is smaller, so preliminary results suggest that the 4975 man is from a later generation. Though some specific features are highlighted white, such as the buttons, showing minimal movement between figurines features. 20% is highlighted red – this looks like movement from mould removal issues.

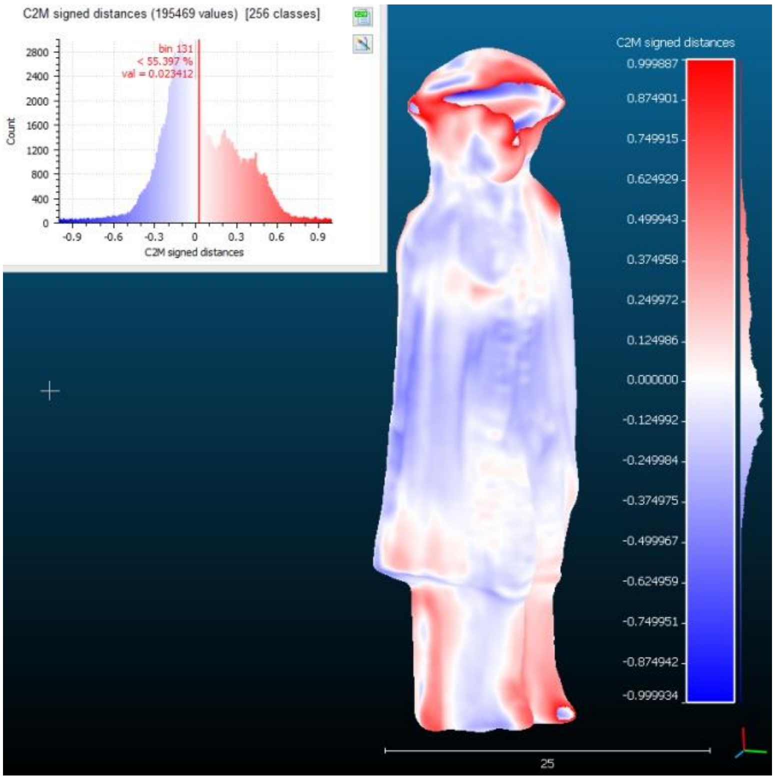


Figure 7.60 1mm parameter with results shown on man 4975. Around 5% of features are in the exact same locations, highlighted white on the model.

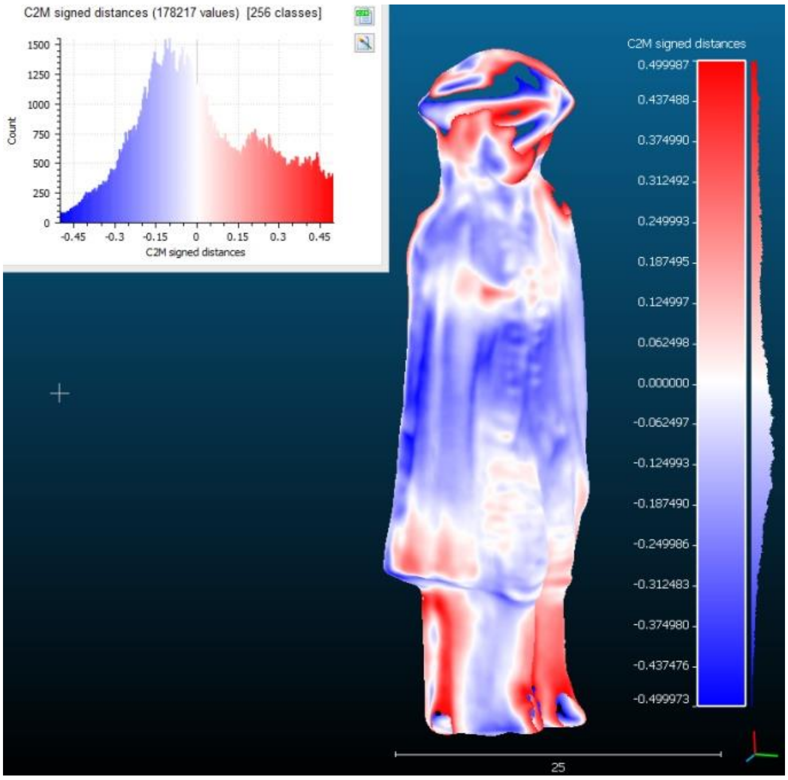


Figure 7.61 0.5mm parameter, with results shown on man 4975. Majority of features which have been removed in this parameter are concentrated around the figurines face, expected due to this region being highly affected my removal from the mould.

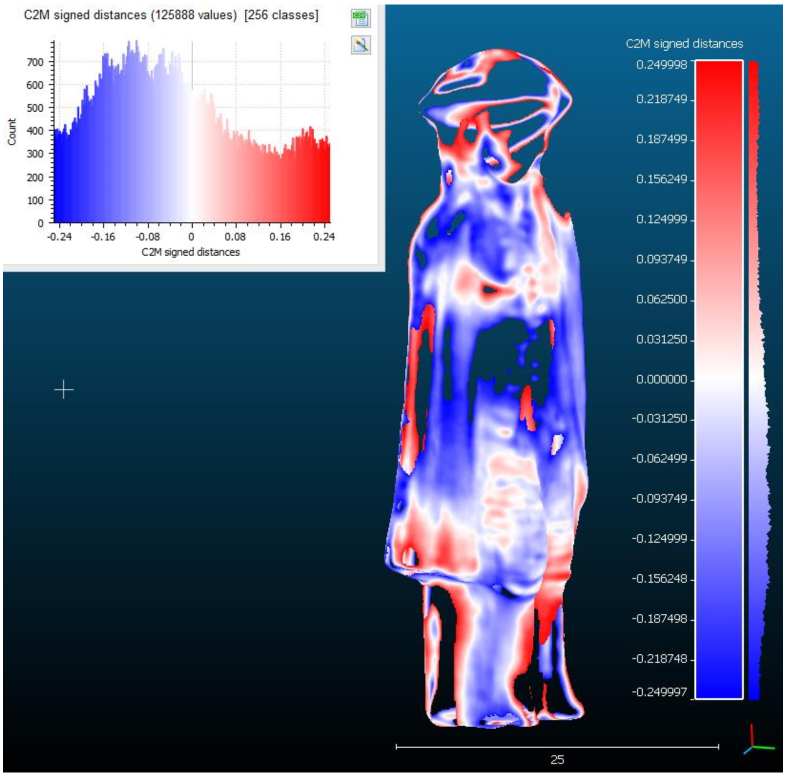


Figure 7.62 0.25mm parameter, with results shown on man 4975. 60.5% of the faces are still present.

7.1.7 Robed King 1854,1130.44 and Bankside King 17681

The final figurine comparisons within this chapter consist of figurines of two potential kings. It is quite clear from the images shown in Figure 7.63 that one of these figurines, 1854,1130.44, has experienced a high level of erosion. This is demonstrated on the overall smoothing of the figurine and small erosional pitting which appear on the figurine's surface. Further erosion and breakage scars visible on the two figurines are identified in Figure 7.64. Due to the high density of erosion experienced on figure 1854,1130.44, the images are displayed without their textures. This highlights the finer details on the figurines without visual interference caused by erosional differences, such as the fall of the drapery folds, and the position of the orb and hands.

Figure 7.63 The two images above are of King 1854,1130.44 and the two images below are of King 17681 (Author's image, with thanks to The British Museum and the Museum of London).

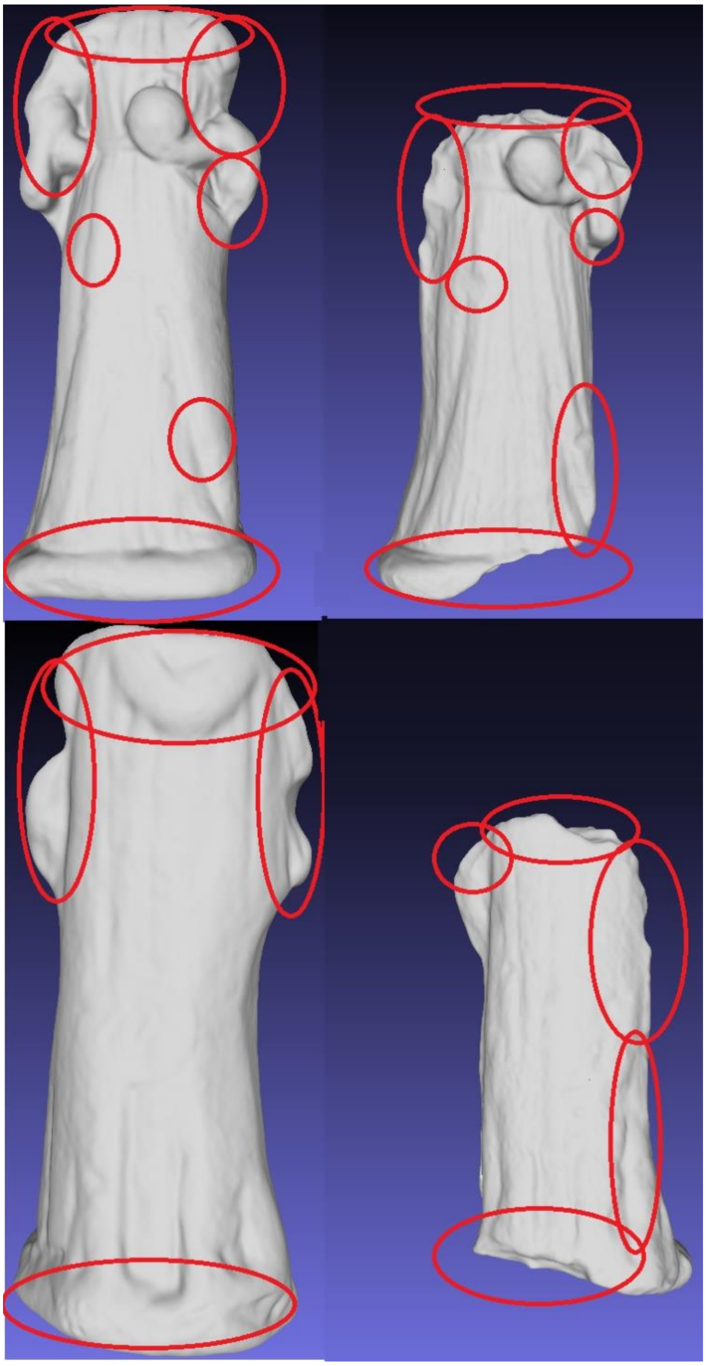


Figure 7.64 Non-textured 3D images of the left two images are of King 1854,1130.44 and the right two images are of King 17681. The red circles indicate areas of erosional scarring.

Overall the results shown in Table 7.14 and Figures 7.65-7.69 suggest that the two figurines come from the same mould family, with potential for the figurines being created within the same generation. Due to the large amount of erosion present on king 1854,1130.44 the histograms present the dulled profile (observed in previous examinations above). Despite these issues, the survival of specific feature placement down to the 0.5mm parameter (shown in Figure 7.68) allows the suggestion that the figurines are at least within the same family and are closely related.

Parameter	Faces	%	Comments
Robed King 1854,1130.44 and Bankside King 17681, results shown on 17681. **RMS = 1.9mm** **STD= 1.1mm** **Mean= -0.1mm** **Shown on King 17681**			
Original Model	522,476	/	/
3mm	507,653	97.2%	A Large orientation is based around the 0 marker, this suggests preliminarily that the figurines are from same generation.
2mm	484,913	92.8%	Hand, orb, belt placement all shown in white. Peak indicators displayed on expected broken areas.
1mm	336,402	64.4%	The regions which have started being removed at this parameter are those expected, these are the highly eroded and broken regions.
0.5mm	167,634	32.1%	Orb, belt, hand, base and some more prominent fabric folds still present at this level.

Table 7.14 Different stages of figurine parameters and the affecting face count and over all surface area percentage representation.

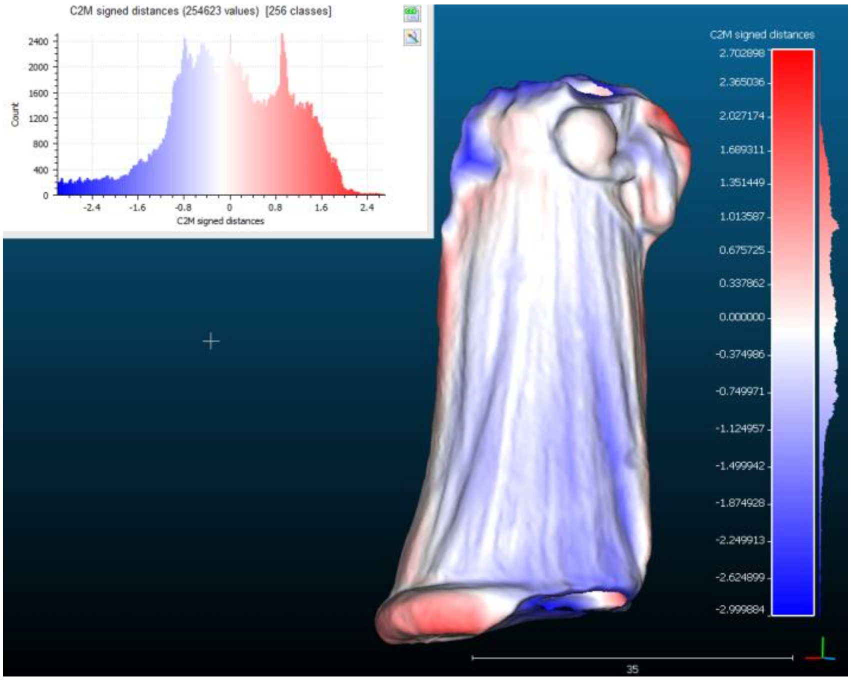


Figure 7.65 3mm parameter shown on figurine King 17681. A Large orientation is based around the 0 marker, this suggests preliminarily that the figurines are from same generation.

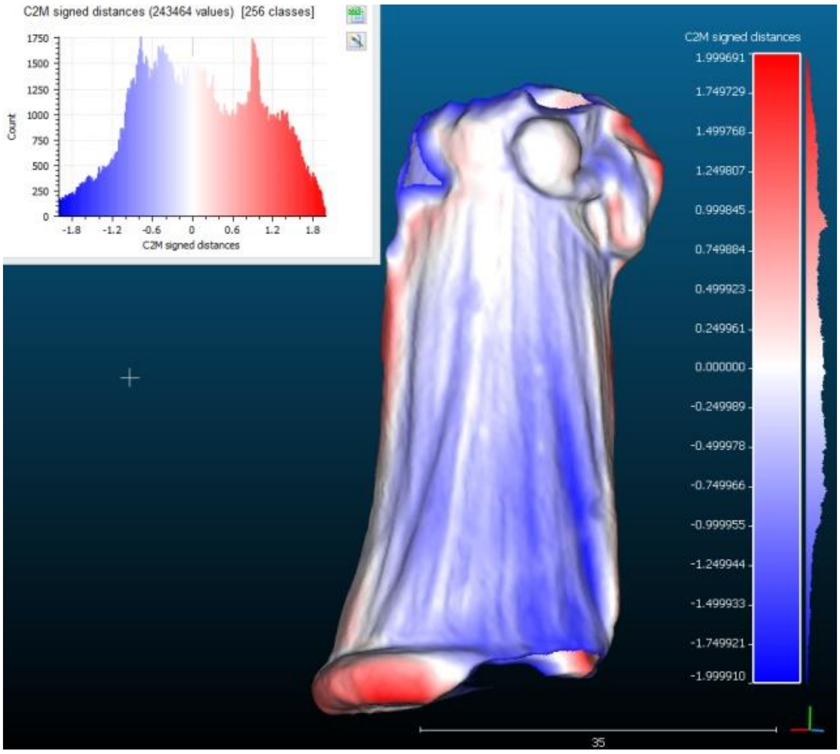


Figure 7.66 2mm parameter shown on figurine King 17681. The hand, orb and belt placement are all shown in white. Peak indicators displayed on expected broken and eroded areas.

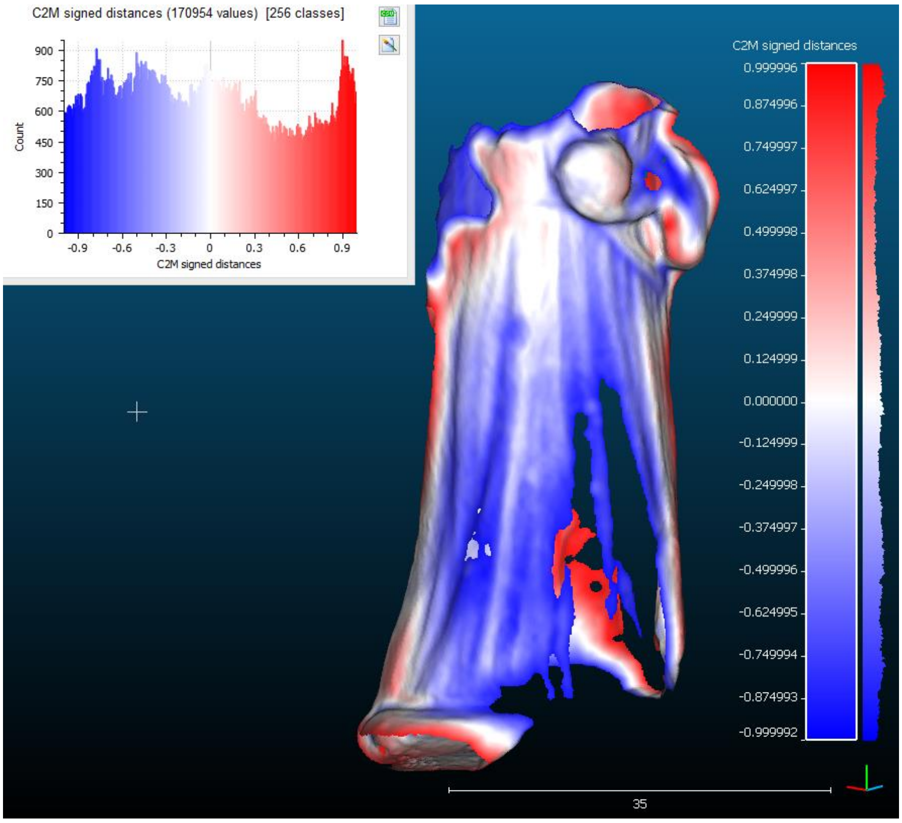


Figure 7.67 1mm parameter shown on figurine King 17681. The regions which have started being removed at this parameter are those expected, these are the highly eroded and broken regions.

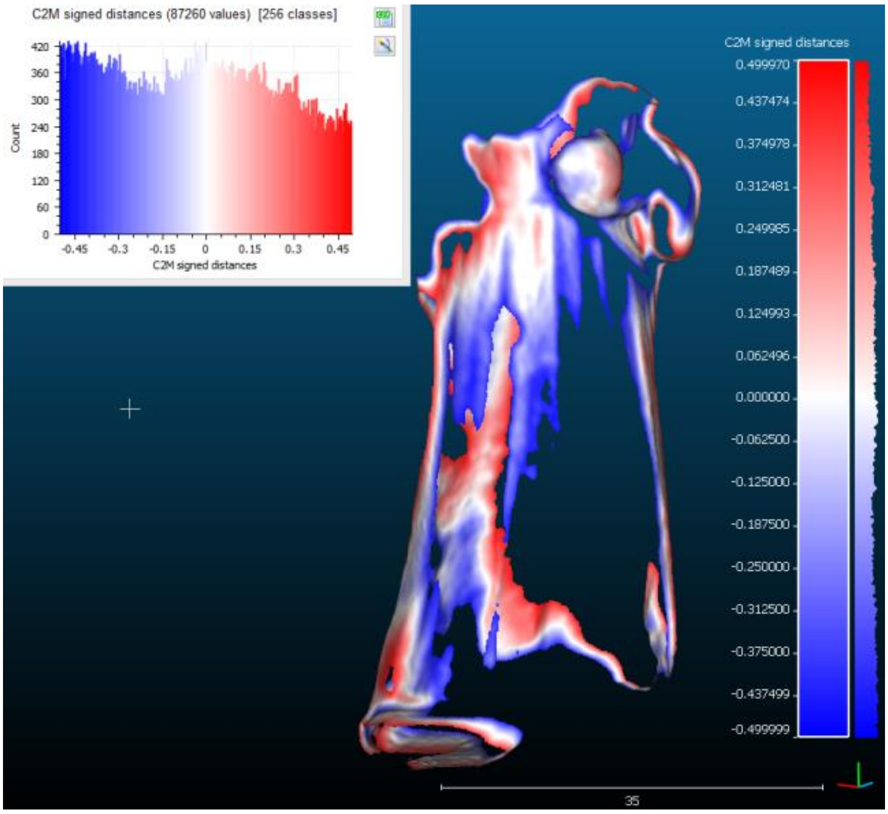


Figure 7.68 0.5mm parameter shown on figurine King 17681, 32.1% of the faces are present.

7.2 Chapter Summary

The application of the 3D comparison methodology outlined in Chapter 6 has demonstrated the ability to observe the relationships between different mould-generated figurines. By presenting a variety of forms of data for each figurine comparison, including the histograms, the models and colour scalar bars, and the overall number and percentage of faces meeting the size parameters, a detailed argument for earlier, later, and same generation figurines can be presented. The level of detail potentially available through the 3D models and comparison software can even allow, in some select circumstances, for the argument that figurines were produced from the same, or a very closely related, mould. This was possible due to a clearer comprehension of figurine transformation during firing, as well as by clearly articulating the consideration required for the impact of erosion and damage present on individual figurines.

This chapter has also shown that while photogrammetry cannot be used to produce comparison data that is as accurate as laser scanning, it can still serve as a preliminary test of similarity. The level of detail attainable utilising the SfM methodology outlined in Chapter 3 can indicate figurines that were produced from related moulds and provide a relatively less expensive means of indicating which mould generated materials would benefit from further assessment. As such, SfM currently does have a place in artefact analysis and comparison methodologies, but one that is suited to preliminary examination and prospection for comparisons, allowing an informed and targeted utilisation of more expensive technology, such as laser scanning and white light scanning.

Overall, the methodology carried out in this thesis provides a clearer indication of accuracy than previous studies, can be utilised for any object made from a mould, and produces data that is repeatable. The approach has also been shown to be accurate enough to indicate varying scales of similarity that can aid in unpicking mould generations and artefact relationships along these family trees. The data produced can be disseminated easily across the research field of mould generation analysis, whose development had become static. This methodology allows for a much more detailed object analysis and comparison, and offers researchers the ability to hypothesise with an increased accuracy on production and distribution processes occurring with the moulded manufacturing world, specifically within this case study the post-medieval pipe clay figurine. In the following chapter this newly collected data on mould generations and relationships will be used in combination with the previous archaeological and historical research presented on these figurines in Chapters 4 and 5 to discuss new developments and understandings on London’s post-medieval pipe clay figurines.

Chapter 8

A Review of the Developments of Material and Technique

This thesis has set out two parallel strands of investigation. Firstly, it has provided the first synthesis of the pipe clay figurines from London, contextualised with other material from Britain, North America, and the Caribbean. Secondly, it has used this dataset to establish the best current methods of 3D modelling for carrying out detailed artefact analysis and mould matching. This investigation of 3D modelling focussed upon techniques that are becoming more affordable and usable by archaeologists, and as such are highly likely to become popular means of applying this technology to archaeological materials. Accompanying this investigation was the clear articulation of workflows, display of data, quantified accuracy, and a repeatable process that can be applied to artefact studies more widely, especially other mould generated objects. This chapter will bring these strands of investigation together, summarising the major developments in theory and context for the figurines, before evaluating the artefact 3D modelling workflows employed within this thesis, with specific attention given to the use of 3D imaging for generation analysis of moulded artefacts. This chapter then concludes with the main outputs of this research, offering suggestions for future pipe clay figurine research, as well as encouraging the wider application for the workflow created in this thesis for artefact 3D comparison.

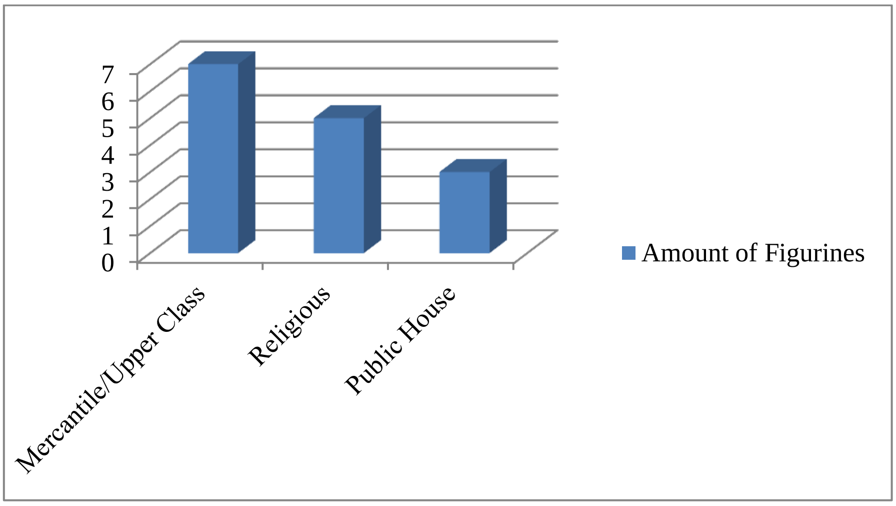
8.1.1 New Insights into London's Post-Medieval Pipe Clay Figurines

As was stated in Chapter 4, there is currently only a small selection of pipe clay figurines from London that provide detailed stratified archaeological data. With these figurines, there appears to be a correlation with the iconography they display and the contexts in which they were found. For example, a 17th century figurine of a female saint was recovered from the refectory crypt at St Mary Overy, or a 16th century figurine of a cleric was recovered from a basement excavation on the site of a Dominican Black Friars friary (see table 4.1), both religious figurines with clear ecclesiastical connections. Such a scenario is seen to occur in many other materials, and the presence of wooden, ivory or metal figurines which display religious iconography would not be considered unusual finds within a religious context, just as figurines, whether they were produced from pipe clay, lead alloy or wood, which display scenes of drinking, allurement, images from the bathhouse or musicians would not be out of context within a public house.

What the contextual data in Chapter 4 has thus demonstrated is that pipe clay figurines can be considered similar to other media of figurine production, displaying imagery within the following spheres: religious icons, royal memorabilia, adult curious and knickknacks, and employed as children's toys. Furthermore, examination of the contexts of deposition have demonstrated that these figurines, made as they were from relatively cheap materials and using well-known techniques with a low production cost, were not restricted to the poorest levels of society, as had previously been suggested (e.g. Van Den Dorpel 2013, 12; Gaimster 2007, 261). Instead, these figurines were present across a range of economic backgrounds, from the underprivileged to merchants or minor gentry. Of the pipe clay figurines examined within this thesis, a higher proportion came from wealthier contexts than any other context (Graph 8.1). This, however, may just be a reflection on the survival rate of these contexts rather than an actual representation of figurine production and distribution. Due to the small dataset of pipe clay figurines recorded with specific contextual data, this consisted of a total of 21 of the London pipe clay figurines, a minimal discussion can be presented on the specifics of the contextual distribution of these figurines within post-medieval London.

The 3D comparison data detailed in Chapter 7 has provided a means of investigating patterns of production and consumption within London as the dataset of figurines increases through more excavation of the city. Unfortunately, no definitive answer can yet be presented on the specifics of pipe clay figurine manufacture within London. What the 3D imaging methodologies have presented is a clear and detailed procedure for the examination and comparison of figurines which appear, on an initial analysis, to be from the same mould. With an improved appreciation and display of figurine metrics this methodology allows a clearer chronological order of figurine generations, complete with likely errors for different scenarios, and an understandable visual ordering to the data that can quantify levels of relatedness in figurine matching and mould generation analysis.

This comparative methodology has provided an approach that is better suited to investigating questions of distribution from production centres and transmission of iconography than other current approaches. This methodology was applied to 14 figurines and has begun to unpick some of the relationships between figurines, highlighting when they were likely from moulds of the same generation or other related generations, and in some cases, an argument has been made for them being made from the same mould. This approach has also been the broadest exploration of analysis methods that overcome geographical and physical obstacles to comparative artefact examination, a key issue in moulded product analysis. This method has made it possible to compare virtually figurines which are separated by museums stores, and/or countries. The success of this development is visible not only via the comparisons between figurines held within different archaeological stores within the UK but also via the comparison analysis undertaken concerning the Charles Gift Site King, USA and the Blackfriars King, London. As such, this methodology has offered a new research avenue for gaining insights into the circulation and distribution of figurines. As the appreciation



Graph 8.1 Distribution rate of figurines in London by type of context they have been recovered from, a total of 15 figurines were analysed.

and understanding of these links increase, so too will knowledge about why these mass-produced items moved across countries and oceans, and also potentially choices made by people about the collection, retention, and disposal of personal ornaments.

Overall, this new method of analysis has helped to enhance comprehension of figurine dissemination and in particular has advocated that these items were a desirable commodity, at a demand level which required a series of moulds of specific typologies of figurines to be produced for production rates to keep pace with demand rates. Once again this only shows an insight rather than total comprehension of production levels, an understanding which is affected by the survival and recovery rate of these figurines within London's archaeological record. However, it does serve as an indicator of the utility of these figurines for examining personal politics, religion, trade links, iconographical motifs, and object materiality in the post-medieval period. What is required now is a larger dataset and preferably some indication of a production site to further unpick some of these themes.

8.1.2 London in Comparison to Germany and the Netherlands

One of the central questions orientating around the London pipe clay figurines is concerned with production origins. This focusses on whether this London dataset was created by British manufacturers, imported from the continent, or created by foreign artisans who had migrated to London. With only one mould (Figure 8.1) recovered from London and no specific production centres yet being recorded within London or the rest of the UK, this preliminary synthesis of the material cannot provide a definitive answer to this problem. It is tempting to suggest that the figurines recovered within England may be imports, due to the lack of production site evidence seen within the UK, however, as Tables 8.1 and 8.2 display, although the themes of iconography are similar, the specific composition of the UK figurines differ substantially when compared to the mainland European examples. Such differences would mean that either the production centres were located within England, but have not been located yet, or that European production centres were manufacturing different figurines for export than for domestic sales. A summary of the different styles of figurines present within the UK compared to mainland Europe will now be discussed to help illuminate the different commercial markets these figurines circulated within.

Table 8.1 represents a selection of figurine comparisons from the British and British colonial markets (to the right of the table) with those comparable from the German and Dutch contexts (to the left of the table). Though 3D comparisons have not been conducted between the figurines in Table 8.1, an initial visual comparison via the evaluation of photographs and measurements of the figurines has been undertaken. From this examination is it suggested that there are potentially close generational sequences amongst Table 8.1’s figurines, evident via the high rate of iconographic and size similarities between the figurines. Though this comparison cannot inform on whether these figurines were produced from the same mould specifically, it can still help us to evaluate the production market. It is clear that there are specific crossovers in iconographies and particular designs between mainland Europe and England. Given that

Figure 8.1 Madonna and Child mould, recovered from the Ling House Site, London, NGR: TQ32878180. (Authors image courtesy of LAARC)

many of the contexts from which the German and Dutch examples have been recovered are earlier in date that those recovered in England, it seems that either the figurine as a finished product or the moulds themselves originated from either Germany or the Low Countries and were brought across the Channel. Another suggestion may be that artisans from Germany and/or the Low Countries emigrated to England and carried on their production and stylistic methods within England. Unfortunately, the lack of archaeological and documentary evidence cannot yet provide an answer to this issue of whether there were workshops within the UK, unlike the evidence available for those present within Germany and the Netherlands (see Chapter 1 for a discussion on these workshops). These comparisons do bring into question the date of two figurines recovered in the UK and dated to the 16th Century. The figurine of Saint Nicholas, ID144, and the figurine of a man in a cloak, ID 80, show high similarity to the figurines produced by Theodor Tries in the mid 1900's. However without further examination of these figurines, which was not possible due to the private sale of the UK examples in an auction, only allows for one of two conclusions, either the UK figurines are examples of earlier production which influenced Theodor Tries designs, or, they have been wrongly dated and are part of the 20th Century production group.

Table 8.1 Post-medieval pipe-clay figurine comparisons between Germany or the Low Countries and British or British Colonies.

Site and details	**German or Low Country example**	**British or British Colonies example**	**Site and Details**
Collection Nos: APM 11.545a Saint Nicholas Period 1930-70 Baumbach, Germany Made by Theodor Tries (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	[redacted]	[redacted]	ID144 Saint Nicholas 16th Century (as recorded) East Anglia (Image from a Private Collector 2012)
Saint Nicholas Period 1920-50 Baumbach, Germany Made by Theodor Tries (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	[redacted]	/	/

Collection Nos: APM 16.113a Made with pipe earth Westerwald, Germany Made by Theodor Tries Period 1920-50 (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	[redacted]		ID80 Male in cloak 18th Century Thames foreshore (Image from a Private Collector 2013)
Collection Nos: APM 03.001 Nude Urinating Male. Period 1650-1700 Amstelveen, Netherlands (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	[redacted]	 Front  Rear	ID5 Nude Male Urinating 1745-1800 Bethnal Green Road, London (Author's image with permission of MOLA)
Collection Number: APM: 08.505 Cupid 1670-1720 Friesland, Netherlands (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	Front [redacted] Rear	Front  Rear 	ID2 Cupid 1700-1720 Aldgate, London (Weinstein 1989, 122 © Society for Post-Medieval Archaeology, reprinted by permission of Taylor & Francis Ltd)

Collection Number: APM 03.642a Woman on Plinth 1670-1740 Gouda, Netherlands (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	Front [redacted] Rear	 Front Rear	ID55 Woman on Plinth Late 17thC London Wall (Image by author with permission from Museum of London)
Collection Number: APM 03.642b Lady 1670-1740 Gouda, Netherlands (Image from the Pijpenkabinet Foundation in Amsterdam n.d.)	[redacted]		ID 95 Lady 1690 76 Eden Street, London (Authors Image with permission from MOLAS)
Bacchus God of wine 17th/18th Century Rotterdam (Unknown n.d.)	[redacted]		ID126 Man on Beer Barrel 18th Century Albert Embankment, London (Author's Image, with permission from LAARC)
Inventory number: 1913 Saint Catherine with wheel ca. 1425 - ca. 1450 Anonymous Utrecht (© Centraal Museum n.d.)			ID46 Saint Catherine with wheel London Late 15thC (Author's image, with permission from The British Museum)

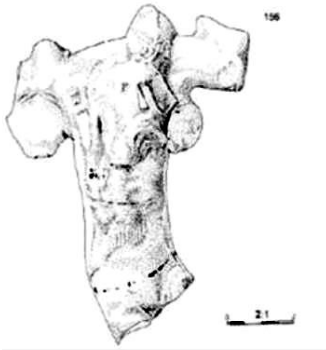
Inventory number 2036 Cleric 1450-1550 Utrecht (© Centraal Museum n.d.)			ID104 Cleric 1600-1700 Southwark, London (Author's image, with permission from The British Museum)
R. Stam collection Male with holding fruit and flowers. Netherlands (Image by B. Van Der Lingen)			ID64 Male with holding fruit and flowers. (Image by author with permission from Museum of London)
Inventory Number 1984 Christ Child 1450-1550 Utrecht (© Centraal Museum n.d.)			ID30 London (Author's image, with permission from The British Museum)
R. Stam collection Netherlands Lady (Image by B. Van Der Lingen)			ID189 Lady with lamb. Mount Vernon, USA (Author's imagel with thanks to the Mount Vernon Archaeology Department)

R. Stam collection Gentleman with staff and hat, with oak leaf on the rear of his legs. Netherlands (Image by B. Van Der Lingen)	 Front  Rear	 Front Rear 	ID190 Gentleman with staff and hat, with oak leaf on the rear of his legs. Mount Vernon, USA (Author's Images with thanks to the Mount Vernon Archaeology Department)
R. Stam collection Gentleman Netherlands (Image by B. Van Der Lingen)		[redacted]	A Gentleman figurine from the Duvall Plantation. (Image from Doepkins 1991)
	/		ID1 Male with tip staff Aldgate, London 1700-1720 (Author’s Image, with permission from LAARC)

The examples in table 8.1 cover only those figurines which appear on preliminary analysis to be related. Figurines which have no identical counterparts present between the regions but which display the same iconographical topic are displayed in table 8.2. The lack of identical counterparts for these figurines could be either due to the lack of their survival in the archaeological record or a variation in the consumer markets between these countries. For example, although each country under discussion has produced figurines of the Madonna and Christ, the representations recovered within the UK display a different form to those recovered from German and Dutch contexts (as shown in table 8.2).

Table 8.2 Figurine comparisons which have no identical counterparts present between the Germany or the Low Coutnries and the UK, but display the same iconographical topic.

Site and Details	Germany or Low Country example	UK example	UK Site and Details
Painted Mary and Child 1470-1480 Utrecht Inventory nos: 11790d (© Centraal Museum n.d.)			ID34 Mary and Christ 17th Century Thames foreshore (Author's image, with permission from The British Museum)
Mary and Child 1425-1450 Utrecht Inventory nos: 1856 (© Centraal Museum n.d.)			ID36 Mary and Christ 16th Century Thames foreshore (Author's image, with permission from The British Museum)

Mary and Child fragment 1425-1450 Utrecht Inventory nos: 1852 (© Centraal Museum n.d.)		/	/
Crucified of Christ fragment 1450-1500 Utrecht Inventory nos: 1997 (© Centraal Museum n.d.)			ID164 Carmarthen Greyfriars, Wales Christ on a Tau cross. 15th – 16th Century (Redknap 1997, 51 Figure 156 with permission From © National Museum Of Wales)
R. Stam collection Netherlands (Image by B. Van Der Lingen)			ID87 Christ with dove and olive branch 17th Century 129Lambeth Road (Author's Image, with permission from LAARC)
Inventory 1878 Christ Utrecht 1450-1550 (© Centraal Museum n.d.)			ID139 Easington village, Country Durham Christ in a cradle (Image from PAS, 2013)

Inventory 1985 Christ 1450-1550 Utrecht (© Centraal Museum n.d.)		/	/
Inventory 1932 Christ 1450-1550 Utrecht (© Centraal Museum n.d.)		/	/
Inventory 1891 Saint Barbra 1425-1450 Utrecht (© Centraal Museum n.d.)			ID88 Saint Barbara 15th Century Tooley Street, London (London Museum Catalogue 1940, Image 2, © British Museum)
Inventory 1878 Saint Barbra 1425-1450 Utrecht (© Centraal Museum n.d.)			

Inventory 1898 Saint Barbra 1450-1475 Utrecht (© Centraal Museum n.d.)			

One element of interest from the figurines in Table 8.2 is the difference in the level of detail between those recovered from Britain and those from Germany and the Low Countries, with significantly more detail and elaborate designs being evident on the Continent. This higher level of detail can be seen in the features, drapery, and accessories, this can be seen very clearly on the drapery of the Mary and Saint Barbara Figurines. This could be argued to present the Dutch and German consumer pieces as more refined pieces of art, a higher class of ornament. In contrast, the figurines which have been recovered from English contexts, though still usually produced at a reasonable standard that included precise seam alignment and scraping, the stylistic elements on the figurines are significantly simpler and plainer in their details and construct. This difference in quality may be one of the clues suggesting production of these figurines in England, copying and manipulating figurine designs from elsewhere. Also of interest are the production dates and how this relates to contemporary events that may be affecting the stylistic and iconographic details of these figurines. Of particular interest to this discussion will be the pre- and post-Reformation influences which controlled the religious art markets within late medieval and post-medieval Europe

8.1.2.1 Martin Luther and the Reformation: Examining the Effects on Religious Art in Germany, the Low Countries and England.

By articulating his ideals through the 95 Theses in 1517, Martin Luther provided a point of crux which had a clear impact upon religious practice and religious art across Europe. Luther's thoughts on contemporary Catholic practice, mirroring the ideas of many of his contemporaries, held them to be indulgent and corrupt. Elaborate commissioned pieces of art were produced and donated to the church with the view of absolving the sins of the donor. These pieces were openly displayed with the intention of them being revered by the masses, but also clearly displaying the wealth and influence of the Church and its hierarchy. This form of indulgent worship was in high contrast to Martin Luther's ideals, which presented a more personal and modest show of devotion. Repentance and salvation were believed to be only achievable through faith alone. Such changes to the ideological tone of the populace can be tracked within the developments of iconography and design within the art world, and will serve as the focus of the following section.

As Protestantism increased in popularity across Europe, there was a corresponding shift from overtly indulgent religious media, now seen as a form of corruption of the church, to a concentration on individual's intimate relationships with God (Wisse 2002). The pomp perpetuated by the Catholic Church was seen as interference with an individual's connection with God and such extravagant artistic commissions were viewed as bribes for the pardoning of sins, and as such should be removed. Consequently, due to a lessening of commissions, artisans began to shift their focus from ornate public art to a form which sympathised with the new protestant consumer market, in particular personal devotion. New repertoires were developed alongside the adaptation of traditional portrayals of religious scenes to better reflect Protestant ideologies (Wisse 2002). Printmaking and moulded items, within which can be included pipe clay figurines production, thrived within this new consumer market due to both their inexpensive nature and the potentially large production sizes, making them ideal for personal, domestic worship (as discussed in Chapter 1).

This shift in the focus of artisanal effort can also be seen in the newly flourishing secular arts, which experienced a boom in portraiture, landscapes, royal, and everyday life images (Sorabella 2007). Prominent artists such as Albrecht Dürer elevated media such as printmaking during the early 16th century, and his works present a good example of artistic transitions for this period. Examples such as his collective prints, referred to as Meisterstiche (Figure 8.2), display the typical artistic styles prior to Martin Luther's 95 Theses and communicate the three main branches of virtues perpetuated within medieval and early post-medieval scholasticism: moral, theological and intellectual (The Metropolitan Museum of Art 2017c). Dürer's work can then be seen to transition to simpler portraits of influential reformers such as Erasmus of Rotterdam, whose works were made more available by the printing press, but which integrated script from Martin Luther's works into the image (Figure 8.3) (The Metropolitan Museum of Art 2017a).

Although Luther's work brought stylistic changes to religious artworks, it did not strip religion of all its aesthetics and there was not an overarching Reformation of iconoclasm seen. Certain cult images, such as the Cult of the Saints or Virgin Mary, were seen to support the churches 'false promise of intercession' (Koerner 2004, 27). The function of art as a method of devotional, indulgent, votive worship conflicted with *sola fides*, whereby redemption would be granted by faith and good works alone. It was, therefore, not upon the subject of the image that Luther's judgement was directed but the purpose of the image. Luther encouraged church artworks as long as the purpose was to instruct rather than to support the perpetuated false theology of donation and indulgence in exchange for redemption (Koerner 2004, 28).

Figure 8.2 Dürer's Meisterstiche, Top left; Melancolia I. Top right; Knight, Death, and the Devil. At the bottom, Saint Jerome in His Study (1513-14), engraving. (Images from ©The Metropolitan Museum of Art 2017b;a;c [open access])

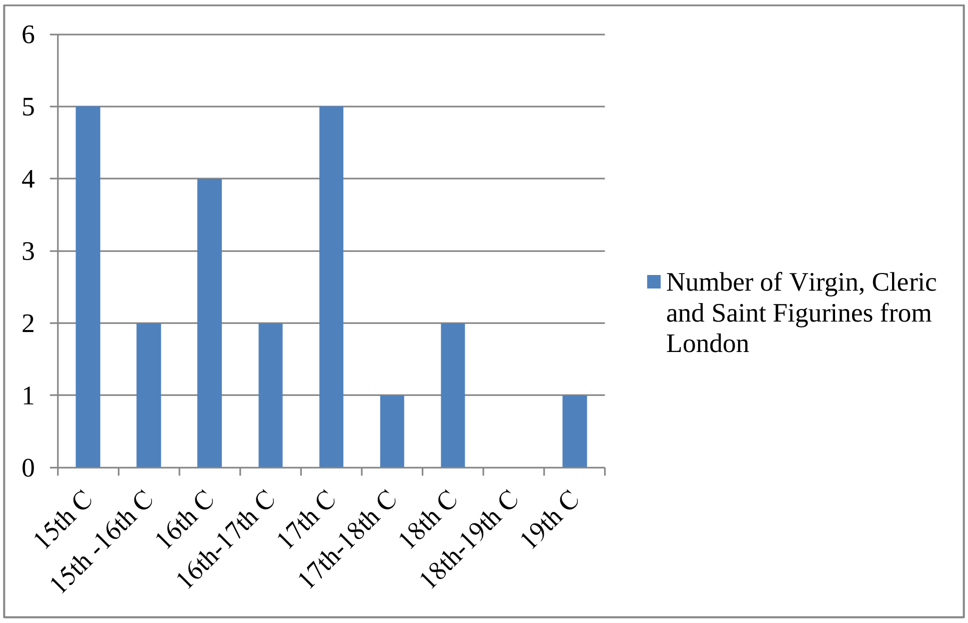
Figure 8.3 Dürer's Erasmus of Rotterdam, 1526, the inscription reads "This image of Erasmus of Rotterdam was drawn from life by Albrecht Dürer''. Engraving. (Image from ©The Metropolitan Museum of Art, 2017*[open access]*)

Luther endorsed images which were not emotionally charged or contained scenes of seduction, but rather mundane and crude in nature. The value of the scene lay only in the message, not their aesthetic worth or magical efficacy (Koerner 2004, 28). Luther's recommendation of a simple form and craft with direct and obvious symbolism enabled all individuals to comprehend the didactic charge present within this new artistic movement (Koerner 2004, 32). Such a theme was something moulded and print media could embody efficiently and effectively, as did a series of new Reformation artists of crude style, such as Lucas Cranach the Elder and the Younger. These two latter artists owned the Witternberg workshop which produced Reformation artworks for the masses. The Cranach's helped to spread the ideologies of the Reformation by producing large quantities of popular motifs via stencils and wood carvings. Within their workshops they and their apprentices were not permitted to produce their own personalised styles but had to work to an overarching workshop style, ensuring that the images were produced as a communal affair with no personalised effects to distract from the message of the images (for a more in-depth discussion on the Wittenberg workshop, see Koerner 2004, Chapter 15). It is to this genre of justified artworks that the pipe clay figurines can be argued to belong, evident in their simplistic, affordable, and mass-produced nature. As discussed in Chapter 1, the presence of elaborate and ornate religious iconography in pipe clay figurines of Germany and the Low Countries, such as the Cult of the Saints and the Virgin figurines, reduced significantly in the 16th century. However, there was a continuation in the production of secular figurines, a pattern which reflected the contemporary artistic fashions of the Lutheran movement.

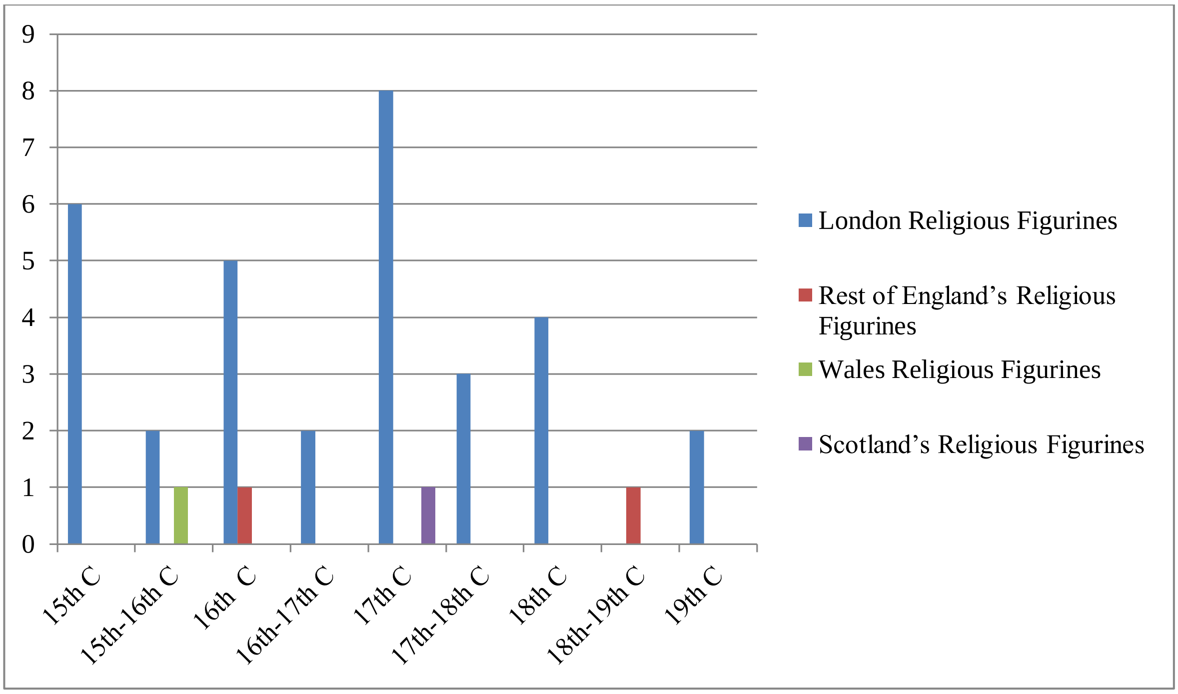
As Graph 8.2 demonstrates, while this reduction in iconography which was condemned by the Protestant faiths is readily observable in Germany and the Low Countries figurine production, it is less clear in the London pipe clay figurines. Graph 8.2 displays the London Virgin, Cleric, and Saint examples from the pipe clay figurines database (Appendix 1). Clearly visible is a continuation in the presence of these classes of figurines within the archaeological record, during, and after the Reformation within London. The continuing presence of this religious iconography, compared to reduction and virtual absence in Europe at the same time of this style of pipe clay figurine, may reflect the impact of the doctrine of the Church of England where communion, vestments and the role of saints had some reflection of earlier catholic practises (Pritchard 2017, Chapter 1), however the specific intercessionary of that relationship was vastly different. The second issue of interest which also appears within the English religious pipe clay figurine iconographical structure is the obvious simplification of detail and the reduction in ornate design. This simplification of form is likely representative of the effects of Lutheranism on German and Low Country artisans, regardless of the less culturally and religiously restrictive markets that these figurines were being exported to, or the potential establishment of British production that maintained older iconographical motifs but produced to the new Protestant stylistic form.

While this theory does help to explain the continuation of production, stylistic changes, and the reasons for either product export or production shift to the UK market, it is still unable to determine certain production specifications. Represented within the archaeological record is the definite shift and rise in the prevalence of post-medieval pipe clay figurines within the English market from the early 16th century onwards. Graphs 8.3 and 8.4 indicate how this rise is not only seen in figurines which present a condemned religious iconography, but also in the genre of general religious iconography and the general production of all themes of pipe clay figurine iconography as a whole. In summary, all three of the below graphs (8.2-4) demonstrate a general rise in figurine production of all iconographic themes in England from the 15th century, reaching a peak during the 17th century.

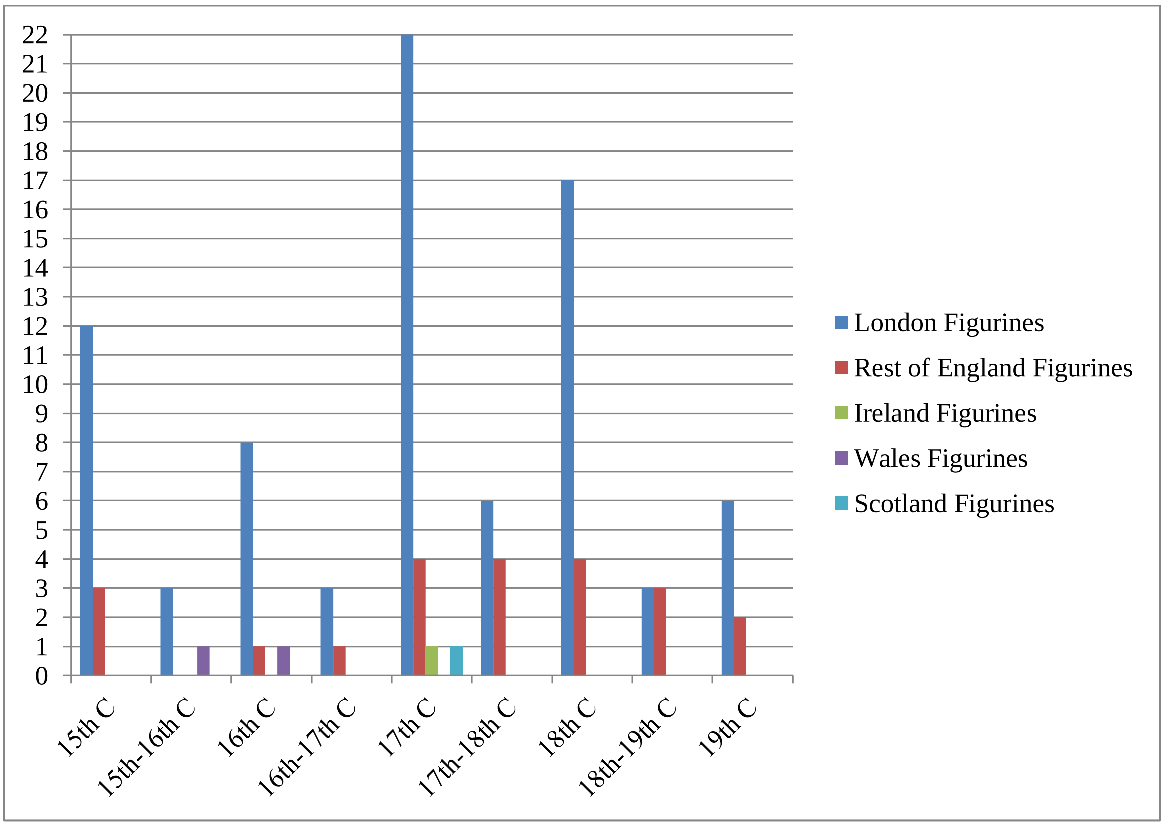
By examining the archaeological remains it is possible to observe the differing levels of adoption or rejection of Protestant ideology present across Europe, and comprehend to what extent these devotional fluctuations influenced the public and material culture. Within Germany, the Low Countries, and England pipe clay figurines provide one material source on these changes. As discussed above, individuals such as Martin Luther had a significant impact on the symbolic weight that artwork could express, and by studying the smaller, more mundane artefacts of iconographical display and the nature of their continuation or cessation within the archaeological record, discuss meaningfully the impact of these religious reforms on the wider populace.



Graph 8.2 Rate of Virgin, Cleric and Saint Figurines recovered between 15th-19th Centuries, London.



Graph 8.3 Graph to show the amount of religious figurines from different centuries in London, the rest of England, Wales and Scotland.



Graph 8.4 Graph to show the amount of figurines from different centuries in London, the rest of England, Ireland, Wales and Scotland.

In the case of England this period of reform can be characterised by four distinct episodes that cover a variety of agendas, ideologies, and political machinations. The initial episode was the Henrician Reformation, initiated under Henry VIII and expressive of both domestic and European-wide political activity that was often articulated around the Protestant Reformation. This was followed by the Edwardian Reformation, initiated under Edward VI, and the Catholic Counter-Reformation enacted under Mary I, both of which could be argued to be rooted in the religious beliefs of the associated rulers as much as by the political environment. The final episode was the Elizabethan reforms during the reign of Elizabeth I, which served to solidify the Church of England and finally establish England as a Protestant nation. Each of these episodes attempted to redefine the monarchy through new and differing state and church identities, causing inevitable political motivations to be central to the shifts in religious identity and practise (Hoeschen 2010, iii). Responses to these cultural changes within England fluxed from compliance to rebellion, with a significant amount of continuation, especially from those individuals not directly associated with political and religious decision making. While iconoclastic practises were officially recommended in various royal and episcopal declarations during the Reformation in England, the material culture present from this period, such as the pipe clay figurines, offer insights into the popular responses to the reforms of the 16th and 17th centuries. The figurines appear to reflect wider practices, with a continual presence of Lutheran condemned religious iconography into the 17th century within England. This form of material culture does not represent overt rebellious acts, but instead demonstrates the variations in belief and practise still present within England, representing the difference between official doctrine and popular practise (Tarlow 2003, 111). However, after the 17th century, where the actions of the Puritans saw much more prevalent iconoclasm and included active state and church participation, religious pipe clay figurines appear to decrease significantly, despite only a small decrease in overall figurines. The balanced and newly divided government, separated into king, Lords, and Commons, and the beginnings of religious tolerance, with a commitment to maintaining connections between the state and the Church of England (Olsen 2017, 304), which followed after the fluid politics and questions over religion experienced within England prior to the 18th century, may have influenced reduction in figurines during the 18th century. Given the political, social and religious turbulence of the 17th century this may well be reflecting the dominance of the Church of England, dominance of the Protestant Monarch, over Jacobite contenders and the movement of iconography in pipe clay figurines to potentially less politicized motifs, such as their use as curios and toys, as is shown in the latter material. Obviously, these trends should be deemed tentative given the relative paucity in the numbers of figurines, but would correlate to wider observations about the nature of religious observance and iconoclasm in England during the 17th century.

Overall, during the Tudor period the employment of imagery for both religious and secular messages became a common practise of visual communication. With a wish to increase comprehension of official messages, visual media, such as print and mould-made objects, aligned themselves perfectly for this function. The book of hours and calendars are prominent examples of this shift in comprehensive public messaging. These processes of circulating memorandums ensured that the majority of society had access to key, yet simplified, messages, and allowed the monarchs to manipulate and disseminate imagery to idealise their rule as they saw fit. Another successful means of attaining this was by ensuring that imagery could easily and affordably circulate around individual’s homes, and both stove tiles and pipe clay figurines opened up this avenue of propaganda. As has been previously discussed in Chapters 1 and 4, the distribution of these products was not restricted to certain social statuses or religious identities, and these devotional items can be traced across London (Gaimster 2003, 124).

Both stove tiles and pipe clay figurines offered a new visual component which allowed popular religious and secular repertoires to circulate inside the domestic sphere and supported the shift in religious devotion from public piety to a more private form of devotion. Each of these forms of material culture could be employed in various avenues of home ornamentation, from house shrines to wall hangings. One central subject that both products were incorporated into was the home’s hearth. Alongside the obvious placement of the stove tiles in this area of the home, figurines were also placed as decorative elements. Some figurines adorned the top of the stove plinths, as see in Jean Froissart's *Chroniques of France et d'Anglettere* (Figure 8.4), which shows a dance hosted by Charles VI in Paris and displays a figurine located above the plinth in the background (Gaimster 2003, 128). The orientation of both religious and secular imagery around the hearth may have enhanced the visual effects offered by these devotional objects, as they became a magnified focus by the radiating heat, illuminated and animated by the fire (Gaimster 2003, 125).

A clear trend appears when tracing the rise and fall of the distribution areas of pipe clay figurines alongside the shifting religious and secular policies and fashions. There is a noticeable shift from the elaborate pipe clay religious figurines which were produced during late medieval and early post-medieval Germany and the Low Countries to plainer designs. There is also a shift in the iconography present within these countries in comparison to the sudden rise of figurines within England. The cessation of certain elaborate and condemned imagery, brought about due to the Lutheran reforms in Germany and the Low Countries, are seen to, in a simpler form, begin circulating the London markets. These figurines were perfectly adapted to comply with the visually motivated state and religious merger brought about and perpetuated by the Tudor reforms, reforms which promoted private religious piety and devotion to the sovereign. As such, it may not be a coincidence that the rise in this form of production, which finds its roots in medieval Germany (See Chapter 1), shifts during the late 15th century and mid-16th century to England at a time when there was also a corresponding increase in the distribution of German artisans living within London. These newly expanded communities, which during Henry VIII's reign reach around 5,000 individuals within London, were central to the introduction of both new religious ideologies and new artistic material culture into England (Gaimster 2003, 138). Whether these immigrant communities were responsible for establishing and encouraging production of pipe clay figurines or instead served as conduits for imports from the continent is unknown, but it is highly likely that whatever the situation this community was influential in those choices.

Figure 8.4 The figurine can be seen to adorn the fire hood, with close up detail of this figurine to the right, in this detail of a miniature of burning costumes of the 'hommes savages' during a masked dance in Paris, at the beginning of Chapter 32, from Jean Froissart's Chroniques, Vol. 4, Netherlands (Bruges), c. 1480, (© British Library Board , Royal MS 18 E II, f. 206r. Biggs 2013 accessed 21/06/2017)

8.1.3 The Impact of European Religious and Political Change on the Colonies

The explorations and advances to the New World carried with them the religious tensions which circulated Europe and the Stuart Kingdoms of England, Scotland, and Ireland, issues further aggravated by the later revolutions against Charles I (Pestana 2009, 67). The Protestant Reformation, which, as discussed above, had challenged the religious status quo within Europe, continued to play a part in the religious spheres in the Atlantic World. Colonisation of the Americas became a method of competitive conversion, offering Catholics an opportunity to rejuvenate their church after the Lutheran attacks in Europe (Pestana 2009, 33). James I, and later Charles I, hoped uniformity of religion, under the umbrella of the Church of England, would prevail within the colonies. The first nine English colonies had the Church of England as their legally established church (Pestana 2009, 68). However, by the time Jamestown had been established in 1607, the first permanent and enduring colony by the English, the Spanish had already established extensive missions along the southern coast of North America as far north as Florida. Therefore, the tenth English colony, Maryland (a colony of particular interest to this study due to the fact that 23 of the 33 American pipe clay figurines were recovered in this state), became an exception to the previous tradition of establishing the Church of England as the designated faith when it was founded in 1632 (Pestana 2009, 68). Instead of being established under uniform religious supervision, Charles I granted Maryland to Lord Calvert, the first Baron of

Baltimore, as a proprietary colony (Pogue 1983, 17). By doing so, Maryland acted as an area of tolerance for the safe practice of Catholicism, in a previously predominantly Anglican region (Passano 1901, 6).

Even with the Royal approval for its formation as a proprietary colony, or perhaps more accurately because of it, Maryland became the focus for contention about faith in the English colonies. The colony became a haven for Catholics seeking a safe place for worship, but the region experienced many turbulent years of political and religious turmoil. These troubles began when the land which was granted to this proprietary colony conflicted with the claims of Protestant Virginians. Previously, the area of Maryland had been granted to Virginia by James I in a charter that was later annulled in 1623. The renewed charter not only took land from the Protestant Virginians but also granted Catholic Maryland more liberal trading rights (Passano 1901, 11). This sparked a series of bloody disputes from 1631-1655 between Clairborne, a wealthy, Anglican parliamentarian planter in Virginia and the Calvert's. This conflict was escalated within the colonies by the execution of Charles I on the 30th January 1649 and the passing of the '*Toleration Act'* of Maryland on the 21st September 1649, which

> '*ordered and enacted… that noe person or persons whatsoever within this Province, or the Islands, Ports, Harbors, Creekes, or havens thereunto belonging professing to beleive in Jesus Christ, shall from henceforth bee any waies troubled, Molested or discountenanced for or in respect of his or her religion nor in the free exercise thereof within this Province or the Islands thereunto belonging nor any way compelled to the beleife or exercise of any other Religion against his or her consent'* (Colonial Assembly of Maryland 1649)

While the act tried to promote freedom to worship, the juxtaposition of circumstances in relation to the beheading of King Charles culminated with Puritans being forcibly removed from Virginia and settling on the Severn River in Maryland, at the newly established site of Providence. This led to further clashes between the Jesuits and Protestants, culminating in 1654 in the resignation of Governor Stone , a Catholic, who was then replaced by Governor Fuller, a puritan (Passano 1901, 19). Governor Fuller passed alteration laws which were then in direct conflict with the '*Tolerance Act.* Following this, in October 1654, the reconstitution assembly passed the reconstituted *Act Concerning Religion*, stating that all were allowed to worship in freedom except Catholics, Episcopalians, and those who '*under the profession of Christ, hold forth the practice licentiousness'* (Farrelly 2012, Chapter 3 footnote 19). This again led to an escalation of bloodshed in the region, which continued without much interference by the rule of Oliver and Richard Cromwell as Lord Protector of England. Even with the return of Charles II to the throne in 1660 and throughout his long reign, conflict continued between the Catholic and Protestant populations within Maryland. This climaxed with the disputes between the popularly elected Maryland Assembly, mainly

Protestant, and the proprietor and his small, predominantly Catholic, Council (Walsh and Fox 1974, 22), as discussed in Chapter 5.

Given the turbulent and often violent events discussed above, material culture is a key piece of evidence for enhancing and critiquing our understanding of the complex religious and political issues that were experienced during the initial stages of colonisation in the Americas. Items such as the pipe clay figurines, alongside other imported objects, help to contextualise events noted in historical documentation, as can be seen in Chapter 5, where the available figurines for the American colonies on the east coast were presented. Such examinations of material evidence offer an insight into how individuals identified with both their religious beliefs and political affiliations, be they Protestant or Catholic, parliamentarian or royalist, as well as providing a source of evidence about the lives of children within the colonies, a group of the population often hidden within the historical records. Of the 27 figurines and one mould so far located in America 24 appear to date to the 17th century and three date to the early to mid-18th Century and one has no date. Two represent kings (one of which seems to be either King Charles I or II); four are Madonna and Child figurines; one is a cupid; 12 are either ornaments or children's toys; three are men with an oak leaf on the rear of their calves which, as discussed in Chapter 5 could have a political significance; one is a potential representation of General George Washington; three are unknown; and one is a soldier mould.

While this dataset is small, the different locations of recovery and their iconography appear to correlate with the historical events which took place in these colonies. The presence of Catholic iconography coincides with the freedom of worship which was initially granted to individuals within Maryland and then further afield. The presence of kings and the potential Jacobite males with oak leaves once again may offer insights into the expression of political ideology circulating in the English colonies. For both the religious and political figurines that are present it might also be suggested, though a little fanciful, that the reason for their deposition into the ground may also have been politically and/or religiously motivated. Certain sites, such as Nicholas Sewall's Plantation, were occupied by those who held contrary ideologies, leading to the movement of people and the destruction of property(Hurry and Grulich 2015, 3). This may also explain why all the figurines seem to date to the 17th century, a clear period of religious and political turmoil and change, as well as a period where mass-production also began to have a distinct impact upon the material culture of large swathes of the populace.

The sudden apparent cessation in the presence of pipe clay figurines in the 18th century may reflect three significant events which affected the ceramic trade from England to America. The first factor, which will have reduced ceramic trade into America from England, was the inevitable growth and development of local pottery manufacturers. Though inferior to imported wares, nonetheless, by the mid-17th

century, much of the ceramic needs for the colonies were being catered for by local craftsmen (Hume 2001, 98). The second, and potentially more significant, factor in the reduction in English ceramics within the English Colonies may have been brought about by the Navigations Act of 1651 and 1660, which required foreign goods to be imported into England and her colonists only via English ships (Hume 2001, 138). These Acts were part of a series of efforts by Parliament (together with Charles II in 1660) to reduce Dutch control on maritime trade, as well as increase revenue from English ports by increasing the number of vessels they could control that paid duties on the goods being shipped through them (Hume 2001, 40). The final factor was the boycotts instigated against England by all the Colonies, except for New York, caused by the Townshend Acts of 1767, and formalising the imposition of taxation without representation, after which followed the Revolutionary War Years, further reducing English ceramics circulation in America (Hume 2001, 114).

8.2 The Comparative Data

Alongside the usual methods of collating and researching an artefact database for the post-medieval pipe clay figurines found in London and English colonies in the New World (discussed in Chapter 6), this thesis has also carried out extensive 3D imaging and artefact matching procedures. This was conducted in an attempt to comprehend whether the common 3D techniques currently being used within archaeology could indicate whether figurines had been produced from the same mould, and if so connect this to the distribution of these figurines across England and the Colonies. Alongside this was the aim of creating a more in-depth understanding of mould generation analysis for pipe clay figurines and establish a methodology suited to the study of moulded artefacts within the archaeology sector. Though the comparative data set was small, with only 14 figurines available for comparison, the results that were produced were clear and of importance. Potentially similar figurines have been studied before, such as the Charles Gift Site king and the London Blackfriars king, previously studied by Hurry and Grulich (2015) and Grulich (2008) (as discussed in Chapter 7). The use of 3D methodologies within this study has enabled a more detailed interpretation of these two figurines, producing overall surface comparisons that were able to offer a highly detailed metric analysis of the similarities and differences between the two figurines. This examination showed a precise alignment of figurine features such as the orb, sword, and rivets on the armour, as well as clearly visualise the small surface differences between the two figurines, all despite the highly differential erosion rates between the two figurines.

The 14 figurines which were selected for this analysis produced results that showed that the figurines, within their comparison groups, had at least been produced from related moulds. The Charles Gift Site King compared to the Blackfriars King indicated a highly probable example of the two figurines coming from the same generation, with a potential for these two figurines to have been produced from the same mould. This conclusion was suggested due to the high percentage of surface similarity seen within the 1mm and below parameters of the 3D comparisons, with 50% of the figurines surfaces were similar under 1mm to each other and that over 25% of the figurines surfaces were similar at 0.5mm, see chapter section 7.1.1 for full details. The cockerel 3D comparisons presented a strong relationship between A5176 and a19159, displayed through both the structure of the histogram, with its central peak orientated around 0, and the high correlation of faces, with 58.36% of faces being present at 0.5mm parameter, that these two figurines are from the same mould generation, with high potential that they are also from the same mould. For cockerel figurine 4973b, no specific assignment of generation could be consigned, due to the erosion levels on the figurine, however the results did suggest that it was from the same family of figurines, as within the 1mm parameter 49.48% of the faces were still present when compared to A5176 and 48.16% remaining when compared to a19159, for the full discussion please see chapter section 7.1.3. The results generated from the Whitechapel King 1854,1130.43 and Thames King 1856,0701.1657 comparisons indicated that the Thames King was marginally smaller, suggesting that this king, though in the same family, may have been produced via a later generation of moulds. The Dorothy with a basket figurines; 1854,1130.45; 1854,1130. 46 and 4972 when digitally compared produced results which indicated that figurine 4972, though the feature placement and composition was incredibly similar when compared to 1854,1130.45 and 1854,1130. 46, overall it was up to 0.5mm larger than the other two figurines, suggesting it was produced from an earlier mould. Figurines 1854,1130.45 and 1854,1130. 46 presented very little variation with just over 14% comparable faces at the 0.05mm parameter, suggesting that these two figurines came from the same generation, and a case could be presented from these two figurines even coming from the same mould. Overall though the digital comparisons for these three figurines was able to conclude that they are all from the same family, and created a suggested family order for the figurine generations as well, please see chapter section 7.1.5 for more details. When figurines 1854,1130.47 and 4975, 'man in hat', 3D comparisons were generated, they displayed another example of figurines related to each by their mould family, however the figurines were produced from different mould generations. While there is high similarity in feature placement, the comparison demonstrated that 52% of 4975 is smaller, this alongside the histogram structure suggests that 4975 is from a later generation, see chapter section 7.1.6 for full details. Finally the 3D comparisons between the Robed King 1854,1130.44 and Bankside King 17681, showed that the figurines were from the same mould family, with the potential from being from the same generation. Even though the histogram results were dulled due to the high erosion levels on 1854,1130.44, the specific feature placement even within the 0.5mm parameter comparison of these figurines is suggestive of a close mould relation, see chapter section 7.1.7 for full details.

By highlighting feature alignments and combining this with a developed examination of the histograms, a better understanding of similarity could be produced. Whilst there were frequent cases of a focus of points around the 0mm difference marker, in some cases the 3D surrogate comparisons could still be appreciated to be from incredibly similar, but not identical, figurines. While these were often very minimal differences that would be difficult to appreciate using traditional measuring, for example, within the Dorothy study, as discussed above, Dorothy 4972 was only 0.5mm larger than figurines 1854,1130.45 and 1854,1130. 46, and figurines 1854,1130.45 and 1854,1130. 46 presented 14% comparable faces at the 0.05mm parameter, it is enough to suggest that figurines came from either the same generation or the same mould in the examples of figurines 1854,1130.45 and 1854,1130. 46, or whether they came from earlier or later generations, in the case of 4972 the results suggested that the figurine came from an earlier generation than figurines 1854,1130.45 and 1854,1130.

A caveat however should be considered during these examinations as well. Different shrinkages will occur depending on the firing temperature, and while most figurines will have been fired at 950-980̊c (Kügler 1995), slight temperature variations within the same kiln during a single firing may occur due to different locations in which figurines are placed or in circumstances of extreme over firing. Though examples of this latter issue will be the exception rather than the rule, the possibility of these temperature fluctuations within or between firings will result in a degree of size differences between the objects produced as David Higgins has suggested (1987) which is included in Chapter 6. This may have an impact on wider studies and this issue should be considered, however for the comparison examples discussed within Chapter 7, within each of the figurine comparisons, the error results fell extremely below the 5%-8% variation noted within Higgins (1987) thesis as demonstrated in table 3. Therefore, as discussed in Chapter 6 the dataset that this thesis has utilised will fall into one of three scenarios, either that this material is not affected by this issue; secondly, that the material may have been affected by over firing on a smaller scale, but this effect is covered by the error parameters and would only result in suggested generational differences between comparisons of one generation, which has usually been a tentative suggestion anyway; thirdly, the material does include one or more figurines that have been significantly over fired.

There are several factors arguing against the third scenario impacting this study. As mentioned previously, there is no evidence to suggest that production of pipe clay figurines found in the UK and America would have produced enough generations to create such large differentiations in figurine sizes that a 5-8% over firing reduction would match a later generation, and given the rarity of extreme over-firing it is also unlikely there is one within a dataset of this size. To these points can be added the results of the 3D comparison, which has also suggested that it is a highly unlikely scenario that such an over-firing would produce the same feature details which would match as exactly to a later generation as those displayed within this study. As such, the impact of extreme over firing does not appear to be evident within this dataset, however, it should be noted that incidences of minor temperature differentiations between figurine firings may have contributed to some of the variations observed in the overall sizes and specific details on the figurines. These variations in size would fall within the error parameters set within this thesis and thus already be accounted for, but consideration of over-firing, both extreme and minor, still serve as a potential warning when studying other mould-generated material culture where larger assemblages and larger-scale manufacturing processes may produce more frequent examples of this issue within a dataset.

Overall, this approach to 3D modelling and mould analysis has not only offered an initial, but pivotal, development in the investigation of pipe clay figurines in London, it has also opened up the possibility for furthering these investigations via comparing the figurines recovered in London with those figurines and moulds found within Germany and the Low Countries. This next stage of analysis may also provide answers to the question about whether figurines were being exported from Germany and the Low Countries, or were being produced in England. As the available number of figurines increases further discussion about the distribution of figurines and possible sources of production may also be developed. The methodology also has ready applicability to any mould-generated artefact, which will be discussed further below.

Table 8.3 Figurines utilised in comparison study in Chapter 7 with hypothetical 5% over firing shrinkage measurement and the actual difference recorded during the comparisons.

Figurine comparison	**Height 5% in mm**	**Width 5% in mm**	**Actual percentage surface area difference**
Charles Gift Site King Compared to London Blackfriars King	6.8-7.4	3.6	Overall 71% of the Blackfriars king's face values are smaller than the American figurine. The majority of which is reduced by 0.97mm At 3mm 94.3% of their faces correlating with a maximum error of no more than 3mm
Cockerels A5176, 4973b and a19159	2.8-3.1	2.51-2.57	**A5176 Compared to a19159:** 95.5% of their faces correlating with a maximum error of no more than 2mm **A5176 Compared to 4973b:** 99.22% of their faces correlating at the 2mm parameter **a19159 Compared to 4973b:** these two figurines do not come from the same generation of mould, as overall 74.15% of a19159 is smaller than 4973b.
Whitechapel King 1854,1130.43 and Thames King 1856,0701.1657	3.2-3.3	1.2-1.25	99.97% of their faces correlating with a maximum error of no more than 2mm 90.42% of their faces correlating with a maximum error of no more than 1mm
Dorothy Holding a	2.5-2.6	0.89-0.9	**1854,1130.45 compared to 1854,1130.46:**

Basket: 1854,1130.45; 1854,1130. 46 and 4972			At 1mm 100% of their faces correlating with a maximum error of no more than 1mm At 0.5mm 96% of their faces correlating with a maximum error of no more than 0.5mm **1854,1130.46 compared to 4972 lower half** At 1mm 98.9% of their faces correlating with a maximum error of no more than 1mm At 0.5mm 98.9% of their faces correlating with a maximum error of no more than 0.5mm **1854,1130.45 vs 4972 with results shown on 4972 lower** At 1mm 99% of their faces correlating with a maximum error of no more than 1mm At 0.5mm 97.5% of their faces correlating with a maximum error of no more than 0.5mm **1854,1130.46 compared to 4972 with results shown on 4972 upper half** At 1mm 98% of their faces correlating with a maximum error of no more than 0.5mm At 0.5mm 96.2% of their faces correlating with a maximum error of no more than 0.5mm **1854,1130.45 vs 4972 with results shown on 4972 upper half** At 1mm 98% of their faces correlating with a maximum error of no more than 1mm At 0.5mm 95.6% of their faces correlating with a maximum error of no more than 0.5mm
Man in Hat 1854,1130.47 Compared to 4975	2.54-2.59	0.77-0.78	At 2mm 100% of their faces correlating with a maximum error of no more than 2mm At 1mm 97.7% of their faces correlating with a maximum error of no more than 1mm At 0.5mm 88.5% of their faces correlating with a maximum error of no more than 0.5mm
Robed King 1854,1130.44 and Bankside King 17681	2.7	2.7	At 2mm 92.8% of their faces correlating with a maximum error of no more than 2mm

8.2.1 Evaluation of Artefact 3D Workflow

In Chapter 2.7 a 3D research workflow was presented (Chart 2.5), that offered a clear and standardised approach to projects employing and analysing 3D surrogates, including steps covering initial project design to publication. These steps were utilised in the production of the research set out in this thesis, with stages one to nine already completed. The process was clear to follow and has ensured that all data has been collected, examined, and presented transparently within the thesis. An indication of the viability of the approach is that no new stages were required to be added to the original workflow. The final stages that have not yet been undertaken involve the storage of the data and publication of the research, although these will be considered and acted upon in due course. Concerning storage, the main archive will be held by the author, with relevant 3D data also being held by the associated institutions that provided access to artefacts.

As part of assessing the viability of the 3D modelling workflow, of great importance was evaluating the appropriate research employability of various techniques, especially SfM. This software has great potential, especially when incorporated into camera domes (figure 8.5), as seen on projects discussed in Hess (2015) and the Bidirectional Texturing Function (BTF) Database Bonn and Measurement Lab (BTFDBB) projects run by the Institute of Computer Science II, associated with the University of Bonn (Klein and Schwartz 2012; University of Bonn 2018). Unfortunately, the guidelines of usage offered by the software websites, for example Agisoft (Agisoft LLC 2011), are not viable for non-studio based metric analysis of artefacts. The methods suggested by the software creators cannot provide viable and consistent results in the field during excavations or when data collection requires travelling to a variety of archaeological stores, both of which are issues which frequently arise during artefact data collection. In these scenarios standard issues that will impact the data include limited workspace, variable work environments (such as light, humidity, air flow), and limited time or restricted access with the material. Such issues have arisen during the research included within this thesis and have been observed to negatively impact the quality of the 3D model produced. Whilst approaches such as SfM provide a means of analysing and comparing material that cannot be examined together physically due to being in separate countries and museum policies design to protect artefacts from damage and loss, the actual quality of the final model is of key consideration when evaluating a technique.

[redacted]

Figure 8.5 Camera Dome for 3D imaging, used by the Institute of Computer Science II (Image from Klein and Schwartz 2012)

In this context of assessing quality, the results from employing SfM specifically for 3D surrogate comparisons, as trialled on the Charles Gift Site king compared to the Blackfriars king, produced low-quality results (as discussed in Chapter 7, section 7.1.2). The SfM results were not accurate enough to conduct detailed macro analysis, especially in comparison to the macro precision which the NextEngine was able to offer, which in some cases provided matches down to 0.05mm. This meant that the figurines modelled by SfM could not be analysed to any level of detail within their 1mm and 0.5mm spheres, which is integral for comprehending mould matching and generational analysis, especially on items of this size. While SfM cannot be employed for figurine and mould analysis at the detail, however, it can still be used as a suggestive or prospective method, highlighting items of potential similarity that fall within the margin of error. As can be seen in Figure 7.12, the histograms highlight that despite the fact that the values produced by the SfM tests dissipate around the 0 marker (an expected result due to a lack in software accuracy) the general shape of the Photoscan histograms mirrors those of the NextEngine histograms. The histogram shape can, therefore, act as a suggestive placement for the comparison models, which can then lead to detailed investigations using more accurate equipment. In the case of this thesis the NextEngine was used, due to the relatively cheaper cost as a laser scanning system but with a high degree of detail, but other modern laser scanning or white light scanning systems can provide an even higher degree of accuracy, but with a commensurately higher price tag.

Alternatively, if projects employing SfM do not require high macro accuracy levels, for example for use in outreach and community engagement rather than metric research, then the employment of this method is still a viable, cheap alternative to other, more expensive, 3D methods. Even so, the unpredictable nature of the SfM software and the 3D models they generate when used remotely and in temporary imaging environments (i.e. outside of a photography lab) means SfM needs to be employed with caution to ensure that the methods are never employed as the sole method of recording. They still require scaling or georeferencing from outside sources, and the models should be produced while there is still access to the original in case of processing issues or incomplete data. It should also be noted that the evaluation of SfM software should be an iterative and continual process, since it is highly likely that both the software, equipment, and techniques associated with SfM will improve to a point where it may become a viable technique for detailed artefact and mould analysis in the near future.

8.2.2 Further application proposals for 3D comparison

Concerning the 3D comparison methodology that was generated by this thesis, the future applications for this process are vast. Firstly, there is the potential for continuing and broadening the pipe clay figurine comparisons between those recovered in the UK compared to the material recovered in continental Europe. Specific interest should be shown initially to those countries which have generated a large corpus of both figurines and moulds such as those recovered in Germany (See Neu-Kock 1988; and the Catalogue from Pijpenkabinet Foundation in Amsterdam n.d.), the Netherlands (Ostkamp 2012; Oostveen 2011; Van Den Dorpel 2013; The catalogue from Rijksmuseum n.d.; The Catalogue from Centraal Museum, Amsterdam; Ostkamp and Helbergen 1974, Rudd Stamm [personal comms]), and Poland (Kowalczyk 2013; Kowalczyk 2010). Furthermore key areas within England such as Norwich, where during preliminary investigations figurines have been recorded ID 152 and 157 in Appendix 1, which have known populations of immigrants settling here should be examined further to explore the question of source of figurines within the UK. These investigations and 3D comparative analysis, will help to broaden the data set which will allow for a developed identifications of specific avenues of figurine production and production chronologies between countries. Such an examination would serve to provide a context within which figurines from other countries could be compared and contrasted, and begin the process of unpicking production and dissemination of specific figurine forms, not just general patterns of iconography. Furthermore, this 3D comparison methodology could also be applied to other corpora of moulded materials such as tobacco pipes, pilgrim badges, or glassware. A trial study of this latter material group is currently in process, aiming to examine generational analysis of Renaissance Lion Stem Glasses via the 3D methodologies presented within this thesis (Crichton-Turley and Garwood. forthcoming.). Consideration could also be made to objects that are considerably older than the later medieval period and the rise of mass production, such as Bronze Age axes, copper alloy dress accessories of all periods, and figurines from the Roman period. Similar research has recently been carried out on the counter marks on Roman Coins, Rhineland. The focus of the study was to quantify the existence of different countermark dies that were used between 7-9 AD. This study aimed to identify individual dies and traces of ordering them by means of increase use-wear by comparing the 3D meshes of the coins using CloudCompare and Optocat (for full discussion see Tolksdorf *et al.* 2017).

Finally, this methodology could also be employed outside of the confines of moulded artefacts into a wider field of studies. By employing this detailed 3D comparative methodology, buildings conservationists are able to integrate monitoring evaluations to gain a detailed report on the movement of both man-made and natural features which may impact on a heritage site. This can be employed in a range of applications including structural shifting and subsidence measurements, pollution affects, deformation of structures such as Dams, or chimney and flue deformation within listed buildings. UNESCO in 2003 was compelled to define the significance of ''digital heritage'' and to establish its value and need for protection (Ottaviano, *et al.* 2018). The use of 3D imaging to obtain orthophotos for metric analysis is helpful for understanding very complex architectural phenomena. Employing these 3D comparison methodologies allows for monitoring and evaluation of structural plastic deformation elements of historic structures, which is becoming increasingly important in restoration. The data generated from these comparisons can be used to identify and to describe defects and degradation, with the view of determining possible performance reduction in existing structures (Gattulli *et al.* 2018, 1). By beginning to produce and compare a series of models of architecture, landscapes, and sculpture, the specific effect and rate of these issues on the historic environment can begin to be quantified. Similar projects have been undertaken by Visintini (2011), whereby both laser and photogrammetric surveying was undertaken to establish the variable rate of subsidence on the Theodorian Mosaic Floor of the Aquileia Basilica. This form of configuration allows for clear visualisation and guidance for conservation requirements of heritage as well as providing an accurate record of the structure. Digital imaging processing allows for the extraction of quantitative and qualitative information, reproduction and comparison of the same scene or structure via these methods and has the potential to monitor structural damages such as cracks, spalling, deformation or collapse (Gattulli et al. 2018, 22-3).

Another avenue for future employment of this 3D comparison methodology could concentrate on the affect that pollution has on heritage. By 3D scanning casts created by museums, such as those held in the Cast Court housed in the Victoria and Albert, and then comparing those scans to 3D scans recording the monuments in the present, a rate of monument degradation could be calculated and if needed conservation actions taken. A similar project has taken place recently between UCL and the British Museum. The project 3D imaged 19th century plaster casts taken from marble sculptures in the Parthenon. These casts were made from large sections of the Parthenon sculpture, the latter have since been exposed to weathering and vandalism. These exposed features were also 3D imaged. Comparative 3D scanning was employed to establish both the accuracy of the casts and their potential to preserve sculptural features which have since been worn away (for discussion on this project see Historic England 2018, 58-64).

Finally, this form of 3D digital comparative analysis can also be employed in studies of bone surface modifications (BSM) for example cut, butchery or teeth marks. Understanding these features is crucial for developing understanding of human and hominin existence. This field of study and forms of identification for BSM has remained contentious, with many previous investigations relying on morphology to identify marks and patterns. Similar projects are currently being undertaken by Torquato *et al* (2018), within this project 3D digital comparative methodologies are being coupled with Procrustes paradigm and the Bayesian approach in an attempt to strengthen statistical confidence in cut mark identification and employed to obtain mark attribution information from the fossil record (for full report see Torquato *et al.* 2018).

8.3 Conclusion

This thesis presents the first comprehensive analysis of the post-medieval pipe clay figurines not only from London, but also an initial examination into the material from the English colonies. This is a previously overlooked corpus of material which has provided a different avenue of insight into individual's daily lives and their responses to secular and religious upheavals which swept through early post-medieval life. The study of these figurines has allowed for; development of theory connected to personal piety, a different perspective on childhood and gender specified toys and their associated meanings as well as how printed media was employed to quickly address changing political and religious policies. This study has presented a case for a developed comprehension of this material, rebuking previous concepts that these, cheap and mass manufactured items, were restricted to the poorest levels of society as has been previously suggested. Instead this thesis has shown how these figurines are from a range of economic backgrounds. The London pipe clay figurine dataset, has displayed that a higher proportion of these figurines have been recovered from wealthier contexts. This conclusion is based on a small contextualised dataset which was available for this specific study, consisting of only 15 figurines, shown in Graph 8.1, therefore currently stands as only a suggestive conclusion. However as further excavations generate more materials, this conclusion can be re-examined and developed accordingly. What is of note however is when the materials recovered in England's new colonies in the New World, see Chapter 5 for more details, are also taken into consideration, a similar situation to that which is seen in London, is presented. The figurines which have been recorded and explored within this thesis from the New World are also often from high-status contexts, for example, at the Washington residence at Mount Vernon (section 5.1.6) it was clear the figurines belonged to members of the main household, since they were discovered amongst the refuse of the main house, not the slave refuse pits.

Further insights into pipe clay figurines functionalities, that this thesis has also displayed demonstrates often that figurine iconography relates to the context in which they are recovered, for example the six religious figurines which are recovered from religious contexts which are discussed in Chapter 4.6, an expected conclusion. While this thesis has managed to generate a deeper understanding of consumer markets that these figurines were present in, it has not been able to conclude specifically on the manufacturing location of London's post medieval pipe clay figurines. With only one figurine mould (Figure 8.1) recovered so far in London, and currently no specific production centres yet recorded in London or the rest of the UK, a definitive answer to whether these figurines were produced within England cannot be concluded. What this thesis has managed to produce is clear arguments for either the potential of English production centres, or production centres based in Germany and/or the Low Countries and exported for the London consumer market.

The analysis of figurines from Germany and the Low Countries compared to those recovered from England and English Colonies, presented in Chapter section 8.1.2, demonstrated that there is a group of materials from German and Dutch contexts which are visually very similar to those recovered from English contexts. The German and Dutch examples which have been recovered are earlier in date that those recovered in England. This could be suggestive of finished products, or the moulds, being exported from German and Dutch workshops to English markets. Or, it may present an example of artisan emigration to England from Germany and/or the Low Countries. Unfortunately, the lack of archaeological and documentary evidence cannot yet provide an answer to this issue. What though is highlighted by these comparisons is the difference in the elaborate levels of details presented on the German and Dutch examples in contrast to the simpler designs recovered from London, shown in Table 8.2. This factor, combined with information concerning production dates of these figurines demonstrated how the cessation of religious figurine production within Germany and the Low Countries and shift of these markets to English contexts during the 16th century, as well as a concurrent transition in figurine design, may be related to contemporary events. Of particular interest to this discussion, which is presented in detail in Chapter section 8.1.2.1, are the pre- and post-Reformation influences which controlled the religious art markets within late medieval and post-medieval Europe. With indulgent worship in high contrast to Martin Luther's ideals, and salvation believed only to be achievable through faith alone, a shift in ideological tone of the populace occurs. This shift can be tracked within the developments of iconography and design within the art world, one which is displayed clearly both by the distribution shift and stylistic changes seen to affect the pipe clay figurines during the 16th century.
This thesis shows a clear presence of the iconography which had been condemned by Martin Luther, within London's pipe clay figurine assemblage from the 16th century through to the 18th century. This continuation may reflect the impact of the doctrine of the Church of England, which had elements of earlier catholic practices still present (Pritchard 2017, Chapter 1). The simplification of detail present within the pipe clay figurine assemblage from London, does present, to a certain degree, the effects of Lutheranism on the German and Low Country artisans who may have either been exporting to these English Markets, or, emigrated to and established English production which maintained some of the older iconographical motifs.

This thesis has therefore demonstrated how mundane artefacts, such as the pipe clay figurines can provide insights into specific and major historical events and the unseen people in the historical narrative. This form of material culture does not represent overt rebellious acts, instead, demonstrates the differences in belief and practise, representing the variance between official doctrine and popular practise (Tarlow 2003, 111).

Furthermore what this research has displayed is a peak in the presence of figurines within the English market during the 17th century, before a significant reduction in figurine production during the 18th century, with a substantial reduction in religious figurines. This transition once could be suggested to reflect the contemporary political and religious situations of the 18th century. With a newly structured government and beginnings of religious tolerance, following the prior centuries of political and religious turbulence, a movement into an iconographical market where there is less of a requirement for politicized motifs and a want for more generalised curios and toys, a shift which can be seen within in the latter materials from the London assemblage.

It should once again be noted that these conclusions are tentative due to the small assemblage of pipe clay figurines, but a suggestive conclusion that nevertheless correlates with the wider observations about the nature of religion and iconoclasm in England during the 16th- 18th centuries.

As stated above this research also has produced a preliminary investigation into those figurines recovered in English colonies within the New World. What the thesis has displayed is a very similar situation seen between the New World figurines, and the London figurines. As mentioned previously the majority of the figurines found within the New World are located in wealthier contexts and once again a correlation of historical events with the figurines and their iconography occurs. There is a distinct presence of catholic imagery amongst the figurine assemblage, which coincides with the freedom of worship which was initially granted to individuals within Maryland and then further afield. The presence of kingly iconography and potentially Jacobite iconography, seen amongst the gentleman figurines with acorn leaves offer insight into expressions of political ideologies which were circulating in the English colonies. Furthermore a cessation of figurines is within the colonies is appears in the 18th century, this may reflect similar issues to those discussed above, but also may reflect relevant trade factors from this period which included; reductions in ceramic trade from England to America due to the growth of local pottery, a reduction due to the Navigations Act of 1651 and 1660, which required foreign goods to be imported into England and her colonists only via English ships (Hume 2001, 138), or finally the boycotts instigates against the English the Townshend Acts of 1767.

The data assembled for this analysis has been collated both using usual methodologies for artefact research, as discussed in Chapter 6, alongside carrying out extensive 3D imaging and artefact matching procedures. These procedures help to explore whether common 3D methodologies currently employed within archaeology such as SfM and Laser Scanning produced accurate enough results to explore mould generational analysis and figurine matching and if so how could this help develop comprehensions of the distribution of these figurines across England and the Colonies. This thesis not only demonstrated that the field of mould generational analysis can be significantly aided by the 3D comparative methodologies produced by this thesis, it also demonstrated the viability of employing SfM for such practices. This study concluded that while SfM has great potential, especially when employed in hardware structures such as camera domes, the overall results offered by SfM are not viable for non-studio based metric analysis of artefacts. SfM was not able to provide viable and consistent results in the field during data collection, when it was removed from a sterile designated 3D imaging laboratory work space. The results produced by SfM (as discussed in Chapter 7, section 7.1.2) were not accurate enough to conduct detailed macro analysis, especially in comparison to the macro precision which the NextEngine was able to offer. Figurines modelled via SfM methodologies were not able to be analysed at the level of detail required by the 1mm and 0.5mm parameters suggested by the mould generational analysis procedures presented within this thesis. What the results however did display is while this methodology cannot be employed as a standalone research tool for this purpose, it can be used as a suggestive method, helping to highlight items of potential similarity that may require further investigation by more accurate methodologies. Alternatively for projects which do not require such as detailed macro analysis of an object, for example in outreach and community engagement, SfM does still offer a viable, cheap 3D imaging methodology.

In contrast to the SfM results, the comparative results which were generated using the NextEngine Laser Scanner showed a detailed and clear evaluation on the metric similarities and differences between figurines within the strict set of analytical parameters set in this thesis, see Chapter 6 for details on comparison parameters. This allowed for the identification of figurine generational relations between 12 of the figurines from the London dataset, and between a figurine from Maryland and one recovered in London, for the results of these comparisons please see Chapter 7. This comparative methodology has provided an approach which can offer a more detailed metric analysis of figurine comparisons aiding investigatory questions concerning distribution from production centres and transmission of iconography, than is currently employed within this field of study. Overall this approach has offered an initial, but essential, development in the investigation of London’s post medieval pipe clay figurines, and has also opened an avenue of possibilities for furthering these investigations. This research would now benefit from a comparative analysis of figurines recovered in Germany and the Low countries, compared to those recovered in London. This next stage of analysis would help to answer further questions orientated around the London figurine’s production locations and with this larger combined dataset the distribution of figurines and possible sources of production may also be developed.

Bibliography

Agisoft LLC. 2011. *Agisoft PhotoScan User Manual*. Available at: http://www.agisoft.com/pdf/photoscan-pro_1_4_en.pdf [Accessed September 19th 2018]

Allan, J.P. 1984*. Medieval and Post-medieval finds from Exeter, 1971-1980*. University of Exeter Press.

Allergretto, K. 2011. *The Ancient Cupid and Bacchus in Renaissance Art*. Lycoming College.

Amico, N., Ronzino, P., & Giancarlo, I. 2012. *Developing an Archaeological Benchmarking Procedure*. Proceedings of the 39th International Conference on Computer Applications and Quantitative Methods in Archaeology: p.13–20.

Ancestry Family Trees. 2018. *Record for Susannah Parsons*. Available at: https://www.ancestry.co.uk/family-tree/person/tree/115252470/person/280145339914/facts [Accessed September 19th 2018]

Anon. The National Archives of the UK (TNA): Public Record Office (PRO), E 122/194/25: Petty Customs Account 1480-1, no. 33: 1 box with toys valued at £7.3s 4d.

Anonymous. 1771. *Description of Cripplegate Ward*. The London Magazine, Or, Gentleman's Monthly Intelligencer 40 (386).

Arnold, D. 2013. *3D-COFORM.D.1.5—Project Final Report. Tools and Expertise for 3D Collection Formation*. EUFP7 funded project. Brighton.

Arnold, D., & Geser, G. 2008. *EPOCH Research Agenda for the Applications of ICT to Cultural Heritage.* Full Report. Available at: http://www.epoch-net.org/index.php?option=com_content&task=view&id=200&Itemid=306. [Accessed September 19th 2018]

Askew, P. 1988. *Excavations at Ling House 10-13 Dominion Street, EC2M 2UX (sort code LIG88*). Department of Greater London Archaeology, Museum of London. London.

Ayre, J., & Harris, R. 1988. *9 Cloak Lane, Skinners Hall kitchen TQ 3253 8088.* London Archaeologist 5(10). Available at: http://www.hobleysheroes.co.uk/round-ups/65-london-archaeologist-1988-vol-5-10. [Accessed September 19th 2018]

Ayres, B. 1985. *Excavations within the north-east bailey of Norwich Castle*. Norfolk.

Ayto, E. 1994. *Clay Tobacco Pipes*. Princes Risborough: Shire.

Balzani, M., Pellegrinelli, A., Perfetti, N., & Uccelli, F. 2001. *A terrestrial 3D laser scanner: Accuracy tests.* CIPA 18th Symposium. Potsdam, Germany, 445–453.

Banerjee, S., Dutta, S., Biswas, P.K., & Bhowmick, P. 2013*. A low-cost portable 3D laser scanning system with aptness from acquisition to visualization.* 2013 Digital Heritage International Congress (DigitalHeritage): p.185–188. Available at:

http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6743729. [Accessed September 19th 2018]

Barber, B., Holder, N., Philipotts, C., Pearce, J., & Richardson, B. 2013. Excavations At Cromwell Green And Westminster Hall 2005-6: Further Evidence For The Development Of The Medieval And Post-Medieval Palace Of Westminster. *Transactions of the London & Middlesex Archaeological Society 64 (1).*

Bartoš, K., Pukanská, K., & Sabová, J. 2014. Overview of available Open-Source photogrammetric softaware, its use and analysis. *International Journal for Innovation Education and Research.* 2(4): p.62–70.

Bathow, C., & Breuckmann, B. 2011. *High-definition 3D acquisition of archaeological objects: An overview of various challenging projects all over the world. 23rd CIPA Symposium:* p.12–6. Available at: http://congressgate.com/cipa/proceedings/pdfs/Keynote speech/Bernd_Breuckmann.pdf.

Bennett, M.J. 2015. *Evaluating the Creation and Preservation Challenges of Photogrammetry-based 3D Models*. IS&T Archiving 2015: p.78–82.

Berg, M. 1999. New commodities, luxuries and their consumers in eighteenth-century England. In M. Berg & H. Clifford (eds) *Consumers and luxury: Consumer culture in Europe 1650-1850*, 63–86. Manchester University Press

Bezzi, L. 2012. *3D documentation of small archaeological finds. ATOR (Arc-Team Open Research)*. Available at: http://arc-team-open-research.blogspot.co.uk/2012/08/3d-documentation-of-small.html [Accessed March 7, 2016].

Biggs, S. 2013. *British Library: Medieval Manuscripts Blog. British Library: Jean Froissart's Chroniques, Vol. 4, Netherlands*. Available at: http://blogs.bl.uk/digitisedmanuscripts/featured-manuscripts/page/24/ [Accessed June 21, 2017].

Blair, I. 2005. *Roman and medieval buildings, an assemblage of rare 18th-century glass, and other finds from 15 – 17 King Street , London EC2*. The London Archaeologist.

Blender 2.75 Foundation. 2015. Blender 2.76b. Available at: https://www.blender.org/ [Accessed February 11, 2016].

Boehler, W., Vicent, M.B., & Marbs, A. 2003. Investigating laser scanner accuracy. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information.* Sciences 34 (Part 5): p.696–701.

Borkowski, T. 1998. *Materialne przykłady codziennej religijności w średniowiecznych miastach śląskich. Drobna gliniana plastyka dewocyjna*. Archaeologia Historica Polona 7: p.47–69.

Borkowski, T. 2004. Produkcja figurek ceramicznych w późnośredniowiecznym Wrocławiu P. Jerzy & W. Krzysztof (eds). Wrocław na przełomie średniowiecza i czasów nowożytnych. *Materialne przejawy życia codziennego, Wratislavia* Antiqua 6: p.207–244.

Borne, P., Courtney, T., & Dixon, P. 1978. The Peacock Inn, Chesterfield. Derbyshire*. The Archaeological Journal Derby* 98: p.7–58.

Bosch, H. The Haywain Triptych. Available at: https://www.museodelprado.es/en/the-collection/art-work/the-haywain-triptych/7673843a-d2b6-497a-ac80-16242b36c3ce. Accessed 18.02.2019

Bradley, R.., Camp, H.., & De Paoli, N. 2014. *The Forts of Pemaquid, Maine: An Archaeological and Historical Study.* Maine Historic Preservation Commission.

Braun, G. 1572. *Map of Cologne 1572*. Available at: http://historic-cities.huji.ac.il/germany/cologne/maps/braun_hogenberg_I_38_b.jpg.

Bruce-Mitford, R.L.. 1939. *The Archaeology of the Site of the Bodleian Extension in Broad Street, Oxford*. *Oxoniensia 4.*

Callage, R., Kille, J., & Luckenbach, A. 1999. An Analysis of 17th Century Clay Tobacco Pipes from the Chaney's Hills Site (18AN1084). *Maryland Archaeology* 35(2): p.27–33.

Callisen, S. a. 1939. The Iconography of the Cock on the Column. *The Art Bulletin* 21(2): p.160–178. Available at: http://links.jstor.org/sici?sici=0004-3079(193906)21:2%3C160:TIOTCO%3E2.0.CO;2-3.

Cassidy, J. 2010. *NARC-704320*. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/385517 [Accessed September 6, 2018].

Centraal Museum. Centraal Museum. Available at: http://centraalmuseum.nl/ontdekken/object/?q=pijpaarde#o:454 [Accessed October 10, 2017].

Cheminant, R. Le. 1981. Armorials from Paul's Wharf. In P. J. Davey & D. J. Pogue (eds) *The Archaeology of the Clay Tobacco Pipe VI. Pipes and kilns in the London region, 102–127.* London: BAR British series 97.

City of London Records Office. London Metropolitan Archives, City of London *OC 360, 24 January 1666.*

Colonial-Assembly-of-Maryland. 1649. *Maryland Toleration Act; September 21, 1649.* The Avalon Project, Yale Law School, Lillian Goldman Law Library, 2008. Available at: http://avalon.law.yale.edu/18th_century/maryland_toleration.asp [Accessed February 12, 2018].

Corporation of London Records Office. *Bills MC1/228/101*. September 1660. London Metropolitan Archives, City of London

Cotter, J. 1994. *Archaeological Excavations at Jamestown, Virginia. Jamestown, Virginia*: Archaeological Society of Virginia.

Crichton-Turley, C.-E., & Garwood, S. (Forthcoming) *3D generation comparisons of Lion Stem Glasses*.

P. Dagobert Gooren. 1959. Onze Lieve Vrouw Van Foy En Noord-Brabant. In J. Xi (ed) *Brabants Heem Tweemaandelijks Tijdschrift voor Brabants e Heem- en Oudheidkund*, 137.

Davis, S., & Henderson, M. 2009. *Marshall Street Baths and Dufours Place Cleansing Depot London W1.* London.

DGLA (S&L). 1988. *ALA88.* London Archaeological Archive and Research Centre Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=445&code=ALA88&terms=ALA88&search=simple&go=Go [Accessed September 6, 2018].

DGLA(S&L). 1987. *L611/87*. London Archaeological Archive and Research Centre Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=697&code=L611/87&terms=38-46+Albert+Embankment%2C+Lambeth%2C+London%2C+&search=simple&go=Go [Accessed February 9, 2017].

Doepkens, W.P. 1991. *Excavations at Mareen Duvall's Middle Plantation of South River Hundred*. Gateway Press.

Doliante, S.J. 2004. *Maryland and Virginia Colonials: Genealogies of Some Colonial Families*. Baltimore: Genealogical Publishing Co.

Doneus, M., Verhoeven, G., Fera, M., Briese, CH., Kucera, M., Neubauer, W. 2011. *From deposit to point cloud–A study of low-cost computer vision approaches for the straightforward documentation of archaeological excavations*. Proceedings of the XXIIIrd International CIPA Symposium 6: p.81–88.

Dorpel, A. 2013. *Middeleeuwse pijpaarden en terracotta heiligenbeeldjes in Zeeland.* Gent University.

DUA. 1974. *BC74.* London Archaeological Archive and Research Centre Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1705&code=BC74&terms=BC72&search=simple&go=Go [Accessed February 9, 2017].

DUA. 1981. *BYD81.* London Archaeological Archive and Research Centre Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1751&code=BYD81&terms=gm152&search=simple&go=Go [Accessed February 9, 2017].

DUA. 1982. *OST82.* London Archaeological Archive and Research Centre Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1975&code=OST82&terms=ost82&search=simple&go=Go [Accessed February 3, 2017].

DUA. 1987. *AHA87*. London Archaeological Archive and Research Centre Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1680&code=AHA87&terms=AHA87&search=simple&go=Go [Accessed February 3, 2017].

DUA. 1988. *LOW88*. London Archaeological Archive and Research Centre Online Catalogue. Available at:

http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1914&code=LOW88&terms=low88&search=simple&go=Go [Accessed September 6, 2018].

Dyson, T. 1998. *Archaeology in Greater London, 1965-1990: A Guide to Records of Excavations by the Museum of London*. A. Thompson, & A. Westman (Eds.) London: Museum of London.

Ebner, M., Hindslry, L., Schimdt, M., & Woods, R. 1993. *Margaret Ebner Major Works.* New Jersey: The Classics of Western Spirituality.

Egan, G. 1990. Post-medieval Britain and Ireland in 1989. *Post-Medieval Archaeology* 24: p.159–211.

Egan, G. 1987. Post-Medieval Britain in 1986. *Post-Medieval Archaeology* 21(1): p.267–293.

Eisen, G. 1927. *Glass: Its Origin, History, Chronology, Technique and Classification to the Sixteenth Century*. New York: WE Rudge.

Elsden, N. 2002. *Excavations at 25 Cannon Street, City of London.* London: Museum of London Archaeology Services.

Farmer, D.H. 1978. *The Oxford Dictionary of Saints* .1st ed. Oxford: Clarendon Press.

Farrelly, M.J. 2012. *Papist Patriots: The Making of an American Catholic Identity.* Oxford University Press. Available at: https://books.google.co.uk/books?id=IH4OxbQYHPQC&pg=PT94&lpg=PT94&dq=‘under+the+profession+of+Christ,+hold+forth+the+practice+licentiousness’&source=bl&ots=-chJt49NkJ&sig=nrb_YhR_pESiwOKrYVNe3PDh4Os&hl=en&sa=X&ved=0ahUKEwjM7q3x8aDZAhUILcAKHY7oAJAQ6AEIKjAB.

Foreman, M. 2014. *NLM-8D3BF4: A Post Medieval Figurine*. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/598081 [Accessed September 6, 2018].

Forsyth, H., & Egan, G. 2005. *Toys, Trifles and Trinkets: Base-Metal Miniatures From London 1200 to 1800*. London: Unicorn Press London.

Forte, M. 2000. *About virtual archaeology: disorders, cognitive interactions and virtuality.*

Fox-Davies, A. 2007. *A complete guide to heraldry.* London: T. C. & E. C. JACK. Available at: https://www.gutenberg.org/files/41617/41617-h/41617-h.htm#page191.

František, G. 2010. The function of small ceramic sculpture. *Archaeologia Historica* 35: p.225–232.

Friederich, F.H.W., & Conijn, W. 1967. *Beeldenstorm in pijpaarde*. Westerheem (67): p.57–63.

Frischer, B., Niccolucci, F., Ryan, N., & Barceló, J. 2002. From CVR to CVRO: the past, present and future of cultural virtual reality. In F. Niccolucci (ed) *Proceedings of the VAST EuroConference, Arezzo, Italy, November 2000.*, 7–18. Oxford: Tempust, BAR International Series 1075.

Fröhlich, C., & Mettenleiter, M. 2004. Terrestrial laser scanning - New perspectives in 3D surveying. *International Archives of Photogrammetry, Remote Sensing* 36(8): p.1–7.

Gaimster, B.D.R.M., & Weinstein, R. 1989. A pipeclay lion figurine from Utrecht, the Netherlands. *Post-Medieval Archaeology* 23: p.11–14.

Gaimster, D. 2003. Pots, Prints and Protestantism: Changing Mentalities in the Urban Domestic Sphere, c. 1480-1580. In R. Gaimster, David and Gilchrist (ed) *The Archaeology of Reformation*, 1480-1580, 132–137. Leeds: Maney.

Gaimster, D. 2007. Of '"idols and devils"': Devotional pipeclay figurines from southern Britain in their European context. In Jäggi, C., & Staecker, J. (eds*) Archäologie der Reformation: Studien zu den Auswirkungen des Konfessionswechsels auf die materielle Kultur*. Berlin. New York: Walter de Gruyter. p. 259–283.

Gaimster, D. 2015. Material Culture, Archaeology and Defining Modernity: Case Studies in Ceramic Research. In A. Gerritsen & G. Riello (eds) *Writing Material Culture History*, 59–66. London: Bloomsbury Publishing

Gattulli, V., Ottaviano, E., & Assunta Pelliccio. 2018. Mechatronics for Cultural Heritage and Civil Infrastructure Management. In V. G. Erika Ottaviano, Assunta Pelliccio (ed) *Mechatronics for Cultural Heritage and Civil Engineering*, 1–31. Springer

Georg Braun, & Hogenberg, F. 1572. *Colonia Agrippina*. Available at: https://www.raremaps.com/gallery/detail/41835mp2/Colonia_Agrippina/Braun-Hogenberg.html.

Georgopoulos, A., Ioannidis, C., & Valanis, A. 2010. Assessing the Performance of a Structured Light Scanner. *ISPRS Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences XXXVIII*. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.222.3346&rep=rep1&type=pdf.

Geyskens, L. 2002. *Beelden en plaketten uit pijpaarde uit Antwerpen*. 5th ed. Antwerp.

Gibb, C. 1997. *A Supplement to The Early Settlers of Maryland.* Annapolis.

Girardon, S., Heathcote, J., & Macgowan, K. 1988*. Excavation Round-up 1988: part 2,* London Boroughs. Archaeological Data Service, The University of York. Available at: http://archaeologydataservice.ac.uk/myads/copyrights?from=2f6172636869766544532f61726368697665446f776e6c6f61643f743d617263682d3435372d312f64697373656d696e6174696f6e2f7064662f766f6c30362f766f6c30365f30332f30365f30335f3037325f3038302e706466.

Glasses, J.D., & Relation, T. 1921. Jacobite drinking glasses and their relation to the Jacobite medals*.* In, *The British Numismatic Society,* 247–283.

GM. 1962. *GM181.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=3114&code=GM181&terms=blackfriars+wreck&search=simple&go=Go [Accessed September 5, 2018].

GM. 1970. *GM302*. London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=3390&code=GM302&terms=blackfriars+wreck&search=simple&go=Go [Accessed September 5, 2018].

Grimm, G.V., & Kaszab-Olschewski, T. 2012. *Heilige, Spielzeug, Glücksbringer Pfeifentonfiguren aus Köln.* University of Bonn.

Grulich, A.D. 2008. *An Enigmatic Monarch : The biography of a headless , mold-made , white pipe clay king recovered in 17th century Maryland Introducing the Charles Gift Site figurine*, Jefferson Patterson Park and Museum.

Guidi, G., Remondino, F., Morlando, G., Del Mastio, A., Uccheddu, F. and Pelagotti, A. 2007. *Performances Evaluation of a Low Cost Active Sensor for Cultural Heritage Documentation*. Sensors Peterborough NH 2: p.59–69. Available at: http://www.icc.cat/web/intranet/Congressos/Optical3DMeasurTechniques2007/pdf/GUIDI_REMONDINO.pdf.

Hall, D., Lindsay, W.J., Caldwell, D.H., Davey, P.J., & Hodgson, G.W.I. 1983. *Excavations at Scalloway Castle*, 1979 and 1980. Proceedings of the Society of Antiquity of Scotland 113: p.554–593.

Henry-Buitenhuis, E. 1990. *Pijpaarden beeldjes uit Leidse bodem*. Leiden.

Heritage-Consulting. 2003. *John Ewen in the Millennium File*. Provo, UT, USA: Ancestry.com Operations Inc.

Hermon S, Nikodem J, P.C. 2006. *Deconstructing the VR-Data Transparency, Quantified Uncertainty and Reliability of 3D Models*. VAST: p.123–129.

Hermon, S. 2011. *Ancient Vase 3D Reconstruction and 3D Visualization.* Conference on Computer Applications and Quantitative Methods in Archaeology: p.59–64.

Hermon, S., Niccolucci, F., & D'ANDRE, A. 2005. *Some evaluations on the potential impact of virtual reality on the archaeological scientific research*. Proceedings of the Virtual Systems and Multimedia 2005: p.105–14.

Hess, M. 2015. *A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts*. UCL.

Hess, M., Robson, S., Serpico, M., Amati, G., Pridden, I., and, Nelson, T. 2015. Developing 3D Imaging Programmes--Workflow and Quality Control. *Journal on Computing and Cultural Heritage (JOCCH) Herit*. 9(1): p.1–11. Available at: http://doi.acm.org/10.1145/2786760.

Higgins, D. 1985. Clay Pipes from the Dorking Area. In P. Davey (ed) *The archaeology of the clay tobacco pipe. More pipes from the Midlands and southern England*. Part 2, BAR British series 100.

Higgins, D. 1987. *The Interpretation and Regioial Study Of Clay Tobacco Pipes; A Case Study Of The Broseley District*. University of Liverpool.

Higgins, D. 2007. A pipe clay figurine. In G. C. and M. A. M (ed) *The Shapwick Project, Somerset: a rural landscape explored*., 684–5.

Hinton, P. 1988. *Excavations in Southwark 1973-76, Lambeth 1973-79.* London and Middlesex Archaeology Society.

Historic St Mary's City. Garrett Van Sweringen (1636– 1698). Available at: https://hsmcdigshistory.org/pdf/Van-Sweringen.pdf

Hoare, W. 1775. *Christopher Anstey with his daughter*. National Portrait Gallery. Available at: http://www.npg.org.uk/collections/search/portrait/mw00158/Christopher-Anstey-with-his-daughter [Accessed December 3, 2015].

Hodge, C. 2014. *Consumerism and the Emergence of the Middle Class in Colonial America*. Cambridge University Press.

Hoeschen, J. 2010. *The English Reformation In Image And Print : Cultural Continuity, Disruptions, And Communications In Tudor Art.* University of Central Florida Orlando, FL.

Hornum, M., Madsen, A., Davenport, C., Clarke, J., Child, K., and Williams, M. 2001. *Phase III Archaeological Data Recovery at Site 18ST704 Naval Air Station Patuxent River, St. Mary's County, Maryland.* Final Report. 241 East Fourth Street, Suite 100 Fredrick, Maryland 21701.

Hurry, S., & Dowling Grulich, A. 2015. *Putti, Kings, and the Mother Of God.* Unpublished.

Ikeuchi, K. 2013. *e-Heritage, Cyber Archaeology, and Cloud Museum*. International Conference on Culture and Computing (Culture Computing). IEEE.

James, T., & Brennan, D. 1998. *Excavations at Carmarthen Greyfriars 1983-1990: 13th–16th Century Earthenware and Oolitic Limestone Floor tiles.* Dyfed Archaeological Trust Reports 1 (1).

Jarrett, C. 2017. A Pipe Clay Cock Figurine from Fulham, London*. Society for Clay Pipe Research Newsletter* (91): p.39–45.

Jenstad, J. 2017. "*The MoEML Team." The Map of Early Modern London.* University of Victoria. Available at: http://mapoflondon.uvic.ca/agas.htm [Accessed February 2, 2017].

Johnson, T. 2007. *Mary In Early Modern Europe*. In T. Beattie & S. J. Boss (eds) Mary: The Complete Resource, 363–476. London: Bloomsbury Publishing

Kaeding, P. 2015. *Map Customizer*. Google Maps.

Kahsnitz, R. 2006. *Carved Splendor: Late Gothic Altarpieces in Southern Germany, Austria and South Tirol*. Getty Publications.

Keller, H. 2005. *Lexikon der Heiligen und biblischen Gestalten: Legende und Darstellung in der bildenden Kunst*. Stuttgart.

Kersten, T., Sternberg, H., Mechelke, K., & Pardo, A. 2004. *Terrestrial Laser scanning System MENSI GS100/GS200 - Accuracy Tests, Experiences and Projects at the Hamburg University of Applied Sciences*. Proceedings in Panoramic Photogrammetry Workshop. IAPRS&SIS 34(5/W16).

Kersten, T.P., & Lindstaedt, M. 2012. *Image-based low-cost systems for automatic 3D recording and modelling of archaeological finds and objects.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 7616 LNCS: p.1–10.

Kibblewhite, M., Tóth, G., & Hermann, T. 2015. *Predicting the preservation of cultural artefacts and buried materials in soil*. Science of the Total Environment 529: p.249–263. Available at: http://dx.doi.org/10.1016/j.scitotenv.2015.04.036.

Killock, D., & Meddens, F. 2005. Pottery as plunder: a 17th-century maritime site in Limehouse, London. *Post-Medieval Archaeology* 39(1): p.1–91. Available at: http://www.biab.ac.uk/contents/20821.

Klein, C.S.R. 2012. *Acquisition and Presentation of Virtual Surrogates for Cultural Heritage Artefacts.* Universität Bonn: p.50–57. Available at: http://cg.cs.uni-bonn.de/en/publications/paper-details/schwartz-2012-virtualsurrogates/ [Accessed February 16, 2018].

Knippenberg, W. 1962. *Pipe Clay Figurines*. Brabants heme: bimonthly magazine for Brabant heme and archaeology,: p.54–57.

Knippenberg, W.. 1970. *Pijpaarden beeldjes VII.* Hilvarenbeek. Brabants heem: tijdschrift voor archeologie, geschiedenis en volkskunde 22: p.93.

Koerner, J. 2004. *The Reformation of the Image*. London: Reaktion Books.

Kowalczyk, E. 2013. *Church Art In The Late Middle Ages and Its Influence Of Everyday Items Illustrated With An Example Of Clay Figurines From Silesia (Poland).* Turku. Available at: https://www.academia.edu/4670763/Church_Art_in_the_Late_Middle_Ages_and_its_influence_on_everyday_items._Illustrated_with_an_example_of_clay_figurines_from_Silesia_Poland_International_Conference_Church_Archaeology_in_the_Baltic_Sea_Region_Turku_Finland_2.

Kowalczyk, E.J. 2010. *Production of clay figurines in late medieval Silesia*. University of Wroclaw.

Kügler, M. 1995. *Pfeifenbäckerei im Westerwald: die Geschichte der Pfeifenbäckerei des unteren Westerwaldes von den Anfängen um 1700 bis heute*. Rheinland-Verlag.

L, H.R. 1903. *Catalogue of the collection of English Pottery in the Department of British and Medieval Antiquities and Ethnography of the British Museum.* London: BMP.

LAARC. 1987. *L611/87.* London Archaeological Archive and Research Centre Online Catalogue. Museum of London1. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=697&code=L611/87&terms=38-46+Albert+Embankment%2C+Lambeth%2C+London%2C+&search=simple&go=Go [Accessed February 9, 2017].

LAARC. 1988. *ALA88.* London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=445&code=ALA88&terms=ALA88&search=simple&go=Go.

LAARC. 2017a. *OST82.* London Archaeological Archive and Research Centre Online Catalogue. Museum of London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1975&code=OST82&terms=ost82&search=simple&go=Go [Accessed February 3, 2017].

LAARC. 2017b. *AHA87.* London Archaeological Archive and Research Centre Online Catalogue. Museum of London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1680&code=AHA87&terms=AHA87&search=simple&go=Go [Accessed February 3, 2017].

LAARC. 2017c. *MSR08.* London Archaeological Archive and Research Centre Online Catalogue. Museum of London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=19824&code=MSR08&terms=msr08&search=simple&go=Go [Accessed February 7, 2017].

LAARC. 2017d. *BYD81*. London Archaeological Archive and Research Centre Online Catalogue. Museum of London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1751&code=BYD81&terms=gm152&search=simple&go=Go [Accessed February 9, 2017].

LAARC. 2017e. *BC72.* London Archaeological Archive and Research Centre Online Catalogue. Museum of London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=1705&code=BC74&terms=BC72&search=simple&go=Go [Accessed February 9, 2017].

LAARC. 2017f. *EDN95*. London Archaeological Archive and Research Centre Online Catalogue. Museum of London. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=2576&code=EDN95&terms=76+eden+street&search=simple&go=Go [Accessed February 11, 2017].

Larwood, J., & Hotten, J.C. 1875. *The history of signboards: from the earliest times to the present day.* Piccadilly: Chatto and Windus.

Leach, P. 1984. *The Archaeology of Taunton: excavations and fieldwork to 1980*. Western Archaeological Trust.

Lemmel, K., Schleif, C., & Schier, V. 2009. *Katerina's windows: donation and devotion, art and music, as heard and seen through the writings of a Birgittine Nun.* pennysylvania: Penn State Press.

Lewisham Council. 2012. *Deptford Creekside Conservation Area Appraisal*. Planning Service – Conservation and Urban Design (May).

Liveauctioneers. *Post Medieval Pipe Clay Figurine Group*. Available at: https://www.liveauctioneers.com/item/17176384_post-medieval-pipe-clay-figurine-group [Accessed September 6, 2018].

Lledó, B. 1997. Mold Siblings in the 11th Century Cullet from Serce Limani. *Journal of Glass Studies* 39(1997): p.43–55.

London Museum. 1940. *Medieval Catalogue London Museum*. City of London: Her Majesty's Stationery Office.

Luckenbach, A. 2004. *Chaney's Hills (18AN1084). Archaeological Study of Colonial Chesapeake Culture.* Available at: http://core.tdar.org/project/6072/chaneys-hills-18an1084 [Accessed October 28, 2016].

MacDonald. L., Guerra. M.F., Pillay. R., Hess. M., Quirke.S., Robson.S., A. 2014. *Practised-based comparison of imaging methods for visualization of tool marks on an Egyptian Scarab.* Image and Signal Processing - 6th international Conference, ICISP: p.239–246. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84903555126&partnerID=tZOtx3y1.

Margeson, S., & Crowfoot, E. 1993. *Norwich Households: The Medieval and Post-Medieval Finds from Norwich Survey Excavations, 1971-1978*. Norwich Survey, Norfolk Museums Service 58: p.267. Available at: http://books.google.co.uk/books/about/Norwich_Households.html?id=_KBnAAAAMAAJ&pgis=1.

Marsden, P. 1971. A seventeenth-century boat found in London. *Post-Medieval Archaeology* (5): p.88–98.

Marsden, P. 1996. *Ships of the Port of London: twelfth to seventeenth centuries AD*. English heritage.

Maryland Archaeological Conservation Lab. 2014a. *18AN1084 Chaney's Hills c. 1658 - 1685*. Maryland Archaeological Conservation Lab. Available at: https://www.jefpat.org/diagnostic/SmallFinds/Site Summaries/18AN1084 Chaneys Hills Site Summary.htm [Accessed October 28, 2016].

Maryland Archaeological Conservation Lab. 2014b. *Chaney's Hills (18AN1084).* Chesapeake Archaeology. Available at: http://www.chesapeakearchaeology.org/SiteSummaries/ChaneysHillsSummary.cfm [Accessed October 28, 2016].

Mayenburg, F. 2015. *Excavated from the Gouda pipe maker Jan Boot.* Groene hart vertellingen. Available at: http://www.groenehartvertellingen.nl/Pagina/bodemvondstenuitgoudsepijpenindustrie.htm [Accessed December 14, 2016].

Mercer, J.F. 1998. London Metropolitan Archives, City of London Com. Ser.fol.95b, box 4, 1587. In A. Willemsen (ed) *Kinder delijt: Middeleeuws speelgoed in de Nederlanden, 292.* Nijmegen: Nijmegen University Press

Miller, H.M. 2006. *St. John's Site.* Historic St. Mary's City: p.1–5.

Moerings, K. 2014. Clay Pipes. *Aviculture Europe*.

MoL. 2012. *80.60 Figurine.* Museum of London. Available at:

https://collections.museumoflondon.org.uk/online/object/30162.html [Accessed September 6, 2018].

MoL. 2014a. *4968 Figurine*. Museum of London. Available at: https://collections.museumoflondon.org.uk/online/object/35553.html [Accessed September 6, 2018].

MoL. 2014b. *4970 Figurine*. Museum of London. Available at: http://collections.museumoflondon.org.uk/online/object/35555.html [Accessed June 6, 2018].

MOLA. 1990. Recent Archaeological Excavations in Greater London: the work of the Department. In *1986 Annual Archaeology Lecture*, Annual Archaeology Lecture

MOLAS. 1995a. *EDN95.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=2576&code=EDN95&terms=76+eden+street&search=simple&go=Go [Accessed February 11, 2017].

MOLAS. 1995b. *KIG95*. London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=2681&code=KIG95&terms=kig95&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 1997. *FER97*. London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=3664&code=FER97&terms=FER97&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 1998a. *DSH98.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=3748&code=DSH98&terms=West+Annexe%2C+Dreadnought+Library%2C+King+William+Walk%2C+Romney+Road%2C+SE10&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 1998b. *SRP98.* London Archaeological Archive and Research Centres Online Catalogue. Available at: archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=4038&code=SRP98&terms=SRP98&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 1999. *DYD99.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=4451&code=DYD99&terms=DYD99&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 2005. *CGW05*. London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=18518&code=CGW05&terms=CGW05&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 2006. *USM06*. London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=18773&code=USM06&terms=USM06&search=simple&go=Go [Accessed September 5, 2018].

MOLAS. 2008. *MSR08.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=19824&code=MSR08&terms=msr08&search=simple&go=Go [Accessed February 7, 2017].

Mount Vernon Ladies Association. 2012. *Clay figurine, woman*. Available at: http://www.mountvernonmidden.org/data/objects2.html?rID=2919 [Accessed September 6, 2018].

Mount Vernon Ladies Association. 2012. *Clay figurine, man*. Available at: http://mountvernonmidden.org/data/objects2Pr.html?rID=2920 [Accessed September 6, 2018].

Mount-Vernon-Archaeology-Department. 2013*. Mount Vernon's Midden Project*. Available at: http://mountvernonmidden.org/hpages/chronology.html [Accessed October 26, 2016].

Mulder, J. Van. 2016. Miracles and the Body Social: infirmi in the Middle Dustch Miracle Collection of Our Lady of Amersfoort. In C. Krötzl, K. Mustakallio, & J. Kuuliala (eds) *Infirmity in Antiquity and the Middle Ages: Social and Cultural Approaches to Health, Weakness and Care*, 241–254. New York: Routledge

Museum of London Archaeology. 1998. *Archaeology in the City of London, 1907-1991: a guide to records of excavations by the Museum of London and its predecessors*. The Archaeological Gazetteer Series 1.

Museum of London Archaeology. 2009. *Tracks through Time: Archaeology and history from the London Overground East London Line*. London: Museum of London Archaeology.

National Gallery of Art. 2017. *15th and Early 16th-Century Germany.* National Gallery of Art: p.1–10. Available at: https://www.nga.gov/features/slideshows/15th-and-early-16th-century-germany.html#slide_1 [Accessed March 14, 2018].

Neu-Kock, R. 1988. *Heilige & Gaukler. Kölner Statuetten aus Pfeifenton.* 1st ed. Museum der Stadt Köln.

NextEngine. 2016. *NextEngine.* Available at: http://www.nextengine.com/products/scanner/specs# [Accessed February 10, 2016].

Nicholls, R.. V.. 1952. Type, Group and Series : A Reconsideration of Some Coroplastic Fundamentals. *The Annual of the British School at Athens* 47: p.217–226. Available at: http://www.jstor.org/stable/30096894.

Nichols, J. 1823. *The progresses and public processions of Queen Elizabeth: among which are interspersed other solemnities, public expenditures, and remarkable events during the reign of that illustrious princess*. Vol 1. London: The Society of Antiquaries. Available at: https://play.google.com/books/reader?id=h2gNAAAAIAAJ&printsec=frontcover&output=reader&hl=en_GB&pg=GBS.PR3.

Noël Hume, I. 1986*.* Collection of Glass from Port Royal, Jamaica with some observations on the Site, its History and Archaeology*. Historical Archaeology* 2 2: p.5–34.

Noël Hume, I. 2001. *A guide to the artifacts of colonial America.* University of Pennsylvania Press.

Okamoto, Y., J. Takamatsu, M. Kagesawa, K. Okada, & K. Ikeuchi. 2005. *3D Database System of Mercede Church: The Use of 3D Models as an Interface to Information.* Available at: http://belgium.vsmm.org/pages/program_tuesday_session2B.html.

Olsen, K. 2017. *Daily Life in 18th-Century England Second*. Greenwood Press.

Olson, B.R., & Caraher, W.R. 2015. *Visions of Substance: 3D Imaging in Mediterranean Archaeology.* North Dakota: The Digital Press. The University of North Dakota.

Oostveen, J. Van. 2011. *(Pijpaarden) beeldjes uit Gorinchem.* Gorinchem. Available at: http://www.xs4all.nl/~kleipijp/kleipijp/.

Oostveen, J. Van. 2014. *Beerput Koninginnestraat, Tiel Afval van het Agnietenklooster en rectoren van de Latijnse school in Tiel*. 1.1. Available at: http://kleipijp.home.xs4all.nl/Literatuur.htm.

Os, H.., & Honée, E.M.V. 1994*. Gebed in schoonheid. Schatten van privé-devotie in Europa 1300-1500.* Amsterdaam: Waanders.

Ostkamp, S. 2001. Productie en gebruik van pijpaarden en terracotta devotionalia in de Nederlanden (ca. 1350-ca. 1550). In J. V. Antonius Böing and Günther Inhester (ed) *Kunst uit de stilte-een kloosterwerkplaats uit de tijd van Dürer*, 283–96. Munster: Westfälisches Landesmuseum

Ostkamp, S. 2012. Utrechtse bodem ? Utrecht en de productie van pijpaarden devotionalia. In M. beelden uit U. 1430-1530 (ed) *Miiddeleeuwse beelden uit Utrecht 1430-1530,* 108–127. Ludion

Ostkamp, S., & Helbergen, A. Van. *1974. De inventaris van een heyligenbacker uit een beerput aan de Utrechtse Putsteeg (1400 -1450).* Assembled Articles 5: p.49–67. Available at: http://www.academia.edu/24695793/S._Ostkamp_and_A._van_Helbergen_2014_De_inventaris_van_een_heyligenbacker_uit_een_beerput_aan_de_Utrechtse_Putsteeg_1400_-1450_._In_H._Clevis_red._Assembled_Articles_5_p._49-67.

Oswald, A. 1985. On The Life of Clay Pipe Moulds. In P. Davey (ed) *The Archaeology of the Clay Tobacco Pipe IX. More Pipes from the Midlands and Southern England*, 5–22. B.A.R

Ottaviano, E., Pelliccio, A. and Gattulli, V. 2018. *Mechatronics for Cultural Heritage and Civil Engineering*. Springer.

Passano, L. 1901. *History of Maryland*. Second edition. Baltimore: Baltimore: W.J.C. Dulany Co Links. Available at: https://hdl.handle.net/2027/nyp.33433081816575?urlappend=%3Bseq=14.

PCA. 1997. *LMD97.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=3797&code=LMD97&terms=LMD97&search=simple&go=Go [Accessed September 6, 2018].

PCA. 2001. *VAC01.* London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=4993&code=VAC01&terms=vac01&search=simple&go=Go [Accessed September 6, 2018].

PCA. 2002a. *HGA02*. London Archaeological Archive and Research Centres Online Catalogue. Available at: http://archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=17541&code=HGA02&terms=HGA02&search=simple&go=Go [Accessed September 5, 2018].

PCA. 2002b. *LLS02.* London Archaeological Archive and Research Centres Online Catalogue. Available at: archive.museumoflondon.org.uk/laarc/catalogue/siteinfo.asp?id=17510&code=LLS02&terms=lls02&search=simple&go=Go [Accessed September 6, 2018].

Pearce, J. 2016. The Geoff Egan Memorial Lecture 2015: Down at The Old Ship and Ball-taverns, trade and daily life in the London Borough of Southwark. *Post-Medieval Archaeology* 50(2): p.181–226.

Pearce, J., & Birchenough, A. 2008. *East London Line Project Northern Extension Bishops Goods Yard: An archaeological post-excavation assessment*. London.

Pestana, C. 2009. *Protestant Empire: Religion and the Making of the British Atlantic World.* Philadelphia: University of Pennsylvania Press.

Pijpenkabinet Foundation in Amsterdam. Amsterdam Pipe Museum. Available at: http://www.pipemuseum.nl/index.php?hg1=&geoniv=&datering_start=&maker=&keyword=pijpaarde&keyword_bool=OR&afb=&wmod=dia&hm=4&sm=3&dbm=1&sortby=datering_kruis&q=1 [Accessed October 10, 2017].

Pitt, K. 2006. *Roman and medieval development south of Newgate Archaeology Studies Series 14.* Museum of London Archaeology Services.

Platt, C., & Coleman-Smith, R. 1975. *Excavations in Medieval Southampton, 1953-1969.* Leicester: Leicester University Press.

Pogue, D.J. 1983. *Patuxent River Naval Air Station Cultural Resources Survey*. Volume I: History and Archaeology. Naval Air Station, Patuxent River, Md.

Pollefeys, M. Van Gool, L.,Vergauwen, M., Cornelis, K., Verbiest, F., Tops, J. 2003. 3D recording for archaeological fieldwork. *IEEE Computer Graphics and Applications* 23(3): p.20–27.

Pritchard, A. 2017. *Catholic Loyalism in Elizabethan England*. University of North Carolina Press.

Private Collector. 2012. *Clay figurine*. Live Auctioneers. Available at: https://www.liveauctioneers.com/item/10925437_post-medieval-pipe-clay-figurine [Accessed October 10, 2017].

Private Collector. 2013. *Clay Figurine*. Timeline auctions. Available at: https://www.liveauctioneers.com/item/17176384_post-medieval-pipe-clay-figurine-group [Accessed August 15, 2015].

Private Collector. 2015. *George Washington Figurine*. Ebay. Available at: http://www.ebay.ie/itm/ORIGINAL-1700S-CHILDS-PIPE-CLAY-TOY-SOLDIER-FIGURINE-OF-GEORGE-WASHINGTON-/161702558684 [Accessed September 6, 2018].

Proctor, L. 2013. *DUR-069221 Post-Medieval Figurine*. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/552058%0ARecorded by: Miss Lauren Proctor [Accessed September 6, 2018].

R. Cary & Co. 1760. Invoice from R. Cary & Co. Showing Purchase for Patsy Custis from London toy Store Unwin & Wigglesworth. In *The George Washington Papers*, Digital file, Manuscript Division. Washington DC: The Library of Congress, Washington, DC Available at: http://memory.loc.gov/mss/mgw/mgw5/116/0200/0280.gif.

Raglan, Lady. 1939. The "Green Man*" in Church Architecture. Folklore Enterprises* 50(1): p.45–57. Available at: http://www.jstor.org/stable/1257090.

Redknap, M. 1997. Painted Pipe Clay Statuettes. In. '*Excavations at Carmarthen Greyfriars, 1983-1990'*. *Medieval archaeology: Journal of the Society for Medieval Archaeology* (41): p.50–4.

Redknap, M. 2008. Personal and hidden devotion in Wales. In Saint Fagans National History Museum (ed) *The Welsh medieval church and its context conference proceedings*, 1–14.

Reesing, I and Michael Hoyle. Notre-Dame de Foy : The Reuse and Dissemination of a Late Medieval Figurine of the Virgin in the Low Countries Author (s): Ingmar Reesing and Michael Hoyle Stable URL : https://www.jstor.org/stable/20355358 Notre-Dame de Foy : the reuse and disseminatio. *Simiolus: Netherlands Quarterly for the History of Art* 33(3): p.145–165.

Reilly, P. 1989. Data visualization in archaeology. *IBM Systems Journal* 28(4): p.569–579. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5387542.

Remondino, F., Spera, M.G., Nocerino, E., Menna, F., & Nex, F. 2014. State of the art in high density image matching. *The Photogrammetric Record* 29(146): p.144–166.

Ridout VI, O. 1969. *National Register of Historic Places Inventory - Nomination Form: All Hallows' Church*. Ann Arundel.

Rijksmuseum. *Pipe Clay Molds*. Rijksmuseum van Oudeheden Online. Available at: http://www.rmo.nl/onderwijs/museumkennis/verhalen/pijpaarden-mallen [Accessed November 11, 2016].

Rocque, J. 2013. *Rocque's Map of Georgian London 1746.* Old House.

Russo, M., Morlando, G., Guidi, G., Milano, P., & Durando, V. 2007. *Low cost characterization of 3D laser scanners.* SPIE Videometrics IX 6491: p.1–9.

Saak, E.L. 2017. *Luther and the Reformation of the later Middle Ages*. Cambridge: Cambridge University Press.

Sheppard, F.H.. 1963. Marshall Street Area F. H. . Sheppard (ed). *Survey of London*; British History Online 31 and 32(Saint James and Westminsters, Part 2): p.196–208. Available at: http://www.british-history.ac.uk/survey-london/vols31-2/pt2/pp196-208.

Sims, D. 1997. Archaeological models: pretty pictures or research tools?*, IEEE Computer Graphics and Applications* 17(1): p.13–15.

Smith, C. 2018. Bridewell J. In, Jenstad (ed). *The Map of Early Modern London.* University of Victoria. Available at: https://mapoflondon.uvic.ca/BRID2.htm?showDraft=true [Accessed September 6, 2018].

Smith, J. 1986a. Advertisements for the Unexperienced Planters of New England, or Any Where. *Barbour 3*: p.254–307.

Smith, J. 1986b. The General Historie of Virginia, New-England, and the Summer Iles. *Babour 2*: p.5–477.

Sorabella, J. 2007. Portraiture in Renaissance and Baroque Europe. In Heilbrunn *Timeline of Art History.* New York: The Metropolitan Museum of Art Available at: https://www.metmuseum.org/toah/hd/port/hd_port.htm.

Stern, M. 1995. *Roman mold-blown glass: the first through sixth centuries*. L'Erma di Bretschneider.

Straube, B. 2011. *Jamestown's Lost Colonists. Finding Trace of Unnoticed Children in the Settlement's Archaeological Record*. The Journal of the Colonial Williamsburg Foundation (Summer 2011): p.66–71.

Straube, B. 2013*.* The Geoff Egan Memorial Lecture 2012*. Post-Medieval Archaeology* 47(2): p.263–280.

Strype, J. 1720. *Billingate Ward. Stow's Survey of London*. Available at: http://www.wikiwand.com/en/Billingsgate.

Sumnall, K. 2013. *LON-9F4604*: A Post Medieval Toy. Available at: https://finds.org.uk/database/artefacts/record/id/572716 [Accessed September 4, 2018].

Sumnall, K. 2015. *LON-1FB313*. Portable Antiquities Scheme. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/704949 [Accessed August 18, 2015].

Tarlow, S. 2003. Reformation and Transformation: What Happened to Catholic Things in a Protestant World? In D. Gaimster & R. Gilchrist (eds) *The Archaeology of Reformation, 1480-1580*, 108–121. Leeds: Maney

The Church of Vedast alias Foster. *St Vedast-alias-Foster*. Available at: http://www.vedast.org.uk/about/ [Accessed September 6, 2018].

The Metropolitan Museum of Art. 2017a. *Heilbrunn Timeline of Art History: Erasmus of Rotterdam*. Available at: https://www.metmuseum.org/toah/works-of-art/19.73.120/ [Accessed November 23, 2017].

The Metropolitan Museum of Art. 2017b. *Heilbrunn Timeline of Art History: Knight, Death, and the Devil.* Available at: https://www.metmuseum.org/toah/works-of-art/43.106.2/ [Accessed November 23, 2017].

The Metropolitan Museum of Art. 2017c. *Heilbrunn Timeline of Art History: Melencolia I.* Available at: https://www.metmuseum.org/toah/works-of-art/43.106.1/ [Accessed November 23, 2017].

The Metropolitan Museum of Art. 2017d. *Saint Jerome in His Study.* Available at: https://www.metmuseum.org/art/collection/search/336229 [Accessed November 23, 2017].

Thomas, C. 2004. *Life and death in London's East End: 2000 years of Spitalfields*. Museum of London Archaeology Services.

Thomas, C., Aitken, R., Bowsher, D., Dayki, A., Harward, C., Holder, N., McKenzie, M., Pitt, K., Thrale, P. 2002. *280 Bishopgate and the Spitalfields Ramp, Spitalfields*. Museum of London Archaeology Services.

Thompson, A. 1981. The Aldgate Clay-Pipe Kiln. In, Davey. P (eds) *The Archaeology of the clay tobacco pipe*, 3–14. BAR. British Series 97. Vol 1

Timeline, H. 2011. *Timeline auctions*. Available at: http://www.timelineauctions.com/lot/pipe-clay-virgin-mary-figurine/3558/ [Accessed August 18, 2015].

Tolksdorf, J.F., Elburg, R., & Reuter, T. 2017. Journal of Archaeological Science : Reports Can 3D scanning of countermarks on Roman coins help to reconstruct the movement of Varus and his legions. *Journal of Archaeological Science*: Reports 11: p.400–410. Available at: http://dx.doi.org/10.1016/j.jasrep.2016.12.005.

Torquato, M.G. et al. 2018. Differentiating between cutting actions on bone using 3D geometric morphometrics and Bayesian analyses with implications to human evolution. *Journal of Archaeological Science* 89: p.56–67.

Tucci, G., Cini, D., & Nobile, A. 2011. *Effective 3D Dizitization of Archaeological Artifacts for Interactive Virtual Museum. 3D Virtual Reconstruction and Visualization of Complex Architectures* (ISPRS) XXXVIII(March): p.2–4.

Tucker, C. 2002. *Testing and verification of the accuracy of laser scanner*. In Symposium on Geospatial Theory, Ottawa

UKDFD. 2016. *Woman and Child*. UK Detectors Finds Database. Available at: http://www.ukdfd.co.uk/ukdfddata/showrecords.php?product=1680&cat=22 [Accessed June 6, 2016].

University of Bonn. 2018. *BTFDBB: BTF Database Bonn and Measurement Lab*. Institute of Computer Science II. Available at: http://cg.cs.uni-bonn.de/en/projects/btfdbb/ [Accessed September 17, 2018].

Unknown. Pipe clay Sculptures. Available at: http://home.kpn.nl/vangemerden/blzsculpture.htm [Accessed October 10, 2017].

Vandiver, P., & Vasil'ev, S. 2002. A 16,000 year-old ceramic human-figurine from Maina, Russia. In M. J. L. Vandiver P.B., Goodway M. (ed) *Materials Research Society Symposium,* 421–431. Materials Issues in Art and Archeology VI; Boston, MA; United States

Varner, G. 2008. *Gargoyles, Grotesques & Green Men: Ancient Symbolism in European and American Architecture*. Lulu Press Inc.

Visintini, D. 2011. Surveying, modelling and navigating the Theodorian mosaic floor of the aquileia basilica. CEUR Workshop Proceedings 806: p.1–11.

Walford, E. 1878a. Bermondsey: The abbey. In, *Old and New London,* 117–133. London: Cassell, Petter & Galpin, 1878 and British History Online Available at: http://www.british-history.ac.uk/old-new-london/vol6/pp117-133 [accessed 9 February 2017].

Walford, E. 1878b. 'Southwark: St Saviour's Church,'. *Old and New London 6* (British History Online): p.16–29. Available at: http://www.british-history.ac.uk/old-new-london/vol6/pp16-29.

Walsh, R., & Fox, W. 1974. *Maryland; a history, 1632-1974.* Maryland City: Maryland Historical Society.

Walton, R. 1660. *British Museum Collection*. British Museum. Available at: http://collection.britishmuseum.org/resource?uri=http://collection.britishmuseum.org/id/object/PPA196087.

Washburn, L.M. 2003. *Toy Story.* Chipstone. Available at: http://www.chipstone.org/article.php/102/Ceramics-in-America-2003/Toy-Story [Accessed November 27, 2015].

Watters, J. 2008. BH-9BB333: *A Post Medieval Toy*. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/235340 [Accessed September 6, 2018].

Webley, R. 2005. *NARC-9887D1 Post Medieval Figurine*. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/99703 Identified by: Mr Robert Webley [Accessed September 6, 2018].

Weinreb, B., & Hibbert, C. 2009. *Suffolk Place*. Historic England. Available at: http://www.pastscape.org/hob.aspx?hob_id=404395 [Accessed February 9, 2017].

Weinstein, R. 1984*. Excavations at Aldgate, 1974*. *Post-Medieval Archaeology* 18: p.122–4.

Willmott, H. 2000. *The classification of lion mask stems from London*. In Annales du 17e Congrès de l´Association Internationale pour l´Histoire du Verre Anvers. 1998, 389–94.

Winter, F. 1903. *Die Typen der figürlichen Terrakotten.* Berlin ; Stuttgart : Verlag von W. Spemann.

Wisse, J. 2002. *The Reformation*. In Heilbrunn Timeline of Art History, New York: The Metropolitan Museum of Art Available at: https://www.metmuseum.org/toah/hd/refo/hd_refo.htm.

Wood, E. 2016. *LON-150511: A Post Medieval Figurine*. PAS. Available at: https://finds.org.uk/database/artefacts/record/id/772691 [Accessed September 6, 2018].

Wood, L. 2008. *East Slingsby Place St Martin's Courtyard Development*. Museum of London Archaeology Services.

Wyngaerde, A. "Plate 10: Section of Wyngaerde's map-view showing Suffolk Place, etc." *Survey of London: Volume 25, St George's Fields (The Parishes of St. George the Martyr Southwark and St. Mary Newington)*. Ed. Ida Darlington. London: London County Council, 1955. 10. *British History Online*. Web. 19 September 2018. http://www.british-history.ac.uk/survey-london/vol25/plate-10.