

Table of Contents

| | |
|--|-----------|
| List of figures | xiii |
| List of tables..... | xvii |
| Abstract..... | xviii |
| 1. Introduction..... | 1 |
| 1.1. Introduction..... | 1 |
| 1.2 Research review and defining research questions..... | 1 |
| 1.2.1 Previous research on the bronze weapons..... | 1 |
| 1.2.2 Defining research questions | 3 |
| 1.3 The Emperor and his tomb complex – defining the temporal and spatial context | 3 |
| 1.3.1 The Qin Dynasty and Emperor Qin Shihuang..... | 3 |
| 1.3.2 The tomb complex, the terracotta warriors and the bronze weapons..... | 5 |
| 1.4 Chapter summaries | 8 |
| 2. Approaches to Standardisation and Labour Organisation..... | 9 |
| 2.1 Introduction..... | 9 |
| 2.2 Standardisation..... | 9 |
| 2.2.1 A definition of standardisation..... | 9 |
| 2.2.2 Parameters affecting standardisation..... | 9 |
| 2.2.3 How to define and measure standardisation from archaeological data? | 9 |
| 2.3 Standardisation and technological organisation..... | 11 |
| 2.3.1 Casting and assembling..... | 11 |
| 2.3.2 Technological models..... | 11 |
| 2.4 Standardisation and specialisation | 12 |
| 2.4.1 Specialisation..... | 12 |
| 2.4.2 The hypothesis of standardisation and specialisation..... | 13 |
| 2.5 Standardisation versus variation: copying error..... | 14 |
| 2.6 Spatial signatures of workshop activity and labour organisation..... | 14 |
| 2.6.1 Point pattern analysis..... | 15 |
| 2.6.2 Spatial randomness, regularity, and clustering..... | 15 |
| 2.6.3 First-order effect and second-order effect | 15 |
| 2.7 Summary | 16 |
| 3. Methodology..... | 17 |
| 3.1 Introduction..... | 17 |
| 3.2 Qualitative classification | 17 |
| 3.2.1 Functional classification of the weapons..... | 17 |
| 3.2.2 Micro-features | 21 |
| 3.2.3 Inscriptions | 21 |
| 3.3 Sampling | 22 |
| 3.3.1 Principles of sampling..... | 22 |
| 3.3.2 Sampling strategy for this project | 22 |
| 3.4 Dimensional measurements and quantitative analysis | 22 |
| 3.4.1 Measuring techniques..... | 22 |
| 3.4.2 Metric variables..... | 23 |
| 3.4.3 Accuracy and precision assessment | 23 |
| 3.4.4 Statistical analysis..... | 24 |
| 3.4.4.1 Cluster analysis..... | 24 |
| 3.4.4.2 Principal Component Analysis | 25 |
| 3.4.4.3 Frequency histogram | 25 |
| 3.4.4.4 Coefficient of Variation | 25 |
| 3.5 Establishing a GIS database and spatial analysis..... | 26 |
| 3.5.1 Original map..... | 26 |

| | |
|---|-----------|
| 3.5.2 Digital map | 26 |
| 3.5.3 Using a local grid | 26 |
| 3.5.4 Spatial statistics – pair correlation functions | 26 |
| 3.6 Integration with archaeometric data | 27 |
| 3.7 Summary | 27 |
| 4. Inscriptions on the Weapons | 29 |
| 4.1 Introduction | 29 |
| 4.2 Types of inscriptions | 29 |
| 4.2.1 Cast inscriptions | 29 |
| 4.2.2 Carved or chiselled inscriptions | 30 |
| 4.2.3 Ink inscriptions | 32 |
| 4.3 The content of the inscriptions and the types of weapons | 32 |
| 4.3.1 Inscriptions on dagger-axes, spears, and halberds | 32 |
| 4.3.2 Inscriptions on lances | 34 |
| 4.3.3 Inscriptions on swords | 37 |
| 4.3.4 Inscriptions on triggers | 37 |
| 4.3.5 Inscriptions on ferrules | 39 |
| 4.4 Spatial patterns of the inscribed weapons | 42 |
| 4.4.1 Spatial patterns of inscribed halberds | 42 |
| 4.4.2 Spatial patterns of inscribed lances | 42 |
| 4.4.3 Spatial patterns of inscribed triggers | 42 |
| 4.4.4 Spatial patterns of inscribed ferrules | 46 |
| 4.5 Function of the inscriptions | 47 |
| 4.5.1 Quality control | 47 |
| 4.5.2 Assembling triggers | 48 |
| 4.5.3 Other functions | 48 |
| 4.6 Summary | 48 |
| 5. Bronze Triggers | 49 |
| 5.1 Introduction | 49 |
| 5.2 Research review | 49 |
| 5.3 Measurements of the bronze triggers | 50 |
| 5.3.1 Sources of data | 50 |
| 5.3.2 Triggers' function and manipulation | 50 |
| 5.3.3 Method of measuring | 51 |
| 5.3.4 Patterns in trigger measurements | 53 |
| 5.3.4.1 Trigger Part A | 53 |
| 5.3.4.2 Trigger Part B | 55 |
| 5.3.4.3 Trigger Part C | 56 |
| 5.3.5 Analysing the patterns of the triggers | 56 |
| 5.4 Coefficients of variation and the degree of standardisation | 58 |
| 5.5 Trigger assembly and technological organisation | 61 |
| 5.6 Spatial analysis | 65 |
| 5.6.1 Parameters affecting the spatial patterns | 65 |
| 5.6.2 A pair correlation function | 71 |
| 5.6.3 Results obtained on assembled triggers | 71 |
| 5.6.4 Activity areas in the pit | 76 |
| 5.7 Summary | 76 |
| 6. Bronze Arrows | 79 |
| 6.1 Introduction | 79 |
| 6.2 Research review | 79 |
| 6.3 Arrow data | 79 |
| 6.3.1 The archaeological origin of the bronze arrows | 79 |
| 6.3.2 Bronze arrows from the five easternmost trenches of Pit 1 | 80 |
| 6.3.2.1 An enumeration of arrows in each corridor | 81 |
| 6.3.2.2 The size of the arrow bundles | 81 |
| 6.3.2.3 Arrow bundles and quivers | 81 |
| 6.3.2.4 Arrow types | 85 |

| | |
|--|------------|
| 6.3.3 A comparison between the arrows from Pit 1 and those from Pit 2 and other sites..... | 87 |
| 6.4 Measurements of the bronze arrows | 88 |
| 6.4.1 Sampling strategy..... | 88 |
| 6.4.2 Methodology of the measurements | 89 |
| 6.4.3 Patterns in the dimensions of the arrows..... | 89 |
| 6.4.3.1 Measurements of the arrow tangs..... | 89 |
| 6.4.3.2 Measurements of the arrowheads | 89 |
| 6.4.4 Coefficient of variation values and degree of standardisation | 92 |
| 6.4.4.1 CV values for the arrow tangs..... | 92 |
| 6.4.4.2 CV values for the arrowheads | 93 |
| 6.5 Arrow production, assembly and labour organisation..... | 94 |
| 6.5.1 Consistency and variability of arrow bundles..... | 96 |
| 6.5.2 Batch or cell production organisation | 97 |
| 6.6 Spatial data..... | 98 |
| 6.6.1 Parameters affecting the spatial patterns..... | 98 |
| 6.6.2 A pair correlation function..... | 102 |
| 6.7 Summary | 103 |
| 7. Bronze Ferrules and Long Weapons | 105 |
| 7.1 Introduction..... | 105 |
| 7.2 Research review | 106 |
| 7.2.1 Ferrules..... | 106 |
| 7.2.2 Bronze blades of long weapons..... | 108 |
| 7.3 Measurements of the bronze ferrules | 108 |
| 7.3.1 Sources of data | 108 |
| 7.3.2 Methodology for the measurements..... | 109 |
| 7.3.3 Measuring patterns in the ferrules..... | 109 |
| 7.3.4 Analysis of the patterns of each type of ferrules | 110 |
| 7.3.4.1 Subgroups within Type I ferrules | 113 |
| 7.3.4.2 Subgroups within type III ferrules..... | 115 |
| 7.3.5 Coefficients of variation (CV) and degrees of standardisation | 117 |
| 7.4 The bronze long weapons..... | 118 |
| 7.4.1 Sources of data | 118 |
| 7.4.2 Measurements of the long weapons | 120 |
| 7.5 Spatial data..... | 121 |
| 7.5.1 Parameters affecting the spatial patterns..... | 121 |
| 7.5.1.1 The ferrules, long weapons, and the battle formation | 122 |
| 7.5.1.2 Workshop practice and labour organisation..... | 127 |
| 7.5.1.2.1 The ferrules | 127 |
| 7.5.1.2.2 The long weapons | 127 |
| 7.5.2 Pair correlation functions on the ferrules | 127 |
| 7.6 Summary and discussion..... | 131 |
| 8. Discussion and Conclusions | 135 |
| 8.1 Standardisation..... | 135 |
| 8.1.1 Projectile Weapons | 135 |
| 8.1.2 Long Weapons..... | 135 |
| 8.1.3 Parameters affecting standardisation | 136 |
| 8.1.3.1 Models, Moulds, and Finishing Practices..... | 136 |
| 8.1.3.2 Behaviour of the craftspeople..... | 136 |
| 8.1.3.3 Efficiency and quality control?..... | 137 |
| 8.2 Organisation of production | 137 |
| 8.2.1 Model of production organisation..... | 137 |
| 8.2.2 Organisational structure and practices | 139 |
| 8.2.3 Craft specialisation and attached production..... | 139 |
| 8.3 Spatial statistics and activity areas..... | 140 |
| 8.3.1 Spatial patterns of triggers and activity areas..... | 140 |
| 8.3.2 Placement of arrows into the pit..... | 141 |
| 8.3.3 Ferrules and long weapons..... | 141 |
| 8.4 Directions for future research..... | 141 |

| | |
|---|-----|
| 8.4.1 Research model for other research within the tomb complex | 141 |
| 8.4.2 Contemporary weapons at other sites | 141 |
| 8.4.3 Bronze versus iron weapons | 142 |
| Bibliography | 143 |
| Appendix 1: Spatial and metric data on triggers: Part A | 151 |
| Appendix 2: Spatial and metric data on triggers: Part B | 159 |
| Appendix 3: Spatial and metric data on triggers: Part C | 167 |
| Appendix 4: Spatial and metric data on triggers: Part D and E | 175 |
| Appendix 5: Correspondence between trigger part groups | 183 |
| Appendix 6: Inscriptions on triggers | 189 |
| Appendix 7: Count and metric data on arrow bundles | 195 |
| Appendix 8: Spatial and metric data on ferrules | 219 |