CONTENTS

List of Tables .................................. XII
List of Plates .................................. XIV
List of Figures .................................. XV
List of Appendices .............................. XVI
Preface ........................................ XVII
Acknowledgements .............................. XIX
Abbreviations .................................. XXI
Turkish Summary (translated by Özlem Çevik) ...... 1

CHAPTER 1
IRON OBJECTS AND IRON-MAKING SOCIETIES

Iron as Artefact .................................. 11
Brief Background to the Review of Relevant Research .. 15
  Iron as a Utilitarian Metal ........................ 18
  Western Iranian Iron ............................ 21
  Assyrian Iron .................................. 23
  Anatolian Iron ................................. 25
  Levantine Iron ................................. 28
  Cypriot Iron .................................. 31
  Egyptian Iron .................................. 33
Discussion of Past Research ......................... 33
Research Questions ............................. 36

CHAPTER 2
MINING, SMELTING AND MANUFACTURE

Ores and Mining in Antiquity ....................... 39
  Native and Ore-bound Copper .................... 39
  Copper Deposits and Mining ..................... 40
  Meteoritic and Ore-bound Iron ................. 41
  Iron Deposits and Mining ..................... 42
The Smelting Process ........................... 44
  Ore Beneficiation ............................ 44
  Roasting and Smelting the Ore .................. 44
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gangue, Fluxes and Slag</td>
<td>45</td>
</tr>
<tr>
<td>Tuyeres and Bellows</td>
<td>47</td>
</tr>
<tr>
<td>The Smelting of Iron</td>
<td>48</td>
</tr>
<tr>
<td>Metallurgical Installations</td>
<td>49</td>
</tr>
<tr>
<td>Ancient Examples of Metallurgical Installations</td>
<td>52</td>
</tr>
<tr>
<td>Manufacturing Copper and Iron Objects</td>
<td>54</td>
</tr>
<tr>
<td>Methods of Fabricating Copper</td>
<td>54</td>
</tr>
<tr>
<td>Casting Copper</td>
<td>54</td>
</tr>
<tr>
<td>Alloying Copper</td>
<td>55</td>
</tr>
<tr>
<td>Working Copper</td>
<td>56</td>
</tr>
<tr>
<td>Methods of Fabricating Iron</td>
<td>57</td>
</tr>
<tr>
<td>Direct and Indirect Production of Iron</td>
<td>57</td>
</tr>
<tr>
<td>Iron ‘Ingots’</td>
<td>58</td>
</tr>
<tr>
<td>Improving Iron</td>
<td>59</td>
</tr>
<tr>
<td>The Smithy</td>
<td>66</td>
</tr>
<tr>
<td>Remarks</td>
<td>69</td>
</tr>
</tbody>
</table>

CHAPTER 3  
THE ENVIRONMENTAL, ARCHAEOLOGICAL AND HISTORICAL SETTING

| Resources and Environment                                             | 71   |
| History and Archaeology                                                | 76   |
| Early Iron Age                                                         | 76   |
| Middle Iron Age                                                        | 77   |
| Late Iron Age                                                          | 81   |
| Hellenistic/Post-Achaemenid – Early Roman                              | 86   |

CHAPTER 4  
ANALYTICAL PROCEDURE AND METHODOLOGY

| Site Selection                                                         | 89   |
| Criteria for Selecting an Object for Analysis                          | 89   |
| Analytical Procedures                                                  | 90   |
| Preparation of Samples for Microscopic Examination                    | 90   |
| Reflected Light Microscopy                                              | 91   |
| Scanning Electron Microscopy                                           | 91   |
| Hardness Testing                                                       | 91   |
| Chemical Analysis                                                      | 91   |
CHAPTER 5
SITE ANALYSIS, COMPARATIVE IRON QUANTITY
AND METALLOGRAPHY IN NORTH EASTERN ANATOLIA
DURING THE FIRST MILLENNIUM BC

Early Iron Age / Pre-Urartian Period ca. 1100–900 BC 104
Sos Höyük 104
Horom 106
Metsamor 107
Karmir Blur 107
Keban Sites 108
Summary and Discussion of Iron in the Early Iron Age Period 110

Middle Iron Age / Urartian Period ca. 850–585 BC 116
Alnıntepe 116
Ayanis 117
Çavuştepe 118
Dilkaya Höyük 119
Urartian Horom 121
İğdır 121
CHAPTER 6
SUMMARIES OF METALLOGRAPHIC RESULTS
AND SOCIAL ORGANISATION IN RELATION TO
IRON PRODUCTION AND USE FOR THE FIRST MILLENNIUM BC

Material Characteristics and Fabrication Techniques Throughout the First
Millennium BC .................................................. 170
  Ferritic Grain Size ............................................ 171
  Chemical Composition ..................................... 172
  Inclusions ....................................................... 174
  Degeneracy in Pearlite .................................... 174
  Evidence of Warm Working ................................ 174
  Compositional Inhomogeneity ............................. 176
  Homogeneity .................................................. 177
CONTENTS

Thermal Treatment and Quench Hardening .......................... 177
Fabrication Techniques .................................................. 178
The Significance of Changes in Function and Material Characteristics of Iron in the First Millennium BC ........................................... 178
Iron Usage Phases in North-eastern Anatolia in the First Millennium BC 178
Comparison of Urartian and Post-Urartian Systems and Iron: Changes in Production .......................................................... 185

CHAPTER 7
CONCLUSIONS

Bibliography ................................................................. 193
Tables .............................................................................. 223
Figures and Plates ........................................................... 261
Appendix A: Reports of Metallographic Results and Chemical Analyses of Relevant Items ............................................ 271
Appendix B: Report of Slag Sample Analysis (by Andrew Kyllo) .......... 383
Glossary of Terms ............................................................ 385