INFORMATION TO USERS

The most advanced technology has been used to photograph and reproduce this manuscript from the microfilm master. UMI films the original text directly from the copy submitted. Thus, some dissertation copies are in typewriter face, while others may be from a computer printer.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyrighted material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each oversize page is available as one exposure on a standard 35 mm slide or as a 17" × 23" black and white photographic print for an additional charge.

Photographs included in the original manuscript have been reproduced xerographically in this copy. 35 mm slides or 6" × 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
An Iron Age in the Philippines? A critical examination

Dizon, Eusebio Zamora, Ph.D.

University of Pennsylvania, 1988

Copyright ©1988 by Dizon, Eusebio Zamora. All rights reserved.
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark √.

1. Glossy photographs or pages √
2. Colored illustrations, paper or print ______
3. Photographs with dark background √
4. Illustrations are poor copy ______
5. Pages with black marks, not original copy ______
6. Print shows through as there is text on both sides of page ______
7. Indistinct, broken or small print on several pages √
8. Print exceeds margin requirements ______
9. Tightly bound copy with print lost in spine ______
10. Computer printout pages with indistinct print ______
11. Page(s) ________ lacking when material received, and not available from school or author.
12. Page(s) ________ seem to be missing in numbering only as text follows.
13. Two pages numbered ______. Text follows.
14. Curling and wrinkled pages ______
15. Dissertation contains pages with print at a slant, filmed as received √
16. Other ____________________________________________________________

______________________________________________________________
AN IRON AGE IN THE PHILIPPINES?: A CRITICAL EXAMINATION

EUSEBIO ZAMORA DIZON

A DISSERTATION

in

ANTHROPOLOGY

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

1988

Vincent C. Pigott
Supervisor of Dissertation

Gregory L. Possehl

Ward H. Goodenough

Brian J. Spooner
Graduate Group Chair
DEDICATION

FOR GIGI,

VINCENT GREGORY AND CHRISTINE MARIE
ACKNOWLEDGEMENTS

Anthropological dissertations are never a product of an individual. They are carried out by several people contributing their expertise in the field. Thus, it would be impossible for me to claim all the credit for this dissertation. This is a product of the group effort of my committee through many years of hard work.

The late Dr. Chester F. Gorman provided the opportunity for me to come to the University of Pennsylvania under the auspices of the Ford Foundation Southeast Asian Archaeology Program, and through the kind help of Ms. Lisa Lyons. I thank them sincerely.

A special thanks is given to Dr. Gregory L. Possehl who has given me the opportunity to continue my graduate studies at the Department of Anthropology, University of Pennsylvania through continuing support from the Ford Foundation. He has extended logistical support and has always believed in my capability as a Southeast Asian student.

Dr. Vincent C. Pigott deserves the highest accolade. He has been tireless in his effort to encourage me to finish this dissertation. To him, my deepest gratitude and appreciation for the comments, criticism, as well as editing of this document. I have spent long hours of discussion clearing my ideas with him. He has been a
good source of inspiration to me and I am proud to be his first Ph.D. student in archaeometallurgy.

I thank the Philippine National Museum, and the staff of the Anthropology Division for allowing me the opportunity to spend an extended period abroad in order to complete my degrees. I am particularly grateful to Dr. Jesus T. Peralta and Dr. Alfredo E. Evangelista. Furthermore, they kindly permitted me to use a group of excavated iron artifacts from the Philippines in this study.

I am truly grateful to Dr. Karl L. Hutterer, Curator, Division of the Orient, Museum of Anthropology at the University of Michigan, Ann Arbor for allowing me to study the Guthe-Michigan iron collection in this dissertation and for his valuable comments and suggestions on the entire work. His efforts on my behalf as an outside reader were substantial. While working in Michigan, I had the opportunity to meet Karl's students Laura Junker, Binky Dalupan and Masao Nishimura. I would like to thank them for their hospitality and ideas while my work was in progress.

Dr. Heather Peters had spent time reading the first draft of this document and contributed her expertise on my China section. Dr. Bennett Bronson, Curator of the Asian Section, Field Museum of Natural History in Chicago pro-
vided me informations on Southeast Asian as well as Chinese iron working. I thank them sincerely for their efforts.

To Professor Ward Goodenough, who served as a committee member, I owe my thanks for his editorial work and comments. Dr. Harold L. Dibble introduced me to computers, statistical techniques and their applications to archaeology. At the Museum Applied Science Center for Archaeology (MASCA), I thank Dr. Stuart Fleming, Scientific Director, for allowing me to use their facilities and laboratory equipment. Mr. Reed Knox Jr., metallographer, deserves a special thanks for helping me interpret the metallography of my iron samples. He has given constant guidance to me at the MASCA metals lab and I would never have progressed in my work without his involvement. To my fellow graduate students at Penn who in one way or another have contributed to my intellectual growth, particularly Gil Stein and Dr. Bryce Little, many thanks to them.

While it is impossible to name every individual I wish thank my friends in other departments at Penn for their moral support. To Ed Francisco my gratitude for helping me transpose tables and Moyeng Castro for drawing Figure 1.1. Last but not least, I am indebted to my family. My wife Gigi, for giving me all the support she could and my children Vincent and Christine for giving me the inspiration to get my degree.
ABSTRACT

AN IRON AGE IN THE PHILIPPINES?: A CRITICAL STUDY

EUSEBIO Z. DIZON

VINCENT C. PIGOTT, Ph.D.
(Dissertation Supervisor)

Based on the limited evidence of iron artifacts and the associated pottery, it has been argued that a "Philippine Iron Age" began sometime between ca. 500 - 200 B.C. This study employing current archaeological and anthropological methods and metallurgical techniques analyzes the evidence for iron in the Philippines. It addresses whether the term "Iron Age" is viable in the Philippine context.

The appearance of iron in certain areas of the Old World is surveyed to provide information on how iron technology developed and was adopted elsewhere. The presence of an Iron Age can imply a complex social organization which assumes a political machinery and economic institutions that deal with the control, distribution and redistribution of resources. Technology is also a system that operates within this complex whole, providing the science and technical knowledge to manipulate
resources for the society.

Philippine ethnographic and ethnohistorical records document that iron was supplied by Chinese traders in exchange for forest products, gold, salt, beads, etc. and that local blacksmiths processed iron for agricultural and household implements. Surpluses were traded to other groups, promoting the continuous diffusion of iron.

Ten iron samples from the Philippine National Museum and 75 samples from the Guthe-Michigan collection were examined metallographically. Microhardness testing was done for qualitative and quantitative analysis. Descriptive and exploratory statistics were used to construct a generalized typology.

The Guthe collection showed variability in morphology, metallurgical treatment and function, projecting a pattern of regional variation among artifact types. The metallography suggested an improvement in iron technology over time. There are no indications of mass or standardized production of iron implements, suggesting local production on a small scale.

This study concludes that there is no real Iron Age in the Philippines but that there were iron-using societies in certain areas beginning ca. 370 B.C. Finally, the study
of iron technology constitutes a mechanism by which an improved understanding of the socio-cultural complexity of pre- and proto-historic cultures in the Philippines and Southeast Asia might be achieved.
# TABLE OF CONTENTS

Acknowledgements
Abstract
List of Tables
List of Figures
List of Photomicrographs

Chapter

## 1 INTRODUCTION

1.1 Theoretical Framework

1.1.1 Objectives
1.1.2 Hypotheses

1.1.2.1 Hypothesis 1
1.1.2.2 Hypothesis 2
1.1.2.3 Hypothesis 3

1.2 Methodology

1.2.1 Collection A
1.2.2 Collection B

1.3 Organization

## 2 A REVIEW OF PHILIPPINE ARCHAEOLOGY

2.1 General

2.1.1 Chronology

2.1.1.1 Beyer (1947;1948)
2.1.1.2 Evangelista (1962)
2.1.1.3 Fox (1970)
2.1.1.4 Jocano (1967;1975)
2.1.1.5 Solheim (1981)

2.1.2 Criticism

2.2 The Emergence of the Philippine "Iron Age"
2.2.1 Beyer's Reconstruction 45
2.2.2 Solheim's Reconstruction 47
2.2.3 Jocano's Reconstruction 49
2.2.4 Fox's Reconstruction 51
2.2.5 Comments 53
2.2.6 Evolutionary Idea of the Iron Age 54

2.3 Ethnographic and Ethnographic Data 57

2.3.1 Northern Luzon 60
2.3.1.1 The Bontoc-Igorot 61
2.3.1.2 The Ifugao 63
2.3.1.3 The Tinguian 65
2.3.1.4 The Nabaloi 69
2.3.1.5 The Zambales Negritos 71

2.3.2 Southern Luzon 72

2.3.2.1 The Hanunoo 72

2.3.3 The Bisayas 74
2.3.4 Mindanao 78
2.3.4.1 The Subanun 79
2.3.4.2 The Maranao 80
2.3.4.3 The Cotabato Manobo 81
2.3.4.4 The Coastal Bagobo 81

2.4 Iron Mining and Smelting in Bulacan 82
2.5 Summary 87

3 A REVIEW OF THE APPEARANCE OF IRON IN THE OLD WORLD 90

3.1 The Development and Use of Iron 94
3.1.1 The Near East and Eastern Mediterranean 96
3.1.2 South Asia 105
3.1.3 China 117
3.1.3.1 Northern China 120
3.1.3.2 Southern China 125
3.1.4 Southeast Asia 133

3.2 Problem Focus 139
3.2.1 Iron Technology 141

3.3 Summary 145
4 THE DATA

4.1 The Earliest Finds - Palawan Materials

4.1.1 Manunggul Cave

4.1.1.1 Metallographic Data on 64-M-40

4.1.2 Tadyaw Cave

4.1.2.1 Metallographic Data on 62-Tt-B-298
4.1.2.2 Metallographic Data on 62-Tt-B-299
4.1.2.3 Metallographic Data on 62-Tt-B-301

4.2 Earlier Studies on Philippine Iron

4.2.1 Bolinao Materials
4.2.2 Cagayan Materials
4.2.3 Sorsogon Materials

4.3 Guthe-Michigan Collection

4.4 Preliminary Classification and Typology

4.4.1 Cebu Materials
4.4.2 Burial Ground 5

4.4.2.1 Metallographic Data on B-5

4.4.3 Burial Ground 6

4.4.3.1 Metallographic Data on B-6

4.4.4 Burial Ground 7

4.4.4.1 Metallographic Data on B-7

4.4.5 Burial Ground 12

4.4.5.1 Metallographic Data on B-12

4.4.6 Burial Ground 17

4.4.6.1 Metallographic Data on B-17

4.4.7 Burial Ground 18

4.4.7.1 Metallographic Data on B-18

4.4.8 Burial Ground 19

4.4.8.1 Metallographic Data on B-19
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4.9</td>
<td>Burial Ground 64</td>
<td>234</td>
</tr>
<tr>
<td>4.4.9.1</td>
<td>Metallographic Data on B-64</td>
<td>235</td>
</tr>
<tr>
<td>4.4.10</td>
<td>Burial Ground 82</td>
<td>236</td>
</tr>
<tr>
<td>4.4.10.1</td>
<td>Metallographic Data on B-82</td>
<td>236</td>
</tr>
<tr>
<td>4.4.11</td>
<td>Burial Ground 84</td>
<td>238</td>
</tr>
<tr>
<td>4.4.11.1</td>
<td>Metallographic Data on B-84</td>
<td>238</td>
</tr>
<tr>
<td>4.4.12</td>
<td>Burial Ground 85</td>
<td>239</td>
</tr>
<tr>
<td>4.4.12.1</td>
<td>Metallographic Data on B-85</td>
<td>239</td>
</tr>
<tr>
<td>4.4.13</td>
<td>Burial Ground 89</td>
<td>239</td>
</tr>
<tr>
<td>4.4.13.1</td>
<td>Metallographic Data on B-89</td>
<td>240</td>
</tr>
<tr>
<td>4.4.14</td>
<td>Burial Ground 93</td>
<td>242</td>
</tr>
<tr>
<td>4.4.14.1</td>
<td>Metallographic Data on B-93</td>
<td>242</td>
</tr>
<tr>
<td>4.4.15</td>
<td>Grave 71</td>
<td>243</td>
</tr>
<tr>
<td>4.4.15.1</td>
<td>Metallographic Data on G-71</td>
<td>243</td>
</tr>
<tr>
<td>4.4.16</td>
<td>Grave 74</td>
<td>244</td>
</tr>
<tr>
<td>4.4.16.1</td>
<td>Metallographic Data on G-74</td>
<td>245</td>
</tr>
<tr>
<td>4.4.17</td>
<td>Grave 76</td>
<td>248</td>
</tr>
<tr>
<td>4.4.17.1</td>
<td>Metallographic Data on G-76</td>
<td>248</td>
</tr>
<tr>
<td>4.4.18</td>
<td>Grave 82</td>
<td>249</td>
</tr>
<tr>
<td>4.4.18.1</td>
<td>Metallographic Data on G-82</td>
<td>249</td>
</tr>
<tr>
<td>4.4.19</td>
<td>Grave 111</td>
<td>249</td>
</tr>
<tr>
<td>4.4.19.1</td>
<td>Metallographic Data on G-111</td>
<td>250</td>
</tr>
<tr>
<td>4.4.20</td>
<td>Grave 114</td>
<td>251</td>
</tr>
<tr>
<td>4.4.20.1</td>
<td>Metallographic Data on G-114</td>
<td>252</td>
</tr>
<tr>
<td>4.4.21</td>
<td>Grave 123</td>
<td>252</td>
</tr>
<tr>
<td>4.4.21.1</td>
<td>Metallographic Data on G-123</td>
<td>253</td>
</tr>
</tbody>
</table>
4.4.22 Miscellaneous 1 254
4.4.22.1 Metallographic Data on M-1 255
4.4.23 Miscellaneous 6 256
4.4.23.1 Metallographic Data on M-6 257
4.4.24 Siquijor Materials 260
4.4.25 Burial Ground 21 261
4.4.25.1 Metallographic Data on B-21 261
4.4.26 Burial Ground 32 262
4.4.26.1 Metallographic Data on B-32 262
4.4.27 Grave 100 263
4.4.27.1 Metallographic Data on G-100 263
4.4.28 Grave 101 264
4.4.28.1 Metallographic Data on G-101 264
4.4.29 Grave 117 265
4.4.29.1 Metallographic Data on G-117 266
4.4.30 Grave 147 266
4.4.30.1 Metallographic Data on G-147 267
4.4.31 Bohol Materials 267
4.4.32 Cave 11 268
4.4.32.1 Metallographic Data on C-11 270
4.4.33 Cave 91 273
4.4.33.1 Metallographic Data on C-91 273
4.4.34 Grave 167 274
4.4.34.1 Metallographic Data on G-167 275
4.4.35 Grave 185 275
4.4.35.1 Metallographic Data on G-185 276
4.4.36 Surigao Materials 276
4.4.37 Cave 5 277
4.4.37.1 Metallographic Data on C-5 278
4.4.38 Cave 55 278
4.4.38.1 Metallographic Data on C-55 280
4.4.39 Cave 56 284
4.4.39.1 Metallographic Data on C-56 284
4.4.40 Masbate Materials 285
4.4.41 Miscellaneous 2 286
4.4.41.1 Metallographic Data on M-2 288
4.4.42 Samar Materials 290
4.4.43 Burial Ground 10 290
4.4.43.1 Metallographic Data on B-10 292
4.4.44 Leyte Materials 293
4.4.45 Cave 14 293
4.4.45.1 Metallographic Data on C-14 294
4.4.46 Mindoro Materials 295
4.4.47 Cave 83 295
4.4.47.1 Metallographic Data on C-83 296
4.4.48 Bukidnon Materials 297
4.4.49 Cave 32 297
4.4.49.1 Metallographic Data on C-32 298
4.4.50 Davao Materials 298
4.4.51 Cave 76 299
4.4.51.1 Metallographic Data on C-76 300
4.5 Summary 300
5 STATISTICAL ANALYSIS 302
5.1 Statistics of the Guthe Collection 302
5.1.1 Type = 1.0 (diamond shaped tang) 307
5.1.2 Type = 1.1 (square shaped tang) 309
5.1.3 Type = 1.2 (rectangular shaped tang) 311
5.1.4 Type = 1.3 (blade of a spearhead) 313
5.1.5 Type = 2.0 (long tang dagger) 313
5.1.6 Type = 2.1 (two edged sword or kris) 315
5.1.7 Type = 3.0 (big pointed bolo) 315
5.1.8 Type = 3.1 (small pinya knife) 316
5.1.9 Type = 3.2 (small L-shaped knife) 318
5.1.10 Type = 3.3 (square-end bolo) 320
5.1.11 Type = 3.4 (medium knife = 12 - 29 cm) 321
5.1.12 Type = 3.5 (small knife = 5 - 11 cm) 323
5.1.13 Type = 3.6 (oval tip knife) 325
5.1.14 Type = 4.0 (harpoon) 327
5.1.15 Type = 5.0 (ferrule or ring) 329
5.1.16 Type = 6.0 (chisel) 330
5.1.17 Type = 7.0 (cast iron) 330
5.1.18 Variability Among Types 331

5.1.18.1 Variable = Blade Angle 332
5.1.18.2 Variable = Blade Length 332
5.1.18.3 Variable = Blade Thickness 334
5.1.18.4 Variable = Blade Width 334
5.1.18.5 Variable = End Angle 336
5.1.18.6 Variable = Hardness 336
5.1.18.7 Variable = Tang Length 339
5.1.18.8 Variable = Tang Thickness 339
5.1.18.9 Variable = Tang Width 341
5.1.18.10 Variable = Ratio of BL/TL 341
5.1.18.11 Variable = Ratio of BL/BW 341

5.2 Summary 345

6 DISCUSSION, CONCLUSION AND RECOMMENDATIONS 347

6.1 Discussion 347

6.1.1 Reply to Hypothesis 1 355
6.1.2 Reply to Hypothesis 2 357
6.1.3 Reply to Hypothesis 3 359

6.2 Conclusion 360

6.2.1 Archaeological Evidence 361
6.2.2 Ethnographic Evidence 366
6.2.3 Statistical Study 370
6.2.4 Metallographic Study 374

6.3 Recommendations for Future Research 376

6.3.1 Survey and Excavation 377
6.3.2 Data Analyses 378
6.3.3 Cross-cultural Study 379

6.4 Final Comments 379

APPENDIX 382
BIBLIOGRAPHY

INDEX
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Statistics of Iron Production in Bulacan, 1884</td>
<td>84</td>
</tr>
<tr>
<td>3.1 Early Iron Finds from Mesopotamia</td>
<td>98</td>
</tr>
<tr>
<td>3.2 Cultural Chronological Stages of North China</td>
<td>119</td>
</tr>
<tr>
<td>3.3 List of Philippine Archaeological Sites Containing Iron Artifacts and their Estimated Dates</td>
<td>140</td>
</tr>
<tr>
<td>4.1 Total Number of Sites, Artifacts, and their Weight (Guthe-Michigan Collection)</td>
<td>184</td>
</tr>
<tr>
<td>4.2 Cross-tabulation of Areas and Artifact Provenience (Guthe-Michigan Collection)</td>
<td>185</td>
</tr>
<tr>
<td>4.3 Summary of Area, Sites and Samples</td>
<td>186</td>
</tr>
<tr>
<td>4.4 Classes and Types of the Guthe Iron Artifacts</td>
<td>192</td>
</tr>
<tr>
<td>4.5 Distribution of Classes and Types of Iron Artifacts (Guthe-Michigan Collection)</td>
<td>212</td>
</tr>
<tr>
<td>5.1 Statistical Data of Type 1.0 (spearheads)</td>
<td>308</td>
</tr>
<tr>
<td>5.2 Statistical Data of Type 1.1 (spearheads)</td>
<td>310</td>
</tr>
<tr>
<td>5.3 Statistical Data of Type 1.2 (spearheads)</td>
<td>312</td>
</tr>
<tr>
<td>5.4 Statistical Data of Type 2.0 (daggers)</td>
<td>314</td>
</tr>
<tr>
<td>5.5 Statistical Data of Type 3.0 (bolos)</td>
<td>316</td>
</tr>
<tr>
<td>5.6 Statistical Data of Type 3.1 (pinya knives)</td>
<td>317</td>
</tr>
<tr>
<td>5.7 Statistical Data of Type 3.2 (L-shaped knives)</td>
<td>319</td>
</tr>
<tr>
<td>5.8 Statistical Data of Type 3.3 (bolos)</td>
<td>321</td>
</tr>
<tr>
<td>5.9 Statistical Data of Type 3.4 (medium knives)</td>
<td>323</td>
</tr>
<tr>
<td>5.10 Statistical Data of Type 3.5 (small knives)</td>
<td>325</td>
</tr>
<tr>
<td>5.11 Statistical Data of Type 3.6 (oval-tip knives)</td>
<td>326</td>
</tr>
<tr>
<td>5.12 Statistical Data of Type 4.0 (harpoons)</td>
<td>328</td>
</tr>
<tr>
<td>5.13 Statistical Data of Type 5.0 (ferrules or rings)</td>
<td>330</td>
</tr>
<tr>
<td>5.14 Statistical Data of Type 7.0 (cast iron vessels)</td>
<td>331</td>
</tr>
</tbody>
</table>
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Location Map of Philippine Sites</td>
<td>2</td>
</tr>
<tr>
<td>2.1 Illustration of Beyer's &quot;waves of migration&quot;</td>
<td>33</td>
</tr>
<tr>
<td>4.1 Floor Plan of Manunggul Cave, Chamber A</td>
<td>150</td>
</tr>
<tr>
<td>4.2 Illustration of Artifact 64-M-40</td>
<td>155</td>
</tr>
<tr>
<td>4.3 Iron-Carbon Equilibrium Diagram</td>
<td>157</td>
</tr>
<tr>
<td>4.4 Floor Plan of Tadyaw Cave</td>
<td>158</td>
</tr>
<tr>
<td>4.5 Forms of Iron Spears and Knives from Tadyaw Cave</td>
<td>160</td>
</tr>
<tr>
<td>4.6 Illustrations of Artifacts 62-Tt-B-298, 299, 301</td>
<td>161</td>
</tr>
<tr>
<td>4.7 Iron Artifacts from Bolinao Site</td>
<td>167</td>
</tr>
<tr>
<td>4.8 Jar Burial 1 at Binisitahan Site, Sorsogon</td>
<td>176</td>
</tr>
<tr>
<td>4.9 Sites Included in this Study</td>
<td>182</td>
</tr>
<tr>
<td>4.10 Illustrations of Type 1.0 (spearheads)</td>
<td>195</td>
</tr>
<tr>
<td>4.11 Illustrations of Type 1.1 (spearheads)</td>
<td>196</td>
</tr>
<tr>
<td>4.12 Illustrations of Type 1.2 (spearheads)</td>
<td>197</td>
</tr>
<tr>
<td>4.13 Illustration of Type 1.3 (spearhead)</td>
<td>198</td>
</tr>
<tr>
<td>4.14 Illustrations of Type 2.0 (daggers)</td>
<td>199</td>
</tr>
<tr>
<td>4.15 Illustration of Type 2.1 (kris)</td>
<td>200</td>
</tr>
<tr>
<td>4.16 Illustrations of Type 3.0 (pointed bolos)</td>
<td>201</td>
</tr>
<tr>
<td>4.17 Illustrations of Type 3.1 (pinya knives)</td>
<td>202</td>
</tr>
<tr>
<td>4.18 Illustrations of Type 3.2 (L-shaped knives)</td>
<td>203</td>
</tr>
<tr>
<td>4.19 Illustrations of Type 3.3 (square-end bolos)</td>
<td>204</td>
</tr>
<tr>
<td>4.20 Illustrations of Type 3.4 (medium knives)</td>
<td>205</td>
</tr>
<tr>
<td>4.21 Illustrations of Type 3.5 (small knives)</td>
<td>206</td>
</tr>
<tr>
<td>4.22 Illustrations of Type 3.6 (oval-tip knives)</td>
<td>207</td>
</tr>
<tr>
<td>4.23 Illustrations of Type 4.0 (harpoons)</td>
<td>208</td>
</tr>
<tr>
<td>4.24 Illustrations of Type 5.0 (ferrules or rings)</td>
<td>209</td>
</tr>
<tr>
<td>4.25 Illustration of Type 6.0 (chisel)</td>
<td>210</td>
</tr>
<tr>
<td>4.26 Illustrations of Type 7.0 (cast iron vessels)</td>
<td>211</td>
</tr>
<tr>
<td>4.27 Pie-Chart Distribution of the Kind of Iron</td>
<td>214</td>
</tr>
<tr>
<td>4.28 Bar-Chart Distribution of the Kind of Iron</td>
<td>214</td>
</tr>
<tr>
<td>4.29 Bar-Chart Distribution of Iron Artifacts</td>
<td>218</td>
</tr>
<tr>
<td>4.30 Pie-Chart Distribution of Cebu Iron Artifacts</td>
<td>215</td>
</tr>
<tr>
<td>4.31 Microhardness Traverse of Artifact B-6-7</td>
<td>223</td>
</tr>
<tr>
<td>5.1 Bar-Chart Distribution of Iron Artifacts By Type</td>
<td>303</td>
</tr>
<tr>
<td>5.2 Illustration of the Metrical Variables</td>
<td>306</td>
</tr>
<tr>
<td>5.3 Variability Chart of Blade Angle</td>
<td>333</td>
</tr>
<tr>
<td>5.4 Variability Chart of Blade Length</td>
<td>333</td>
</tr>
<tr>
<td>5.5 Variability Chart of Blade Thickness</td>
<td>335</td>
</tr>
<tr>
<td>5.6 Variability Chart of Blade Width</td>
<td>335</td>
</tr>
<tr>
<td>5.7 Variability Chart of End Angle</td>
<td>337</td>
</tr>
<tr>
<td>5.8 Variability Chart of Hardness</td>
<td>338</td>
</tr>
<tr>
<td>5.9 Bar-Chart Distribution of Hardness Numbers</td>
<td>338</td>
</tr>
<tr>
<td>5.10 Variability Chart of Tang Length</td>
<td>340</td>
</tr>
<tr>
<td>5.11 Variability Chart of Tang Thickness</td>
<td>340</td>
</tr>
<tr>
<td>5.12 Variability Chart of Tang Width</td>
<td>342</td>
</tr>
<tr>
<td>5.13 Variability Chart of Ratio = BL/TL</td>
<td>342</td>
</tr>
<tr>
<td>5.14 Variability Chart of Ratio = BL/BW</td>
<td>343</td>
</tr>
</tbody>
</table>
### List of Photomicrographs

<table>
<thead>
<tr>
<th>Photomicrograph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 64-M-40 (X400) Relict &quot;ghost&quot; pearlite</td>
<td>383</td>
</tr>
<tr>
<td>4.2 64-M-40 (X400) Slag inclusions</td>
<td>383</td>
</tr>
<tr>
<td>4.3 62-Tt-B-298 (X400) Ferrite and pearlite grains</td>
<td>384</td>
</tr>
<tr>
<td>4.4 62-Tt-B-299 (X400) Ghost structures - pearlite</td>
<td>384</td>
</tr>
<tr>
<td>4.5 62-Tt-B-301 (X400) Ferrite grains</td>
<td>385</td>
</tr>
<tr>
<td>4.6 62-Tt-B-301 (X400) Metal trapped in a slag</td>
<td>385</td>
</tr>
<tr>
<td>4.7 B-5-19 (X400) Fine lamellar microstructures</td>
<td>386</td>
</tr>
<tr>
<td>4.8 B-5-20 (X400) Coarse ferrite grains</td>
<td>386</td>
</tr>
<tr>
<td>4.9 B-6-7 (X200) Flattened slag inclusions, unetched</td>
<td>387</td>
</tr>
<tr>
<td>4.10 B-6-7 (X400) Martensitic structures</td>
<td>387</td>
</tr>
<tr>
<td>4.11 B-6-8 (X400) Fine grain martensite</td>
<td>388</td>
</tr>
<tr>
<td>4.12 B-6-9 (X100) Uneven ferrite grain distribution</td>
<td>388</td>
</tr>
<tr>
<td>4.13 B-6-9 (X400) Microhardness pyramid impression</td>
<td>389</td>
</tr>
<tr>
<td>4.14 B-7-23 (X200) Flattened slag inclusions</td>
<td>389</td>
</tr>
<tr>
<td>4.15 B-7-23 (X100) Uneven ferrite grain distribution</td>
<td>390</td>
</tr>
<tr>
<td>4.16 B-7-23 (X400) Pearlite colonies in bands</td>
<td>390</td>
</tr>
<tr>
<td>4.17 B-7-24 (X400) Spheroided pearlite</td>
<td>391</td>
</tr>
<tr>
<td>4.18 B-7-25a (X400) B&amp;ectectoid composition</td>
<td>391</td>
</tr>
<tr>
<td>4.19 B-7-25b (X400) Flattened slag inclusions</td>
<td>392</td>
</tr>
<tr>
<td>4.20 B-7-25b (X400) Martensitic structures</td>
<td>392</td>
</tr>
<tr>
<td>4.21 B-7-25c (X100) Uneven grain distribution</td>
<td>393</td>
</tr>
<tr>
<td>4.22 B-7-25c (X600) Widmanstätten structures</td>
<td>393</td>
</tr>
<tr>
<td>4.23 B-12-19 (X400) Uniform grain distribution</td>
<td>394</td>
</tr>
<tr>
<td>4.24 B-17-33a (X100) Carburized edge</td>
<td>394</td>
</tr>
<tr>
<td>4.25 B-17-33a (X200) Martensitic structures</td>
<td>395</td>
</tr>
<tr>
<td>4.26 B-17-33b (X600) Fine grain, pearlite colonies</td>
<td>395</td>
</tr>
<tr>
<td>4.27 B-18-15 (X100) Uniform coarse ferrite grain</td>
<td>396</td>
</tr>
<tr>
<td>4.28 B-18-17 (X400) Austenite grain, slag inclusions</td>
<td>396</td>
</tr>
<tr>
<td>4.29 B-19-20a (X100) Uneven ferrite grain distr.</td>
<td>397</td>
</tr>
<tr>
<td>4.30 B-19-20a (X400) Pearlite colonies</td>
<td>397</td>
</tr>
<tr>
<td>4.31 B-64-14a (X100) Coarse ferrite grains</td>
<td>398</td>
</tr>
<tr>
<td>4.32 B-64-14b (X400) Martensite, bainite structures</td>
<td>398</td>
</tr>
<tr>
<td>4.33 B-82-17 (X200) Coarse ferrite grains</td>
<td>399</td>
</tr>
<tr>
<td>4.34 B-82-17 (X400) Fine bainite microstructures</td>
<td>399</td>
</tr>
<tr>
<td>4.35 B-84-13a (X100) Wrought iron, uneven ferrite</td>
<td>400</td>
</tr>
<tr>
<td>4.36 B-85-19a (X400) Martensite, bainite structures</td>
<td>400</td>
</tr>
<tr>
<td>4.37 B-89-8a (X400) Idiomorphic crystal on slag</td>
<td>401</td>
</tr>
<tr>
<td>4.38 B-89-8a (X400) Pearlite colonies</td>
<td>401</td>
</tr>
<tr>
<td>4.39 B-89-8a (X400) Pearlite colonies, uneven grain</td>
<td>402</td>
</tr>
<tr>
<td>4.40 B-89-8b (X400) Hypo-eutectoid composition</td>
<td>402</td>
</tr>
<tr>
<td>4.41 B-93-15 (X100) Gradual carbon distribution</td>
<td>403</td>
</tr>
<tr>
<td>4.42 G-71-18a (X100) Fine spheroidized carbide</td>
<td>403</td>
</tr>
<tr>
<td>4.43 G-74-6a (X200) Slag stringers in pearlite matrix</td>
<td>404</td>
</tr>
<tr>
<td>4.44 G-74-6a (X400) Spheroidized pearlite</td>
<td>404</td>
</tr>
<tr>
<td>4.45 G-74-7a (X100) Fine grain pearlite, steel</td>
<td>405</td>
</tr>
<tr>
<td>4.46 G-74-7a (X400) Compound weld-like line</td>
<td>405</td>
</tr>
<tr>
<td>Page</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>4.47</td>
<td>G-74-8a (X100) Hyper-eutectoid steel</td>
</tr>
<tr>
<td>4.48</td>
<td>G-74-8b (X400) Slags in coarse grain ferrite</td>
</tr>
<tr>
<td>4.49</td>
<td>G-76-11 (X100) Slags in coarse grain ferrite</td>
</tr>
<tr>
<td>4.50</td>
<td>G-82-6 (X400) Martensite, bainite structures</td>
</tr>
<tr>
<td>4.51</td>
<td>G-111-40a (X100) Uneven grain distribution</td>
</tr>
<tr>
<td>4.52</td>
<td>G-111-40b (X400) Fine martensite</td>
</tr>
<tr>
<td>4.53</td>
<td>G-114-3 (X400) Martensitic structure</td>
</tr>
<tr>
<td>4.54</td>
<td>G-123-6 (X100) Decarburized edge</td>
</tr>
<tr>
<td>4.55</td>
<td>M-1-26a (X400) Pearlite colonies</td>
</tr>
<tr>
<td>4.56</td>
<td>M-1-26b (X100) Gradual carbon distribution</td>
</tr>
<tr>
<td>4.57</td>
<td>M-1-26c (X100) Slag inclusion in oxide</td>
</tr>
<tr>
<td>4.58</td>
<td>M-6-51a (X100) Carburized edge</td>
</tr>
<tr>
<td>4.59</td>
<td>M-6-52 (X100) Fine grain, even distribution</td>
</tr>
<tr>
<td>4.60</td>
<td>M-6-52 (X400) Martensite, bainite structures</td>
</tr>
<tr>
<td>4.61</td>
<td>M-6-53a (X100) Even distribution, martensite</td>
</tr>
<tr>
<td>4.62</td>
<td>M-6-54 (X400) Martensite, bainite structures</td>
</tr>
<tr>
<td>4.63</td>
<td>B-21-17 (X400) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>4.64</td>
<td>B-23-8 (X100) Uniform grain distribution</td>
</tr>
<tr>
<td>4.65</td>
<td>B-23-8 (X600) Hypo-eutectoid composition</td>
</tr>
<tr>
<td>4.66</td>
<td>G-100-7 (X400) Eutectoid, pearlite colonies</td>
</tr>
<tr>
<td>4.67</td>
<td>G-101-7a (X400) Relief structures in ferrite</td>
</tr>
<tr>
<td>4.68</td>
<td>G-117-13a (X100) Equiaxed ferrite grains</td>
</tr>
<tr>
<td>4.69</td>
<td>G-147-2a (X400) Fine martensite structures</td>
</tr>
<tr>
<td>4.70</td>
<td>G-147-2a (X400) Pearlite colonies, fine grain</td>
</tr>
<tr>
<td>4.71</td>
<td>C-11-400i (X100) Cementite matrix</td>
</tr>
<tr>
<td>4.72</td>
<td>C-11-400i (X400) Lamellar pearlite &amp; graphite</td>
</tr>
<tr>
<td>4.73</td>
<td>C-11-400j (X200) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>4.74</td>
<td>C-11-400k (X400) Pearlite colonies, fine grain</td>
</tr>
<tr>
<td>4.75</td>
<td>C-11-400L (X400) Uniform grain distribution</td>
</tr>
<tr>
<td>4.76</td>
<td>C-11-400m (X600) Tempered martensite, carbide</td>
</tr>
<tr>
<td>4.77</td>
<td>C-11-401b (X400) Eutectoid composition</td>
</tr>
<tr>
<td>4.78</td>
<td>C-11-401c (X100) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>4.79</td>
<td>C-91-6 (X100) Carburized edge, slag inclusions</td>
</tr>
<tr>
<td>4.80</td>
<td>G-167-2 (X400) Coarse pearlite structures</td>
</tr>
<tr>
<td>4.81</td>
<td>G-185-5 (X100) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>4.82</td>
<td>G-185-5 (X400) Pearlite colonies in band</td>
</tr>
<tr>
<td>4.83</td>
<td>C-5-27 (X100) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>4.84</td>
<td>C-55-38 (X100) Carburized edge</td>
</tr>
<tr>
<td>4.85</td>
<td>C-55-50a (X400) Eutectoid composition</td>
</tr>
<tr>
<td>4.86</td>
<td>C-55-50b (X100) Hyper-eutectoid composition</td>
</tr>
<tr>
<td>4.87</td>
<td>C-55-50c (X100) Three-zone composition</td>
</tr>
<tr>
<td>4.88</td>
<td>C-55-50c (X400) Eutectoid, Widmanstätten struc.</td>
</tr>
<tr>
<td>4.89</td>
<td>C-55-51a (X100) Uneven carbon distribution</td>
</tr>
<tr>
<td>4.90</td>
<td>C-55-51b (X400) Uneven carbon distribution</td>
</tr>
<tr>
<td>4.91</td>
<td>C-55-51b (X100) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>4.92</td>
<td>C-56-25a (X100) Coarse grain ferrites</td>
</tr>
<tr>
<td>4.93</td>
<td>C-56-25a (X400) Widmanstätten structures</td>
</tr>
<tr>
<td>4.94</td>
<td>C-56-25b (X400) Spheroidized carbide</td>
</tr>
<tr>
<td>4.95</td>
<td>M-2-31 (X400) Metal in a slag inlusion</td>
</tr>
<tr>
<td>4.96</td>
<td>M-2-31 (X100) Uneven ferrite grain distribution</td>
</tr>
<tr>
<td>4.97</td>
<td>M-2-55a (X400) Martensite &amp; bainite plates</td>
</tr>
<tr>
<td>4.98</td>
<td>B-10-16a (X200) Uniform fine ferrite grain distr.</td>
</tr>
<tr>
<td>4.99</td>
<td>B-10-28a (X200) Uneven ferrite grain distr.</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>4.100</td>
<td>C-14-11 (X200) Martensite, Widmanstätten struc.</td>
</tr>
<tr>
<td>4.101</td>
<td>C-83-6 (X100) Uniform fine ferrite grain distr.</td>
</tr>
<tr>
<td>4.102</td>
<td>C-83-6 (X100) Uneven grain distr. Widmanstätten</td>
</tr>
<tr>
<td>4.103</td>
<td>C-32-3 (X100) Uniform fine grain distribution</td>
</tr>
<tr>
<td>4.104</td>
<td>C-32-3 (X400) Dendritic structures, pearlite</td>
</tr>
<tr>
<td>4.105</td>
<td>C-76-21a (X400) Ferrite grain in oxide matrix</td>
</tr>
</tbody>
</table>
Chapter 1

INTRODUCTION

In the Philippines (see Figure 1.1) prehistoric and protohistoric archaeology began during the first quarter of the twentieth century; however little of these archaeological data have been systematically analyzed within an anthropological frame of reference. Most of the studies are basically of descriptive analyses of archaeological remains, primarily in the form of site reports. The Old World three-age system of artifact classification is usually followed with some minor modification. The purpose of this dissertation is to analyze the current evidence for the coming of iron in the Philippines. At present, there is: 1) substantial ethnographic evidence of iron trade between local inhabitants of most of the Philippine archipelago and the Chinese and various Southeast Asian

1. For the non-Philippine specialist, prehistory began at the earliest possible period of the terminal Pleistocene ca. 10,000-20,000 years ago and lasted until the "Developed Metal Age Period" ca. A.D. 900, and this overlapped with the beginning of the protohistoric period which lasted through A.D. 1521, the coming of the Spaniards. For a more detailed discussion see Chapter 2.
Figure 1.1 Location Map of Philippine Sites
peoples (e.g. Beyer 1947, 1948; Fox 1970; Solheim 1975; Hutterer 1973b, 1977b); reports on iron technology, i.e. blacksmithing processes by anthropologists (e.g. Barton 1922; Cole 1922; 1945; Conklin 1957; 1980) and some mining and smelting processes by a mining geologist (McCaskey 1903). 2) archaeological evidence on the Philippine Iron Age which is based mainly on pottery typology (Beyer 1947; 1948; Solheim 1964; 1981) and which needs to be re-assessed technologically as well as anthropologically. 3) the vast number of iron artifact collections from different Philippine sites which should be subjected to various metallurgical examinations in order to understand their technological nature. This dissertation attempts to analyze the evidence for iron which has been derived from excavations over approximately the past sixty years, treating it in accordance with current archaeological, anthropological, and metallurgical methods and techniques.

Rigorous laboratory and statistical techniques in the analysis of iron artifacts, employed to draw cultural and economic conclusions have never before been used in the Philippines. Such techniques have been applied in this study. In this dissertation an examination of certain iron collections from the early archaeological expeditions in the Philippines has been undertaken as part of the investigation. The work seeks the evidence for the coming
of iron-use and the technological development of iron working as well as its implications for the economic and cultural subsystems of the Philippines within the insular Southeast Asian culture area.

Although Solheim (1964) has studied the ceramics belonging to what was suggested as the "Philippine Iron Age" by Beyer (1947; 1948), it is not clear whether or not there is an actual Iron Age in the Philippines. Solheim's definition of the Philippine Iron Age requires the presence of iron artifacts in a pre-porcelain bearing context. The associated pottery types then become "Iron Age" ceramics. Then, when similar pottery types are found in other Philippine sites, these sites are designated as "Iron Age" even without the actual presence of iron. The basic question is, does the mere presence of iron artifacts in the archaeological record certify the existence of an Iron Age? This issue has been fully discussed in Chapters 2 and 3.

Unlike the archaeology of many other closely related areas of the world, where the chronology and typology of artifacts is fairly well established, Philippine archaeology is still in its infancy and thus, very sketchy. Archaeological data in the Philippines lacks a firm chronological, typological, and regional ordering. Therefore, to explore the advent and development of a
technology such as iron we must understand that we are only at the beginning of such an attempt in this part of the world.

1.1 Theoretical Framework

This dissertation is aimed at defining the role of early iron and iron technology in the Philippines, and its impact on Philippine culture. Critical to this investigation is an anthropological/archaeological approach to culture change (e.g. Childe 1951; Steward 1955; L. White 1959; Goodenough 1966; Wallace 1972) to technological change (e.g. Foster 1962; Bernard and Pelto 1972), addressing the question of diffusion versus independent invention, and assessing the role of innovation (e.g. Steward 1929; Kroeber 1940; Barnett 1940; 1942; 1953; 1964; Rowe 1966; Rogers 1979) in the development of metallurgy (e.g. Childe 1944; Rowlands 1971; Wertime 1973; Smith 1976; Muhly 1981; Pigott 1982b). Through what social processes did metal-use develop in the Philippines? Can an actual Iron Age or a Metal Age be defined in the Philippines?

Various scholars including Childe (1936; 1944; 1951), and L. White (1959) have suggested that the
development of technology is directly related to the level of social complexity as well as its corresponding social organization. Childe (1936:35; 1951) pointed out that unless there were full-time specialists (such as miners, smiths, craftsmen, merchants, traders, priests, soldiers, etc.) who were not directly involved with food procurement, the Bronze Age would not have evolved. He recognized, however, that societies practicing bronze technology varied greatly in social and political organization. He concluded that bronze and iron technology required craft specialization (for extraction, processing, and distribution) and permitted the accumulation of "social surplus" which, in some societies, led to urbanization-states-civilization. Implicit in this view is that a sophisticated technology such as metal working presupposes a social organization that permits a high degree of division of labor in the form of occupational specialization. When we reach a point where archaeological data permits, this idea is worthy of testing in the Philippine example.

Leslie White (1959:19) went further to a more technologically deterministic viewpoint "...the social organization of a people is not only dependent upon their technology but is determined to a great extent, if not wholly by it, both in form and content." A third and more
current view is found in Rowlands's (1971) critical archaeological interpretation of prehistoric metalworking societies, which is an investigation of the general assumptions concerning the Metal Age with the aid of ethnographic data from modern small-scale societies. He proposed "to distinguish metalworking as a separate cultural institution which can be seen to be composed of a number of socio-economic activities" (Ibid.:210). He found that there are numerous ethnographic references to show that the smith in many societies only contributes his skill to production while the customer supplies the raw materials and/or fuel and/or labor.

In many societies metalworking is not a full time occupation, for the smith, may at the same time, participate in the general economy of owning the fields, animals, etc., which he and his family maintain. The smith in such cases is therefore not fully dependent on the community to supply him with the bulk of his food (Rowlands 1971:219).

In Southeast Asia, the study of prehistoric metalurgy, economics, social organization and complexity have received very little attention. At least in mainland Southeast Asia, particularly Thailand, with the archaeological excavation of Ban Chiang (Gorman and Charoenwongsa 1976; White 1982), metals like bronze and iron have undergone special metallurgical examinations (Smith 1973; Stech Wheeler and Maddin 1976; Haryono 1982; Natapintu; 1982; Pigott and Marder 1984) to assess their technical and
technological significance. As a follow up, there is now the Thailand Archaeometallurgy Project (TAP) directed by V. Pigott and S. Natapintu (Pigott 1984), for continuing research on ancient mining and archaeometallurgy in that country. There has never been research of this kind in insular Southeast Asia.

To date, only Hutterer (1973b:128; 1977:184) has argued that:

a well developed metal technology implies among other things, a certain degree of craft specialization, a relatively differentiated economy which can afford the energy expended in the extracting, processing and distribution of metals, and a trade network that brings together ores and fuels and disposes of the finished products.

Although this statement refers to the internal trade in the Philippines, it can be argued that the same is true elsewhere in Southeast Asia as well as in China. Once internal trade is developed, external trade is likely to follow.

Hutterer feels that bronze and iron are not the only items of potentially foreign origin in Philippine sites of the first millennium A.D. Ornamental objects of precious or semi-precious stones not native to the islands are common, especially beads of carnelian and occasionally jade. His observations of the larger archaeological context also suggest that glass ornaments, which appear
together with the early iron, may have been of foreign manufacture. "It seems possible to enlarge this list considerably to include such items as gold ornaments, earthenware pottery, rare raw materials, condiments such as salt and so forth" (Hutterer 1977:186). It is interesting to note that in China, during the early first millennium A.D., salt and iron were two important commodities controlled by the state (Gale 1931). In addition, the appearance of carnelian beads and glass at iron bearing sites in Thailand is a matter of current research interest there (Glover 1980).

Although Hutterer cites trade as probable reason for the appearance of metal artifacts, glass ornaments, and highly fired ceramics in Philippine archaeological sites, he is careful to note that his claim "remains as much a conjecture as earlier evaluations" and that "only future archaeological research, focusing specifically on this problem, will enable us to shed new light on it" (op cit.). It is this line of thought which motivated me to initiate this investigation.

1.1.1 Objectives

One purpose of this investigation is explicitly to test some ideas put forward by researchers (Beyer 1947; 1948; Solheim 1964; 1981; Fox 1970; Jocano 1967; 1975;
Peralta 1977; Hutterer 1973b; 1974; 1976; 1977) who have dealt with the coming of iron in the Metal Age of the Philippines. There are many questions that could be addressed. Is there evidence for the local manufacture of iron artifacts in the Philippines, or were people there using only iron brought from elsewhere? If this is true, how did the iron artifacts (and, perhaps the technology) arrive in the Philippines and from where did it come? How did the receiving society adapt to this new material? Did local peoples finally develop the technological processes required for production of iron or did they continue to rely on foreign trade? Most of these questions cannot be answered satisfactorily due to the limitation of the data which are presently available. At this point one positive step should be the development of a systematic typology of Philippine iron based on the combination of attributes including morphology (form and style), composition and metallurgical treatment and function. This may be accomplished through an examination of the available collections of iron artifacts in the Philippines. It will provide an opportunity for further testing of the questions raised above.

Ethnographic records as well as ethnohistorical documents are very important for a well rounded anthropological interpretation of the archaeological record.
Historically, the Philippines was first colonized by the Spaniards in 1521. The Americans took over from 1898 to 1935. The Spaniards did not formally write ethnography about the peoples of the Philippines. However, Blair and Robertson (1903-09) compiled and translated into English Spanish documents such as mission letters and governmental directives, which reveal important insights regarding the "native's way of life". An attempt to write Philippine ethnography was also made by Ferdinand Blumentritt in 1882 and his work was recently translated from German by Maceda (1980).

When the Americans arrived in the first part of the twentieth century, a number of ethnographic studies were produced, particularly in the northern part of Luzon and south in Mindanao. These early American anthropological studies include Jenks' work on the Bontoc-Igorot (1905); Moss' work with the Nabalois (1920); Cole's extensive anthropological study on the Tinguians (1922); and Barton's research among the Ifugao (1922). Finally we must mention Kroeber's synthesis on the peoples of the Philippines (1919); and later Cole's (1945) synthesis on the peoples of Malaysia, Indonesia, and the Philippines. The subjects and interests of all these anthropologists include religion, head-hunting, material culture, trade and exchange of goods, including iron and other metals, as well as
ironworking technology. However, these materials have never been examined in relation to interpreting the Metal Age in the Philippines. This, therefore, is what I shall try to do. This is attempted below (see Chapter 2).

1.1.2 Hypotheses

To give more specific direction to the proposed research, three testable hypotheses have been formulated. They are not entirely independent of one another and their implications are anthropologically important for the definition of processes instrumental in the formation of Philippine lowland complex societies. These hypotheses are as follows:

1.1.2.1 Hypothesis 1

If iron implements found in Philippine archaeological sites were brought as trade goods in the form of finished products, then it may be possible to suggest their area of origin. Possible locations would include the South China provinces of Kwantung and Fukien, the Santubong Delta in northwest Borneo as well as mainland Southeast Asia. The South Chinese provinces have traditionally been believed to have been the source of trade between mainland Asia and the Philippines (Beyer and De Veyra 1952; Fox 1970). The Santubong Delta in Borneo has long been held to
have been the location of an important iron producing complex dated 14th century A.D. (Harrisson and O'Connor 1969:18). However, Christie (1986) has argued cogently that the Santubong Delta site has been misinterpreted. Its date and its function as an early iron processing site, as well as its scale and magnitude have now come into question. More and more is becoming known, also, about the beginning of iron working in Thailand, which dates to mid-first millennium B.C. if not earlier (J. White 1982; Pigott and Marder 1984; Bronson 1984).

If iron was imported to the Philippines from external sources, one may expect that these had some fairly large-scale and well-organized iron industries. Such large-scale iron works are known to have existed in China by A.D. 1000 or earlier, using technology to mass produce cast iron (see Jue-ming 1983). The resulting artifacts would have been very homogenous among themselves in terms of material composition as well as form. Thus, if iron artifacts found in the Philippines originated from these large-scale iron foundries in China, they should also show a high degree of homogeneity in material, form and treatment. Distinguishing wrought iron from cast iron artifacts may also help to discriminate between production centers.
1.1.2.2 Hypothesis 2

If iron was brought to the Philippines as a raw material in the form of wrought or cast iron and then processed into finished products by local blacksmiths, then we might expect to find some degree of homogeneity in the composition of the artifacts, but not necessarily in their morphology and metallurgical treatment. In this case there may be significant regional differences within the Philippine archipelago reflected in artifact morphology and perhaps variability in metallurgical treatment. We may be able to establish this regional variability by comparing artifacts of identical function, such as bolos (large knives), from different areas. For instance, weeding bolos from sites in Cebu should be compared to weeding bolos from sites in Luzon.

1.1.2.3 Hypothesis 3

If iron artifacts found in the Philippines were locally made from metal smelted from domestically mined ores, then a different pattern would emerge. We would expect to find inter- and intra-regional variability in artifact morphology, composition, and metallurgical treatment. We would expect to find some centralized mining, smelting, and iron working industries that should
cluster geographically in regions where ores are found. For instance, we might locate a center in Cebu (Hutterer 1973a), Victorias, Negros Occidental (Tenazas 1973), or another one in Pila, Laguna (Tenazas 1968). One may expect to find a pattern of regional clustering in the variability of the major attributes; that is, artifacts within a geographic region should be more similar to each other with regard to style, composition, and technological treatment than they are to artifacts from other regions. Depending on the intensity of production, which is related, in part, to the ratio of supply and demand, we may also expect to find irregular distribution of those artifacts with special functions. Finally, due to the development of iron technology over time, we might expect to find more sophisticated iron products (medium to high carbon steel, perhaps quenched and tempered) in the later periods.

1.2 Methodology

In order to test these hypotheses, ideally we should have a relatively large sample of iron artifacts that are well distributed over the entire Philippine archipelago and over the entire period of metal's occurrence. In order to generate statistically valid inferences, it would be necessary to draw a stratified
random sample from existing collections, controlling for both geographic and chronological representation. Artifacts which did not have adequate chronological control would be rejected. Good provenience control with regard to site and stratigraphic association of the selected sample is important. At present, in the Philippines there exists a fairly large corpus of early iron artifacts that has been collected and excavated over the past sixty years. However, access to this collection in its entirety was not possible. This study is based upon the collections of excavated iron artifacts available in the U.S. as well as those in published excavation reports. From these materials an initial attempt to construct a generalized typology of iron artifacts from the Philippines from the early period onwards was made. As a first step towards estimating the significance of iron-use in the Philippines the attempt has been made to summarize the available evidence concerning the early use of iron in the Philippines. In compliment to the literature research, two case studies of collections were made and serve as models to demonstrate how a large scale study of the entire iron corpus might be undertaken at some future point. The collections studied are the following:
1.2.1 Collection A

Initial metallographic analyses were conducted on ten iron artifacts from the archaeological collections of the Philippine National Museum (Dizon 1983). These artifacts came from three different sites in Luzon from the periods known as the "Developed Metal Age" or "Iron Age" in the Philippines ca. 200 B.C. to A.D. 200 to the "Period of Contact and Trade" which is roughly between the 10th - 15th century A.D. The Philippine National Museum sent four more samples, which have been studied, dating from the early periods ca. 370 - 50 B.C. (Stuiver and Pearson 1986). These artifacts constitute Collection A.

1.2.2 Collection B

In 1922-25 the University of Michigan sent an expedition to the Philippines. The archaeological work was conducted by Carl Guthe (1927;1929), who visited a total of 542 sites in central and southern Philippines. These sites range from the first century A.D. to the 15th century. The collections are presently housed in the University of Michigan, Museum of Anthropology. In examining Guthe's field notes, catalogues, and collections, it was determined that there are at least 41 sites which yielded 487 inventoried iron artifacts and fragments. An estimated 5%
of these are complete implements and 95% are fragmentary. With the kind permission of the curator, Professor Karl L. Hutterer, almost all the complete artifacts were sampled. These 75 artifacts constitute Collection B.

The two case studies thus are composed of Collections A and B. The complete iron artifacts were measured, and metrical variables such as maximum length, length of the blade, length of the tang, width, thickness, end or point angle, edge or blade angle, etc. were taken. Indices presented in the form of ratios and proportions were computed as new variables (e.g. the ratio of length over width). Non-metrical variables such as the general morphology of the tool, curvature of the blade and other significant characteristics were noted and also coded as nominal variables. The goal was to develop a systematic typology of Philippine iron artifacts using the objective metrical attributes of the artifacts. It was hoped that meaningful relationships could be derived from the observable variables (see Dunnell 1972; Clarke 1972; Doran and Hodson 1975; Whallon and Brown 1982).

The standard operating procedures for metallographic examination and other metallurgical tests were followed where such analysis was possible in both Collections A and B. (see Kehl 1949; Gifkins 1970; Chase 1979). At MASCA (Museum Applied Science Center for
Archaeology, University of Pennsylvania), sections that were cut from iron artifacts and these were mounted, polished and etched for metallographic microscopy. Micro-hardness testing was done for qualitative and quantitative analysis. This test was done using the Buehler Micromet II: the sample is impressed by a pyramid shaped diamond pin with a known load and for a known time limit. The inverted pyramid impression on the sample is then measured by the micrometer of the Micromet II and the readings from the two axes of the pyramid are taken. An average is computed from these two readings and the result is located on the table of DPH Numbers of its respective load and time of the load. An average of three tests with various loads were done on each sample when possible. There were cases where the sample was too small for such determinations.

The data from Collection B were subjected to a battery of statistical analyses, using existing computer programs including SAS (Statistical Analysis System) and SPSS (Statistical Package for the Social Sciences) on an IBM 4341 model computer at the DRL (David Rittenhouse Laboratory). The intent was to construct an overall typology. Both descriptive and exploratory statistics were used. In descriptive statistics, each artifact and the total collection under study were described in terms of relative frequencies, distribution, and analysis of
variance, whereas in exploratory statistics, different relationships among the variables were examined for possible significance. Questions such as the following were addressed: does the metallurgical treatment of an artifact have something to do with its morphology and function?; is there a relationship between material composition and metallurgical treatment?; is metallurgical treatment important to the blade?; what is the relationship between blade length and tang length among the types of iron artifacts?

1.3 Organization

As mentioned, Chapter 2 reviews Philippine archaeology with emphasis on the appearance of iron and the idea of a Philippine "Iron Age" or a "Metal Age". It also provides a discussion of iron working in the Philippines based on ethnographic accounts. Questions was raised regarding the existence of a true Philippine Metal Age. Unlike Thailand and Indonesia, where there is archaeological evidence of mining and smelting, there has so far been no actual archaeological documentation of ancient mining and smelting in the Philippines except during the historic times in Angat, Bulacan, as reported by McCaskey (1903). It is not really known whether iron artifacts
found in Philippine archaeological sites were imported or locally made.

Chapter 3 is a selective survey of the appearance of iron in certain regions in the Old World, and an examination of the term "Iron Age." It provides some basic information on how iron technology developed within certain other cultural areas. Furthermore, it provides a brief discussion of how iron was adopted in these places.

Chapter 4 is a presentation of the results of the metallurgical analyses of Collections A and B. These are grouped according to the earliest artifacts excavated in Palawan, the earlier studies of ten iron artifacts from Luzon (Dizon 1983), and the bulk of the Guthe-Michigan iron collection from the central Philippine region, the Visayas.

Chapter 5 comprises the statistical analysis of the iron artifacts in the Guthe-Michigan collection and significance of this analysis to this study. This is the first study of this kind on iron artifacts from the Philippines and from Southeast Asia as a whole. It presents a descriptive statistical analysis of the data and attempts some exploratory techniques.

Chapter 6 is a discussion of the processes involved in the coming of iron technology, and a conclusion,
comprising a summary of results and recommendations for future research.
Chapter 2

A REVIEW OF PHILIPPINE ARCHAEOLOGY

This chapter will discuss the general orientation of Philippine archaeology and prehistory. It will review the main reconstructions of Philippine culture-history and give an anthropological assessment of these reconstructions. Philippine ethnographic examples and ethnohistorical accounts will also be examined for their relevance to the introduction, use, and manufacture of iron. This will provide those who are not Philippine specialists a better understanding of the state of Philippine archaeology and prehistory.

2.1 General

The archaeological record consists mainly of materials that are the result of past human activities. These material remains come in the form of artifacts, features and ecofacts (Sharer and Ashmore 1979:70ff). Prehistoric artifacts were first positively identified in
Europe in the early nineteenth century as truly produced by human behaviour. These artifacts were then classified according to their raw materials, and to each class of raw material was ascribed a stage of development in prehistory. For instance, those made of stone were grouped together and were believed to represent the Stone Age; those made of bronze were grouped together as representative of the Bronze Age; finally, artifacts made of iron were also grouped together as representing the Iron Age. This grouping was believed to reflect a technological progression through time from the working of stone, to the use of bronze and iron. Thus, it was thought that stone working came first, since stone can simply be worked by flaking, knapping, chipping, grinding, etc., whereas bronze working is more complex and would therefore have come later; finally, iron-working is an even more sophisticated technique of manufacturing and would have been the latest to appear. Eventually, this kind of classificatory system became a hallmark in prehistoric archaeology, known as the traditional European three-age system. It is popularly associated with C.J. Thomsen, since he was first to use it in an exhibition of artifacts at the National Museum of Denmark in 1807 (Daniel 1981). This three-age classificatory system has since become the standardized categorization of archaeological materials and sites in the Old World. The Philippines, being a part of the Old World,
is no exception in this case.

Generally, archaeological sites in the Philippines have been identified according to the cultural material remains they contain. Using the Old World sequence, for instance, if an archaeological site is found to have artifacts of pebble/cobble and/or flake tools, the site and the cultural materials are usually identified to be of the "Palaeolithic" or Old Stone Age. It is generally assumed that palaeolithic societies subsisted by hunting and collecting, even if this cannot be demonstrated in every case on the basis of palaeobiological remains. If a site is associated with pottery, blade and ground-edge or polished stone tools, then it is said to be a "Neolithic" or New Stone Age site. Again, it is usually assumed that Neolithic communities engaged in sedentary agriculture, even if there has not yet been any paleobotanical evidence of plant cultivation, paleozoological evidence of animal domestication, or any real archaeological evidence of Neolithic habitation activity areas. If a site has metals like copper, bronze, gold and iron, it is called a "Metal Age" site (again, even if there has never been found any actual evidence of mining, smelting or metal-working at the site). Finally, if a site includes porcelain, glass beads, metals, etc., then it is classified as a "Contact and Trade" site. Some sites contain assemblages of flake tools
and other lithic artifacts that are generally believed to be the Palaeolithic as well as pottery that is generally believed to be Neolithic, in undisturbed stratigraphic association. W. Peterson (1972) has used the term "anomalous" for such sites. Even the contemporary Tasaday group, which was found using stone tools, was described as a "stone-age tribe" (Sharer and Ashmore 1979:459). Hence, typology as well as chronology remain important problems in Philippine anthropology, archaeology and prehistory.

In the New World, the typology of sites and archaeological remains was also a problem. The Old World terminologies, which are basically derived from the three-age system concept, were thought not to be applicable to the culture-historical development of the New World. Thus, New World archaeologists have dismissed these terms, and substituted new ones they believe are more appropriate. Willey and Phillips (1958) devised a cultural sequence for the New World that includes Lithic, Archaic, Formative, Classic and Postclassic stages. This model integrates descriptions of artifacts and processual interpretations of material culture with the aid of ethnographic analogy. Jocano (1967; 1975) applied similar New World terms like Germinal, Formative, Incipient, and Emergent periods in his reconstruction on Philippine prehistory. Solheim (1981) in his reconstruction also used
similar terminologies, although he (1972; 1975) had previously attempted to introduce such terms as Lithic, Lignic, Crystallistic, Extensionistic periods, and the period of Conflicting Empires for the whole region of Southeast Asia.

Basically, both the Old and the New World models involved a succession of stages that suggest a unilineal, uniform development of culture. Such models may not be applicable to the Philippines, as we shall see later. Moreover, these models are primarily typological in nature, that is, descriptive rather than explanatory. The traditional three-age system of the Old World is based on technological change. Technology is seen as indicative of cultural development in general. For instance, it was suggested that the societies in the Stone Age were "savage" hunter-gatherers, having egalitarian social organization, and living in bands; societies in the Bronze Age were conceived of as "barbarians", settled agriculturalists or pastoralists, organized in the form of chiefdoms, in which they had some kind of stratification or ranking system; and finally, societies in the Iron Age were thought to have attained "civilization" and to have developed states of their own (see Morgan 1877; Childe 1936; 1951; Steward 1955; White 1959). These descriptions do not necessarily hold true everywhere, as has been demonstrated archaeo-
logically in many parts of the world. This issue will be discussed further in the next chapter.

2.1.1 Chronology

Chronology has always been a problem in Philippine archaeology and prehistory. Generally, tropical environments do not preserve the type of organic remains well which are most suitable for radiometric dating. Typically, the Philippines, lying in the tropics, has yielded few charcoal samples. Unfortunately, even the handful of samples of datable organic materials that have been recovered from archaeological sites have not been dated radiometrically due to lack of funds. Moreover, while too much reliance has been put on C-14 determinations, there are many other dating techniques such as archaeomagnetic dating, thermoluminescence, geochronology, dendrochronology, pollen analysis, etc. which have yet to be tested in the Philippines.

There are at least five "chronological charts" which have been designed for the archaeology of the Philippines. Most of these chronological reconstructions are based on the typological arrangement of artifacts and the comparison of these artifacts with known dates from elsewhere in Southeast Asia. At present, there is no framework of absolute dates, i.e. a chronological
framework, that would encompass and represent the whole Philippine archipelago; given the large number of archaeological sites distributed over more than 7,100 islands, very few actually have C-14 determined dates. The present basis of chronology and typology in Philippine archaeology is the Palawan (Tabon Caves) sequence and the Cagayan Valley project of the Philippine National Museum (Fox 1970; 1978; Fox and Peralta 1974). Integration of other archaeologically excavated sites into the general chronological scheme has also been attempted by the Anthropology Division of the Philippine National Museum in 1971 and by Jocano (1975) and Solheim (1981). In this paper, Philippine dates written in capital letters "B.C." are C-14 converted in the latest available table of conversion by Stuiver and Pearson (1986), and dates in small letters, "b.c." are mainly based on inferences derived from typology and other related forms of dating.

Generally, the chronological charts used in Philippine archaeology can be divided into an Old World approach and a New World approach. Beyer (1947; 1948), Evangelista (1962), and Fox (1970) followed the Old World model, while Jocano (1967; 1975) and Solheim (1981) followed the New World model. The following are their reconstructions:
2.1.1.1 Beyer (1947; 1948) -

PALAEOLITHIC:
1. Early Pleistocene - 500,000 years ago or more
2. Medium-early Pleistocene - 400,000 yrs. or more
3. Middle Pleistocene - 300,000 to 250,000 or more
4. Medium-late Pleistocene - 120,000 to 100,000
5. Late-late Pleistocene - **ca.** 50,000 to 20,000

MESOLITHIC:
6. Large Implement Culture - **ca.** 20,000 to 15,000
7. Typical Pre-Neolithic Microlith Culture;
   Middle to Late Post Pleistocene - **ca.** 12,000 to 8,000 b.c., more or less

EARLY NEOLITHIC:
8. Bacsonian-type Mixed Proto-neolithic and Early Neolithic horizon - **ca.** 6000 to 4000 b.c.
9. Typical Waizenbeil (oval, cylindrical or lenticular axe-adze) Culture - **ca.** 4000 to 2250 b.c.

MIDDLE NEOLITHIC:
10. Early true shouldered axe-adze culture
    (Schulterbeil) - [no date given]
11. The ridge adze (Riegelbeil) culture - [no date given]
12. Tanged Hawaiian and East Polynesian adze
    culture [no date given]
13. Early transitional "Hoifung" adze-type -
    between 2250^nd^ 1750 b.c.

LATE NEOLITHIC:
14. The true developed rectangular and trapezoidal
    adze (using very hard and highly polished
    stones) cultures - between 1750 and 1250 b.c.
15. Characteristic early transitional forms of
    modified butt, ancestral to the early true
    "stepped"-adze (Stufenbeil) - **ca.** 1250 to 800 b.c.
16. True Yangshao and Dongson cultures, with
    developed "jade-cult" - **ca.** 800 to 500 b.c.
17. Final or "Philippine" form of the stepped adze,
    with sawing, hole-boring, and "jade-cult"
    jewelry, etc.; with some imported Greek-
    culture beads and coins, about 500 to 200 b.c.

BRONZE AGE: - mixed with (15), (16), and (17) of the
Late Neolithic, **ca.** 800 to 250 b.c.
PREHISTORIC IRON AGE: - **ca.** 250-200 b.c. to 9th
   century A.D.
18. Early - incised pottery, without slip covering,
    **ca.** 200 b.c. to 300 A.D.
19. Late — slip covering and molded pottery, ca. 300-850 A.D.
(Jar-Burial Culture: contemporary with Late Iron Age about 300-850 A.D — Pre-Porcelain in the Philippines.)
PORCELAIN AGE: — Pre-Spanish; 9th to the 16th century A.D.
20. Early Monochrome Period — Tang and Early Sung, 9th to 12th century;
21. Later Monochrome Period — Southern Sung and Yuan, 13th — 14th century;
22. Early Ming Period — 15th and early 16th centuries;
23. Late Ming Period — late 16th and early 17th centuries.
SPANISH PERIOD REMAINS: — Historic; 17th to 19th century.
24. Early — 1565 to British occupation in middle 18th century;
25. Late — 1765 to 1898.

Henry Otley Beyer (1883–1966) was an American school-teacher who joined the Thomasites¹ in coming to the Philippines in 1905. He carried out extensive, but not intensive and systematic, archaeological fieldwork covering almost all of the Philippine archipelago. Beyer was a trained chemist and geologist but not an archaeologist. Nevertheless, he gained professionalism from practical experience in the field and pursued his research for more than half a century. He was indeed one of the earliest investigators of Philippine prehistoric archaeology.

Beyer's primary, detailed work in Philippine prehistory (1947; 1948; Beyer and De Veyra [1947] 1952) presented theories involving an "elaborate series of

1. Thomasites were American school teachers, recruited to offer their services in the Philippines at the turn of the century, after the Spanish–American war.
migrations based on minute typological variations in adzes on the idea contained in Heine Geldern's 'Urheimat' of 1932 (Bellwood 1979:207). He claimed that the Philippines was populated by means of several "waves of migrations" from the Asiatic mainland (Figure 2.1), as well as the Malaysian-Indonesian islands and that the migrants carried distinctive "cultures" with them. Each group of migrants was identified with "racial type" along with a typical material culture which would represent a period in Philippine prehistory. For instance, Beyer believed that early forms of man such as Homo erectus and archaic Homo sapiens, like those found in mainland China and the island of Java, may have walked across land bridges that linked the Philippine islands with Asia at various times during the Pleistocene, following the migrations of megafauna (see also Von Koenigswald 1956). To date, no early human fossils have been found in the Philippines, although numerous lithic materials similar to those found in China and Java as well as fossils of Pleistocene megafauna have been found in some parts of the Philippine archipelago; e.g. in Luzon – the Cagayan Valley, Pangasinan area, Cubao district in Metro Manila, Panay Island in the Visayas, and also in some parts of Mindanao such as Davao (Von Koenigswald 1956). We do not know what happened to the megafauna: whether these animals were killed-off by the early inhabitants (Homo erectus?); or whether they became extinct for environmental
Figure 2.1 Illustration of Beyer's "waves of migration" theory. (Jocano 1967:132)
reasons. Hence, this is a phase in Philippine prehistory that is poorly known archaeologically.

Beyer thought that each different type of "Neolithic" adze and axe was brought to the Philippines at a different time by separate groups of migrating peoples. For instance, he thought that sometime between 5,000 and 6,000 years ago the "Indonesian type A" people started arriving in the Philippines with well made plank-built boats under sail. These people, he thought, had ground or polished stone axes, adzes, chisels and other tools with round and oval cross-sections, which are suggestive of advanced culture and craftsmanship. He further theorized that they lived in grass-covered houses with wooden frames, having rounded roofs much like a modern Quonset hut, built directly on the ground or over a pit dug a meter or more in the ground. Moreover, he argued that they constructed some roughly-built stone walls around their homes, practiced dry agriculture, growing chiefly millet and yams. He estimated that about 12 per cent of the present population of the Philippines inherited the physical features of these people who were tall and slender (Beyer and De Veyra [1947] 1952:1). Somewhat later ca. 1500 B.C. came the "Indonesian type B" or Late Neolithic people from Indo-China (Vietnam) and the South China coast to Luzon and Formosa in good-sized dug-out boats carrying with them a
distinctive culture. Beyer (op cit.) has imaginatively described this culture in detail, including their clothing, house-construction, stone-work, food, and physical stature. Much of this is pure conjecture, for which there exists no real archaeological evidence nor has there been systematic testing conducted to date in the Philippines. Although there is archaeological evidence of "Neolithic" ground or polished stone tools in some Philippine sites, there has been no contextual analyses and palaeobotanical study conducted on these materials except for a typological study (Lynch 1949).

2.1.1.2 Evangelista (1962) -

1. Historic - A.D. 1521
2. Proto-Historic Period - ca. A.D. 1000
3. 'Iron Age' - ca. A.D. 100
4. Neolithic -
   a. Late - 1500 b.c. or earlier
   b. Early - 4000 b.c. or earlier
5. Proto-Neolithic [Mesolithic] - ca. 10,000 b.c.
6. Palaeolithic - begins 250,000 b.c.

Evangelista (1962) did not elaborate much on his or Beyer's reconstruction in his paper entitled "Tentative Chronology of Philippine Prehistory," except to reorganize Beyer's ideas. For instance, Beyer thought that pottery appeared late in the Philippines, during his Iron Age period. On the contrary, Evangelista and Fox (1957a; 1957b) found that pottery was associated with Neolithic
materials, and Evangelista assigned pottery as a result to the "Neolithic" period. In addition, Evangelista did not believe that there was a Copper or Bronze Age in the Philippines, and he was quite convinced that the main technological transition in the Philippines was that from stone to iron.

In addition, Evangelista compiled a systematic description of the salient characteristics of each period although there was little archaeological evidence in support of such reconstructions. For instance, although he claimed that root crop agriculture and shifting cultivation were characteristic of the Early or Proto-Neolithic ca. 4000 B.C., there has been so far no substantial archaeological report published documenting these claims empirically. Although a significant number of sites have been excavated, to date none of them have been recognized as habitation sites, whether in "Neolithic" or "Iron Age," context.

2.1.1.3 Fox (1970) -

1. The Palaeolithic - 50,000 to 8,000 B.C.
2. The Neolithic -
   a. Early Phase - 8000 to 2000 B.C.
   b. Late Phase - 2000 to 500 B.C.
3. The Metal Age -
   a. Early Period - 500 to 200 B.C.
   b. Developed Period - 200 B.C. to A.D. 1000
4. Age of Contact and Trade with the East -
   1100 to the 15th century A.D.
This chronological reconstruction by Fox (1970) was adopted by the Anthropology Division of the National Museum of the Philippines as an official chart for the conventional understanding of Philippine prehistory. We must bear in mind, that Fox’s sequence for the Philippines as a whole is based mainly on an extrapolation of a sequence found on one part of Palawan Island. Hence, it may not really be applicable for the whole archipelago. Although, Fox did not explicitly rule out the idea of successive waves of migrants occupying the Philippines at various times, he favored the concept of population movements within mainland and insular Southeast Asia, with the Philippines being a part of that process. He remained basically a diffusionist in the way he interpreted the archaeological data of Philippine prehistory.

Fox wrote (1967:93) that "there is no evidence from Palawan of a distinct 'Copper-Bronze Age,' although copper, bronze, and jade tools and ornaments are associated with the jar burial tradition and with either polished stone tools or iron implements." Thus, he considered this transitional period when copper and bronze tools are found with stone and/or iron implements as the "Chalcolithic" period. However, he (Fox 1970:121) maintained that this period was "brief and transitional," and since he also maintained that the basic transition was from stone to
iron, the term "Chalcolithic" is thus unnecessary. He favored then the term "Metal Age," which he divided into an Early Period where bronze, copper and other metals appeared, and a Late period where iron was the predominantly used metal.

2.1.1.4 Jocano (1967; 1975) -

1. GERMINAL PERIOD - ca. 250,000 to 10,000 b.c.
2. FORMATIVE PERIOD - ca. 10,000 to 500 b.c.
3. INCIPIENT PERIOD - ca. 500 b.c. to the 10th century A.D.
4. EMERGENT PERIOD - ca. 10th cent. to the 15th century A.D.
5. PERIOD OF CONQUEST - the historic era

Jocano proposed New World terminologies for an analytical scheme for grouping and analyzing the related cultural regularities which can be derived from archaeological materials. He is more nationalistic in his approach to the discipline, for his primary aim was to find a true Filipino identity through archaeology and anthropology. He was quite convinced that his scheme was new and represented an entirely different framework for Philippine prehistory. Hutterer (1976:222) criticized Jocano's reconstruction, stating that:

though he (Jocano) explicitly disavows diffusionist thinking, his description of the periods differs little from traditional ones except for the use of new names. Furthermore, his terminology implies uniform development for the whole area...
2.1.1.5 Solheim (1981) -

1. THE ARCHAIC PERIOD - ? dating from the first arrival of man in the Philippines to 5,000 b.c.
2. THE INCIPIENT FILIPINO PERIOD - from 5,000 to 1,000 b.c.
   a. Early Incipient - 5,000 to 3,000 b.c.
   b. Middle Incipient - 3,000 to 2,000 b.c.
   c. Late Incipient - 2,000 to 1,000 b.c.
3. THE FORMATIVE FILIPINO PERIOD - from 1,000 b.c. to A.D. 500
   a. Early Formative - 1,000 to 500 b.c.
   b. Middle Formative - 500 b.c. to A.D. 100
   c. Late Formative - A.D. 100 to 500
4. THE ESTABLISHED FILIPINO PERIOD - from A.D. 500 to 1521, with the coming of the Spanish and the beginning of "history"

Solheim is another pioneer of the modern archaeological approach in the Philippines and the rest of Southeast Asia. He started working in the Philippines in the late 1940's and his 1954 Ph.D. dissertation in Anthropology at the University of Arizona was a test of Beyer's diffusionary theory concerning the Philippine "Iron Age" (Solheim 1964).

The above scheme is the most recent one proposed by Solheim (1981) as the "new" framework for Philippine prehistory. In this reconstruction, he took the liberty of utilizing other Southeast Asian archaeological materials to show a relationship between the Philippines and the rest of the region. Solheim is more explicit in his assumption that there were complex population movements between
mainland and insular Southeast Asia rather than successive waves of migrations in a periodic manner as proposed by Beyer (1947; 1948). These population movements, Solheim attributes to the activities of the hypothetical "Nusantao" people, whom he thinks were seafarers and traders traveling the whole of Southeast Asia, and thus were responsible for many of the similarities in the archaeological data found throughout the region. Furthermore, Solheim believes that the "Nusantao" were speakers of proto-Austronesian and were responsible for the spread of the Austronesian family of languages in insular Southeast Asia and the Pacific. In the Pacific Islands, Bellwood (1979) has noted that speakers of Austronesian languages have a long archaeological tradition. On purely linguistic grounds, Goodenough (1982:53) has estimated that differentiation among the Austronesian languages must have begun by at least 4000 B.C., but such differentiation could have been taking place on the mainland of Asia for some time prior to any overseas migration.

2.1.2 Criticism

The application of these unilinear stage models is only a matter of convenience. Since terminology and the use of the three-age system had been standardized in the Old World, the terms were applied for the sake of
conceptual unity, even though some adjustments had to be made in their meanings.

The use of the chronological charts involves more or less arbitrary markers to divide Philippine prehistory according to neat stadial sequences of events. However, as pointed out by Hutterer (1976), we should not view Philippine prehistory, or for that matter Southeast Asian prehistory, in terms of a uniform stadial developmental sequence, because the archaeological as well as the ethnographic data do not fit such models. These models are inadequate to accommodate the archaeological data at hand.

Furthermore, although these chronological charts made for Philippine prehistory seems to be "evolutionary" in character, most are actually diffusionist in conception. Only new terminologies were applied but the same idea of the diffusion of culture in various area of the Philippines is there, as well as the same concept of unilinear development.

Hutterer (1974; 1976) was compelled to dismiss these unilinear models because he believes that they are inadequate and insufficient to explain both the archaeological and ethnographic data. He adopted an entirely different theoretical approach to analyze the archaeological record of the Philippines by interpreting the data
from a cultural ecological and evolutionary perspective (Hutterer 1973b; 1974; 1976; 1977). He tried to illustrate this approach by proposing a hypothetical explanation for certain events in the cultural evolution of Philippine lowland societies. Hutterer (1974:287) stated that:

*tropical Southeast Asia is characterized by the fact that groups of widely diverse subsistence systems and levels of socio-cultural complexity coexist within limited geographical areas. These groups maintain their separate identities in spite of geographical interspersion and a certain amount of interaction between them.*

He believes that there are no homogeneous or uniform stages of Stone, Bronze or Iron Ages that would represent the whole of the Philippine archipelago and the rest of Southeast Asia. Instead, he suggests that prehistoric trade played a major role in the cultural evolution of Southeast Asia, especially in the formation of the complex socio-political organization of Philippine lowland societies. The presence of iron artifacts in the Philippines could, for example, be explained through long distance maritime trade.

2.2 The Emergence of the Philippine "Iron Age"

Since the focus of this dissertation is on the Philippine "Iron Age," it is appropriate here to review the
research pertaining to this period in Philippine prehistory. Of course, most of our present knowledge on this period comes from the early works of Beyer, Solheim, Jocano and Fox, and each of their theories will be discussed in detail below.

Although iron first makes its appearance in the Near East towards the middle of the 3rd millennium B.C., at sites such as Alaça Hüyük, Chagar Bazar and Tell Asmar, its qualities and quantities were not appreciated until the advent of the Iron Age at the end of the 2nd millennium B.C. Traditionally, the beginning of the Iron Age is seen as: "following the collapse of the Hittite Empire (where iron technology had been developed but kept a closely guarded monopoly) under the onslaught of the Sea People ca. 1200 BC, when iron technology spread quickly throughout Western Eurasia" (Daniel 1977:115). However, this view has been effectively disputed by Muhly (1982) who contends that there was really no evidence for any sort of monopoly. The Iron Age is generally seen a continuation of many Bronze Age traditions. According to Muhly (1982:43-44), "At the end of the Late Bronze Age, there was a worldwide upheaval of destructions, invasions and migrations. Whether the crises were related to one another is unknown". Nevertheless, iron technology probably first developed in the Eastern Mediterranean with Greece and
Cyprus playing dominant roles, while the introduction of iron metallurgy in Palestine came about through contacts with the Aegean world and the migrations of the Philistines and other Sea Peoples. Tools and weapons previously made of bronze were, during the Iron Age, replaced by iron. Culturally, this period is associated with expanding population, growing villages, towns and cities, invasion, conquest and warfare, increasing social complexity and stratification, and an expanding trade economy (Childe 1944; 1951). This issue will be discussed further in Chapter 3.

The term "Iron Age", as it is applied in the Philippines, simply signifies the presence in sites of iron artifacts including projectile points, spearheads, arrowheads, as well as finely decorated earthenware potteries. There is little direct evidence at present to indicate as to whether or not these artifacts were locally manufactured or imported. However, other period markers are said to include cloth weaving, wet-rice agriculture and probably glass making, in association with population expansion (Beyer and De Veyra 1952; Jocano 1967; 1975). It is again not clear, however, whether or not these claims are based on independent evidence or extrapolated to the Philippines on the basis of findings elsewhere. There has been little systematic archaeological investigation of this question.
thus far.

2.2.1 Beyer' Reconstruction

According to Beyer, metal artifacts began to appear in the Philippines between 800 and 500 B.C., introduced in connection with the fifth wave of migrations. Beyer and De Veyra ([1947] 1952:1) wrote:

FIFTH in the chain of incursions was probably a continuation of the fourth, but was marked by a distinctly improved and advanced culture, featured by the first use of metals. This fifth group began arriving between 800 and 500 B.C. and brought with them copper and bronze tools and ornaments. This group also retained the green jade ornaments and small tools of their immediate predecessors. It seems probable that this advanced group introduced irrigated rice culture, and built the first rice terraces. They also introduced Central Asian methods of copper mining and smelting, and used the forge and bellow. This culture is usually known as the Copper-Bronze Culture, although it might be called the Terrace Culture...

Beyer (1948:54) believed that either the copper/bronze artifacts themselves, or the metal of which they were made, came to Luzon from northern Indo-China (presently known as Vietnam) or the South China coast. This idea was based on the comparison of a limited number of archaeological materials from Luzon with others found in Hongkong and in the Dong-son culture area of Indo-China (Vietnam). The people said to be responsible for the introduction of these artifacts in the Philippines were
thought to have built the first rice terraces in Northern Luzon and were thus believed to have been the ancestors of the Ifugao and other neighboring groups. Beyer's view of the Ifugao was that they represented remnants of ancient Bronze Age societies.

SIXTH and the last of prehistoric migrations, occurring between 300 and 200 B.C. brought from the south our most numerous and advanced prehistoric people - the Iron Age group usually known as Malays. They filtered in fleets of dug-out boats up from the west coast of Borneo into Luzon via Palawan and Mindoro, and in another ocean pathway through the Celebes Strait to Mindanao and Visayas. In addition to advanced irrigated agriculture, these migrants brought four new industries: (1) the smelting, forging and manufacturing of tools, weapons, utensils and ornaments of iron and other metals; (2) the manufacture of a great variety of turned and decorated pottery; (3) the art of weaving cloth on a hand loom; (4) the manufacture of beads, bracelets and other ornaments of green and blue glass. These crafts seem to have originated in India and to have spread from there to Indo-China and Southern Malaysia, finally reaching the Philippines by way of Borneo and Celebes...

The problem with Beyer's analysis of the archaeological materials he found in the Philippines is that he assumed all of these were brought ready made by different groups of peoples coming to the Philippines in various periods. Each group of people was identified as being of a particular physical type and having a distinctive culture. This assessment leaves no room for internal development of culture within the Philippine archipelago. Every new idea is viewed as having been brought from elsewhere.
2.2.2 Solheim's Reconstruction

There are two versions of Solheim's reconstruction of the "Philippine Iron Age." The first was formulated in 1954 and published in 1964, and the second was released in 1981. Solheim's (1964) early study is an examination of Beyer's hypothesis concerning the Philippine Iron Age. However, instead of using the whole cultural assemblage of Iron Age sites, especially those materials which I view as being the most relevant because of their implications for the cultural and social organization of a people, namely, iron artifacts, Solheim used pottery in defining types of "Iron Age" sites in the Philippines. He suggested that there were four groups of pottery types found in the Iron Age sites he examined and these represented the Kalanay, Bau, Novaliches and Loboc Pottery Complexes respectively. Speaking about the Central Philippines, he says: "The majority of the pottery and of the sites belonged to the Kalanay Complex. Next comes the Bau Complex, followed by the Novaliches and Loboc Complexes, both only with few sites" (Solheim 1964:207-08).

On the basis of this evidence, Solheim attempted to revise Beyer's reconstruction of the Philippine Iron Age. The use of iron came first into the Philippines between 400 and 100 B.C., and was carried to separate areas by two or three groups of people.
The "Kalanay" people, coming from Annam and Tonkin, settled in the Visayan Islands and Palawan. The "Novaliches" people, probably settled around Manila Bay and in northern Palawan and the Calamianes. Beside iron forging, these people brought with them industries of cloth weaving and the manufacture of blue and green glass ornaments. The Malays, coming from the south, moved up Mindanao, but not to the southern Visayas where the Kalanay people had arrived earlier. The Malays probably brought metal working into northern Luzon, but at what time is not known (Solheim 1964:211-12).

Solheim's disagreement with Beyer concerned primarily the date of the arrival of iron artifacts and the consequent spread of "Iron Age" peoples within the Philippines. He also believed that iron artifacts and the technology of iron working were brought into the Philippines by two separate groups, one from Vietnam and Tonkin and the other from Indonesia.

Recently Solheim (1981) revised his view by presenting a new alternative scheme for the whole of Philippine prehistory. Within this framework, he categorized a Formative Filipino Period from ca. 1,000 b.c. to A.D. 500, which is further subdivided into three parts, namely: 1) Early Formative, from 1,000 to 500 b.c., 2) Middle Formative, from 500 b.c to A.D. 100, and 3) the Late Formative, from A.D. 100 to 500. He argued that during the Early Formative changes appeared to be more radical, and the period was characterized by the rapid development of jar burial, the proliferation of styles of forming and decorating pottery associated with burials, the use and manufacture
of bronze artifacts, and the presence of an increasing number of jade, carnelian and gold ornaments (Solheim 1981:37).

Moreover, (Solheim 1981:39) maintains that "the Middle Formative saw the first use of iron artifacts in the Philippines; but there is nothing to indicate that iron was locally manufactured at this time, and iron objects are rare until early in the Established Period." He assumed that the presence of metals and metalworking technology in the Philippines was brought by the "Nusantao" traders and sea-farers.

2.2.3 Jocano's Reconstruction

Jocano was the first scholar to introduce the use of New World terminologies in Philippine prehistory. Like New World archaeologists, he assumed that indigenous cultural developments occurred within the Philippine archipelago. However, although Jocano (1967; 1975) considered his reconstruction evolutionary because he believed that there were internal changes going on among the indigenous peoples in the Philippines, he did not succeed in his portrayal of this view. He questioned the validity of people arriving in waves of migration in a neat periodic manner bringing with them distinctive cultures, yet his alternative explanation does not really carry much weight because there is not much archaeological evidence to
support his contentions.

Jocano identified the period when iron first appeared as the Incipient Period, ca. 500 B.C. to the 10th century A.D. He (Jocano 1967:142) wrote:

Extensive use of metal characterized this period. This marked the beginning of dramatic changes in the lifeways of ancient Filipino. We call this the incipient period. By incipient we mean the beginning of the levelling of local cultural differences. This developing configuration of social and cultural values among the people was the result of the appearance of metal tools and extensive use of agriculture as the major device of extracting a living from the environment. The people became more and more sedentary because cultivated patches yielded enough food supply. Among the known staple crops were a variety of upland rice and millet.

Pottery also began during this period. ... The art of smelting and forging of iron, a method known as "Malay Forge," was introduced from the south. The manufacture of glass beads and bracelets in two colors began. Weaving, which was by this time highly developed in Indonesia, soon spread in the Philippines.

...Toward the end of this period, influences from the neighboring countries stimulated dramatic changes in the way of life of the ancient Filipinos. Trade was the principal stimulant of these contacts. The first group of foreigners to have direct contacts with the early Filipinos were the Arabs...

Jocano tried to justify his position by pointing out that the people in the Philippines at that time were already indigenous Filipinos, in the sense that they were the immediate ancestors of contemporary Philippine lowland groups and had a sense of cultural and political unity
within the archipelago. However, it is not clear that this was the case, because even today the majority of the people in the Philippines are very regionalistic in their view of themselves. This means that they prefer to identify themselves as part of a specific ethnic or linguistic group rather than part of an over-arching Philippine political entity. Each of these ethnolinguistic groups has had a different cultural development as well as socio-cultural adaptation. For instance, the Agta Negritos in Palanan maintain their hunting-gathering subsistence activities while coexisting with the lowland Christianized Palanan, who are basically wet-land rice agriculturalists, traders, etc. (J. Peterson 1978).

2.2.4 Fox's Reconstruction

Among the major works of Fox dealing with Philippine prehistory and archaeology is The Tabon Caves (1970). Like Beyer (1947; 1948), although using a simpler scheme, Fox established four broad cultural "Ages" intended for use in describing the cultural sequence of Philippine prehistory. What was traditionally known as the "Philippine Iron Age" is now reclassified to the "Developed Phase of the Metal Age".

Using data derived from excavations in Palawan, Fox (1970:123) suggested that the Early Period of the Metal Age
in the Philippines dated from ca. 700 to 200 b.c. He admitted however, that these dates are not secure but were calculated by extrapolating from C-14 dates obtained from charcoal samples taken from later stratigraphic deposits. Fox (1970:14-18) has indicated though, that bronze, copper and gold, and possibly iron, were encountered in the Early Period.

Nevertheless, Fox (1970:15) felt that a single C-14 date of 2140 +/- 100 B.P. or ca. 190 b.c. was secure. Using the correction factors established by Stuiver and Pearson (1986), this date can be recalibrated to give a range between 370 - 50 B.C. This sample was taken from the Chamber B of Manunggul Cave in Palawan and Fox maintained that this was the earliest absolute date for the presence of iron in the Philippines. He was quite convinced that "the island of Palawan was probably one of the first areas to be reached by iron (if not the first) although iron and its manufacture unquestionably diffused with great rapidity..." (Fox 1970:112).

Fox described this period as the Developed Phase of the Metal Age, since there was positive evidence of the presence of iron artifacts in burials. He (Fox 1970:124) further speculated that:

It is even possible, as suggested by comparative data from Indo-China, that rare iron implements -- "drift iron" but not the knowledge of
iron-making -- accompanied the first appearance in the Philippines of bronze and copper. Iron is found in the key Indo-China sites such as Sa-huynh which show close relationships with the Palawan jar burial sites.

Drift iron is iron from elsewhere found on the sea shore that was used by people as a form of raw material. This has been discussed in detail by Rickard (1934).

Fox's reconstruction of the Metal Age in the Philippines was accepted by his colleagues in the Philippine National Museum including Legaspi (1974b) and Peralta (1977). The problem with Fox's reconstruction is that he was very dependent on the Palawan materials, which need not really represent the whole of the Philippine archipelago. To project patterns found in a small area or a single site over the rest of the Philippines is of questionable validity, considering the cultural complexity of the archipelago.

2.2.5 Comments

The whole reconstruction of the Philippine "Iron Age" to date has been based on the idea that there is a uniform unilineal development of culture, where technology is a key factor in the progression from one stage to another. Because there has not been any evidence for the indigenous development of iron technology in the Philippines, it has generally been assumed that the technology of
iron-working, various cultural markers and other factors relating to the Iron Age were imported to the Philippines from South India, Indonesia, Vietnam, and South China. Though we may never be able to exactly pinpoint the origin of the cultural, social and technological elements characteristics of the Iron Age in the Philippines, we might be able to learn about important technological and economic aspects associated with the introduction of iron in the Philippine archipelago through a critical examination of the iron artifacts themselves.

2.2.6 Evolutionary Idea of the Iron Age

It was Henry Lewis Morgan's *Ancient Society* (1877) that introduced a developed evolutionary framework in anthropology. Leacock (1974:iv) comments that "in this monumental work (*Ancient Society*), he (Morgan) outlines the manner in which man worked himself up from 'savagery' through 'barbarism' to 'civilization', through the invention of successively more efficient methods of production, and he hypothesizes the forms major social, economic and political institutions took in each period."

Morgan further subdivided the periods of savagery and barbarism into three sub-periods which he called Older, Middle, and Later, where there are corresponding conditions that he named Lower, Middle, and Upper (1877:9).
Morgan (1877:9–12) describes each period and its conditions. In his 6th stage iron plays a pivotal role:

VI. Later Period (Upper Status) of Barbarism. From the invention of the process of smelting iron ore with the manufacture and use of iron tools, and ended with the invention of a phonetic alphabet, and the use of writing in literary composition. Here civilization begins. This leaves in the Upper Status, for example, the Grecian tribes of the Homeric age, the Italian tribes shortly before the founding of Rome, and the Germanic tribes of the time of Ceasar.

The traditional interpretation of the Iron Age was offered by Childe (1936; 1944; 1951) as both an archaeological age and a technological stage involving major social and cultural transformations. Steward (1955:17) notes that:

no one disputes that hunting and gathering, which is Childe's diagnostic of 'savagery,' preceded plant and animal domestication which is his criterion of 'barbarism,' and that the latter was a precondition of large populations, cities, internal social differentiation and specialization, and the development of writing and mathematics, which are characteristics of 'civilization'.

Although Childe had reservations regarding the transformation of the Early Bronze Age societies, he held that this one archaeological stage (the Metal Age) covers two major cultural or sociological stages — barbarism and civilization. He (Childe 1951:26) wrote that "...the use of metal — for instance, in imposing industrial specialization and trade or by making advance transport
available — was an essential precondition for civilization."

Lowie went even further in his interpretation of Childe. He wrote that "if a tribe practices metallurgy it is clearly not on the plane of savagery; only stock breeders and farmers forged metals" (Lowie 1940:45). Steward comments that although Lowie had written the above statement he (Lowie) denied that cultures can be graded on the basis of metallurgy because the Africans for example, were metallurgists but lacked other features of more developed civilizations (Steward 1955:20).

In fact, Rowlands' (1971) findings in his study of prehistoric metalworking societies argued against Childe's view that there was a central agency governing the rise of metallurgy and that the work of metalsmiths involved full-time craft specialization (that is, metalsmiths economically supported throughout their life by the other sectors of the society). Rowlands found that there are numerous ethnographic references to show that the smith in many societies only contributes his skill to production while the customer supplies the raw materials and/or fuel and/or labor. He wrote:

In many many societies metalworking is not a full time occupation, for the smith may at the same time, participate in the general economy of owning the fields, animals, etc., which he and his family maintain. The smith in such cases is
therefore not fully dependent on the community to supply him with the bulk of his food (Rowlands 1971:219).

The evolution of metallurgy in the Philippines in general may be far from the traditional sequences of copper, bronze and iron. Although, archaeologists have maintained that the use of copper and bronze in the Philippines was "brief and transitional" before iron appeared, this period was still necessary to give the early metal-smiths considerable time to experiment and discover the uses of iron. This period would also have been the stage for the innovation of iron technology.

2.3 Ethnographic and Ethnohistoric Data

In the Philippines, there are a number of ethnographic as well as ethnohistoric examples that illustrate how tribal peoples acquire metals for their own consumption. Most of these peoples have the knowledge of forging, smithing, steeling, etc. Suggestions have been made that their knowledge of metal technology was imported from Indonesia and Malaysia. Distinctions should be made here between the primary and secondary use of iron or any metal for that matter. The primary production of iron involves the knowledge of mining its ores, processing and smelting. On the other hand, the secondary use of iron
only involves the reworking of iron, such as smithing, forging and steeling.

Most of the above accounts were written in the early part of the 1900s, when it was generally believed that there were no clear traces of a prehistoric age of stone or copper in the Philippines (Jenks 1905; Barton 1922; Kroeber 1928). Kroeber (1928:114) particularly, notes that "even the Negritos, although they do not work metal, may be said to be living in an iron age condition, because they possess knives obtained in trade from their neighbors." There are no known ethnographic accounts of iron smelting in the Philippines.

Kroeber distinguished between societies with so little iron that its use was restricted only to finished products, and more advanced societies that possessed a greater abundance of the metal for processing and manufacturing tools and other types of implements. According to his distinction, the Negritos and other remote "pagan" groups belonged to the former, whereas the Tinguian, Kalinga, Bontok, Bagobo and Mandaya, all of whom are also pagans, had not only obtained iron but had learned how to work it as well. Kroeber further noted that

2. Pagan is a term used by the missionaries and early ethnographers to refer to non-Christian and/or non-Muslim Philippine tribal groups.
although these people knew how to work the metal, they did not obtain a sufficient supply to meet all their wants, so that iron and bamboo-tipped spears, for instance, were used side by side.

Kroeber also believed that iron technology was not native to the Philippines but was imported from Borneo, where it was already well developed earlier. He (Kroeber 1928:115-16) wrote:

At first, manufactured articles are likely to have been introduced; subsequently, the raw material was imported in trade, and with it the knowledge of working it. The operations of mining and smelting were not understood. In fact, very little advancement has been made in this direction through the past four centuries, probably because the islands seem to be naturally poor in iron ores. The mineral has been worked in Bulacan, but the mining here appears to be entirely post-Spanish. ... The Filipino smith always remained dependent on importation of his raw materials, and in this sense his entire industry may be described as a parasitic one.

Two comments regarding Kroeber's (1928) statement. First, McCaskey's (1903) report on iron mining, smelting and processing of agricultural tools in Angat, Bulacan suggests that it was pre-Spanish in origin and continued during the Spanish period. The mines and their operations were taken over by the Spaniards apparently without the proper cooperation of the indigenous population. Second, the Philippines is certainly not poor in iron ores as was argued by Kroeber (1928), since recent geological mining
surveys have shown that iron ore ranks fourth in value of production among Philippine minerals. Philippine iron ore has been exported to Japan, and varies in quantity from 1,000,000 to 2,000,000 tons annually (Wernstedt and Spencer 1967:253). Although there is an abundance of iron ore in the Philippines, the question is why iron technology did not develop early in Philippine culture.

2.3.1 Northern Luzon

Anthropologically speaking, Northern Luzon is one of the most explored and researched areas in the Philippines. Ever since the Spaniards colonized the islands in the last half of the sixteenth century, the attention of Western observers has been attracted by Northern Luzon because of its "exotic" qualities. This tradition was continued by American colonizers at the turn of the last century. There were several reasons for this. First is the attraction of the scenic beauty of the man-made environment, the rice terraces, and the mild temperate weather as opposed to the hot and humid tropical climate of the rest of the Philippines. The second reason is the diversity of ethnolinguistic groups inhabiting the area. Third is the seemingly exotic behaviour of the tribal peoples inhabiting this part of the country most of whom practiced at one time head-hunting or head-taking and a
variety of related activities. A number of American and European anthropologists have been involved with these different groups up to the present day.

2.3.1.1 The Bontoc-Igorot

One of the earliest exhaustive ethnographic accounts of any group in the Philippines was that of the Bontoc-Igorot (Figure 1.1) by Jenks (1905), who was the Chief of the Ethnological Survey, Department of the Interior, during the period of the American Government in the Philippines. Jenks (1905:114-15) believed that there was no "stone age" in the Bontoc-Igorot area, and wrote that "there are many vestiges of the wood age to-day; several show the use of wood for purposes usually thought of as solely within the sphere of stone and metal."

Jenks found that the Igorot had their own metal technology, in particular an iron and steel industry and a little copper and brass working. He noted that the village of Baliwang, which is situated about six hours north of Bontoc, made most of the metal spear blades used in the Bontoc area. Sapao, located about a day and a half to the south, made excellent metal blades, but they seldom reached the Bontoc culture area, although blades of inferior production from Sapao were found in Ambawan, the southernmost pueblo of the area. Jenks (1905:125-26)
described the smithies as follows:

Baliwang has four smithies, in each of which two or three men labor, each man in a smithy performing a separate part of the work. One operates the bellows, another feeds the fire and does the heavy striking during the initial part of the work, and the other—the real blade maker, the artist—directs all the labor, and performs the finer finishing parts of the blade production.

The smithies are about 12 feet square without side walls. They have a grass roof sloping to within 3 feet of earth, enlarging the shaded area to near 20 feet square. Near one side of the room is the bellows, called "op-op,'" consisting of two vertical, parallel wooden tubes about 5 feet long and 10 inches in diameter, standing side by side. Each tube has a piston or plunger, called "dot-dot';" the packing ring of the piston is of wood covered with chicken feathers, making it slightly flexible at the rim, so it fits snugly in the tube. The lower end of the bellows tubes rest in the earth, 4 inches above which a small bamboo tube leads the compressed air to the fireplace from each bellows tube. These small tubes, called "to-bong'," end near an opening through a brick at the back of the fire, and the air forced through them passes on through the brick to the burning charcoal. The outer end of the to-bong' is cut at an angle, and as the tubes end outside the opening in the brick, the air inhaled by the bellows, as the plungers are raised, is drawn from back of the fireplace—thus the fire is not disturbed.

The fuel is an inferior charcoal prepared by the Igorot from pine.

This bellows is found throughout the Archipelago and is evidently a Malayan product. It is believed that it came to Bontoc with the Igorot from their earlier home and is not, as some say, a Chinese invention. The Igorot manufacturer of metal pipes uses exactly the same kinds of bellows, except that it is very much smaller, and so appears like a toy.
Jenks (1905:126) also noted that much of the iron employed in the manufacture of Igorot weapons was bar iron coming from China to the Islands of Candon, in Ilokos Sur. However, the people readily made weapons from any iron they might acquire, greatly preferring the scraps of broken Chinese cast-iron pots, vessels purchased primarily for making sugar. In his choice of cast iron the Igorot exhibits a practical knowledge of metallurgy, since cast iron can be made into a good wrought steel. Cast iron can be transformed into a good steel by the process of decarburization otherwise, cast iron per se cannot be forged.

In this particular instance, then, cast iron was imported from China to Northern Luzon and processed by local smiths. This would mean that, although a local iron and steel industry might flourish, iron mining and smelting may never have developed. It would be valuable to know what part of China this imported iron came from.

2.3.1.2 The Ifugao

The Ifugao are among the best known groups in Northern Luzon (Figure 1.1), primarily because of their great construction of rice terraces and maintenance of dams and ditches with the use of only the crudest of tools. Moreover, earlier in the century it was said that among the
Ifugao, "head-hunting not only is permitted....; it is even an honorable pursuit" (Cole 1945:131).

Cole (1945:135) reported that the Ifugao possess iron tools and weapons such as spears, broad bladed knives, etc., but lack the head-ax. They also have ornaments made of brass like earrings, armlets, and leglets and pipes made of copper. All of these products are manufactured locally on the typical Malayan forge.

Barton (1922:426) notes that "long knives, spears, pots, and salt are articles of trade between districts" in the Ifugao area. Also, in western Ifugao, the Sapao people (the same people previously mentioned by Jenks 1905) act as middle men in the purchase of highly prized Chinese jars and gansas (gongs). This indicates the importance and complex role of trade involving metal. Local people like the Sapao, acting as middle men mustu have had some kind of notions on the things which were more or less among the metals being traded.

The most recent account on the Ifugao is the work of Conklin (1981). Conklin notes that iron forging with the use of the Malayan piston-type double bellow forge plays a major role in the current agricultural activities of the Ifugao. This is so because most of their agricultural implements are made of metal, i.e. iron and
steel. He is of the opinion that iron smithing is a later importation to the Ifugao but probably before the coming of the Spaniards.

The situation in the Ifugao area thus, is a well established local trade network between the Ifugao and other neighboring peoples who in turn may have already been trading with the Chinese for iron and other products.

2.3.1.3 The Tinguian

The Tinguians occupy the lower mountain territory of northwest Bontoc, Northern Luzon. Their stronghold is the province of Abra, although they extend into Ilocos Sur and Ilocos Norte. Along the border of Ilocos Sur and in Southern Abra are several Igorot villages made up of immigrants from the Bontoc and Sagada regions (Cole 1922; 1945:149).

At least during the 1920's when Cole was conducting his fieldwork, he observed that there was little iron work done in the Abra valley. This was because of competition with the Ilocano smiths of Santa and Narvacan in Ilocos Sur, and the cheap products brought by Chinese traders from the coast, to as far inland as Bengued. These traders had swamped the native industry (Cole 1922:413). He noted that forges were still found in many villages of eastern Abra,
particularly those of the upper Buklok river, but the real center of the industry was around Balbalasang, on the eastern side of the mountain range.

Cole believed that iron-working had long been known, not only in the Philippines, but throughout Malaysia, and that it was evident that these regions secured the art from the same source as did the people of Assam, Burma, and eastern Madagascar. He felt this was true because the description of the Tinguian forge and iron-working applied equally well in Southern Mindanao, Borneo, Java, Sumatra, Assam, Burma, and Madagascar, with very little modification. He attributed the development of iron technology to a Southeast Asian origin, although he noted that:

Long before the arrival of the Spanish in the Philippines, the Chinese had built up such a lively trade in iron bars and caldrons that it was no longer necessary for the natives to smelt their own iron ore; if indeed they ever did so. This trade metal was widely distributed, and then reworked by the local smiths. Even to-day the people of Balbalasang make the long journey to Bengued, or even to Vigan, to secure Chinese iron, which they carry back to their mountain forges (Cole 1922:413-14).

Cole stated that there was no positive proof that the Filipinos formerly mined and smelted iron, but that there was a strong probability that they did so, prior to the introduction of metal trade. He held this opinion, because deposits of magnetite and hematite ore found in
Abra, in Ilocos Norte, Angat, Bulacan, Albay, and other parts of the Islands were abundant. Thus, locally produced iron might have supplied the needs of many Philippine tribes, including the Tinguian. Cole (1922:414-15) noted that "on several occasions, when on the trail, the natives have called our attention to boulders, apparently of hematite, which they recognized as iron." He also argued that it seems probable that the whole industry had a common source somewhere in Southeast Asia, and was spread or carried as a unit. However, when trade relations with the Chinese who brought smelted and cast iron bars to be worked locally by the natives, developed the arduous tasks of mining and smelting became unnecessary, and were quickly given up.

Cole (1922:415) describes the Tinguian iron-workers in the following:

The smithies are small structures with grass roofs, but no sides or floors (Plate LXII). At one end is a raised bamboo bench in front of which stands the forge. This consists of two upright wooden cylinders, usually logs hollowed out, known as po-opan. In each of these is a piston plunger (doEydoyog) at the lower end of which is a wooden ring packed with corn husks and chicken feathers. When this is pushed downward in the cylinder, it compresses the air and forces it out of the opening in the base, but when it is drawn up, the packing collapses and allows the

plunger to be raised without effort. These pistons are worked so that one is rising, while the other is falling. The cylinders stand in a wooden block out of which bamboo tubes (tulongan) conduct the air into a tube of fire clay (ibong), and this in turn carries it into the charcoal fire. There are no valves, as in the Chinese bellows, but the bamboo tubes fit loosely, and the fire is not drawn back. Near to the hearth is a stone anvil (dalisdisan), while a heavy stone hammer, a small iron hammer, and iron pinchers complete the outfit.

The fire is lighted, and the operator sitting on the bench alternately raises and lowers the plungers in the cylinders until the fire burns brightly; then the smith puts metal into the coals and allows it to remain until it reaches a white heat. It is then removed and placed on the anvil, where his helper beats it out with a large hammer. This is a stone weighing twenty or more pounds, fitted inside the handles so that it can be used with both hands. As a rule, it is swung between the legs, and is allowed to strike the metal as it descends, but some of the men raise it above the shoulder and strike a much more powerful blow. If two pieces of metal are to be welded together, as is often the case when broken caldrons are used, they are laid, one overlapping the other, and are held together with a damp fire-clay. In this condition they are placed in the fire and heated, and are beaten together. It often takes several firings to bring about a perfect weld.

After the initial shaping, the smith completes the work with the small hammer, and the blade is ready for tempering. A bamboo tube of water is placed near by, and the blade is again inserted in the fire and brought to a white heat. The smith withdraws it and watches it intently until the white tone begins to turn to a greenish-yellow, when he plunges it into the water. The tempered blade is now smoothed down with sandstone, and is whetted to a keen edge. Head-axes, spear-heads, adzes, a few knives, and the metal ends for the spear-shafts are the principal products of the forge.
2.3.1.4 The Nabaloi

According to Moss (1920:211), the Nabaloi are an Igorot group, living in the southern part of the sub-province of Benguet, the most southerly part of the territory occupied by the Igorot. On the south of the territory inhabited by the Nabaloi is Pangasinan and Ilocos—both provinces inhabited by Christian Filipinos. On the southeast is Nueva Viscaya, also largely an Ilocano province; but the township of Kayapa, which borders Benguet, has a mixed population of Nabaloi, Kankanay, and a subgroup of Igorot called Waks, which consists of only a few members.

Moss (1920:225) noted that the Nabaloi do less blacksmithing (salbit) than the northern Igorot, and their work is not as good. The tools used are of the simplest kind. A large stone (salbitan) fixed in the ground serves as an anvil, and the hammer is also of stone. The handle consists of two pieces of wood fitted into grooves on opposite sides of the hammer and held in place by rattan. Two vertical parallel pieces of bamboo, each with a wooden plunger wrapped with chicken feathers, serve as bellows (vabyab).

With this crude equipment the following tools are made:
An ax (guassay) about six inches long and two inches wide at the cutting end. The other end of the blade is hammered square and fitted into a hole burned into a wooden handle. This is the only instrument the Nabaloi have for heavy cutting.

An adze (chumpag) which is a little shorter but slightly wider than the ax. The blade is fitted into the handle in the same way. The adze is used for smoothing house timber.

A long heavy knife (atak) or bolo with a wooden or horn handle held in place by a network of rattan strands. It is carried in a wooden sheath which is fastened to the body with a belt. The bolo is used for light cutting, or instead of the ax when the latter is not available.

A hand spade (sankab) consisting of a long flat piece of iron about one and a half inches wide at the cutting end. The other end is square and fits into a wooden handle which has been made hollow by burning. It is strengthened by a network of bejuco. The hand spade is the principal tool used by women when doing agricultural work.

A small knife (taad) with a fixed blade, used for peeling camotes, making baskets, and other light work.

A very crude spear (gayum) is sometimes made by Nabaloi blacksmiths, and occasionally a ploughshare (Danchok ni aracho) to be used on the old Filipino one-handled style of stock (Kayo ni aracho); but more often these are imported (Moss 1920:225-26).

Moss (1920:226-27) found that there was a limited amount of gold mining done by the Nabaloi, and that the panning process was used. Quartz was first pulverized and then worked as placer. The towns located in the mining section sometimes pay in gold dust (balitok). When the Nabaloi sell their products, they are paid in money
(pilak), copper (gambang), pots, and gold dust. The Nabaloi were buying cotton cloth, blankets, salt, tobacco, hogs, and dogs from the neighboring lowland provinces of Pangasinan and La Union.

2.3.1.5 The Zambales Negritos

The province of Zambales (Figure 1.1) is not a part of northern Luzon, but but it is included here because this is where the northern Negritos (as opposed to the Agta) are located. The Negritos are found in scattered groups throughout the Zambales Mountains, a range paralleling the southwest Luzon coast and occupying most of the Zambales Province, together with contiguous portions of Tarlac, Pampanga, and Bataan (Lebar 1975:26). Those in the Mt. Pinatubo region of southern Zambales have been intensively studied by Fox (1953). According to Fox:

among the Pinatubo, blacksmithing is easily the major craft specialty. A great variety of arrow points, bolos, and even crude shotguns are made locally, utilizing the "Malayan" bellows. Smiths and smithing are subject to taboos and ritual behavior not found among the lowland Sambal (in Lebar 1975:26).

It is said that forest products like beeswax, and tobacco were traded to lowlanders for cloth, salt, pots, metal, and rice. Metal arrow points, manufactured by the Pinatubo smiths, were traded to other Negrito groups throughout the Zambales Range.
2.3.2 Southern Luzon

There is not much in the way of ethnographic or ethnohistoric information on Southern Luzon except for the Hanunoo (Mangyans). However, archaeological investigations have shown that there were a number of sites where prehistoric and protohistoric iron artifacts are found in this region (Janse 1941; 1944; 1946; Beyer 1947; Tenezas 1964; 1968; Dizon 1979a; 1979b).

2.3.2.1 The Hanunoo

The Hanunoo represent one of the ethnolinguistic groups collectively known as the Mangyans who live on the island of Mindoro, the seventh largest island in the Philippines, approximately one hundred sixty-odd kilometers south of Manila (Figure 1.1). There are at least eight groups of Mangyan who are all "pagan" mountaineers, but who speak mutually unintelligible languages, have little direct contact with each other or with the coastal Christians, and who are loosely organized politically.

According to Conklin (1957:64), Hanunoo occasionally make a journey into the lowlands to work at menial domestic or agricultural tasks for Christians in order to obtain beads, metal objects, or red cloth in
barrio and village stores. He notes too that:

Hanunoo men use the Malayan piston bellows type of forge (pandayan) to reshape or retemper old steel blades or to cut, shape and temper new blades for bolos, spears, chisels, and knives of various sizes. At this stage the production and repair of slashing bolos is perhaps the most important activity aside from, but directly connected with, swidden clearance. For a day at the forge, two men may spend three of four days collecting and burning the heartwood of sapotaceous coastal tree bansalagun (Minusops parvifolia R. Br.) to make charcoal. Inferior but usable substitutes for bansalagun are — in order of decreasing quality — the green branches of the trees ?agaspang (Brennia cernua [Poir.] Muell.-Arg.), ?analib (Drypetes sp.), and barayung ?urungen (Cassia fistula L.). Once the charcoal is ready, and the required tools and metals have been assembled, two or three men procure the water needed for tempering and spend a day in the settlement where the forge is located. In any area the size of Yagaw, there is usually at least one forge. In 1953, the nearest one to Parina was at Tarubung [Plate 8] (Conklin 1957:55).

Conklin observed that different types, shapes, and sizes of bolos or knives have various functions. He (Conklin 1957:56) wrote:

Hanunoo bolos, of more than 15 styles, consist of single-edged, single-beveled blades, 40 to 50 centimeters long, maximally 4 to 8 centimeters wide, and about 0.5 centimeter thick at the base; hafted and sheathed in smooth-grained woods such as balanti? (Kleinhovia hospita L.), hafting is made secure by cementing the tail of each blade with the gummy sap of the moraceous tree kubi-gubat (Artocarpus sp.) and by adding tight woven binding rings of finely stripped ?uway (Calamus sp.). Style, size, and weight of bolos are determined not only by the sex and age of the user but also by the kind of agricultural work envisioned. For slashing light underbrush and for most spreading and notching, shorter, thinner blades are preferred; blades of larger and
heavier dimensions are better for cutting heavier timber and for lopping (Figure 9, a). The bevel is always on the underside when making a normal side stroke; hence the bevels on right- and left-handed bolos are reversed.

Bolos break or crack more often at the gamasun-making stage than during the rest of the year. Therefore, the Hanunoo adult usually has at least one, and more often three or four spare blades stuck behind the slats of his house wall ready for hafting and use if needed. Much time is consumed in the daily sharpening of bolo blades, and in rehafting, and repair of damaged cutting equipment. Some of this work is done at the swidden site, during breaks. A good sharpening stone is taken to a new swidden site where it may be kept in almost constant use.

2.3.3 The Bisayas

The Bisayas (sometimes spelled Visayas) consist mainly of Samar, Leyte, Bohol, Cebu, Negros, Panay, and Masbate Islands, encircling the Visayan Sea in the central Philippines (Figure 1.1) at approximately 10-12 degrees North (Lebar 1975:70). There has been much speculation concerning the name Bisayas for these islands and their coastal inhabitants, most particularly with respect to a possible historical connection with the people of the same name in the Brunei Bay area of northern Borneo. Others have seen in the same evidence for a relationship with the tenth-century kingdom of Srivijaya, centered on Sumatra. Although it does not appear that Srivijaya or the Javanese kingdom of Madjapahit which overlaps with and continues later than Srivijaya ever exercised other than nominal
hegemony in the Philippines (Rausa-Gomez 1967), the indirect influence of these early Hinduized centers is evident throughout the southern islands in respect to such things as religious nomenclature, mythology, and writing (see Kroeber 1918; Benedict 1916). It appears that Brunei was an important entrepot under both Srivijaya and Majapahit and that it was most likely Hinduized and (later) Islamized Malayans of Brunei descent who colonized the coastal estuaries of Panay and the neighboring islands, laid the foundations of the pre-Spanish Bisayan culture described in the accounts of the earliest explorers (see Santaren 1956; Bewsher 1956; Carroll 1960).

The present population of the Bisayan islands is made up of remnant Negrito or Negrito-like groups in the foothills of Panay and Negros, generally referred to as Ati or Negritos; scattered groups of swidden-farming, Proto-Malay hill tribesmen, chiefly on Panay and Negros and generally referred to as Bukidnon; and the numerically superior and politically dominant lowland Christian Filipino population, referred to generically as Bisayans and by speech categories as Sugbuhanon (Cebuano); Hiligaynon (Ilongo, Panayanon); Waray-waray (Samar-Leyte, Samarenyo); Aklan (Aklanon); Hantik (Antiquenyo, Hamtikanon, Pantikanon); Hiniraya (Kiniraya, Binukidnon); Banton, etc. (Lebar 1975:70-71).
As mentioned, there are other peoples in insular Southeast Asia who also call themselves Bisaya (alternatively, Bisayah, or more rarely, Basaya); they generally inhabit the lower or middle reaches of those rivers in Northern Sarawak and Western Sabah that flow into Brunei Bay (Lebar 1972). In Brunei, the term is often applied to closely related groups (Orang Bukit, Dusun, Tutong Dusun) on the Tutong river (Bewsher 1959; Harrisson 1962b; Peranio 1972:163). Leach classifies the Bisaya as Para-Malay. Thus, the Muslim Melanau and Kedayan rate as Malays, as do "about half of the Bisaya-Bukit group in Sarawak" (Leach 1950:33).

According to Peranio (1972:164), the Bisaya of Borneo never had the knowledge of the arts of forging and smelting metals, they lacked the loom, and apparently had no knowledge of pottery-making. Their clothing was originally made of bark, and their carpentry and wood carving skills were well developed. He reports that the Bisaya formerly traded exclusively with the Malays, providing sago, rice, and jungle products in exchange for such things as cloth, earthenware, glazed ceramics, brassware, silver objects, and metal tools. Nowadays such trade is almost exclusively in the hands of the Chinese. Trade with upriver groups is on a small scale; occasionally, Bisaya provide such products as camphor,
dammar resin, and rice (to the Muruts, Kelabits, and more recently the Iban) in exchange for large "war boats" and salt.

Although we do not have any complete or detailed ethnographic and ethnohistoric accounts regarding the presence of metal and/or iron technology among any group in the Bisayas, they have been included in this subsection because the bulk of the iron artifacts that are subjected to analysis in this paper come from the Visayan or the central Philippine region. archaeologically, the Bisayas is a very interesting area because of its inter-island situation, which has always been conducive to the movement of peoples and to interaction and trade. There is very little information regarding the origin of these people, where they came from, why they moved to these islands, and how they settled there. Claims have been made that there might have been iron mining and/or smelting sites in Cebu (Hutterer 1973a), and in the island of Negros (Tenazas 1973; 1974). However, to date, there have been no further archaeometallurgical investigations on the archaeological evidence found in these sites.

If the suggestion that the present peoples of the Bisayas were originally from Northern Borneo is true, then how can one account for the presence of iron mining and/or smelting sites in Cebu and Negros if, as Perinio
(1972:164) said, "the Bisaya never had the knowledge of the arts of forging and smelting metals?"

2.3.4 Mindanao

Lebar (1975:31) notes that protohistoric Mindanao (Figure 1.1) appears to have been inhabited by peoples of a primarily generalized Malayan stock, speaking languages related to those found elsewhere in Insular Southeast Asia. According to him, there was some evidence of an earlier Negrito strain among modern tribes inhabiting the hillsides, predominantly among the Mamanua, but this population must have been relatively small and rapidly absorbed by later arrivals who drifted in, probably via Borneo and the Sulu Archipelago. The indigenous cultures would seem to have been characterized by a relatively high degree of homogeneity, in part, due to the earlier Hindu influences, and in general, conforming to the reconstructed lowland cultures of Tagalog and Bisayan peoples at the time of the first Spanish contact (see Benedict 1916).

Despite supposedly close linguistic connections between the southern Philippines and northern Borneo and Celebes, cultural similarities do not appear to be of the type that would reflect protohistoric migrations in either direction (see Cole 1913). Today the majority of indigenous cultures on Mindanao are virtually extinct or fast
disappearing under the impact, first, of Muslim institutions, but, most profoundly, as a result of the wholesale immigration of Christian Filipinos from the north that has accompanied the proliferation of government-sponsored resettlement schemes and economic development programs, beginning as early as 1913.

2.3.4.1 The Subanun

The Subanun are "pagan" shifting cultivators in the interior of Zamboanga, the large mountainous peninsula of western Mindanao. Christians, Muslims, and other "pagans" of Zamboanga use words such as suban'on or subanen to designate any interior-dwelling groups. These terms have the common meaning of "up-stream people." The peoples so designated represent a distinctive cultural and linguistic group, with a common original language and culture (Frake 1957). According to Frake, Eastern and Western Subanun form a subgroup of the Central Philippine language group (see Eggan et al. 1956).

According to the ethnographic accounts, the Subanun trade iron, and iron is forged locally to make knives and other tools. Christie (1909:40) noted that the traditional wealth, formerly traded from the coast, consisted of old Chinese jars, gongs, brass cannon, and cloth.
2.3.4.2 The Maranao

The Maranao are traditionally centered around Lake Lanao, the largest deep-water lake in the Philippines, at an elevation of 670.56 meters and within the western segment of the fertile Bukidnon-Lanao Plateau, western Mindanao. It has been reported that the Maranao used the lost wax process to produce brass jars, containers, and musical instruments. Iron was forged, and gold and silver were worked. It was said that there was no marked social advantage or disadvantage attached to metal working, although there were remnants of associated taboos (Mednick in Lebar 1975:36).

It was observed that with the decline of local markets, peddlers had extended their activities, and small groups of itinerant Maranao were to be found in almost every major market in Mindanao, either buying, or selling, or both. This was said to be a continuation of an old tradition, wherein traders moved between the "pagan" hill peoples and the coast, which was the source of valued objects like metal, porcelain, weapons, etc., coming from greater Malaysia.
2.3.4.3 The Cotabato Manobo

According to Maceda (in Lebar 1975:45) the central portion of Cotabato's southwestern highlands, behind the coastal towns of Kalamansig, Lebak, and Kraan, is occupied by scattered settlements of "pagan" hill tribesmen — referred to as Manobo or Tudag by Maguindanao in the surrounding lowlands, and Duslangan by the Tiruray, their highland neighbors to the north. It was said that the Manobo in this part of Cotabato have undergone considerable culture contact, which explains the presence of metalworking among them. Thus it was observed that they have blacksmiths who made blades and spear points. Anklets and bracelets of silver and bronze were made by the lost wax process and these items were traded with the other Manobos and with lowlanders.

2.3.4.4 The Coastal Bagobo

Bagobo in a linguistic sense refers to a language group known also as Bagobo within a larger family of languages called Manobo, which has its greatest degree of differentiation within the central Mindanao highlands (Lebar 1975:58). Beyer (1917:38) has observed that the Bagobo were the most extensively ornamented people in the whole of the Philippine Archipelago. Their woven hemp cloth and items
of clothing were decorated with embroidery and beadwork and these were widely traded. The smithies were hidden from public sight among the fields and these produced fine work in brass, bronze, and iron. The Bagobo knives were famous, as were the small bells cast by lost wax process by melting down pieces of old bronze gongs of Chinese origin.

The Bagobo had well established trade with the neighboring Bilaan, Tagakaolo, and Ata peoples. Hemp, knives, and bells were traded to the coast in return for beads, shell discs, and salt. It was said that wealth was calculated in terms of rice, sugarcane liquor, gongs, jars, antique spears and swords, finely woven and decorated textiles, and girdles and arms and leg bands of brass and copper. Gongs, especially the old ones, were highly valued because they served as standard units of barter in trading valuable objects and calculating large debts and marriage payments (Benedict 1916:84).

2.4 Iron Mining and Smelting in Bulacan

The only known report on early iron mining and smelting in the Philippines was done by H.D. McCaskey in 1903. This report was primarily a geological reconnaissance of the iron region of Angat, Bulacan. McCaskey was a
mining engineer then at the Mining Bureau of the Philippines. He wrote that the mineral industry of Bulacan was confined to the mining and smelting of iron, the washing of the sands of the mountain streams for gold, and the calcining of limestone (McCaskey 1903:43).

In connection with this subject McCaskey had quoted at length the following from Abella who says, in his "Brief Sketch of Mining in the Philippine islands," published in Madrid in 1883:

Next to gold this metal (iron) is one of the earliest exploited in the Philippines. There exists abundant deposits of it, the best known being situated on the western flanks of the central mountain range of the Island of Luzon.

Those deposits in the district of Morong were, in reality, first exploited for the purpose of manufacturing munitions of war; and presently those of San Miguel de Mayumo, and those of Angat, in Bulacan were exploited for the manufacture of mountain knives (bolos), plowshares, and kitchen utensils. These articles were of excellent casting and quality, and were purely for local consumption.

It is interesting to note that at the time of McCaskey's visit, there was a Chinese ironmaster, named, Ong-Sayco, who had worked in the Bulacan smelters for over thirty years and who was then, the "maestro" in charge of the new Constancia smelter, solicited on March 21, 1873. Would this imply even at this late date that iron technology was also being imported from China?
McCaskey (1903:57) wrote that:

During my visit he (Ong-Sayco) complained that we Americans overpaid native labor throughout the Islands and that the native employers with limited plants could not compete for labor. As it is he must blow out his furnace from time to time to put his limited force to cutting timber for charcoal, to the making of molds, tuyeres and other supplies, and to general repair work. He estimated four months' smelting a year as good, that is, producing from 2,000 to 3,000 pairs (a pair = 1 plowshare and a point) each month, four months, as medium, or producing from 1,500 to 2,000 pairs, and four months, during which time the furnace is largely out of blast, as poor, or producing from 800 to 1,000 pairs.

McCaskey (1903:58) provides the only statistics available of iron production in Bulacan. The information is for the year 1884 and was furnished by the governor of Bulacan on February 4, 1886.

Table 2.1

Statistics of Iron Production In Bulacan, 1884  
(After McCaskey 1903:58)

<table>
<thead>
<tr>
<th>Pueblos</th>
<th>Number of Furnaces</th>
<th>Number of Plowshares</th>
<th>Number of Operatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Miguel -</td>
<td>3</td>
<td>20,000</td>
<td>25</td>
</tr>
<tr>
<td>San Miguel -</td>
<td>2</td>
<td>10,000</td>
<td>10</td>
</tr>
<tr>
<td>Angat - - -</td>
<td>2</td>
<td>12,000</td>
<td>18</td>
</tr>
<tr>
<td>Angat - - -</td>
<td>1</td>
<td>8,200</td>
<td>14</td>
</tr>
<tr>
<td>Angat - - -</td>
<td>1</td>
<td>8,200</td>
<td>14</td>
</tr>
<tr>
<td>Total - -</td>
<td>9</td>
<td>58,400</td>
<td>81</td>
</tr>
</tbody>
</table>

Table 2.1 provides us an idea of the plowshare production by a small scale industry. The total of 58,000 plowshares produced by 9 furnaces in 81 operations in a
year is not bad at all for a small society. Imagine how much recycling and reworking can be done on these 58,000 plowshares. Moreover, this does not count yet the iron points mentioned along with the production of these plowshares as pairs.

According to McCaskey (1903:44) the earliest record contained in the Mining Bureau with reference to iron mining bears the date December 12, 1781, and is the letter-order of instructions to the "governor of Angat" through the governor of Bulacan from the Superior Government of Manila, to render every possible assistance to Chaplain Don Juan Belli, of the Royal Armada, in the working of his mine. The implication of this is the iron mining had been in existence prior to 1781. Precisely how much earlier what time will not be known unless archaeometallurgical investigation is conducted in this area of Bulacan. As it has been noted by McCaskey there was evidence of ancient iron working in the area.

McCaskey (1903:53) claimed the metallurgy of iron is confined entirely to Bulacan. At the time of his visit to Angat, there was one blast furnace in operation. Smelting and casting was done in one area. Mining was done on an eroded exposed surface deposit at the mines and because of very limited needs, there was no need for deep shaft mining operations.
Concerning the operation of the mines, McCaskey (1903:55) noted the few tools required, such as pokers, stirring rods for the furnace, and ore hammers and picks for the ore beds, and these are all of wrought iron.

**Ore Preparation**

The ore beds are worked, as I have mentioned, in the open and in the most primitive manner. No system whatever is followed, save the very rudest methods of "stripping" and quarrying. The ore being broken down by means of crowbars, picks, and small sledge hammers, is carefully hand sorted and carried by cargadores to the smelter. Here it is reduced to a uniform size of about 1 1/2 by 1 1/2 by 1 1/2 inches by means of a small cube-shaped hammer having four breaking edges (Ibid.:55).

**Charcoal Fuel**

The charcoal is burned nearby by the smelter men, who cut the forest tress of the third, fourth, and fifth groups for the purpose. They make an excellent quality of well burned charcoal, and to this valuable fuel much of the success of the native smelters is due (Ibid.:56).

**Reduction Process**

The process of reduction is comparatively simple as the ore is self-fluxing and the fuel is very pure, there being no fluxes required whatever, save from the boga rock above mentioned. This reduction is caused by carbon monoxide which is itself produced by the carbon dioxide of the burning fuel coming into contact with the hot charcoal (Ibid.:56).

**Production**

The slagging of the silica and alumina with a certain proportion of the iron is rapidly formed and escadores (slagmen) draw off the slag every
two or three minutes when the furnace is working well. The pourings are made every two or three hours. The pouring pot is filled, and the maestro passes down the line of molds, with the pot of molten metal upon which floats a cover of burning charcoal; and he rapidly fills mold after mold. The remaining metal is returned to the hearth. As rapidly as the castings harden in the molds the latter are taken down and opened, the castings thrown out, and the surfaces of the molds are lined with paint and prepared for another pouring. About 15 molds are in constant use by one furnace in good running order, 8 of these plowshares and 7 points. ... The plowshare of the largest size weighs 4 9-10 pounds.

According to McCaskey (1903:57), the laborers required for one furnace are almost as many as for two. The group is composed by 2 maestros or foremen, who have general charge, 1 escribiente, or clerk, 2 escoradores, or slagmen, who also act as brajenantes, or molders, 4 heladores, or blowers and from 4 to 7 othe common laborers who obtain to prepare the ore and fuel.

2.5 Summary

In this chapter the general orientation of Philippine archaeology and prehistory has been discussed. Basically the traditional European three-age system has been followed in the Philippines, as in the rest of the Old World. Because of the discrepancy between artifact types and the dating of the sites, typology and chronology can be confusing. For example, flake tools are said to be of the
Palaeolithic tradition, dated to the Upper Pleistocene up to approximately 8,000 B.C. in the Philippines. However, there are marginal groups even to this present age who still utilize flake tools. The same is true with regard to the Iron Age. Whenever artifacts of iron are located in any archaeological site, the site is generally categorized as belonging to the "Iron Age" which is approximately dated to begin around 200 B.C., because this was the earliest date found by Fox (1970) for the appearance of iron and taken to mark its first introduction into the Philippines. This assumption is reassessed in later discussion.

It has also been noted in this chapter that there are ethnographic as well as ethnohistoric accounts on the secondary use of iron and its technology in the Philippines. Only McCaskey's (1903) report accounts for the primary extraction of iron through mining and smelting processes as well as production of agricultural implements. This information may be of help in attempts to reconstruct the use of iron in prehistory. It appears that there is a pattern emerging of how iron was being worked and supplied among the ethnic groups surveyed. Iron in the form of raw material was supplied by the Chinese traders, and this was forged locally by native blacksmiths, who used the "Malayan" type of forge with a double piston cylinder bellows. The question is where did this "Malayan forge"
come from and how long has it been used in the Philippines. With regard to ancient mining in general, does the ethnographic situation reflect the prehistoric pattern in the Philippines?
Chapter 3

A REVIEW OF THE APPEARANCE OF IRON IN THE OLD WORLD

This chapter is a review of the appearance of iron in the Old World. It would perhaps be best to examine first the meaning of the term "Iron Age" since this has so often been used in the archaeological literature. In 1980, Wertime and Muhly published an edited volume, entitled The Coming of the Age of Iron the main purpose of which was to give an explicit metallurgical and pyrotechnological context to the term Iron Age. They commented that:

In 1819 Christian Thomsen first proposed the three-age system of Stone Age, Bronze Age, and Iron Age. But in the twentieth century the term Iron Age has become more and more associated with pottery types and related artifactual aspects of civilization. It accordingly has become less and less associated with the metal iron (Wertime and Muhly 1980:xiii).

What does the term "Iron Age" really mean? Authorities in archaeology like Daniel (1977) and Bray and Trump (1976) have given no definite assigned meaning to the phrase "Iron Age." All that has been said is that the Iron Age is signaled by the appearance of iron in the archaeological
context, and then they go on to describe this phenomenon from site to site throughout the regions of the world. At least Snodgrass (1980), in the volume mentioned above, has defined his criterion of "working iron", that is, forging the "iron used to make the functional parts of the real cutting and piercing implements that form the basis of early technology" (1980:336). Using this criterion of working iron he discerned three broad stages in the development of an iron technology, which according to him, are applicable to Eurasia and the Mediterranean. He wrote:

In stage 1, iron may be employed with some frequency, but it is not true working iron according to the definition given above. In the main, its employment is for ornament, as is appropriate for the expensive commodity which we know it to have been in many cases. But this ornamental use must be extended to cover objects that have the outward form of real weapons and tools, yet whose circumstances reveal that they played no practical role. Iron-bladed daggers are worth mentioning specifically because of the time-honored use of the dagger as a prestige object, a component of "dress uniform," and the consequent tendency to choose materials for their costliness rather than their effectiveness.

In stage 2, working iron is present but is used less than bronze for implements of practical use.

In stage 3, iron predominates over bronze as the working metal, although it need not, and usually does not, completely displace bronze even in this role (Snodgrass 1980:336-7; see also Pleiner and Bjorkman 1974).

Nevertheless, as has been mentioned in the previous chapter, the Iron Age can often be a continuation of the
Bronze Age with the main distinction that tools, weapons and implements, which were previously made of bronze, are replaced by iron. Thus, this whole period can be described collectively as the Metal Age, an age anthropologically associated with the concepts of expanding population and the establishment of new settlements, such as villages, towns, and cities. It seems that this period was often marked by invasions, conquest, and warfare between groups of people and these events were related to the phenomena of increasing social and political complexity and stratification. The latter is also associated with an expansion of both local and long distance trade economies. Viewed from this vantage point, a question arises regarding areas for which there is no evidence of a separate Bronze Age but where iron is introduced at some point. Is it justified to speak of an Iron Age in such cases? In the regions of West, East and South Africa, it is claimed that there was no Bronze Age, and the transition of technology was from lithic to iron (Van der Merwe 1980). Likewise, in the Philippines (see Chapter 2) where a number of archaeologists including Evangelista (1962), Fox (1970), Legaspi (1974b), Peralta (1977), and Solheim (1981) have, on the one hand, denied the existence of a true Bronze Age and yet, on the other argue for the presence of a true Iron Age.
Questions may be raised regarding the validity and nature of the term *Iron Age* when applied archaeologically to various areas of the world. Does the term properly connote a particular period only in the culture-history of regions such as the Near East, Europe, and India? In these areas the classic sequence of a Stone Age, Bronze Age and Iron Age seems to be applicable and entails the local appearance, development, and use of iron technology. This assumption can prompt the question, "where was the earliest instance of the development of iron?" Consequently, a diffusionist outlook can arise with regard to the distribution of iron artifacts and iron technology throughout the world. In this view, iron technology would be seen as diffusing from a "center" or even "centers" of iron production.

Or does the term *Iron Age* mean simply an archaeological stage in the socio-cultural and historical development of any group of people? Perhaps it is better to describe the various cultures having iron artifacts and iron-technology as *iron-using* or metal-using societies (for whatever metal they utilize), rather than classify them as Iron Age people.
3.1 The Development and Iron-use in the Old World

In this section, we must first distinguish the different forms and types of iron. There are, in regard to origin, three forms of iron. First, there is meteoritic iron which is a kind of iron coming from the sky. It is a workable form of iron and there is ample archaeological evidence that meteoritic iron was used by early people (Knauth 1974; Bjorkman 1973; Waldbaum 1980). Meteoritic iron is often distinctive and detectable because of its high nickel content, however recent work by Reed Knox (1987) brings this into question. Second, there is telluric iron, which is a native form of iron containing a small amount of nickel, cobalt, copper, and carbon. It is very rare and found mainly on Disco Island, Greenland (Buchwald and Mosdal 1985). Wertime (1980:11) notes that "some believe that this 'telluric' iron was extruded in volcanic magma from deep in the earth." Last we have smelted iron, which is the subject of this paper. This is a form of iron made by man from iron-rich ores like magnetite, hematite, limonite, etc. When we talk about iron, we refer to the smelted form. Smelted iron can be produced in two major forms; wrought iron via the direct or bloomery process (Van der Merwe and Avery 1982) and cast
iron via the blast furnace (Hodges 1976). These alloys differ primarily in the amount of carbon they contain.

It has been argued that the discovery, development and use of iron evolved from an earlier knowledge of bronze technology. The Bronze Age setting gave the ancient smiths enough pyrotechnological experience to experiment with different kinds of metals and their ores (Maddin, Muhly and Wheeler 1977; Muhly 1980; 1982; Wertime 1980; Pigott 1981; 1982b). For instance, Wertime (1980:13) writes that:

...the working of iron was an inevitable technical by-product of copper and lead smelting anticipated by the pyrotechnologic uses of iron ... Iron was directly involved as a flux in the development of consistent techniques of smelting silicious ores of lead and iron.

These views imply that: 1) one must have previous experience in copper or lead smelting before one can discover the technology for smelting iron; 2) in order to investigate the phenomena relating to the appearance of iron, one must look into sites documenting the earliest copper and/or lead smelting and working; and 3) because of the complexity involved in the working of these metals and the skills and knowledge of pyrotechnology it involves, it is inevitable to suggest that metallurgy could only have been invented once, and its technology must have diffused from the place of origin, the Ancient Near East, for example.
The question is, what if there was no previous experience in the smelting of copper or lead in a region where iron occurs, is it still possible then, to discover and work on iron? Could iron be independently discovered and worked as a metal? Can iron smelting be done without a prior knowledge of copper smelting?

3.1.1 The Near East and Eastern Mediterranean

One very likely source of early iron technology, if one follows a diffusionist view, is the ancient Near East, which has yielded the earliest evidence of metal working including that of iron. It stands, therefore, as the classic example of the technological transition from stone working to copper, then bronze, and finally to iron. It is generally accepted that in this region the successful smelting of iron ore was achieved as a result of the earlier and longer tradition and experience of smelting copper and bronze. Iron first appears in the archaeological record of the Near East at sites such as Alaqa Höyük, in Anatolia; Chagar Bazar, in Syria; and Tell Asmar in Iraq towards the middle of the 3rd millennium B.C. (Daniel 1977:115; Walbaum 1980). But these are isolated and rare occurrences of the metal as a decorative, high status material. It is not until the later centuries of the 2nd millennium B.C. that we see iron occur in any quantity.
Waldbaum (1980:69-70) contends that the earliest smelted iron find date ca. 5000 B.C., recovered from Grave A at Samarra in northern Iraq. This object is a four-sided instrument with a preserved length of ca. 4.30 cm. It is not clear if it is meteoritic iron. Table 3.1 shows a chronological order of the earliest iron objects found in Mesopotamia. Waldbaum's dates for these artifacts are those used in the following discussion, not those of the original excavators. Mallowan (1936:26-27) presented the early evidence of man-made iron found at Tell Chagar Bazar in North Syria in level V ca. 2450-2340 B.C. Two fragments of iron were later found from level III with the same date (Mallowan 1937:98). Frankfort (1950) has also reported an iron blade with a bronze hilt found at Tell Asmar in Iraq which was dated between ca. 2450 and 2350 B.C. Starr (1937:125) documented a bronze blade with an iron hilt from Yorgan-tepe (Nuzi) from the Hurrian Period, ca. 1600-1375 B.C., and a fragment of iron from Mari near the remains of the pre-Sargonid temple of Ishtar and the iron tools and weapons of the Kapara period from Tell Halaf provide the evidence of the use of iron in the second millennium B.C. in Iraq (see Forbes 1950:446). By the time of the Neo-Assyrian Empire and its great king Sargon II, ca. 721-05 B.C. iron had come into fashion, and iron artifacts were found in large numbers.
Table 3.1
Early Iron Finds From Mesopotamia
(After Waldbaum 1980:60-76)

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>IRON OBJECT/S</th>
<th>PROVENIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000 B.C.</td>
<td>-four-sided instrument</td>
<td>-grave A at Samarra, N. Iraq</td>
</tr>
<tr>
<td>3100-2800</td>
<td>-fragment</td>
<td>-Uruk-Warka, between Temples D &amp; E of the Anu Ziggurat</td>
</tr>
<tr>
<td>(Early Protoliterate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2800-2600</td>
<td>-a lump</td>
<td>-from Khafajeh</td>
</tr>
<tr>
<td>(Early Dynastic II)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2800-2340</td>
<td>-three &quot;button-like&quot; pieces of inlay</td>
<td>-Kish palace A, floor of room 61</td>
</tr>
<tr>
<td>(ED II/III)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2450-2340</td>
<td>-fragments of dagger blade with copper handle</td>
<td>-found among the hoard of copper objects, Tell Asmar</td>
</tr>
<tr>
<td>ED III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ED III</td>
<td>-fragments of flat tool blade</td>
<td>-Ur, Royal Cemetery, tomb PG/580</td>
</tr>
<tr>
<td>ED III</td>
<td>-fragment</td>
<td>-Tell Chagar Bazar, level 5, grave G 67</td>
</tr>
<tr>
<td>ED III</td>
<td>-two fragments</td>
<td>-Tell Chagar Bazar, level 3</td>
</tr>
<tr>
<td>ED III</td>
<td>-fragment</td>
<td>-Mari, near the pre-Sargonic Temple of Ishtar</td>
</tr>
<tr>
<td>15th cent.</td>
<td>-a dagger with copper blade and hilt made of two iron plates fastened to the blade with an iron rivet</td>
<td>-Nuzi, stratum II</td>
</tr>
<tr>
<td>(Hurrian Period)</td>
<td></td>
<td>-a small spherical bead -floor of temple A</td>
</tr>
</tbody>
</table>

It must be noted that very little archaeometal-
Surgical analysis has been done among the iron artifacts from these sites and it is possible that some of them could be meteoritic in origin. Among the Assyrian iron artifacts from sites in Iraq which have been studied metallographically are three artifacts from Assyrian Khorsabad (Pleiner and Bjorkman 1974; Pleiner 1979), and at least eight artifacts from Nimrud (Curtis et al. 1979). Pleiner's study revealed that the artifacts, a hoe, an adze, and an iron bar were made of a relatively soft wrought iron inhomogeneously carburized in some cases. The result of the metallographic investigation of Curtis and colleagues of the materials from Nimrud are similar to that of Pleiner's. The Nimrud artifacts were made of wrought iron with various degree of carburization as well as decarburization depending on a particular sample. Thus there is an indication that while iron was being produced in some quantity by the Assyrians, steel was remarkably uncommon.

Western Iran as a research area is of particular importance because:

It is an area that is well defined geographically, comparatively well researched archaeologically, and important metallurgically. The Zagros Mountains as well as the great central deserts of Iran provided ancient metalworkers with a variety of ores. Western Iran's geographical position was critical to ancient trade networks linking Central and South Asia with the Caucasus, Anatolia, Mesopotamia, Syria-Palestine, and beyond. Moreover, during
the past 25 years, a great deal of archaeological research has been done in Western Iran, making it particularly appropriate for an anthropological interpretation of the role of ancient metallurgy. In this area the transition from bronze to iron metallurgy occurred at the end of the 2d and beginning of the 1st millennium B.C. (Pigott 1980:417).

The general chronological sequence of the Iranian Iron Age is based on the work of Dyson (1965) and Young (1965), and since then, this sequence has undergone only minor revisions based on C-14 correlations (Pigott 1981:11-12). The chronology of northwestern Iran is divided into four parts, namely:

Iron I: 1450/1350 - 1100 B.C.
Iron II: 1100 - 800/750 B.C.
Iron IIIB: 800/750 - 600 B.C.
Iron IIIA: 600 - 300 B.C.

In the Iron I period, the evidence for the metallic iron is so scarce as to be almost nonexistent. For instance, in western Azerbaijan, only a single finger ring was recovered from a Hasanlu V grave. In Central, or Tehran province, Sialk A contained a single iron dagger and an iron punch. In the province of Luristan, at Tepe Giyan level I\(^3\) grave 23 yielded an iron dagger. It is therefore hypothesized that Iron I period is more or less an experimental stage (if any at all) in the technology of iron metallurgy, but culturally speaking it has some vestiges of the Late Bronze Age tradition as well as
indicators of the coming Iron Age. Iron in this period is still considered as a precious metal and it is mainly utilized for the manufacture of ornamental artifacts. Although there were daggers found, these may have been functional as well as of ceremonial, symbolic and/or prestige value (Pigott 1980:420).

Cultural continuity is observed between Iron I and Iron II periods. However, during the Iron II Period, iron began to appear in great quantities in settlements as well as in cemetery contexts in Western Iran. The only collection of iron artifacts of any consequence from non-funerary contexts in this period are from Hasanlu (Pigott 1981:180). The results of metallographic studies of iron artifacts from Western Iran are generally in agreement with the other areas, including those from Assyrian iron mentioned earlier.

The process of the intentional steeling of wrought iron artifacts does not appear to have been practiced with any regularity. Furthermore, the effects of inadvertent decarburization of iron in the oxidizing atmosphere of the blacksmith's forge may have acted to retard the effectiveness of western Iranian smiths in their efforts towards perfecting the techniques of steeling. A low level of technological sophistication is documented both for western Iranian iron and that from Assyria (Pigott 1981:180-181).

It has also been noted that the presence of bimetallic artifacts of bronze and iron marked the
transitional stage between bronze and iron in Western Iran. Bronze smiths may have been experimenting with the capabilities of iron as a new material with which to replace bronze. Following the initial occurrence of iron in northwestern Iran, there is a significant increase in number of iron artifacts in the whole area of the central and southern part of western Iran by the Iron III Period. During this period, iron effectively replaced bronze as a material for tools and weapons, while bronze, on the other hand, gradually became a more decorative material. One general theory holds that in the Ancient Near East the coming of iron may have been prompted by limitations in the supply of tin and copper due to the interdictions of major trade routes, ultimately restricting the availability of bronze in quantity.

It has consistently argued that increased socio-cultural complexity within Western Iran provided the proper setting in which the technology of iron production was adopted, while intensified Assyrian involvement in western Iran is held to be primarily responsible for the adoption of iron during the Iron II and Iron III periods (Pigott 1980; 1981; 1982b).

It is clear, therefore, that the adoption of iron in western Iran, and certainly elsewhere in the Old World, was not based solely on technological factors, but upon the
interrelationships of socio-cultural, economic, and political conditions at the time. Although the initial technological discoveries are noted as an important factor for the beginning of iron metallurgy, technology should not be considered as the prime mover in socio-cultural change (see Heskel and Lamberg-Karlovsky 1980).

In the Eastern Mediterranean, the significance of the coming of iron has been recognized by scholars as a major part of the transition from the late Bronze to the Iron Age. Waldbaum (1978; 1980) has documented the early use of iron in the Bronze and Late Bronze Age Periods prior to 1200 B.C.

The chaos created in the eastern Mediterranean around 1200 B.C. by the movements of the Sea Peoples and the repercussions of their activities resulted in political and ethnic realignments which archaeologists have recognized as a break in continuity and cite as the beginning of a new phase in ancient life. The increased use of iron has been justly singled out as an important technological change during this time and "Iron Age" is the name given to this period (Stech-Wheeler, et al. 1981:245).

In comparison with certain other areas of the eastern Mediterranean, apparently little iron was used in Palestine during the Bronze Age. However, according to Stech-Wheeler and her colleagues (1981:246), "the three hundred years following 1200 B.C. were crucial in the development of effective iron working in Palestine." One of their most important studies is based on the metal-
lurgical examination of a group of iron artifacts excavated at Tell Ta'anach in Palestine (Ibid.). Their results suggest that by the late tenth century B.C. blacksmiths supplying northern Palestine were able to produce carburized iron (steel), a product superior to bronze. Complementary studies of iron artifacts from Philistine sites in the south did not reveal such consistent technical achievements. The investigators also state that although the original impetus to work with iron may have come from an outside source, the industry developed through experimentation with locally produced metal. Among the factors crucial to the development of iron technology in Palestine were an abundance of iron ore, interest in working it, and the need to maintain a supply of metal products for consumers (Ibid.:265).

Muhly (1982:44,48) has summarized well the situation in the eastern Mediterranean as follows:

1. The Iron Age developed in response to a material shortage, a crisis created by the disruption of international trade routes. When bronze became scarce, those smiths were forced to fall back on local resources and to make do with what was available nearer to home. Iron metallurgy developed against this background.

2. Iron technology probably first developed in the
Eastern Mediterranean, with Greece and Cyprus playing the dominant roles. The introduction of iron metallurgy into Israel (ca. 12th century B.C.) came about through contacts with the Aegean world and the migrations of the Philistines and other Sea Peoples.

3.1.2 South Asia

The archaeometallurgy of South Asia has been traditionally linked with that of the Near East. It is commonly believed that the knowledge of copper based metallurgy diffused from Iran through Afghanistan and Pakistan ca. 3000 B.C., and from there to the sub-continent of India ca. 2500 B.C. (Banerjee 1965; Lamberg-Karlovsky 1967; Agrawal 1971; Fairbanks 1975; Agrawal and Guzder 1980; Shaffer 1984). One of the reasons why metallurgical technology in this region has been traced back to the Near East is because no experimental stage of metalworking has been found in the earliest levels where metals occur (Lamberg-Karlovsky 1967:145). The evidence of ceramics and seal marks which indicate occasional trade and contact between the Near East and India (Oppenheim 1954; Potts 1978; Possehl 1979; 1982; 1986) is another reason that would account for the diffusion of iron technology in India. Hence, according to Lamberg-Karlovsky (1967:145), "we must look elsewhere toward Iran and Mesopotamia for its
origin, and the available evidence for metallurgical development in India and Pakistan at the moment indicates an early connection with Iran." However, Shaffer (1984) has claimed otherwise with regard to iron. According to him:

the present data, though limited, indicate South Asia experienced its own indigenous development of an iron technology. Through intrusive "Early Harappan" ceramics, associated with limited use of iron at Afghan sites, a gradual development of iron technology can be defined in South Asia throughout the second millennium B.C. (Shaffer 1984:58).

Sources of information about the Iron Age of India have come from 1) ancient texts, 2) archaeological excavations and 3) ethnographic evidence. Historians were supported by some geologists who argued that there is extensive evidence of iron ore deposits, especially in South India, where, it has been argued by some, that iron working technology was independently discovered (Subrahmanyan 1964:350-51). Thus, they regard India as the home of the world's first discovery of iron working! This idea has been pursued by some metallurgists specializing in early iron who were fascinated by the Indian wootz steel as well as the famous Iron Pillar in Delhi (Pleiner 1971). As we shall see later, contemporary Indian archaeologists have picked up the same argument that the widespread distribution of iron ore in India provides the possibility of independent development of iron technology in the many
centers were iron has been recovered archaeologically in the subcontinent.

Early literature on the Iron Age in India is biased. For instance, Gordon (1950) was of the opinion that iron smelting in India developed at a very late date, ca. 250 B.C., because he felt that there was no evidence for the use of iron in India prior to this point. Wheeler (1959) argued that India received the necessary knowledge for iron working ca. 500 B.C., as a result of the Greco-Roman incursions.

Indian archaeologists today tend to defend the idea of an early independent discovery and development of iron working technology particularly in Central India, Malwa and Berar, and especially in megalithic South India (Chakrabarti 1976; 1983; Agrawal and Guzder 1980; Ghosh and Chattopadhyay 1982). These are all extreme views of the development of iron metallurgy in India. According to Allchin and Allchin (1982:309), a more acceptable view is that of Banerjee (1965), who held that iron working in India began as early as 1000 B.C. and became more common around 800 B.C.

Clark (1977:279) suggested that iron working was first adopted around 800 B.C. in the territory between the Sutlej and the middle Ganges and with the occurrence of
Painted Grey Ware (P.G.W.) with which it was often found. P.G.W. could well have developed from the monochrome grey ware encountered in the Ghandara graves. The people who used it lived in timber-framed, mud-walled houses. Their material culture, which included iron and glass, was in some ways inferior to that of the city dwellers of the Indus basin who had lived some fifteen hundred years earlier. With a rather heavy European prehistoric background, Clark (1977) interpreted the Indian Iron Age as similar to that in Europe. Clark (1977:281) wrote:

The process of deforestation and the breaking up of the hard calcareous soils was sharply accelerated when iron working technology expanded down the lower Gangetic plain during the sixth and fifth century B.C. to reach the rich iron deposits of Bihar. This decisive phase is well defined in the archaeological record by the appearance of a distinctive new pottery, Northern Black Polished Ware. Although at Hastinapur and elsewhere it replaced Painted Grey Ware, the change was evidently a matter of fashion rather than one involving movements of population.

However, in a more recent paper, Agrawal and Guzder (1980) have argued that there may have been many centers of metallurgical developments in India which do not necessarily point to a derivation from the Near East. For instance, ever since Thailand has emerged in the picture of early metallurgical development, those archaeologists have re-evaluated the metallurgical evidence from the different zones in India. Their conclusion is that:
metal technology in prehistoric India did not come from one source. Metallurgical know-how in the northwest was derived from West Asia; the Central Deccan and western Indian Chalcolithic cultures were probably largely indigenous, as also their metallurgy, though at the present stage of our knowledge a Harappan influence cannot be ruled out. The southern zone imported the little metal it had from the Chalcolithic cultures. The 'north-eastern' zone would have derived its metallurgical know-how from Southeast Asia, or else arrived at its invention independently (Agrawal and Guzder 1980:291-92).

Chakrabarti (1976) is of the opinion that the present archaeological evidence indicates that there are at least six early iron-using centers in South Asia, namely:

1. Baluchistan, ca. 800 B.C.- Here there are two type sites and they are not chronologically related. First, come the cairn-burial sites which extend in a sort of a chain from Fars in Iran to the Zhob-Loralai area in northeast Baluchistan. Second is the type site represented by Pirak (Pakistan), where there is no break between the earlier Chalcolithic level and the iron bearing level. There were no copper finds and there seemed to be some evidence of local manufacture for iron.

2. The North-west, ca. 900 B.C.- In the north-northeast of Peshawar, between the Kunar-Chitral on the west and the Indus on the east lies Gandhara Grave culture where iron materials range from spearheads, arrowheads, pins or nails, spoons, finger rings
cheek-bars, etc. A reference may also be made to the few iron finds at the Saraikhola near the Bhir mound, Taxila.

3. The Indo-Gangetic Divide and the upper Gangetic valley, ca. 800 B.C. - Here the regional sequence has been identified at sites like Hastinapura, Atranjikhera and Noh. The identifying marker of the period where iron appears is called the Painted Grey Ware (P.G.W.), which was recognized first at Ahichchatra, with swastikas, sigmas, short spirals, etc. as designs in black on straight-sided bowls and dish shapes. The iron artifacts include an arrowhead, spearhead, knife-blade, dagger, hoe, fish-hook, tong, adze and nail. Slag and furnace remains were found at Atranjikhera and Hastinapura, hence direct evidence of local smelting.

4. Eastern India, ca. 750 B.C. - The representative sites are Chirand, Mahisdal and Pandurajar Dhibi and the context is a black-and-red ware level which continues from the earlier level in association with microliths. It was noted that an iron sickle, or more correctly identified now as a rice thresher, was found in a "Neolithic" level at Barudih (Ghosh and Chattopadhyay 1982). Iron materials consist of an arrowhead, spearhead, chisel and nail. Iron ore was
abundant in Mahisdal and slag was found, while at Pandurajar Dhibi furnaces, slags and artifacts were located.

5. Malwa and Berar in Central India, **ca.** 1100 B.C. — In Malwa and the northernmost part of the Maharastra sites like Nagda, Eran, Prakash and Bahal have appreciably thick deposit of an immediately post-Chalcolithic black-and-red ware with iron artifacts. At Nagda alone, 2.2 meter thick deposit was excavated containing iron objects including a double-edge dagger, socket of an axe, spoon, flat axe, with a broad cutting edge, ring, nail, arrowhead, spearhead, knife, and sickle. It is said there there is a good continuity between the iron bearing level and the earlier Chalcolithic level.

6. The Megalithic South, **ca.** 1000 B.C. — The general area is that of Mysore, Kerala, Madras, Andhara and the southern part of Maharastra. There the iron finds were innumerable, ranging from axes and swords to hooks for hanging lamps. Only a few of the megalithic graves have been properly excavated. It was found that, stratigraphically, the Megalithic phase overlapped with the earlier Neolithic level and continued well into the historic period. The origin of Megalithic traditions in India still remains
Hence, the possibility of independent development of metallurgy in India is not totally ruled out, and in fact the idea is currently pursued by Indian archaeologists (Sahi 1980; 1983; Hegde 1981; 1983; Chakrabarti 1983). According to Chakrabarti (1983) and Tripathi (1985) iron was probably indigenous and discovered as a by-product of copper smelting. Prakash and Tripathi (1986:578) concluded in their paper that based:

from archaeological evidence and ethno-technological evaluation, it is evident that iron first appeared in India between 1300 and 1200 B.C. and by 1000 B.C. was in use all over the subcontinent.

All of these early centers of early iron development are located near substantial iron ore deposits. In fact, one of the arguments made by Indian archaeologists regarding the independent invention of iron metallurgy in India is the widespread availability of iron ore. However, Pleiner (1971:6) is skeptical of this argument, for the reason that the mere presence and/or abundance of raw materials for iron working does not necessarily lead to the origin of iron technology. In order for iron technology to develop, a number of factors are involved. One, of course, is the availability of iron ore, which is an environmental condition, while the rest are primarily socio-economic and cultural in nature. It is
these latter factors which, in the long run, exercise the strongest influence in the origin of technological traditions such as iron working.

Ethnographic evidence from tribal groups like the Asur (Leuva 1963) indicates that until recent years tribal peoples in many parts of the subcontinent continued to smelt their own ores by methods which are not only relatively primitive, but which share much with the techniques observed, for example, among the iron-smiths in many parts of Africa (Allchin and Allchin 1982:309). For instance, Verrier Elwin recorded five decades ago that the modern Agaria smiths of Central India differed little from a picture that archaeology has recently reconstructed. The excavation of an Early Historic smelting site at Dhatwa in Southern Gujarat and the subsequent investigations by Hegde (1973) into the metallurgical technology have revealed many salient features of ancient Indian smelting and iron smithery.

Locally available ore and fuel were employed; the ore was first roasted, then crushed; it was next mixed with charcoal and fed into small furnaces in which a draught was created with bellows. The resultant bloom was removed from the furnace and again heated for forging in an open hearth. The slag was removed by hammering while the surface of the metal was simultaneously carburized and case hardened. Further, the hammered metal was beaten into a thin strip, and later several such strips were forged welded together to shape metal of a size suitable for making a given tool. The hardness and strength of these products was mainly derived form the process of carburization,
tempering, annealing and quenching (Allchin and Allchin 1982:310).

In a conference on the "Recent Advances in Indian Archaeology: 10-12 December 1983," held in Pune, Chakrabarti (1983) delivered a strong statement indicating that "there were a number of early iron-using foci in India by the close of the second millennium B.C. and there is no reason to link the beginning of iron in inner India to any influence or movement of people from West Asia." He claimed, further, that iron metallurgy in India began as an offshoot of copper metallurgy. He asserted, that once the basic elements of iron technology were established, they continued till the end of the pre-industrial period at the beginning of the twentieth century. Chakrabarti does not favor treating the early historic materials, for instance those dating after 700 B.C. including Northern Black Polished (N.B.P.) wares in the Gangetic valley, as part of the Iron Age of India. This is because he wants to address the issue of the Iron Age phenomenon in the Indian context with a sharper focus on its economic and cultural aspects.

Reactions to his paper by his colleagues like Banerjee (1983), Joshi (1983), Sahi (1983), Sinha (1983), and Thaplyal (1983) varied. For instance, Banerjee and Thaplyal remain conservative on the question of independent origin of iron in India. They maintain that so long as the evidence for the use of iron (Banerjee 1965:106) in West
Asia is dated earlier than that in India, the possibility of the introduction of this metal as a result of West Asian contacts remain. Joshi supports Chakrabarti completely, since he himself had earlier suggested an independent beginning of the Iron Age in South and North India. Sinha notes that Chakrabarti's study of the Indian Iron Age is handicapped by two factors: 1) the paucity of data; and 2) the comparative lack of scientific analyses of the iron samples. Sahi points out that there are certain stages in the development of iron metallurgy in India:

1. Extraction of iron from chalcopyrite¹ (1500/1300 B.C. - 1100 B.C.)

2. Extraction from Haematite etc. (Jodphura, 1100 B.C. - 750 B.C.)

3. Steeling Process (Mahurjhari-Khapa, 700 B.C.)

4. Rust proof iron pillar (Mehrauli Iron Pillar, 400 A.D.)

Regarding phaseology, he suggests a compromise and argues for the inclusion of at least the earliest phase of the Early Historical period into the Iron Age of India. For, according to Sahi, in this phase there is an overlap

1. Author's note: chalcopyrite is not used for the smelting of iron. It can be used however, for copper smelting.
between the P.G.W. and the N.B.P. wares in northern India, and the Black-and-Red Wares (B&R.W) with the N.B.P. wares in the rest of India. Thus he proposes a three-fold periodization of the Indian Iron Age:

Iron Age I (1500/1300-1100 B.C.) - Chalco-iron phase

Iron Age II (1100-750 B.C.) - Pre N.B.P. phase
[P.G.W. and B&R.W]

Iron Age III (750-500 B.C.) - Early N.B.P. phase

The trend of research concerning the origin and development of iron working technology in India today becomes more and more intriguing because the complexity of the problem of the Iron Age has been given sharper focus. Among the problems being addressed are the issue of cultural relationships and the question of economic as well as socio-political developments of the period in question. Questions which need to be answered include the following:

How different was village life in the Iron Age from the previous Harappan (Copper-Bronze Age) civilization? Was there an improvement in the quality of life of the people with the coming of iron? Was there a shift in population and settlement pattern? How is the coming of iron manifested in the cultural context of the Iron Age? We would hope that these questions will be resolved in the course of present and future archaeometallurgical research by our Indian colleagues.
3.1.3 China

China presents an intriguing problem. Whenever one speaks of China, one always thinks of it as the great "civilized" China, referring in reality to North China, where the Shang Dynasty emerged along the banks of the Yellow River. This is due to the Sino-centric bias of northern Chinese archaeologists and prehistorians. Traditionally, the north is seen as the center of Chinese civilization, and the south as a primitive region which is "uncivilized". Northern Chinese archaeologists (An Zhimin 1979-80; Hsia Nai 1977; Li Chi 1977) virtually do not accept any early cultural development in South China and claim that the south had a backward economy. In fact, people in the south were normally termed "barbarians".

It is generally agreed that China was unified in 221 B.C. by Shih Huang Ti, the first emperor of the Ch'in dynasty. This resulted in the consolidation of the Chinese as a people with a single culture and a sense of common nationality (Chang 1978:471). However, before this unification, there were major cultural differences between the north and the south. As we shall see later in this

2. Actually, the cultural differences persisted well after unification and became finally submerged, to some extent, only with the major Han expansion a thousand years or so
discussion, the southern region of China is geographically and culturally more closely related to Southeast Asia rather than to the northern part of China, at least before the unification of the whole of China as it exists today. Perhaps this is one of the reasons why most northern Chinese archaeologists tend to give more emphasis to the sequence of cultural development in the North. In protohistoric times, Southeast Asia for them was backward and its culture primitive; the reasons for this include the absence of massive architectural and monumental archaeological remains, no historical documentation because there is no early writing system, no centralized form of government. Certain scholars have been unable to accept independent cultural development from the south or Southeast Asia without any stimulus from the north.

The following Table 3.2 is a simplified version showing the early cultural chronological stages of Northern China.

--------
later (Hutterer: personal communication).
Table 3.2

Cultural Chronological Stages of North China
(After Chang 1978:474)

<table>
<thead>
<tr>
<th>CULTURAL STAGE</th>
<th>DATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesolithic</td>
<td>? - 7000 B.C.</td>
</tr>
<tr>
<td>Pre-Yang Shao</td>
<td>7000 - 5000 B.C.</td>
</tr>
<tr>
<td>Yang-Shao</td>
<td>5000 - 3200 B.C.</td>
</tr>
<tr>
<td>Lungshanoid</td>
<td>3200 - 2500 B.C.</td>
</tr>
<tr>
<td>Lung-Shan</td>
<td>2500 - 1850 B.C.</td>
</tr>
<tr>
<td>Shang</td>
<td>1850 - 1100 B.C.</td>
</tr>
<tr>
<td>Western Chou</td>
<td>1100 - 771 B.C.</td>
</tr>
<tr>
<td>Eastern Chou</td>
<td>770 - 221 B.C.</td>
</tr>
<tr>
<td>Han/Ch'in</td>
<td>221 - A.D. 220</td>
</tr>
</tbody>
</table>

A copper knife is reported from a good archaeological context of the later phase of the Yang-Shao Neolithic, represented by the Ma-chiayao Culture of eastern Kansu dated ca. 3000 (Hsia Nai 1977:90; An Zhimin 1979-80:38). Bronze had already appeared by the Shang Period in early second millennium B.C. in Northern China. While archaeological materials from the Eastern Chou Period states of South China include iron implements along with bronze implements, although the latter were far more abundant in most regions. According to Li (1985:315), "the origin of the use of iron in China is a question in Chinese archaeology that has not yet been solved." The previous definition of the Chinese "Iron Age" was based upon the available iron materials excavated then, but these statements have now been repeatedly superseded by continued
new finds.

3.1.3.1 Northern China

Recent information from China indicates that copper and copper-bronze technology was present in pre-Shang times (An Zhimin 1982:3). Chase (1983:119) has argued that metallurgy was introduced into China from the West and once the production of bronze had begun, its development became independent of outside influence (see Gettens 1969). The advances of bronze working from the 2nd millennium B.C. onward contributed to the rise of highly developed iron metallurgy in ancient China. It has been suggested by Umehara that "the bronzesmiths of the Shang dynasty probably already had some chemical knowledge of iron and had a practical mastery of its use, as shown by the chemical analysis of some Anyang bronze artifacts" (Chang 1978:351). The first sign of iron-use appeared in the form of iron-blades of Yueh axes with bronze hafts, excavated at the Shang site in Kao-ch'eng-hsien, Hopei, with a reliable C-14 date of 1498 +/- 114 B.C. The iron blades were found to be of meteoric origin (Gettens, Clarke and Chase 1971; Barnard 1983:248). The most recent finds of similar bimetallic artifacts were from Liu-chia-ho, P'ing-ku-hsien, Peking. Barnard and Sato (1975:85) have argued that:

Such articles would have entered the Middle States' area as the result of occasional contacts
with nomadic peoples far to the west and beyond the present boundaries of China. There is no evidence at all which would allow us to assume that these meteoric iron blades could have been worked by Chinese artisans in Shang and Western Chou times. On the contrary, one might now point to this early evidence of the metal iron in China and comment upon the introduction (a) made absolutely no impact on current and and latter metallurgical technology (i.e. smithy work did not develop), and (b) had nothing to do with the Chinese discovery of cast-iron some five or six centuries later. The unusual articles were simply treated as a curiosity (emphasis added).

The early use of iron in China is believed to begin toward the end of the Ch'un-ch'iu, or Spring and Autumn period (770 - 476 B.C.) and the beginning of the Chan-kuo, or Warring States period (475 - 221 B.C.). This is confirmed by the first occurrence of iron objects in Period IV (Early Warring States) of the Chung-chou Road sequence at Luoyang, Honan (Chang 1978). As far as archaeometallurgical evidence is concerned, it would seem very likely to place the emergence of iron metallurgy as a major industry for toolmaking in ancient China around the 6th century B.C., at the latest, although the techniques probably were not perfected and widely used until the 5th century B.C. It is significant to find that in China both cast iron (pig iron), steel, and wrought iron appeared at about the same time though their interrelationship are not yet clear. Needham (1958) supposed that bloom iron production existed at some time in China. However, Rostoker, Bronson, Dvorak and Shen (1983:197) insisted that
"the ancient Chinese smelters seem to have bypassed bloom iron production." Tylecote (1976) and Chang (1978) are of the same opinion that there is no archaeological evidence for smelting to bloom iron in early Chinese metallurgy. Hence, Rostoker and his colleagues concluded that "the few wrought iron or steel artefacts are not distinguishable from the product of a fining process applied to cast conversion (Ibid.)."

According to Li (1985:322) the artifacts from Yang-chia shan in Ch'ang-sha include not only steel but cast iron. The iron bars found in the Wu tomb in Ch'eng-ch'iao in Liuho were wrought iron made with repeated hammering, but the iron bowls found in the same site were cast iron. Moreover, the iron spades and iron adzes of the early Warring States period (475 – 221 B.C.) found at the cement factory of Luoyang at Honan were also made of cast iron, based on metallographic analysis. Hence, it is clear that in the late Spring and Autumn and early Warring States periods (475 – 221 B.C.), wrought iron, cast iron, and steel all existed. Li has argued that the iron adzes of Luoyang were the earliest cast iron to spread in China. In order to appreciate the significance of this accomplishment, one must have some background about iron technology (see Chapter 3.2.1, Section on Iron Technology; Van der Merwe 1969; Chang 1978; Barnard and Sato 1975;
Li (1985:322-3) argues that it is misleading to claim that the earliest cast iron in China belonged to the late Spring and Autumn period (770 – 476 B.C.) and that iron metallurgy was characterized by cast iron from the very beginning in China, "unlike the rest of the world, where prior to the production of cast iron there was a long process of development of wrought iron." He believes that it is unreasonable to argue that wrought iron and cast iron developed at the same time. Li argues that unless cast iron technology came from outside (which is most unlikely), the appearance of cast iron must indicate that a very long history of iron metallurgy preceded it. The problem with the study of iron in China is that so much emphasis is given to cast iron technology and very little attention has been given to wrought iron and steel which are more common in the rest of the ancient world.

Since the manufacture of iron in China was similar to that of copper and bronze, i.e. both had artifacts shaped by casting, it was possible to produce iron *en masse*. It is the large scale and mass production of metal, whether bronze or iron, which makes China different from the rest of the ancient world. Franklin (1983:285) argues that "considerations of scale are important in reconstructing the technical and societal processes that
the occurrence of certain artifacts can indicate." She distinguishes metal-working, which consists of small-scale metallurgical activities, from metal-production, which consists of large-scale activities. A society may have the basic knowledge of metallurgy, necessary for what she identifies as metal-working, but may not fulfill the cultural and social conditions for metal-production. For instance, Philippine societies like the Bontoc-Igorot, Ifugao, Tinguian, etc. (see Chapter 2), engaged in metal-working activities and yet they lacked a centralized power directing such activities.

Furthermore, Franklin argues that the evidence of metal-production is usually interpreted as an indication of social stratification, professional specialization, and permanent production centers. This is similar to Childe's (1936; 1944; 1951) argument that metallurgy is a precondition for what we call civilization; however, Franklin modifies this view in arguing that the mere presence of metallurgy does not really indicate socio-cultural complexity until there is enough evidence for large scale metal production. She believes that:

The increase in the scale of metallurgical activities that the transition from metal-working to metal-production indicates certainly signals a growth in technical competence. The increase in technical knowledge is a necessary condition for this transition, but not a sufficient one. It is here worthwhile to inquire into the factors, other than technical knowledge, that made bronze
production possible in Shang China. We know in today's world that adequate know-how is not enough to transfer a technology successfully from the laboratory to the factory (Franklin 1983:285-86).

We have to visualize metal-production in terms of the processes involved, for instance the mining activities. One can ask who controls the mines? How many people were involved in the mining operations? Were there mining "engineers" (specialists) at that time? How deep did the miners have to go in the mine shafts? Then, let us look at the smelting operations: What was the rate of smelting per day, week, month, year, etc.? How far were the smelting sites from the mines and the "factories"? Finally, in the actual production of artifacts, how much was to be produced? What was the ratio of supply and demand? How was the distribution done? These types of activities on any scale certainly needed a good deal of coordination if not centralization, which must have been institutionalized.

3.1.3.2 Southern China

The Tsinling Mountains and the Huai River serve as boundaries between the northern and southern Chinese ecological zone. As stated previously, northern Chinese archaeologists generally look at the southern region as "uncivilized." K.C. Chang, however, regards the basic
differences between the two regions as mainly environmental and climatic. The south has a different response to its own semi-tropical condition. He noted that "the early civilizations in South China were largely based upon rice cultivation, whereas millet was the staple food in the north" (Chang 1978:410). Nevertheless, although Chang allows for possible independent advancement in South China, he is still of the opinion that "cultural stimulations from other civilizations - primarily those of the Shang and Chou of North China - must have provided an initial or crucial impetus" (emphasis mine). Does this also mean that without the cultural stimulation from the North, Southern China would have never developed or become civilized? If so, then Chang himself is no different in his views from his Northern Chinese colleagues.

Peters (in press) looks at probable indigenous socio-cultural development in Southern China as early as the Neolithic period. She concludes that in a broad sense, in Southern China, particularly in the Hubei region, there is a development along similar lines as the neolithic cultures found in the Yellow River valley region. "Although archaeologists have not yet uncovered entire neolithic villages as they have in the north, we know that a village farming economy based on rice cultivation has developed in this region. The ceramic sequence indicates
an increased technology with the passing of time." It must be kept in mind that in Mainland Southeast Asia around the Neolithic period of China, parallel development was also evident at least in Northern Thailand (Gorman 1969; 1970; 1971; 1975; Higham 1977).

Who were the people of South China before they became Chinese? According to Meacham (1980:55), the aboriginal inhabitants of South China were closely akin in many ways to the peoples of Southeast Asia. This has been indicated by the ethnological-geographical region which extended as far north as the Yangtze River and the Tsin-ling Mountains, even in ancient times. The coastal inhabitants were known by the name they apparently called themselves: Yueh or Yuet or Viet. Several major ethnic groups in China developed their own civilizations, which included for example, their own writing systems; among them were the Yueh (Dian) Wu, Qu, Xu and Yi (Hutterer: personal communication).

Furthermore, these Yueh people were noted for their skills in navigation and their savagery in battle. The Yueh people were called "uncivilized barbarians" because they were not Chinese from the central plain. The population of the early state of Yueh which was centered in the Lower Yangtze practiced wet rice cultivation and engaged in trade along the coast. There is evidence that
as early as the Shang dynasty some items of the Yangtze region were reaching North China as tribute and as trade goods (Meacham 1980:79). The Yueh were also known for their metal working skills. Indeed very sophisticated bronze drums were produced in southwest China. According to Peters (in press), there are bronze ritual vessels discovered at Huangpi Yangjiawan and the inscribed bronze zun beaker found near Hanyang, although these are stylistically Shang. "However, the finds near the Jiangxi border, while still dated to the Shang period, reflect a more local style, for example the bronze drum excavated from Chongyang Xian, the bronze nao bells from Yangxin Baisha ...." Schofield (1940) wrote at length about the possible "Chinese" influence on the prehistoric Yueh peoples of this area, and noted that many of the decorations on pottery and bronze do bear some similarity to those of the Shang and Chou periods in North China. Others seemed to him to be more related to Southeast Asia.

Archaeological evidence of the remains of houses built on stilts found on the early coastal settlement at Ho-mu-tu in Chekiang province and associated with rice and dated to 5000 B.C. shows that houses were similar to those found in Southeast Asia today. While the Ho-mu-tu and later Lungshanoid Neolithic cultures of the Yangtze delta are different in many ways from those of Southeast Asia,
there are many shared features, such as the cultivation of wet-field rice, stilt-dwellings and the stepped and shouldered adze.

Meacham (1980) contends that the linguistic and ethnographic evidence suggest a general Austro-Thai ethnic affiliation for these peoples. The Vietnamese retain the name "Yueh" and are the direct descendants of the southernmost branch of this population – the Nan Yueh. Similarly, the Cantonese are also still called "Yueh" and are probably derived in large part from the aboriginal population. The origins of the Cantonese, as an ethnic group having their own distinctive identity, was only as recent as the T'ang dynasty (A.D. 618-907).

The Yueh, sometimes called the "Hundred Yueh", were certainly a diverse population, and may have included tribes speaking different languages and with markedly different customs. The Thai-speaking Chuang of Kwangsi province today have oral traditions akin to those of earlier occupants of coastal areas, and may have been included in the Yueh. Similarly, the Li tribes of Hainan Island are almost certainly descended from the Yueh.

In South China, the rise of Bronze Age cultures (ca. 1300-500 B.C.) has traditionally been seen in the light of the impact of Shang and Chou civilizations on the
more primitive southern "barbarians". In recent years, however, evidence has been brought to light of equally early bronze-working cultures in northern Vietnam, in Yunnan province and in the Lower Yangtze Basin. More recently, the Thai materials from Ban Chiang (Gorman and Charoenwongsa 1976; White 1982) raise further questions about to the traditional Sino-centric interpretation of the development of metallurgy in South China. Meacham (1980:62) comments that:

Therefore, it is not at all clear to what extent (if any) the civilization of north China influenced the development of metallurgy and of more advanced political and social organization in the south. There is no evidence that the knowledge of bronze was closely linked with the spread of the other attributes of civilization, such as cities, writing, distinct economic classes, kingship, priesthood, etc.

The earliest known metal objects in South China are seven bronze ritual vessels from a tomb at Ta-ts'un in Hsin-hai-lien City, and bronze knives and arrowheads from Chiao-chung site in Tung-hai. Both sites are located in Northern Kiangsu. These bronze artifacts are considered to belong to the Western Chou Period ca. 1100 - 750 B.C. (Chang 1978:411). Bronze metallurgy is attributed to the Lungshanoid foundation during the Geometric period — "Small pieces of bronze objects have been found in many Geometric sites dated to a pre-Han dynasty period and evidence of local bronze foundries has been discovered at many sites in
southern Kiangsu" (Chang 1978:414). Pottery crucibles and fragments of bronze have been found in the lower stratum of this culture at Pei-yin-yang-ying, near Nanking, indicating the practice of bronze metallurgy in the local village communities. Another Bronze Age site on Lamma island, with similar types of pottery, was recently dated by the C-14 method to ca. 700 B.C. (Meacham 1980:14).

Chang (1978:417) has argued that "if the Shang civilization had come to the lower Yangtze at the very least, there cannot be any question that the Western Chou had also come this far". Why not? Groups of bronze vessels of probable Western Chou types had been discovered not only in the lower Yangtze Valley in Tan-t'u, I-cheng, and Nanking in southern Kiangsu but also from such southern localities as Ch'ang-hsing, on the western shore of T'ai-hu Lake in northern Chekiang, and T'un-hsi in southern Anhwei, in the upper reaches of the Ch'ien-t'ang-chiang (Chekiang River) *Ibid.*. While this situation could be true in the case of bronze, it may not be necessarily so in the case of iron. Just because, remains of stone plows that were triangular in shape and closely similar to the iron plows of North China, were unearthed in a Geometric horizon context at Yu-yao Hsien, Chekiang, this should not suggest that the iron plow technology of the contemporary civilizations elsewhere had local imitations in the Hu-shu
culture and its related phases. What if the Northern Chinese were the ones who copied or imitated the stones plows from the South with their (Northern Chinese) advanced iron working technology? Nevertheless, the fact remains that iron artifacts have been found in two tombs at Ch'eng-ch'iao in Liu-ho associated with bronze vessels and very similar to the Ts'ai Hou tomb finds in Shou Hsien and, thus, dated to late Spring Autumn *Ibid*.

According to Chang (1978:422) "by the time of Eastern Chou when civilization flowered in the Wu and Yueh strongholds of Kiangsu and Chekiang, evidence is widespread that bronze (and iron) metallurgy was established in the Geometric ware sites of Kiangsi, and bronze objects are found in Fukien and Taiwan." In all the southeastern coastal areas bronzes of the Warring States types were still found in association with stone implements of Neolithic type and with Geometric ware. "At the habitation sites in Tseng-ch'eng and Shih-hsing, iron axes and hoe blades were found indicating that by this time the use of iron for agricultural implements was widespread in the eastern part of South China." In addition to agricultural implements, iron was used to make axes, knives, adzes, weapons (swords, *chi* halberds, and arrowheads), and even ornaments (ring and belt hooks). Lead was another metal melted by the Ch'u smiths, who fashioned it into mortuary
money and covers for wooden handles. But as far as the archaeological data show, bronze was still the basic raw material for artifacts (Chang 1978:430). More iron implements were found in the early Chan-kou period (475–221 B.C.). Over and above these, there were more iron implements and even iron weapons in the late Chan-kuo and the beginning of Western Han (206 B.C. – A.D. 220).

3.1.4 Southeast Asia

In Southeast Asia the term "Metal Age" is commonly used rather than the more familiar traditional European terms, wherein the Bronze Age is distinguished from that of the Iron Age. In Southeast Asia this is so because on current evidence it is often the case that bronze and iron were often in use together in most sites (Bellwood 1979:180).

Before the discoveries at Ban Chiang and other Thai sites like Non Nok Tha, Ban Tong, Don Klang, etc., some of which date to roughly the second millennium B.C., it was traditionally believed that the origin of metallurgy and metal working for the whole of mainland and island Southeast Asia was to be found in the Dong Son sites of North Vietnam and the southern fringe of China at around 800 B.C. Pearson (1962) has presented a long history regarding Dong Son and its origin. He indicates that early
scholars argued that the Chinese civilization had influenced the development of the Metal Age in Southeast Asia. However, in fact, very few of the Dong Son materials are truly related to the north Chinese civilization, among exceptions are mirrors, some **ko**, etc. (Hutterer: personal communication).

Heine-Geldern (1937;1966) argued for a Hallstatt and Caucasian derivation of the Dong Son Culture at about 800 B.C., as a result of direct migration from Europe and Western Asia to Yunnan (Bellwood 1979:190-91)! This idea greatly confused the issues of Dong Son origins, and made the situation worse especially for the Southeast Asian archaeologists. First, it added more confusion to the already existing complex problem of the Metal Age in Southeast Asia. Secondly it asserted a diffusionist outlook from a European center. At any rate, more recent archaeological evidence suggests that the Dong Son was the result of local social and cultural developments in northern Southeast Asia. According to Bellwood (1979:191), Nguyen (1975) has reported that evidence for bronze-working has now been found in sites along the Red River, estimated to date back to 2000 B.C. It has been claimed that by the first millennium B.C. socketed axes, spearheads, pediform axes, sickles and fishhooks were being manufactured at sites such as Dong Dau and Go Mun near Hanoi. Vietnamese
archaeologists are intent on refuting any suggestions of outside influence from China or the West on the development of their culture.

J. White (1982:44) wrote that the most important and unanticipated discovery of the Middle Period in Ban Chiang in northeast Thailand (ca. 1000–300 B.C.) was the presence of iron artifacts which now constitute some of the oldest iron objects in East Asia. These artifacts include iron bangles found associated with the burial of a five-year-old child, a bimetallic bracelet with a bronze bangle encircled by iron rings which had either been wrapped around the inner bangle or had slipped over it and corroded over time into place, and two bimetallic (bronze and iron) spearpoints. A radiograph has shown that the bronze hafts had been cast on to nubs extending from the forged iron blade. Pigott and Marder (1984:281) have argued that these bimetallic artifacts which are now dated to the Middle phase at Ban Chiang between, ca. 800 and 400 B.C., may well be representative of a transitional period of experimentation with iron for decorative purposes which was to lead to the recognition of the utilitarian value of the new material. Bimetallism is a pattern that has long been recognized of the transitional phase between the Bronze and the Iron Ages both in Europe and the Near East, i.e., the phase between the use of iron as a ceremonial
and decorative material and its full-fledged use as the desired material from which tools and weapons are forged.

The archaeometallurgical study of Pigott and Marder argues that with the long tradition of bronze making before the final appearance of iron, metal workers had abundant time to experiment and hone their skills. Therefore, it is possible that iron metallurgy may be seen as an innovation out of the prior bronze technology; "in other words iron metallurgy was a new line of development which represented a recombination of previously existing knowledge (1984:279)." In addition, it was noted that weather copper sulfide ore bodies similar to that at Tonglushan may well have existed in mainland Southeast Asia. Tonglushan is a copper mining and smelting site in Hubei province, Central China. "Closely associated with the copper ores at Tonglushan are substantial deposits of iron oxide found in the oxidized upper zone of the ore body where an iron hat or gossan had formed" (Ibid.:280). In this condition, the naturally occurring iron would have fluxed the copper smelting operation, as evidenced in part by an analysis of slags which contain as much as 40-50% iron. Thus, prehistoric metal workers would have become familiar with the basic properties of iron long before they began to smelt iron intentionally for its own sake.

It has been pointed out by Bronson (1985) that one
of the reasons for assuming that the origin of iron technology in Southeast Asia was not derived from China is that all the early iron artifacts found in Southeast Asia were made by the direct or bloomery process, whereas those from China were manufactured by the indirect or blast furnace process. Most archaeologists today agree that iron came into use in mainland Southeast Asia a thousand years or more after the appearance of locally manufactured copper and bronze. "Most also agree that iron antedates the advent in the region of substantial Indian or Chinese influence, which does not become evident before 100 B.C. - A.D. 100" (Bronson 1985:205). Bayard (1980:106) believes that "... iron working technology [in Southeast Asia] was an outgrowth of native bronze technology, not an importation from outside. He placed the beginnings of the use of iron in Northeast and Central Thailand in the first half of the first millennium B.C." (Bayard 1984:6). Kijngam (1983:10) proposed a date of 600 B.C. for the earliest iron in Northeast Thailand, based on radiocarbon dates from the site of Ban Chiang Hian. Using the same materials, a more conservative date of 400 B.C. has been suggested by Higham (1983:7). In Vietnam, iron seems to appear at an early date too, between ca. 800 and 400 B.C., at least in nine sites. Unfortunately, there is less information available about the Vietnamese sites than about sites in Thailand (see Bronson 1985). Actually, the information presented
above may not really be representative of mainland Southeast Asia as a whole since the samples come only from two countries.

Insular Southeast Asia poses a more problematic issue in terms of the beginning of metallurgy in general and iron technology in particular. Bronson (1985:208) claimed that "no iron-associated materials with credible dates of earlier than 100 B.C. have been found anywhere in Malaysia, Indonesia or the Philippines." However, as we have seen in Chapter 2, Fox (1970) believed that the Philippine Metal Age began around 500 b.c., and was certain that iron first appeared ca. 190 b.c. (2140 +/- 100 B.P., recalibrated to 370 - 50 B.C.). Bellwood (1979:220) is of the opinion that in the islands the Metal Age began about 500 b.c. and lasted until A.D. 1000; it was marked by the Jar Burial culture represented at Tabon and Kalanay (both Philippine sites), and Niah and Talaud Islands (both Indonesian sites). The problem we are faced with here is the long date range available for the first appearance of iron artifacts. There could have been so many things that could have happened between 300 B.C. and A.D. 30. How much more if we consider the period between 500 B.C to A.D. 1000? It is not yet known at what point within this time range the beginning of iron technology in insular Southeast Asia should be fixed.
3.2 Problem Focus

The question of an "Iron Age" in the Philippines needs to be examined in greater detail. First, we have to investigate the nature of the evidence. Is there a considerable experimental stage of working iron? Although it has been suggested that the early iron finds in the Philippines were ornamental as well as status symbols since these were excavated in graves (Solheim 1981:147; Hutterer personal communication), we do not know if these materials were manufactured locally. These iron artifacts include daggers, knives, and spearheads or projectile points. Could this be the stage 1 of Snodgrass (1980) [see Chapter 3, Introduction]? What period would represent his stage 2 and stage 3 in the Philippine "Iron Age"?

Questions must also be raised regarding the quantity and quality of the iron artifacts found in the Philippines. In the Iron Ages of the Near East, Europe, India, and China there are a great number of iron artifacts observed in the archaeological record suggesting a large scale manufacturing industry ranging from personal ornaments to household implements, tools and weapons. Iron artifacts have been found in the following excavations.
### Table 3.3

List of Philippine Archaeological Sites Containing Iron Artifacts and their Estimated Dates

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manunggul Cave, Palawan</td>
<td>270 - 50 B.C.</td>
<td>Fox 1970;</td>
</tr>
<tr>
<td>Tigkiw na Saday</td>
<td>200 B.C.-A.D. 200</td>
<td>Dizon 1979a; Dizon 1979b; Evangelista, Ronquillo and Flores n.d.;</td>
</tr>
<tr>
<td>Binisitahan Site</td>
<td>&quot;Metal Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Cabarruan Site</td>
<td>&quot;Metal Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Kulaman, Plateau Cotabato</td>
<td>&quot;Metal Age&quot;</td>
<td>Maceda 1964; Maceda 1965; Roales 1983; Solheim 1951; Solheim 1955;</td>
</tr>
<tr>
<td>Anda Peninsula, Bohol</td>
<td>&quot;Metal Age&quot;</td>
<td>Tenazas 1974; Solheim 1964;</td>
</tr>
<tr>
<td>Sn. Narciso, Tayabas</td>
<td>&quot;Early Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Makabog, Masbate</td>
<td>&quot;Early Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Maguho, Bacon Negro</td>
<td>&quot;Early Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Central Philippines</td>
<td>&quot;Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Batungun Cave, Masbate</td>
<td>&quot;Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Southern Mindanao</td>
<td>&quot;Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Sohoton Area, sw. Samar</td>
<td>&quot;Iron Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Bagumbayan, Masbate</td>
<td>&quot;Late Iron Age&quot;</td>
<td>Bay-Petersen 1981; Bay-Petersen 1982; Bondon 1983; Kurjack and Sheldon</td>
</tr>
<tr>
<td>Bagumbayan, Masbate</td>
<td>ca. A.D. 900</td>
<td></td>
</tr>
<tr>
<td>Aguit-Vinson</td>
<td>&quot;Late Metal Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Seminohoh Cave, Lebak</td>
<td>&quot;Late Metal Age&quot;</td>
<td></td>
</tr>
<tr>
<td>Cotabato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basey, Samar</td>
<td>A.D. 960-1368</td>
<td>Hutterer 1973b; Dinopol 1978;</td>
</tr>
<tr>
<td>Cubay, Sn. Dionisio</td>
<td>A.D. 962-1279</td>
<td></td>
</tr>
<tr>
<td>Iloilo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Ana, Manila</td>
<td>A.D. 1095</td>
<td></td>
</tr>
<tr>
<td>Victorias, Negros</td>
<td>pre-10th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Bo. Maguigirig, Solana-Cagayan</td>
<td>ca. 10th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Bais Region, Negros</td>
<td>10th-13th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Tanjay, Negros</td>
<td>10th-14th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Calatagan, Batangas</td>
<td>10th-15th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Batangas</td>
<td>13th-15th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Pila, Laguna</td>
<td>13th-15th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Sustan, Butuan City</td>
<td>14th-15th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Cebu City, Cebu</td>
<td>14th-15th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Bolinao, Pangasinan</td>
<td>14th-15th c. A.D.</td>
<td></td>
</tr>
<tr>
<td>Puerto Galera, Mindoro</td>
<td>ca. 15th c. A.D.</td>
<td></td>
</tr>
</tbody>
</table>
Apparently, based on evidence to date, there has been no site found from which the evidence suggests the presence of massive production or a large scale industry of iron in the Philippines. The ethnographic record has no account of any large scale iron production in the archipelago. Thus, iron production would be expected to have been done in a small scale context, if ever iron was manufactured locally. At least in the late protohistoric period, ca. 13th - 15th century A.D., there are signs of local smelting activities documented in the archaeological record (Hutterer 1973a; Tenazas 1968; 1973; 1974; Junker 1987a; 1987b), but so far none of these have been investigated archaeometallurgically.

At present it would be best to examine the available collections of iron artifacts in different museums in order to document the quality and quantity of these materials. Metallographic investigation is necessary to determine the quality of their manufacturing technique. Perhaps a preliminary typology of the iron artifacts found in these collections could result from this study.

3.2.1 Iron Technology

At this point it would be useful to give a brief discussion on the technology of iron working, since we have
a mixed collection of both wrought iron, mild to high grade steel, as well as cast iron pieces. With the evidence of Chinese ceramics, porcelain, and some coinage, it is always probable that cast iron vessels and other pieces were among the goods widely traded in the Philippines at around the first millennium A.D.

The technology of cast iron differs considerably from the wrought iron. Wrought iron was the most popular type of iron in the ancient world except in China. It frequently contains less than 0.5% carbon, and such iron is technically classified as a low-carbon steel. It is produced by the direct or bloomery process, which involves 1) the mining of ores, 2) the preparation and roasting of ores, 3) the smelting process, and 4) the forging process (Hodges 1976:80ff.).

Coghlan (1956:46-47) wrote that there are three important factors in the production of iron by the direct process. These are as follows:

1. The ores to be smelted must be sufficiently protected by the fuel bed against rapid oxidation which would be caused by contact with an excess of iron.

2. Some sort of smelting furnace is required. The furnace may be with or without induced draft.
3. The furnace temperature must be high enough to enable the metal to reach a semi-fused or plastic condition so that a workable bloom be obtained.

He further noted that some of the early pottery furnaces, such as those that produced the Tell Halaf pottery, could achieve the temperature of 1000-1100°C., and the availability of such technology down thorough the Bronze Age may have played an important role in the early smelting of iron.

Wrought iron was not intentionally melted anywhere in the ancient world due to its very high melting point (1,535°C). However, accidental instances have been recorded (see Pigott, McGovern and Notis 1982). It is generally soft, but tough, fibrous and malleable. Unless wrought iron is converted into steel, it is not the best material for tools and weapons.

Cast iron on the other hand, is a brittle alloy of iron with a carbon content ranging between 1.5% and 5%, which occurs in two forms - white iron and grey iron... The best known characteristic of cast iron is its melting point (ca. 1,150°C), which is lower than that of steel (ca. 1,400°C) or wrought iron (1,535°C) and allows it to be cast in a molten state similar to bronze (Van der Merwe 1969:26).

The production of cast iron in China consisted of treating the iron ore in a blast furnace at a temperature of no less
than 1,130°C; here the ore loses oxygen, gains carbon, and is converted into liquid metal. Cast iron is neither weldable nor malleable, and therefore, it is suitable only for objects unlikely to suffer shock or impact (Needham 1980:507). Only in China was the appropriate furnace for the production of cast iron in use before the Christian era (Van der Merwe 1969:26).

Wrought iron can be converted into steel (i.e. carburized) and cast iron can be decarburized to become steel. "In its simplest analytical definition, steel is an alloy of iron and carbon, in which the carbon content may vary between 0.1 percent and 2.0 percent, depending on the kind of steel involved" (Van der Merwe 1969:22), such as high-carbon steel, medium-carbon steel and low-carbon steel. The basic fact about steel is that its carbon content is intermediate between that of wrought iron and cast iron. For all cutting edges a hard steel is required, but the rest of the blade should ideally be ductile and have a certain elasticity (Needham 1980:508). To convert wrought iron into steel, a process called cementation, carburization, or case hardening, is used where the iron is heated to a temperature above 900°C for a long time and kept covered with carbon. On the other hand, to rid cast iron of its carbon content, it must be treated under oxidizing conditions, and is thus decarburized (Rostoker et

3.3 Summary

In this chapter, we have examined the term "Iron Age", its origin, development and use in the anthropological and archaeological literature. In the Old World, the long tradition of the Bronze Age has provided the experimental stage on the coming of iron. Metalsmiths came into contact with iron first as a fluxing agent and then experimented more and more with its use. The pattern is that iron is first treated as an valuable metal, used mainly for ornamental, decorative or symbolic objects before it became a utilitarian material for tools, implements and weapons. Although, we can state that Iron Age is a continuation of the Bronze Age wherein tools, implements and weapons that are previously made of bronze are now replaced by iron. However, this does not imply a simple switch of tools, implements and weapons but a more complex adoption of technology since bronze technology is very different from that of iron.

The term Iron Age signifies a developmental stage in culture history, an age which is often associated anthropologically with increasing social, economic and
political complexity and stratification, expanding populations and the establishment of new settlements such as villages, towns and cities. Invasion, conquest and warfare are some other characteristic features, including the expansion of local and long distance trading networks. Iron Age then must be defined according to these criteria and therefore, the mere presence of iron in an archaeological context does not necessarily mean an Iron Age setting but that perhaps the existence of an iron-using society, which may be the case in the Philippines.
Chapter 4

THE DATA

The first part of this chapter concerns the data used in the archaeometallurgical research of the Philippine Metal Age. First, we shall deal with the earliest iron specimens excavated by Fox (1970) between 1962 to 1964 in the Palawan area. Most of the metal artifacts from this excavation have never been analyzed metallurgically except for an elemental analysis for copper, tin, and zinc (Fox 1970:135). The iron samples in particular, have had absolutely no metallurgical analysis. Fortunately, some of these iron specimens, were sent to me by the National Museum of the Philippines for this specific study. Hence, we will have a fresh look at these earliest materials from Palawan. In addition, my past archaeometallurgical studies of Philippine iron will be reviewed. Finally, the analyses of the Guthe 1922-25 collections, which are presently curated at the Museum of Anthropology, University of Michigan, will be presented.

In the second part of this chapter, models suitable
to the data in this study are proposed with the aid of analytical methods such as typology i.e. morphological descriptions of the artifacts, including stylistic and functional study. In addition, various statistical analyses have been performed that may be of help in developing metal artifact typology. Then, the results of the metallurgical analyses are presented. Finally, an evaluation is made of the various analytical methods as well as of the data used in this study in order to formulate a set of conclusions concerning the role of iron working technology in Philippine societies.

4.1 The Earliest Finds - Palawan Materials

Fox (1970) claims that the earliest metals found to date in the Philippines are the artifacts excavated in the Palawan area. Among these materials are copper-bronze and iron tools and implements dating to between ca. 890 to 190 b.c. These dates were calculated using the "conventional" radiocarbon age (BP) with 5568 half-life. Calibrating these dates with the new high-precision tables formulated by Pearson and Stuiver (1986), 890 b.c. will have a range of 1125 - 909 B.C. and 190 b.c. ranges from 370 - 50 B.C. (Stuiver and Pearson 1986). This means that the appearance of metals in the Philippines, particularly in Palawan could
be much earlier than it was thought to be. Furthermore, Fox's evidence of casting molds suggest a developed stage of bronze casting technology, although unfortunately we have no metallurgical analyses on the actual specimens yet. Some of the Palawan iron artifacts are considered below, following a brief report on their respective archaeological contexts.

4.1.1 Manunggul Cave

According to Fox (1970:109) the discovery of Manunggul Cave was made by Mr. Victor Decalan, Mr. Hans Kasten, and volunteer workers from the United States Peace Corps in March 1964. This led to a re-exploration of all the high cliffs of Lipuun Point. Mannungul Cave is situated 114.3 meters above mean sea level and to the south of Tabon Cave. Fox considered it as a burial cave with a spectacular setting, "being tucked into the face of a sheer cliff overlooking the South China Sea on the eastern side of Lipuun Point."

Fox describes Mannungul Cave as composed of four chambers with three openings, but only two were used for jar burials. He named these two chambers A and B. According to Fox, Chamber A has a large round mouth, with a width of seven meters and a length of nine meters (Figure 4.1). It is well lit and dry throughout. Chamber B, on the
other hand, is tunnel-like having a second opening on the
northeast side of the cliff. This sloping chamber averages
about two and one-half meters in width and is ten meters in
length.

It is said that excellent charcoal samples, which
were apparently from ritual fires, were obtained during the
earliest phase of the excavations of both Chambers A and B.
These charcoal samples were forwarded immediately for
radiocarbon analysis and the results were published in
Berger and Libby (1966:479):

UCLA-992A. MANUNGGUL CAVE, PALAWAN 2840 +/- 80
or 890 b.c. Charcoal from Manunggul cave,
Quezon, Palawan, Philippines (9°20' N Lat,
117°45' E Long), from Chamber A, subsurface.
Nat. Mus. catalogue 1964-M-86. Associated with
Early Iron-age with Sa-Huy'nh funerary pottery.
NEW DATE = 1125 - 909 B.C.

UCLA-922B. MANUNGGUL CAVE, PALAWAN 2660 +/- 80
or 710 b.c. Charcoal from same location as
UCLA-992A. Nat. Mus. catalog 1964-M-48, 49,
57. Should be similar of age as above. NEW DATE
= 910 - 797 B.C.

UCLA-992C. MANUNGGUL CAVE, PALAWAN 2140 +/- 100
or 190 b.c. Charcoal from same cave, but Chamber
B, surface and sub-surface. Nat. Mus. catalog
1964-M-136, 137. Associated with jar burial
assemblage with iron. NEW DATE = 370 - 50 B.C.

Fox (1970:112) stated that a C-14 date of 190 b.c.
from Manunggul Cave Chamber B is the first absolute date
for the presence of iron in the Philippines and agrees with
Beyer's (1947:208) estimate for the beginning of the "Iron
Age" in the Philippines ca. 250-200 b.c. However, the
newly calibrated date places the first appearance of iron in Palawan earlier than was thought, by at least two centuries. The consequence of this statement is that within the span of two centuries, from the introduction of iron manufacturing technology to its subsequent use, it is possible that experimentation with iron working could progress to a certain degree of technological sophistication. However, such a development is by no means assured.

Fox stressed that the island of Palawan was probably one of the first areas to be reached by iron (if not the first) and although iron and its manufacture must have diffused with great rapidity, there were undoubtedly many coastal and lowland areas of the Philippines which continued to use stone tools until well into the Christian era. To show the unevenness of the development of technology in the whole of Philippine archipelago, Fox cited one of the Bato Caves in Sorsogon Province, southern Luzon, as an example. The site yielded a Late Neolithic assemblage of primary burial jars, polished tools, blades of chert, and stone and shell beads. A C-14 determination of 179 A.D. (uncorrected) was obtained (Fox and Evangelista 1957a). It is likely, moreover, that the Late Neolithic in Sorsogon persisted into the Christian era (Fox and Evangelista 1957a; 1957b), as noted, followed directly by
the appearance of iron. In Palawan, there was evidence of an intervening period in which copper and bronze were used, before iron.

Furthermore, Fox believes that although "drift iron" implements may have diffused rapidly, the actual production of iron in the Philippines probably occurred at a much later date. He compared the dates of Manunggul Cave, Chamber A, 710–890 b.c. as consistent with the C-14 date from Batungan Cave, Number 8, Masbate, of 754 +/- 100 b.c. for a Late Neolithic assemblage of stone tools and pottery (Solheim 1959a:162;165, and figures). What Fox did not know then was that if his dates and Solheim's date were recalculated according to Pearson and Stuiver (1986), there would be a difference of 350 years between the two sites. Hence, a comparison between the Manunggul and Batungan caves then is not so appropriate or useful because a time lag of 350 years could make a considerable difference in cultural and technological development.

According to Fox (1970:117) the artifacts associated with Chamber B and Area C are typical of the materials in all of the Developed Metal Age sites throughout the Philippines which are associated with iron. These are very distinct from the previous Neolithic materials, especially the pottery and beads. Iron fragments were common. Included in this study is one piece
with a mat impression in the rust-oxidized crust. (Philippine National Museum Accession Number of 64-M-40). It could have been a blade of a knife having the following dimensions: the maximum length is 7.1 cm (mostly blade, the tang being broken); the maximum width is 1.2 cm; and the maximum thickness is 0.4 cm. It weighs 7.5 grams and the blade angle is 21 degrees (Figure 4.2).

4.1.1.1 Metallographic Data on Artifact 64-M-40

In an unetched condition, Artifact 64-M-40 is mostly oxide with minute islands of intact metal. When etched with 2% Nital, and observed at high magnification (x400 and x600) within the residual metal there are seen some "fossilized" or "ghost structures" of pearlite (Knox 1963). Relict pearlite is observed mostly inside the grain boundaries where its lamellar microstructure is most visible (Photomicrograph 4.1). Carbides seemed to have survived better than the metal itself. In some fields there are some parallel plates in the interior grains which suggests high carbon content in these particular fields. This reflects the precipitation of cementite during cooling in a hyper-eutectoid steel, where the end result is pearlite, plus grain boundary cementite and some plate cementite.

The fine grain indicates completion of hot working
64-M Manunggul Cave, Quezon, Palawan, PHILIPPINES

SPECIMEN - IDENTIFICATION - WEIGHT - CONDITION
64-M-40 - blade of a knife - 7.5g - Poor

MEASUREMENT DATA (in centimeter):
maximum length = 7.1  blade length = 7.1 (br)  tang length = broken
maximum width = 1.2  blade width = 1.2      tang width = broken
max. thickness = 0.4  b. thickness = 0.4     t. thickness = broken
weight = 7.5 grams    b. angle = 21 deg.     tip angle = broken

Figure 4.2 Illustration of Artifact 64-M-40
slightly above the critical temperature in the lower part of austenite field, as would be expected in a thin blade (see Iron–Carbon Phase Diagram on Figure 4.3). Slag inclusions are also observed in other fields (Photomicrograph 4.2). This suggests that the knife was carefully hot forged and quenched. We have no microhardness test data for this artifact simply because there is not enough metal to be tested.

4.1.2 Tadyaw Cave

Tadyaw Cave is described by Fox (1970:151) as one of the largest jar burial caves on Lipuun Point. It is a winding tunnel 94 meters in length and passes through a limestone cliff from one deep valley to another (Fox 1970:Fig.46; here Figure 4.4). Tadyaw is the only burial cave on Lipuun Point with mouths facing the interior valleys and not the sea. Fox wrote that:

The front entrance, however, is near a passageway through the towering cliffs which faces the South China Sea, and the cave is easily accessible from this direction. The limestone rocks in the trail through this passageway are worn and highly polished from continual use of the trail today by wild pigs and other animals and probably in the past by movements of people to this great burial cave.

Fox has estimated that at least 500 jars, jar covers, and smaller vessels were scattered on the surface of this cave. He found that most of the vessels were
Figure 4.3 Phase diagram of the Fe-Fe₃C (metastable) alloy system; γ is fcc, α is bcc Fe, and P is pearlite, a two-phase α + Fe₃C structure. (Brick et al. 1977:127)
Figure 4.4 Floor Plan of Tadyuz Cave
(After Fox 1970:Fig. 46)
located in three dark interior chambers, with only a few in the front and rear entrance chambers. According to Fox, the pattern in Tadyaw of placing burial jars in interior chamber is unusual. Whole jars, covers, and smaller pots were recovered, but most of the vessels had been broken and scattered by wild pigs and porcupines nesting in the cave (Fox 1970:Plate XI). He believes that jars broke while the cave was still being used for burial and had been piled on shelves along the edges of the chambers.

Apparently, Fox did not thoroughly finish the excavation in this cave. He wrote "excavations have been completed only in the 'rear window' of this cave and preliminary testing begun in the three interior chambers. Completion of the excavation of this cave, extremely rich in artifacts, remains a major task" (Fox 1970:151). He comments though that his excavations have shown that all chambers of the cave were used for burial primarily during the Developed Metal Age. Fox (1970: as illustrated in Figure 47; here reproduced as Figure 4.5) has recovered numerous fragments of iron including sizable portions of spear points (47-a-b-e), blades of knives, and chisels (47-f). These have a projecting shank or tang to insert into a handle. The end of one blade is ornamented (Fig. 47-g). There are only three artifacts from the Tadyaw Cave that were sent to me by the Philippine National Museum.
Figure 4.5 Forms of iron spears and knives from Tadyaw Cave.
(After Fox 1970: Fig. 47)
Figure 4.6 Illustrations of Artifacts G2-Tt-B-298, 299, 301
Figures 47-e and 47-g are among the artifacts included in this study. The analyses of the three specimens are as follows:

1) 62-Tt-B-298 – tang of a knife, in a very poor condition (Figure 4.6);

2) 62-Tt-B-299 – tang of a knife (Fig. 47-e, Fox 1970), is also in a very poor condition (Figure 4.6);

3) 62-Tt-B-301 could also be a tang of a knife (Fox 1970:Fig. 47-g), and in fair condition (Figure 4.6).

4.1.2.1 Metallographic Data on Artifact 62-Tt-B-298

MEASUREMENT DATA (in centimeter):
max length = 6.5  blade length = 2.1(br) tang length = 4.3
max width = 3.0  blade width = 3.0  tang width = 1.5
max thickness = 1.1  bl thickness = 1.1  tg thickness = 0.8
weight = 17.4 grams  bl angle = 20 deg.  tip angle = broken

In an unetched condition there were some slag inclusions observed in Artifact 62-Tt-B-298. After it was etched with 2% Nital, the sample had a uniformly distributed, fine, ferrite grain structure with discontinuous patches of pearlite (Photomicrograph 4.3). It is probably a low carbon wrought iron with an estimate of 0.10% carbon content. In some fields pearlite seems to disappear and spheroidized carbide appears as coarse spheroids. This would suggest that the cooling process
must have been very slow or that the spheroids may have developed during the process of reheating. Alternatively the spherodized areas may have resulted from hot forging near the eutectoid temperature.

It has a general average of 186 VHN on a composite zone of ferrite and pearlite. The low reading is 183 and the high reading is 195 VHN. This is a fairly good average figure for a low carbon wrought iron.

4.1.2.2 Metallographic Data on Artifact 62-Tt-B-299

MEASUREMENT DATA (in centimeter):
max length = 7.0 blade length = 2.0(br)tang length = 5.0
max width = 2.6 blade width = 2.6 tang width = 1.1
max thickness = 0.7 bl thickness = 0.7 tg thickness = 0.8
weight = 15.7 grams bl angle = 21 deg. tip angle = broken

In its unetched condition the sample from Artifact 62-Tt-B-299 is mainly oxide and there are almost no islands of intact metal to be seen. When etched with 2% Nital, some slag inclusions are observed to have survived in the oxide. Some ghost pearlite structures were also observed under high (x400) magnification (Photomicrograph 4.4). There are no intact islands of metal available for microhardness testing of this sample.
4.1.2.3 Metallographic Data on Artifact 62-Tt-B-301

MEASUREMENT DATA (in centimeter):
max length = 3.8   blade length = 0.8 (br)   tang length = 3.0
max width = 2.9   blade width = 2.9   tang width = 2.0
max thickness = 0.4   bl thickness = 0.4   tg thickness = 0.3
weight = 11.0 grams   bl angle = broken   tip angle = broken

In an unetched state the sample from Artifact 62-Tt-B-301 was observed to be highly oxidized. There are very few tiny islands of metal found. After the sample was etched with 2% Nital it was observed that there was almost no pearlite found in the surviving metal, even under a high (x400) magnification (Photomicrograph 4.5). The carbon content is estimated to be approximately 0.05%. Internal crystallographic boundaries are observed where the grain boundaries are oxidized along a straight plane rather than at random. Corrosion might be the factor in this phenomenon. In one field a metal island is found entrapped in slag where its surrounding matrix is completely oxidized metal (Photomicrograph 4.6).

The hardness test results are quite high when compared to Artifact 62-Tt-B-298. The composite ferrite and pearlite spot has an average of 275 VHN, a low reading of 260 VHN and a high reading of 290 VHN. Artifact 62-Tt-B-301 is therefore harder than Artifact 62-Tt-B-298, although it still is considered a low carbon steel.
According to Fox fragments of bronze and copper were also excavated in Tadyaw Cave, although these were less numerous than those in iron. The recovered portions of green glass bracelets, triangular in cross-section, are similar in type to those excavated in Manunggul Cave, Chamber B and Area C. Fox states that there are four common types of Metal Age beads: (1) large, light blue glass beads; (2) dark (cobalt?) blue glass beads; (3) small opaque red glass beads; and (4) large opaque red glass beads. The opaque red glass beads were first encountered in the Early Metal Age sites but these appear to be the numerous types recovered in "Iron Age" sites throughout the Philippines.

4.2 Earlier Studies on Philippine Iron

In 1982 archaeometallurgical analyses were conducted on some Philippine iron materials from the Bolinao, Cagayan, and Sorsogon sites dating to the periods known in Philippine prehistory as the "Developed Metal Age" or the "Iron Age" and the "Period of Contact and Trade" (Dizon 1983). Unfortunately the artifacts in this study were so few that they did not allow us to picture accurately the growth and development of a specific metal technology (iron) in a given period of time in the
Philippines.

4.2.1 Bolinao Materials

Bolinao is a town which belongs to the province of Pangasinan on a cape located in the northeastern end of Zambales peninsula (Figure 1.1). The Balingasay Site (64-F) on this cape was excavated by a team of archaeologists from the Philippine National Museum, Anthropology Division, headed by Avelino M. Legaspi (Legaspi 1974a). The site (an open site) was brought to his attention in the latter part of January 1964 because of pot-hunting activities. Legaspi began to explore and survey the site in March 1964. He dug a test trench of two-square meters to a depth of 50 centimeters below the surface, and skeletal remains with grave furniture were exposed (Legaspi 1974a:3). According to him, "the Bolinao archaeological excavation was done in two phases - the first from April 20 to June 6, 1964 during which 41 graves with cultural materials were exposed (including the test dig) and the second phase from May 15 to June 22, 1966 during which 11 graves were excavated" (Legaspi 1974a:4). Some of the iron implements recovered from Bolinao are shown in Figure 4.7. Legaspi's study of the trade potteries associated with the graves suggests that the site was utilized as a burial place from the latter part of the 13th century to the middle part of the
Figure 4.7 Some of the iron implements found as grave furnishings at the Balingasay Site (64-F), Bolinao, Pangasinan. Note that (e) Specimen 64-F-175, a square-edged bolo or big knife is one of the samples analyzed. (After Legaspi 1974a)
15th century A.D.

The following artifacts from Bolinao, Pangasinan were the samples taken for metallographic analysis.

1) Artifact 64-F-14, an iron tanged projectile point (spearhead), 21.4 cm in length, 3.7 cm in width (broadest part), had an average thickness of 0.4 cm. It is in a good state of preservation and has excellent metal in it, with an average hardness of 142.3 VHN. The edge of the blade is a lot harder (179.5 VHN) than the interior (105 VHN). This artifact was excavated from Grave 2, and identified as Object 4.

2) Artifact 64-F-80, a crushed iron implement, probably a spearhead. It is badly preserved. This object was excavated from Grave 24 at a depth of 66 cm below the datum point.

3) Artifact 64-F-94, another crushed projectile point, probably a spearhead and badly preserved. When it was sampled no metal was seen, only oxide was observed. The artifact was excavated from Grave 28 at a depth of 81 cm. The remaining piece had a maximum length of 7.5 cm, width of 3.3 cm and an average thickness of 0.7 cm.

4) Artifact 64-F-150, a crushed, corroded iron implement probably a dagger. The largest piece measures
10.2 cm and 4.2 cm in width while the smallest piece has a
tang and dimension of 7.5 cm in length, 5 cm in width and
an average thickness of 0.4 cm. The artifact was excavated
from Grave 34. It could have been a two-edged dagger.

5) Artifact 64-F-151, a crushed and corroded iron
implement, probably an arrowhead. Only the shaft which
appeared to be a rod is recognizable. It has a dimension
of 5.3 cm in length and an average diameter of 0.9 cm. Its
average hardness reading is 139 VHN. This specimen was
also excavated from Grave 34.

6) Artifact 64-F-175, a rusted iron implement
commonly known in the Philippines as a "square-edged bolo"
or a big knife. It is in good condition. The artifact was
evacuated from Grave 47 at a depth of 66 cm and was found
in a broken earthenware vessel beside the right humerus of
skeletal remains. This square-edged bolo has a dimension
of 22.7 cm in maximum length, of which 12.7 cm consists the
length of the blade with a maximum width of 5.5 cm and an
average thickness of 1.3 cm. Its edge, with a hardness
reading of 171 VHN is a bit harder than its interior (146.6
VHN). Therefore, average hardness of this artifact is 159
VHN.

Most of the Bolinao iron artifacts are oxidized,
but we found evidence of traces of low levels of
carburization in them. Moreover, slag inclusions are often observed which indicate that the artifacts were manufactured from smelted ores. Two of these iron specimens, Artifact 64-F-14 (a spearhead), and Artifact 64-F-175 (a square-edged bolo) have well preserved iron. Both artifacts have low carbon content which was roughly estimated to be approximately 0.3 to 0.4%, and this was corroborated with the microhardness test. The spearhead appears to be less carburized though than the bolo. The pearlite structures (Tylecote 1962:315; Gifkins 1970:56, 68; Brick, Pense and Gordon 1977:131-135) of both samples were observed in an evenly dispersed pattern and interspersed evenly among the pearlite colonies are grains of ferrite. This distribution pattern is due to homogenous carburization and this suggests intentional carburization processing of the two artifacts. The term "mild steel" is therefore applicable to both artifacts.

The rest of the samples from Bolinao such as Artifacts 64-F-80, 64-F-94, and 64-F-151 (which are all probably spearheads or some kind of projectile points), and Artifact 64-F-150 (which is probably a dagger) exhibited only traces of carbides and "ghost structures" of the surviving pearlite. Poor preservation of these artifacts could be explained by the fact that Bolinao Site is located right beside the China Sea.
4.2.2 Cagayan Materials

The province of Cagayan lies in the northeastern tip of Luzon, the largest island in the Philippines (Figure 1.1). Its archaeological record ranges from the Palaeolithic Period (probably 10,000-20,000 years ago) to the Age of Contact and Trade (11th to 15th centuries A.D.). There were two artifacts from Cagayan Valley coming from two different localities - one from the Barrio Maguirig Site (71-Q) in Cabaruan, Solana, and the other from the Cortez Site (II-80-J) in Barrio Dugo, Camalaniungan.

The site at Barrio Maguirig (71-Q) in Solana, Cagayan is classified a jar burial open-site in the Age of Contact and Trade ca. 10th century A.D. The artifact was found on the surface by Yogi Aoyagi, a visiting Japanese archaeologist in 1971. The site, however, was excavated in March 1974 by a team from the Anthropology Division headed by Wilfredo Ronquillo under the supervision of Alfredo E. Evangelista. In an unpublished preliminary report Ronquillo and Flores (1974) wrote that "the site was considered ... as important for Philippine prehistory since up to this writing, archaeological records show that jar burial was a practice during the Neolithic. The associated porcelain and stoneware sherds in the jar burial site suggest the possibility that jar burial practices in
the Philippines might have even continued into the Age of Contact and Trade". The metal sample in question is Artifact 71-Q-107, a rusted iron sheet with a dimension of 7.5 cm in length, 6.1 cm in width and 0.3 cm in thickness. It is likely that this piece could have come from a cooking vessel. It has intact metal in good condition. The artifact is a surface find in square E-72.

Artifact 71-Q-107 is a cast steel having a structural dendritic growth pattern. It was probably made from molten iron cast in a mold and cooled very rapidly. This is a very hard and brittle metal with an average micro-hardness reading of 643 DPH (Diamond Pyramid Hardness).

If this surface find could be confirmed as dating to the 10th century, the age of the site, it would not be surprising to find such a fragment of a cooking vessel made of cast steel in the Philippines. By the 10th century A.D., Chinese traders had been dealing with the local population for sometime, as evidenced by the presence of Chinese trade ceramics.

The melting point of cast iron is around $1400^\circ$C depending on the metal's carbon content. Working with cast iron requires a more sophisticated furnace design, construction, as well as operation. Cast steel is
manufactured in a blast furnace, which represents a refinement in design of the early shaft furnace. Only in China was the appropriate furnace used before the Christian era (Jueming 1983) and then continually utilized and improved after this era.

Cortez Site (II-80-J), an open site is in Barrio Dugo, Camalaniugan, Cagayan. The site was excavated by a team headed by Alfredo Orogo from the Anthropology Division of the Philippine National Museum. He suggests that the site is probably of the Metal Age, ca. 500 B.C. to A.D. 500. The artifact found in this site is II-80-J-1288, identified as iron stone but it could be a slag. It has a magnetic property with high density. Its pattern is very irregular and it measures 4 cm on its longest side, 1.5 cm at the shortest side, 2.4 cm in width and 1.6 cm in thickness. It was excavated on September 22, 1980 in Square NW 351 at a depth of 191 cm below datum point having the coordinates N-S 50 cm; E-W 13 cm.

First, it was not clear whether Artifact II-80-J-1288 having a magnetic properties, is smelting slag or an unaltered iron ore like natural magnetite. Under low power magnification, the heterogenous conglomerate structure of this artifact was observed. However, under high power magnification, some lath-like structures were noticed on its matrix. The lath-like structures are
normally produced by firing to high temperature. After the sample was subjected to an X-ray diffraction test, it turned out to be a natural magnetite mineral. This suggest however, that there are natural magnetite mineral deposits at or near the site suitable for mining purposes.

4.2.3 Sorsogon Materials

The province of Sorsogon is situated at the southern tip of Luzon, more than 600 kilometers from Manila (Figure 1.1). There have been a number of excavations of jar burial sites in this area, one of which is the Binisitahan Site (V-79-L5), an open site in Boton, Casiguran, Sorsogon. Specifically, the site is located in the intersection of $12^\circ05'\text{N}$ north latitude and $124^\circ03'\text{E}$ east longitude with an elevation of approximately 25 meters above mean sea level. Binisitahan Site was excavated from April to May 1979 by a team of archaeologists headed by the author (Dizon 1979b) and from the Anthropology Division of the Philippine National Museum. Preliminary findings from the site suggest that it was utilized as a burial mound during the Developed Metal Age, roughly dated to ca. 200 B.C., and the practice of jar burial must have persisted at the site until the Age of Contact and Trade ca. 13th century A.D. These dates are based only on the associated ceramics, having a relative chronology built upon their
typology. The artifacts from Binisitahan are:

 Artifact V-79-L₅-18 is a heavily corroded iron implement which is probably a projectile point or spearhead. The artifact on the jar was found embedded in a heavy clay matrix, hardened and highly oxidized. It was excavated inside Jar 1, found in Square NE 102 at a depth of 75 centimeters from the present surface (Figure 4.8).

 Artifact V-79-L₅-37 is another heavily corroded iron artifact. It is difficult to tell whether it is an iron slag or oxidized metal. The artifact was excavated in Square SW 354 at a depth of 10 centimeters from the present ground level.

 There is little information to be gained from these two samples as they are both completely oxidized. Unfortunately, not even traces of carburization could be observed in the two artifacts. All that can be seen are "fingerprint-like" structures in both samples, most notably on Artifact V-79-L₅-37. These structures are probably the result of corrosion. Corrosion must have attacked the artifacts in layers. The heavy corrosion is due to the fact that the artifacts were excavated inside burial jars where the conditions were humid.

 In summary then, the metallurgical analysis and metallographic examination conducted on these ten artifacts
Binisitan Jar Burial Site (V-79-L3)
Baton, Casiguran, Sorsogon

Figure 4.8 Jar Burial 1 excavated at the Binisitan Site (circa 200 B.C.), Casiguran, Sorsogon, from which Specimen V-79-L3-19, probably a projectile point or spearhead was found in situ. (After Dixon 1979b)
have revealed: (a) low and medium carbon steel implements and tools from the Balingasay Site, Bolinao, Pangasinan, ca. between the 14th and 15th century A.D.; (b) A cast steel fragment of Artifact 71-Q-107, which is probably a piece of a cooking vessel, suggesting the presence of cast iron technology by around the 10th century A.D. However, although the artifact was found in Sitio Maguirig, Cabaruan, Solana, Cagayan Valley in northern Luzon, it may have come originally from China through trade. At that time China was already well advanced in its iron industry (see Chapter 3); (c) Although Artifact II-80-J-1288 turned out to be natural magnetite mineral, it suggests at least the possibility of mining magnetite ore for smelting at the Cortez Site, in Camalaniugan, Cagayan Valley; and (d) Finally, the "fingerprint-like" structures found on the materials from the Binisitahan Site, in Casiguran, Sorsogon, require more research on the process of oxidation under humid tropical conditions, in order to understand fully their true nature.

4.3 The Guthe-Michigan Collection

When the Americans took over the government of the Philippines from the Spaniards and Filipinos in the early 1900s, many of them became aware of the enormous number of
Asiatic ceramic vessels and sherds found in caves and farm lands, which were later identified as burial grounds. The most prominent among them was Dean C. Worcester, Secretary of the Interior, who urged the University of Michigan to organize an expedition to conduct "anthropological explorations in the Philippine Islands." Hence, between 1922-25 the Michigan expedition was directed by Carl E. Guthe (1927; 1929). The purpose of this expedition was to gather additional data upon the commercial relations between the Filipinos and the Asiatic civilizations by means of a study of the grave furniture or goods occurring in the various types of burials in the archipelago.

Guthe's original plan was to make a reconnaissance of the entire coast line of the archipelago, but practical problems prevented the completion of this plan (1929:79). Therefore, he devised a sampling strategy by arbitrarily dividing the Philippines into halves on the thirteenth meridian, confining the expedition to the southern half, which includes practically all the Visayan region, the island of Mindanao, and the Sulu Archipelago (Figures 1.1 and 4.9). Although he recorded a total of 542 sites, this figure is inconsistent with his sampling procedure, since he included 3 sites from Luzon and 6 "general" sites which were probably of unknown location, hence, the total should be 533 sites. Only 65 of these 533 sites yielded iron
artifacts, constituting only 12.2% of the total sample. The majority of the sites visited were described mainly as "ceramic" sites. This does not mean necessarily that these "ceramic" sites contained no iron artifacts; but, in fact, the "Iron Age" sites, only a minority of the graves contain iron (Hutterer: personal communication).

The Guthe collection has already been the subject of two dissertations. The first one was done by Wilhelm G. Solheim II, entitled "The Philippine Iron Age," in 1954 at the University of Arizona and published in 1964 in the Philippines under a new title "The Archaeology of Central Philippines." The second is a locational study of prehistoric island settlement in central Philippines done by Henson in 1983 at the State University of New York at Buffalo. Although Solheim (1964) touched on most of the Guthe materials, his main concern was the pottery of the "Philippine Iron Age" instead of the iron artifacts themselves. Although photographs of the iron artifacts were published by Solheim, there was no attempt to analyse or conduct a formal study on these iron materials. Henson, on the other hand, only made use of the burial location records for a computerized statistical analysis of settlement pattern. He did not touch upon the iron materials.

Although, both Solheim (1964) and Henson (1983)
have acknowledged some of Guthe's written work (1927; 1935; 1938), it seems that they both missed an article (Guthe 1929) which contains extensive information regarding his collection. From this article, it is clear that Guthe attempted to secure an adequate knowledge of the physical features of the entire region and to obtain representative data and specimens from the better known sites in each locality. However, he wrote "Obviously it was quite impossible in the short time of two years, to make an intensive study of all the special regions of this area" (Guthe 1929:80). Thus, he hired "agents" trained for the purpose to gather data for him and made few excavations himself. He grouped the materials according to their locations into five classes namely:

1. Burial ground - for large groups of inhumations

2. Graves - for isolated inhumations

3. Caves - for the materials and inhumations found in caves

4. Miscellaneous - for the materials which bear evidence of ancient workings and those mixed with ethnographic specimens

5. Doubtful - those materials with incomplete data, obscure, or quite impossible to reconstruct.
My own work on the Guthe collection is primarily on the iron artifacts which were regarded by Solheim (1964) as belonging to the "Philippine Iron Age" (Figure 4.9). Although for a number of these it is impossible to stratigraphically reconstruct their original provenience because most of them were collected by Filipino "agents". An attempt has been made to analyse these artifacts by types and their methods of manufacture to try to reconstruct their functions. Artifacts from the "doubtful" group are not included in this study.

All the iron artifacts were sorted according to their respective proveniences. For instance, in the manner of Guthe all the artifacts taken from burials were grouped together; all the artifacts coming from caves were grouped together; those that were from graves formed another group; those that were classified as miscellaneous were also grouped together. Each of the specimens was then matched with its respective accession number found in The University of Michigan Philippine Expedition Field Catalogue 1922-25. In some cases, a number of specimens were lumped together under one number. In order to differentiate the "identifiable" artifacts from the rest of the fragments contained under one number, therefore, letters were added to the original accession number. For example, of the three artifacts under B-7-25, one was
Figure 4.9 Map of the southern Philippines with locations of archaeological sites covered in this study. West coast of Siquior, from north to south, C27, E37, C44, C58, C60, E23, C74. West coast of Bohol south from C39, C39, C31, E48. South half of Bohol, southeast from B124, B107, C214, B103, C11.

(After Solheim 1964:Fig. 24)
assigned to B-7-25a, the next one B-7-25b, and the third B-7-25c, keeping therefore the original accession numbering system.

There are more than 1,500 pieces of iron artifacts from the Guthe collection. A piece might measure 0.5 x 0.5 cm and just be a broken fragment impossible to identify, or a complete identifiable artifact. Thus, in order to standardize my quantification weights of all the specimens were taken. Their total weight is 30.2441 kilograms. Out of the more than 1,500 pieces of iron there are 131 identifiable artifacts. 76 of these 131 were sampled for metallographic analyses. Before a sample was taken, the specimen was carefully measured and illustrated. All the samples were cut using a motorized Dremel tool with a silicon carbide cut-off disk (#409). On the average samples taken have the size of 0.5 x 0.5 x 0.3 cm, weighing between 0.3 to 0.8 grams. Most of the samples were taken from the cutting edges of tools and weapons, or at times from the most conspicuous intact metal. Some of the artifacts were photographed. The following table summarizes the number of sites, artifacts and their total weight in the Guthe collection.
Table 4.1

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SITES</th>
<th>SPECIMENS</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burials</td>
<td>22</td>
<td>389</td>
<td>3,999.5 gms.</td>
</tr>
<tr>
<td>Caves</td>
<td>25</td>
<td>803</td>
<td>20,702.0 gms.</td>
</tr>
<tr>
<td>Graves</td>
<td>14</td>
<td>218</td>
<td>2,680.2 gms.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4</td>
<td>130</td>
<td>2,862.4 gms.</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>1,540</td>
<td>30,244.1 gms.</td>
</tr>
</tbody>
</table>

There are 12 areas or Philippine provinces containing the 65 sites which are associated with iron artifacts mentioned in the Guthe field record. However, only 10 of the 12 areas and 41 of the 65 sites were selected due to lack of vital information and materials. The two of the Philippine provinces which were excluded from the study of the Guthe collection are Palawan and Sulu. In the following table are the total number of sites included in this study of the Guthe materials.
Table 4.2
Cross-tabulation of Areas and Artifact Provenience

<table>
<thead>
<tr>
<th>AREA</th>
<th>Burials</th>
<th>Caves</th>
<th>Graves</th>
<th>Misc.</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cebu</td>
<td>13</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>Siquijor</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Bohol</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Surigao</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Masbate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Samar</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Leyte</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mindoro</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bukidnon</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Davao</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total 10 areas</strong></td>
<td><strong>16</strong></td>
<td><strong>9</strong></td>
<td><strong>13</strong></td>
<td><strong>3</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

As mentioned before, there are 131 identifiable iron artifacts from the entire Guthe collection but only 76 of these were selected for sampling since the rest of the 131 iron objects are obviously of late historic and recent origin including Spanish keys, candle holders of tin, wires, etc. It is sometimes very difficult to identify metals like iron and lead if their state of preservation is not good. This occurred with Artifact B-52-6 from Siquijor which was thought to be an iron bracelet (16.1 grams), but which after closer scrutiny in the laboratory was positively identified as lead. Hence, this particular artifact was deleted from the record where statistical analysis is concerned, thus making 75 the total number of iron artifacts examined from the Guthe collection.
4.4 Preliminary Classification and Typology

Classification is a way of organizing materials for more rigorous analytical studies. It is the systematic ordering of informations into "groups", "classes" or "types". What then, are archaeological types? As early as the 1940s, Alex Krieger had attempted to clarify the meaning of the terms "type" and "variation" when applied to archaeological materials. He wrote that "the purpose of a type in archaeology must be to provide an organizational tool which will enable the investigator to group specimens into bodies which will have demonstrable historical meaning in terms of behavior patterns" (Krieger 1944:272, emphasis original). It can be argued however, that variations never
acquire social recognition or meaning beyond their origins and are of little significance. This of course, was due to the lack of perception of the variability of the archaeological record and that the understanding of the relationship between the material remains and human behavior at that time was not as sophisticated as it is today.

Do types really exist? How can we recognize types? Who should name a type of artifact? These questions were the subject of a debate between Spaulding (1953; 1954) and Ford (1954a; 1954b; 1954c). Spaulding argued for what is now called "emic" classification: that types are to be recognized as such by the people in question. On the other hand, Ford argued for "etic" classification: that types are to be constructed for and by the archaeologist. The problem with Spaulding's argument is that we cannot really ask the people in question about what their types of artifacts were.

The subject of archaeological classification has been critically evaluated and reviewed by a number of scholars including Rouse (1960), Clarke (1968/1978), Dunnell (1971), Hill and Evans (1972), Doran and Hodson (1975), and Gardin (1980). Rouse (1960) for instance, speaks of "historical" types when the diagnostic modes selected have time-space significance, and "descriptive"
types when the diagnostic modes selected are intrinsic to the nature of the artifacts. Dunnell (1971) used a neutral term "arrangement," which he divides into 'grouping' and 'classification'. Grouping is an arrangement in the phenomenal realm, while classification is an arrangement in the ideational realm. Under 'grouping', Dunnell uses statistical classes and numerical taxonomic classes; whereas, under 'classification' he provides paradigmatic and taxonomic classes.

According to Clarke (1978:35) "most archaeological entities consist of clusters or aggregates of entities of lower taxonomic rank. We are concerned with groups, groups of groups, and groups of groups of groups of attributes based on observational data." For him, culture groups are clusters of cultures, cultures are clusters of assemblages, assemblages are clusters of types, types are clusters of artefacts and artefacts are clusters of attributes or traits. Then, he formulated a distinction between a monothetic group and a polythetic group. By monothetic group, he means a group of entities so defined that the possession of a unique set of attributes is both sufficient and necessary for membership. In other words, a belief in the single "type-fossil" idea, as the criterion for group membership. On the other hand, by polythetic group, he means a group of entities such that each entity possesses a
large number of attributes of the group; each attribute is shared by large number of entities and no single attribute is both sufficient and necessary to the group membership. Monothetic grouping is the traditional and prevailing type of classification used in archaeology. Clarke advocates the use of polythetic grouping and this was followed in the Guthe iron collection.

Hill and Evans (1972:261) came to the conclusion that types are indeed "real", existing as non-random clusters of attributes. Hence, they disagree with Ford's idea that types are simply invented. Furthermore, they suggested that there is no single "best" type division or classification of a given body of materials, but rather that there can be many equally "good" divisions; that we cannot formulate standardized types; but that types do not represent the basic data. For them, it is hypothetical if types should represent ideas, preferences, customs or mental templates (i.e. something in the mind of the maker), function, chronology, something else or all of these. Doran and Hodson (1975) prefer the calculation of attributes of variables in terms of percentages in order to recognize the patterning or clustering of types from the total collection (see also Spaulding 1953; 1960). Gardin (1980) distinguishes "intrinsic" features such as the physical characteristics of for instance a pot, its
geometrical shape, color, clay temper, inscriptions, decorations, etc. from the "extrinsic" features such as time, location, and function.

As mentioned before, materials from the Guthe iron collection were first grouped according to the type of site they came from; such that all the B (burial) materials are grouped together, the C (cave) specimens are grouped together, the G (grave) artifacts are grouped together. The M (miscellaneous) iron pieces are also grouped as one (Table 4.1), the iron artifacts were sorted by provenience or locality (Tables 4.2 and 4.3). Sorting by type of site was merely a convenient device by which to organize the Guthe material. This is to show their spatial distribution. It is very difficult to sort the Guthe materials by period, since in most cases stratigraphic records don't exist. Nevertheless, in some cases where full documentation is available, the attempt was made to establish some kind of chronology by means of associating the iron artifacts with known dated ceramics; these artifacts have their own special treatment. It is important to reiterate at this point that iron artifact described in this typology were derived from mortuary context.

The next step was to group the iron materials according to their morphology, i.e. their general shape,
form, style, size, and other intrinsic attributes. There is no single "type-fossil" to match a particular type number, but only attributes that are either present or absent in the artifact. Incomplete and complete artifacts are matched according to the presence or absence of observable attributes. For instance, even if only the tang of an artifact remains, as long as it has the characteristics or attributes present in a particular Type 1.0, then it grouped with this Type 1.0 which may consist predominantly of complete artifacts.

Generally, the Guthe iron artifacts in this study are grouped into seven classes and 17 types. These seven classes and 17 types are open ended such that one can add more classes or types to either or both of them. A class is represented by a first digit number while a type is separated by a point and followed by another number. For example, all spearheads are grouped as class 1 and each of these spearheads will by typed as 1.0, 1.1, 1.2, etc. The following Table 4.4 list the classification and typology of the Guthe iron artifacts:
### Table 4.4

Classes and Types of the Guthe Iron Arifacts

<table>
<thead>
<tr>
<th>SPECIMEN</th>
<th>SITE</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-5-20</td>
<td>CEB</td>
<td>1.0</td>
<td>diamond shaped tang in X-section</td>
</tr>
<tr>
<td>C-5-27</td>
<td>SUR</td>
<td>1.0</td>
<td>diamond shaped tang in X-section</td>
</tr>
<tr>
<td>C-11-400j</td>
<td>BOH</td>
<td>1.0</td>
<td>diamond shaped tang in X-section</td>
</tr>
<tr>
<td>G-74-7a</td>
<td>CEB</td>
<td>1.0</td>
<td>diamond shaped tang in X-section</td>
</tr>
<tr>
<td>G-185-5</td>
<td>BOH</td>
<td>1.0</td>
<td>diamond shaped tang in X-section</td>
</tr>
<tr>
<td>B-10-28a</td>
<td>SAM</td>
<td>1.1</td>
<td>square shaped tang in X-section</td>
</tr>
<tr>
<td>G-76-11</td>
<td>CEB</td>
<td>1.1</td>
<td>square shaped tang in X-section</td>
</tr>
<tr>
<td>G-167-2</td>
<td>BOH</td>
<td>1.1</td>
<td>square shaped tang in X-section</td>
</tr>
<tr>
<td>M-6-51a</td>
<td>CEB</td>
<td>1.1</td>
<td>square shaped tang in X-section (Tang)</td>
</tr>
<tr>
<td>B-5-19</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>B-7-23</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>B-7-24</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>B-12-19</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>B-82-17</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>G-82-6a</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>G-117-15a</td>
<td>SIQ</td>
<td>1.2</td>
<td>rectangular tang in X-section (Tang)</td>
</tr>
<tr>
<td>M-1-26b</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>M-6-52</td>
<td>CEB</td>
<td>1.2</td>
<td>rectangular tang in X-section</td>
</tr>
<tr>
<td>B-10-16a</td>
<td>SAM</td>
<td>1.3</td>
<td>blade only of spearhead</td>
</tr>
<tr>
<td>B-6-8</td>
<td>CEB</td>
<td>2.0</td>
<td>long tang dagger (2 edge)</td>
</tr>
<tr>
<td>B-7-25a</td>
<td>CEB</td>
<td>2.0</td>
<td>long tang dagger (2 edge)</td>
</tr>
<tr>
<td>B-18-15</td>
<td>CEB</td>
<td>2.0</td>
<td>long tang dagger (2 edge)</td>
</tr>
<tr>
<td>B-89-8a</td>
<td>CEB</td>
<td>2.0</td>
<td>long tang dagger (Tang only)</td>
</tr>
<tr>
<td>G-114-3</td>
<td>CEB</td>
<td>2.0</td>
<td>long tang dagger (Tang only)</td>
</tr>
<tr>
<td>G-123-6</td>
<td>CEB</td>
<td>2.0</td>
<td>long tang dagger (2 edge)</td>
</tr>
<tr>
<td>C-91-6</td>
<td>BOH</td>
<td>2.1</td>
<td>2 edged sword</td>
</tr>
<tr>
<td>C-55-50a</td>
<td>SUR</td>
<td>3.0</td>
<td>big pointed bolo</td>
</tr>
<tr>
<td>C-55-50c</td>
<td>SUR</td>
<td>3.0</td>
<td>big pointed bolo</td>
</tr>
<tr>
<td>C-55-51a</td>
<td>SUR</td>
<td>3.1</td>
<td>small pointed knife (pinya knife)</td>
</tr>
<tr>
<td>C-55-51b</td>
<td>SUR</td>
<td>3.1</td>
<td>small pointed knife (pinya knife)</td>
</tr>
<tr>
<td>G-74-8b</td>
<td>CEB</td>
<td>3.1</td>
<td>small pointed knife (pinya knife)</td>
</tr>
<tr>
<td>B-6-7</td>
<td>CEB</td>
<td>3.2</td>
<td>small L-shaped knife</td>
</tr>
<tr>
<td>B-19-20a</td>
<td>CEB</td>
<td>3.2</td>
<td>small L-shaped knife</td>
</tr>
<tr>
<td>G-100-7</td>
<td>SIQ</td>
<td>3.2</td>
<td>small L-shaped knife</td>
</tr>
</tbody>
</table>
Table 4.4 (Continued)

Classes and Types of the Guthe Iron Artifacts

<table>
<thead>
<tr>
<th>SPECIMEN</th>
<th>SITE</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-18-17</td>
<td>CEB</td>
<td>3.3</td>
<td>square-end bolo (length 30-60 cm)</td>
</tr>
<tr>
<td>B-64-14a</td>
<td>CEB</td>
<td>3.3</td>
<td>square-end bolo (length 30-60 cm)</td>
</tr>
<tr>
<td>B-64-14b</td>
<td>CEB</td>
<td>3.3</td>
<td>square-end bolo (length 30-60 cm)</td>
</tr>
<tr>
<td>C-55-50b</td>
<td>SUR</td>
<td>3.3</td>
<td>square-end bolo (length 30-60 cm)</td>
</tr>
<tr>
<td>G-71-18a</td>
<td>CEB</td>
<td>3.3</td>
<td>square-end bolo (length 30-60 cm)</td>
</tr>
<tr>
<td>M-6-54</td>
<td>CEB</td>
<td>3.3</td>
<td>square-end bolo (length 30-60 cm)</td>
</tr>
<tr>
<td>B-17-33a</td>
<td>CEB</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>B-17-33b</td>
<td>CEB</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>B-84-13a</td>
<td>CEB</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>B-89-8b</td>
<td>CEB</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>B-21-17</td>
<td>SIQ</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>C-11-400L</td>
<td>BOH</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>C-83-6</td>
<td>MIN</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>G-74-6a</td>
<td>CEB</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>G-101-7a</td>
<td>SIQ</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>G-147-2a</td>
<td>SIQ</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>M-1-26a</td>
<td>CEB</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>M-2-31</td>
<td>MAS</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>M-2-55a</td>
<td>MAS</td>
<td>3.4</td>
<td>medium knife (length 12.0-29.9 cm)</td>
</tr>
<tr>
<td>B-7-25c</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>B-32-8</td>
<td>SIQ</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>B-93-15</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>C-11-400m</td>
<td>BOH</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>C-11-400k</td>
<td>BOH</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>C-55-38a</td>
<td>SUR</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>G-74-8a</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>G-111-40a</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>G-111-40b</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>M-1-26c</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>N-6-53a</td>
<td>CEB</td>
<td>3.5</td>
<td>small knife (length 5.0-11.9 cm)</td>
</tr>
<tr>
<td>B-7-25b</td>
<td>CEB</td>
<td>3.6</td>
<td>oval tip knife (medium)</td>
</tr>
<tr>
<td>B-85-19a</td>
<td>CEB</td>
<td>3.6</td>
<td>oval tip knife (small)</td>
</tr>
</tbody>
</table>
Table 4.4 (Continued)

Classes and Types of the Guthe Iron Artifacts

<table>
<thead>
<tr>
<th>SPECIMEN</th>
<th>SITE</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-11-401b</td>
<td>BOH</td>
<td>4.0 harpoon</td>
<td></td>
</tr>
<tr>
<td>C-11-401c</td>
<td>BOH</td>
<td>4.0 harpoon</td>
<td></td>
</tr>
<tr>
<td>C-56-25a</td>
<td>SUR</td>
<td>4.0 harpoon</td>
<td></td>
</tr>
<tr>
<td>C-56-25b</td>
<td>SUR</td>
<td>4.0 harpoon (Tang only)</td>
<td></td>
</tr>
<tr>
<td>B-6-9</td>
<td>CEB</td>
<td>5.0 ferrule (ring)</td>
<td></td>
</tr>
<tr>
<td>C-76-21a</td>
<td>DAV</td>
<td>5.0 ferrule (ring)</td>
<td></td>
</tr>
<tr>
<td>B-52-6</td>
<td>SIQ</td>
<td>5.0 ferrule (ring) ½</td>
<td></td>
</tr>
<tr>
<td>C-14-11</td>
<td>LEY</td>
<td>6.0 chisel</td>
<td></td>
</tr>
<tr>
<td>C-11-4001</td>
<td>BOH</td>
<td>7.0 cast iron</td>
<td></td>
</tr>
<tr>
<td>C-32-3</td>
<td>BUK</td>
<td>7.0 cast iron</td>
<td></td>
</tr>
</tbody>
</table>

The distribution of classes and types of iron artifacts by site included in this study from the Guthe collection are in Table 4.5. At the end of this table is the description of each type. These are illustrated in the following figures: Figure 4.10 for Type 1.0; Figure 4.11 for Type 1.1; Figure 4.12 for Type 1.2; Figure 4.13 for Type 1.3; Figure 4.14 for Type 2.0; Figure 4.15 for Type 2.1; Figure 4.16 for Type 3.0; Figure 4.17 for Type 3.1; Figure 4.18 for Type 3.2; Figure 4.19 for Type 3.3; Figure 4.20 for Type 3.4; Figure 4.21 for Type 3.5; Figure 4.22 for Type 3.6; Figure 4.23 for Type 4.0; Figure 4.24 for Type 5.0; Figure 4.25 for Type 6.0; and Figure 4.26 for Type 7.0.
Figure 4.10 Illustrations of Type 1.0
(diamond shaped tang spearheads)
Figure 4.11 Illustrations of Type 1.1
(square shaped tang spearheads)
Figure 4.12 Illustrations of Type 1.2
(rectangular shaped tang spearheads)
Figure 4.13 Illustration of Type 1.3 (blade of a spearhead)
Figure 4.14 Illustrations of Type 2.0 (long tang daggers)
Figure 4.17 Illustrations of Type 3.1 (pinya knives)
Figure 4.18 Illustrations of Type 3.2 (L-shaped knives)
Figure 4.19 Illustrations of Type 3.3
(square-end bolos, 30 - 60 cm length)
Figure 4.20 Illustrations of Type 3.4
(medium knives, 12.0 - 29.9 cm length)
Figure 4.21 Illustrations of Type 3.5
(small knives, 5.0 - 11.9 cm length)
Figure 4.22 Illustrations of Type 3.6 (oval-tip knives)
Figure 4.23 Illustrations of Type 4.0 (harpoons)
Figure 4.24 Illustrations of Type 5.0 (ferrules or rings)
Figure 4.25 Illustration of Type 6.0 (chisel)
Figure 4.26 Illustrations of Type 7.0 (cast iron vessels)
Table 4.5

Distribution of Classes and Types of Iron Artifacts from the Guthe Collection

<table>
<thead>
<tr>
<th>Type</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CEB</td>
</tr>
<tr>
<td>1.0</td>
<td>2</td>
</tr>
<tr>
<td>1.1</td>
<td>2</td>
</tr>
<tr>
<td>1.2</td>
<td>8</td>
</tr>
<tr>
<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>2.0</td>
<td>6</td>
</tr>
<tr>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>3.0</td>
<td>0</td>
</tr>
<tr>
<td>3.1</td>
<td>1</td>
</tr>
<tr>
<td>3.2</td>
<td>2</td>
</tr>
<tr>
<td>3.3</td>
<td>5</td>
</tr>
<tr>
<td>3.4</td>
<td>6</td>
</tr>
<tr>
<td>3.5</td>
<td>7</td>
</tr>
<tr>
<td>3.6</td>
<td>2</td>
</tr>
<tr>
<td>4.0</td>
<td>0</td>
</tr>
<tr>
<td>5.0</td>
<td>1</td>
</tr>
<tr>
<td>6.0</td>
<td>0</td>
</tr>
<tr>
<td>7.0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>42</td>
</tr>
</tbody>
</table>

Type Description

1.0  spearhead with diamond shaped tang in X-section
1.1  spearhead with square shaped tang in X-section
1.2  spearhead with rectangular tang in X-section
1.3  blade only of spearhead
2.0  long tang dagger (2 edge)
2.1  2 edged sword
3.0  big pointed bolo
3.1  small pointed knife (pinza knife)
3.2  small L-shaped knife
3.3  square-end bolo (length 30-60 cm)
3.4  medium knife (length 12.0-29.9 cm)
3.5  small knife (length 5.0-11.9 cm)
3.6  oval tip knife
4.0  harpoon
5.0  ferrule (ring)
6.0  chisel
7.0  cast iron
It should be noted from the above table that Type 2.0 (double edge daggers with long tang) are found only in Cebu. This is very significant because there are six of these artifacts localised in this region, one of the ten main areas included in this study. Although, there was only one example of Type 2.1 (two edged sword) from Bohol and also one example of the Type 6.0 (chisel) from Leyte, these are not so significant judging from the relative number of the artifacts being considered here and also from the point of site distribution.

Regardless of the type of iron artifacts in the Guthe collection, the distribution of the kind of iron i.e. whether they are cast iron, high, medium and low carbon steel and/or simply wrought iron, is depicted in Figures 4.27 and 4.28. These figures are based on the relative carbon content estimated in the metallographic examination of each individual sample. Cast iron objects are least represented in the collection. There are only two artifacts made of cast iron and these constitute 2.7% of the group. The low carbon steel and wrought iron materials have the highest number, comprising 28 artifacts or 37.3% of the collection included in this study. There are 23 samples or 30.7% of high carbon steel. Finally, the medium carbon objects comprise 22 artifacts or 29.3%. 
DISTRIBUTION OF THE KIND OF IRON
(Guths-Michigan 1922-28 Collection)

- Cast iron (2.7%)
- High carbon (30.7%)
- Low carbon (37.3%)
- Medium carbon (29.3%)

Figure 4.27 Pie-Chart Distribution of the Kind of Iron

DISTRIBUTION OF THE KIND OF IRON
(Relative Carbon Content)

<table>
<thead>
<tr>
<th>Kind of Iron</th>
<th>Number of Each Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low carbon</td>
<td>28</td>
</tr>
<tr>
<td>Medium carbon</td>
<td>22</td>
</tr>
<tr>
<td>High carbon</td>
<td>23</td>
</tr>
<tr>
<td>Cast iron</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4.28 Bar-Chart Distribution of the Kind of Iron
4.4.1 Cebu Materials

Cebu lies at the geographical center of the Philippine archipelago (Figure 1.1). Its unique location positions the island midway between the two major islands of Luzon and Mindanao, and at the same time it is closed off from the open expanses of the Pacific Ocean as well as the Sulu Sea by the other Visayan islands (Wernstedt and Spencer 1967:468). Cebu has a land area of 4421.13 square kilometers, its overall length is 196.33 kilometers and its width does not exceed 32.186 kilometers.

Cebu has always been important archaeologically as shown through the work of Hutterer (1973a). Although this work began as a archaeological salvage project, Hutterer was able to put together a coherent picture of a pre-hispanic local Cebuano community, never done before in Philippine archaeology. His findings are as follows:

There are 13 strata found with three recognizable cultural levels which he labeled Horizons I, II, III in the Cebu City sites. All of these cultural levels were used for burial, although there is sufficient evidence of habitation in Horizon II, including remains of post holes of houses, kitchen middens and black, humus-rich habitation soil.
Horizon I represents the lowest and therefore the earliest period. It is "characterized by absence of trade pottery, which led to the dating of this cultural level as sometime within the first millennium A.D., prior to the beginning of formal trade contacts with China which occurred around the late 9th or early 10th century A.D." (Rutterer 1973a:55). A burial in this period was furnished with an iron dagger, gold, blue-glass, and carnelian beads which are commonly found in the "Philippine Iron Age" context.

There was a temporal lag of site use after Horizon I, perhaps caused by a changing shore line and an associated shift in the settlement. Horizon II, the second cultural level is dated on the basis of associated export ceramics from China and Indochina ranging in date from the early 13th to the middle or end of the 15th century A.D. The early Cebuanos lived in stilt houses close to the water; the basis of their economy was fishing. A small group of the population was engaged in specialized crafts: iron smithing, pottery, and probably also weaving. The Cebuanos also maintained a lively trade with fellow Filipinos as well as with foreign ports.

Horizon III, the third cultural level was found intruding into Horizon II and separated by a stratigraphic break. It is dated towards the end of the 15th century and
characterized by new mode of interment, namely flexed position as well as the use of a plank coffin.

The relevance of Hutterer's (1973a) work is that first, it provides us with the basic information about a stratigraphic profile of a site in Cebu. In some ways, this site is comparable with those sites that were visited by Guthe between 1922 to 1924. Secondly, some of the artifacts that were excavated by Hutterer are also directly comparable with the materials collected by Guthe. Thus, Hutterer's artifact identifications are used as the basis for identifying artifacts in Guthe's collection, some of which are misidentified. For instance, there were some double edge daggers among the Guthe collection that were misidentified as spearheads.

In the Guthe-Michigan data, out of the 41 sites studied there are 22 sites from Cebu alone, and these sites comprise 53.65% of the total number of sites considered here. Among the 75 iron samples analyzed from the Guthe collection, 42 are from Cebu. These constitute 56% of the total sample. The distribution of these iron materials from Cebu is seen in Table 4.5 and Figures 4.29 and 4.30. The following sites and their respective artifacts will be discussed according to the general categories of Burials, Caves, Graves, and Miscellaneous.
Figure 4.29 Bar-Chart Distribution of Cebu Iron Artifacts

Figure 4.30 Pie-Chart Distribution of Cebu Iron Artifacts
4.4.2 Burial Ground 5

The site of Burial Ground 5 (B-5) is at Lagtan, near the river Mananga, just north of Talisay and 8 kilometeres south of the City of Cebu. At B-5 two well preserved iron spearheads were found. Both of them were identified with the Visayan name Bancao, and are in excellent condition (see Figure 4.10) first is Artifact B-5-19, classified as Type 1.2 (spearheads with rectangular tang in cross section). The other is Artifact B-5-20, grouped as Type 1.0 (spearheads with diamond shaped tang in cross section). These artifacts were associated with Asiatic ceramics such as green jars and bowls, grey and white plates, brown cups, washed out blue and white plates, a flat white plate with crackled appearance, a festoon-lip bowl and shell bracelets. The ceramic materials in this burial (B-5) are traditionally dated to 14th to 15th century A.D. by ceramicists like Aga-Oglu (1946; 1948) and Fox (1964).

4.4.2.1 Metallographic Data on B-5 Artifacts

In an unetched condition Artifact B-5-19 is relatively clean metal with small amount of slag inclusions. It looks like a modern steel. After the sample was etched with 2% Nital it was observed that, under
low (x100) magnification Artifact B-5-19 shows a uniform distribution of fine grain structures of pearlite and ferrite. This artifact is a medium carbon steel, approximately 0.3% to 0.4% carbon. At x200 magnification the grains along the edge have been compressed which suggests intentional cold working. Under higher (x600) magnification, the lamellar microstructure appears to be fine and according to Knox "in a modern parlance these are called 'normalized' structures which suggest evidence of the metal being forged hot, and cooled in air from above the critical temperature." (Photomicrograph 4.7) Normalization would be defined here as air cooling from above the critical temperature of about 950°C. This spearhead has an average hardness of 309 VHN.

Artifact B-5-20 has an enormous number of slag inclusions when observed in an unetched condition. After it was etched (2% Nital), this spearhead was found to be a wrought iron with coarse ferrite grains (Photomicrograph 4.8). It has almost no carbon content and this was also reflected in its low hardness readings with an average of 172 VHN.

4.4.3 Burial Ground 6

According to Guthe's (1922-25) fieldnotes, the site of B-6 is on a hilltop, just to the east of the Bulacao
River, in a cornfield. On the top of the burial were fragments of two broken bowls with a spearhead and skeleton just under them. B-6 was a round pit in white marl, and it was obviously thought to be a secondary burial. The pit or cut is slightly elliptical measuring 31 X 27 centimeters. It is on the side of the hill, almost the top, facing southeast. The bottom of the pit was 47 cm below the surface, and 25 cm below the level of the uppermost dish. The white marl is overlain by 20-25 cm dark earth and upper jars are 30 cm below the surface. There were six fragments of six vessels in the burial and two iron implements. Altogether, the three iron artifacts from this burial are the following:

1. Artifact B-6-7, classified as Type 3.2 (small L-shaped knife, Figure 4.18);

2. Artifact B-6-8, classified as Type 2.0 (dagger with long tang, Figure 4.14); and

3. Artifact B-6-9, classified as Type 5.0 [some kind of a ferrule or a ring (Figure 4.24) to hold the tang of a spearhead, knife, or a dagger].

It is said that B-6 is very near to Grave 70. Apparently however, there was no mention of any iron artifact found in G-70. This could have been simply a sampling error or due to incomplete excavation at Grave 70.
4.4.3.1 Metallographic Data on B-6 Artifacts

In an unetched condition Artifact B-6-7 has a number of slag inclusions which appear to be flattened most probably by hammering (Photomicrograph 4.9). After it was etched (2% Nital) the sample showed martensitic structures indicating that it was quenched and as a result hardened (Photomicrograph 4.10). During this process, martensite forms in plates. It is difficult to estimate the amount of carbon in a martensitic structure because of possible uneven distribution. On one side the microstructure appears to be dark, since there is probably a greater amount of carbon there. A microhardness traverse indicates decarburization before or during the hardening process (Figure 4.31). On the other side, the microstructure appears light, suggesting that perhaps there is less carbon there. Nevertheless, the average carbon content is probably about 0.50%. There is an irregular distribution of martensite grain size. This knife has been heated before quenching in water at least to above the critical temperature of the ferrite and austenite phase, i.e. above 700°C or more depending on the amount of its carbon content. Definitely, the carbides indicate tempering to a high temperature of perhaps 500°C, thus it is over tempered for use as a good knife. The metal is too soft for its
Microhardness Traverse of B-6-7

Across the Center

Figure 4.31 Microhardness Traverse of Artifact B-6-7
ideal purpose although its average hardness is 343 VHN. Nevertheless, depending on its function as an artifact it could always have been resharpened.

In an unetched condition Artifact B-6-8 has a small number of slag inclusions which appear to have been flattened perhaps during hammering. After it was etched (2% Nital) it appeared that this dagger is basically martensitic in microstructure with small grain size (Photomicrograph 4.11). There appear some lath-like structures that look like spheroidized perlrite. This suggests that this dagger might have been tempered. There is also evidence for tempering in the martensite. The temper is probably closer to the optimum in this object than in Artifact B-6-7. The average hardness of Artifact B-6-8 is 412 VHN which is quite high for a regular dagger.

In an unetched condition Artifact B-6-9 has a number of slag inclusions scattered throughout the sample. When etched (2% Nital) it appeared to be a wrought iron with irregular distribution of grain size. On one side the grains are fine, while on the other they are coarse (Photomicrograph 4.12). Along the boundaries of the fine grains are very fine perlrite colonies. Fine grain ferrites are located in the interior. On the coarser grain side are bands segregating the finer grains from the coarse grain regions. These bands are perhaps caused by
phosphorus segregation (Tylecote and Thomsen 1973). At the extreme point, there is almost no carbon. However, the carbon content is estimated to be approximately 0.10% to 0.15% on the average. The mean hardness of this ferrule is 142 VHN (Photomicrograph 4.13).

4.4.4 Burial Ground 7

The site of Burial Ground 7 is on a hill directly at the back of the buildings of the Cement works in Naga, about 22 kilometeres southwest of Cebu City. Guthe (1922–25) has recorded 10 skeletons for B–7 ranging from child to adult burial. Each burial has an average depth of 20–25 centimeters below the surface. Some of the burials are furnished with ceramics, beads, shells, and iron implements while some are not. It seems to me that this is a clear case of status and/or sex differentiation. Unfortunately there was no mortuary analysis conducted on this particular burial. Nevertheless, Guthe was keen to note the soil stratigraphy:

The black earth in which the remains occur is shallow — not more than 1/2 meter deep and usually about 35 cm. Below this is disintegrated yellowstone in the form of small pebbles, obviously undisturbed. In the black earth are a great many shells and sherds of native ollas, what I should imagine a village dump site should be. The place is on a gently sloping hillside facing the sea, about 30–40 meters above high tide, and a half kilometer from the shallow beach.
The iron artifacts from B-7 included in this study are as follows:

1. Artifact B-7-23, grouped as Type 1.2 (spearhead with rectangular tang in cross section, Figure 4.12);

2. Artifact B-7-24, also grouped as Type 1.2 (spearhead with rectangular tang in cross section Figure 4.12);

3. Artifact B-7-25a, classified as Type 2.0 (long tang double edge dagger Figure 4.14);

4. Artifact B-7-25b, identified as Type 3.6 (oval tip knife Figure 4.22); and

5. Artifact B-7-25c, classified as Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21).

Although they were not specifically identified according to their accession number, Guthe recorded that all of the above artifacts are directly associated with Skeletons 2, 4, and 6. He had rough sketches of the burials, showing the in situ positions of the specimens, which were also accompanied by field notes. For instance, "Skeleton 2 (has) very friable beads around right lower arm, and scattered nearby. Iron lance head beside left femur. Cock's spur beside right femur." This "cock's spur" must have been B-7-25c in my identification. Then,
for Skeleton 4, he noted that the spearpoint was toward the feet. Finally, for Skeleton 6, Guthe wrote that:

On right lower arm was a mother-of-pearl bracelet, now in small pieces. On the right shoulder, edge to head, length parallel to body, a flat ended iron implement. Along the left femur was a wide iron lancehead and beside it one of the characteristic small knives, both points toward feet.

The 'flat ended iron implement' we can identify as B-7-25b. However, which among the spearheads belong to what skeleton is difficult to tell. Nevertheless, the 'wide iron lancehead' could be the long tang double edge dagger (Type 2.0), since this particular type has always been identified as 'spearpoint', 'spearhead', or 'lancehead' by Guthe.

4.4.4.1 Metallographic Data on B-7 Artifacts

In an unetched condition Artifact B-7-23 has a number of slag inclusions which appear to have been flattened by hammering (Photomicrograph 4.14). After it was etched (2% Nital) this spearhead was observed to be a mild steel with an approximately 0.25% carbon content and pearlitic microstructure i.e., mainly slightly spheroidized pearlite. It has a fine grain size on one side and is relatively coarser from the middle to the other side (Photomicrograph 4.15). There is more carbon on the side where the grain size is finer. There are several bands, perhaps the results of phosporous segregation appearing at
the middle section of the sample, which suggest that the specimen might have been welded from a variety of wrought iron materials. The same pattern of pearlite colonies is also observed in the oxide adjacent to the actual metal especially under high (x400) magnification (Photomicrograph 4.16). The average hardness of this spearhead is 161 VHN.

Artifact B-7-24 has some fine slag inclusions and contains more oxide than metal when observed unetched. After it was etched with 2% Nital, this spearhead revealed a uniform, fine grain microstructure. It is difficult to ascertain whether it is tempered martensite or spheroidized fine pearlite (Photomicrograph 4.17). It must have been a fairly high carbon steel as indicated by its dark color. It may have been heat treated, quenched, and tempered. The average hardness of this spearhead is 297 VHN.

In an unetched condition, we see a number of slag inclusions, which appear to have been flattened due to hammering in Artifact B-7-25a. A line of oxide, perhaps wustite, was observed along the sides of the slag inclusions. A minute island of metal was also found trapped inside the slag inclusion. When etched (2% Nital), this dagger has a fine grain high carbon steel with an estimate of approximately 0.7% carbon. Coarse pearlite structures are observed here and there in the microstructure. There is a discontinuous network of
ferrite. Some pearlites have no clear ferrite boundaries, due perhaps to a localized eutectoid composition. The average hardness of this dagger is 293 VHN (Photomicrograph 4.18).

Artifact B-7-25b in an unetched condition shows some slag inclusions which appear to have been flattened (Photomicrograph 4.19). When etched with 2% Nital this knife has a very fine grain size uniformly distributed over the entire field. Basically it is martensitic in microstructure, i.e. the knife was quenched (Photomicrograph 4.20). Although it is martensitic, Artifact B-7-25b has an average hardness of 380 VHN. The relatively low average hardness indicates tempering.

In an unetched condition, Artifact B-7-25c shows slag inclusions which appear to have been flattened. After it was etched (2% Nital) the knife revealed a duplex grain structure, which is a mixture of coarse and fine grain (Photomicrograph 4.21). At the coarse grain boundaries are Widmanstätten structures (Photomicrograph 4.22). These may have been formed during cooling from the coarsening temperature. The Widmanstätten structures appear to be intersecting in different crystallographic planes. The ferrites must have formed first at and then within the austenitic grain boundaries. The metal must have been air cooled. The carbon content is estimated to be 0.3% to
0.4%. The average hardness of this knife is 152 VHN.

4.4.5 Burial Ground 12

The site of B-12 is in the Barrio of Pitogo, Minglanilla, Cebu. According to Guthe (1922-25), this is a mountain district. The materials collected from this site were Chinese ceramic wares, two iron implements, a couple of bracelets, and a few teeth. The iron artifact included in this study is Artifact B-12-19a. It is categorized as Type 1.2 (spearhead with rectangular tang in cross section, Figure 4.12).

4.4.5.1 Metallographic Data on B-12 Artifact

Artifact B-12-19a has very few slag inclusions as observed in an unetched condition. After it was etched with 2% Nital the spearhead showed a uniform, fine grain distribution. Under x400 magnification, some grain boundaries appeared to have been outlined by ferrite (Photomicrograph 4.23). The sample is composed of a mixture of ferrite, martensite, pearlite and bainite. Its average hardness is 399 VHN. This dagger is a true steel.

4.4.6 Burial Ground 17

Burial Ground 17 is located in Barrio Tapul,
Municipality of Talisay, Cebu. It is in the hills back from the shore, and near Grave 74 (Guthe 1922-25 fieldnotes). There are two iron artifacts from this site. One is Artifact B-17-33a and the other is Artifact B-17-33b. Both artifacts are classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20). They are associated with ceramic vessels, shell bracelets, gold beads, inlay beads, and glass beads.

4.4.6.1 Metallographic Data on B-17 Artifacts

In an unetched condition Artifact B-17-33a shows a number of slag inclusions which appear to have been flattened by hammering. When etched (2% Nital), the knife has a uniform distribution of fine grain size (Photomicrograph 4.24). There is a concentration of carbon along the edge and the knife is definitely carburized at the tip, suggesting selective application of carburization on the part of the smith (Photomicrograph 4.25). Even at the oxide, relict pearlite colonies or "ghost structures" are observed. The average hardness of this knife is 144 VHN.

Artifact B-17-33b has very little slag inclusion when observed in an unetched condition. After it was etched with 2% Nital, the knife appeared to be a mild steel
with a uniform carbon distribution. This is reflected in its fine grain size which is also homogeneously distributed. Fine pearlite is observed under x600 magnification (Photomicrograph 4.26). Some inter-pearlite and ferrite grain boundaries are also noticed. It must have been rapidly air cooled. The average hardness of this knife is 202 VHN.

4.4.7 Burial Ground 18

The site of Burial Ground 18 is in the mountains set back from the coast of Barrio Ginbitayan, Minglanilla, Cebu. A number of artifacts were collected from B-18: ceramics, including green bowls, white dishes, light grey bowls, brown jugs; miscellaneous beads; and a number of iron implements, i.e. spearpoints, bolos, and knives. Among the iron artifacts collected as samples to this study are Artifact B-18-15, which is classified as Type 2.0 (dagger having long tang, Figure 4.14), and Artifact B-18-17, which is grouped under Type 3.3 (square end bolo with the length of between 30 to 60 centimeters, Figure 4.19).

4.4.7.1 Metallographic Data on B-18 Artifacts

In an unetched condition Artifact B-18-15 shows a number of slag inclusions, which appear to have been
flattened by hammering. When etched with (2% Nital), the dagger shows a uniform grain size (approximately No. 6 ASTM), which is homogeneously distributed over the entire sample (Photomicrograph 4.27). The average hardness of Artifact B-18-15 is 163 VHN. It is low carbon wrought.

Artifact B-18-17 observed in an unetched condition has very few slag inclusions, which appear flattened perhaps due to hammering. When etched (2% Nital) the bolo showed indications of a fairly coarse grain austenite and is hypo-eutectoid in composition. The original austenite grains (a high temperature phase) are surrounded now by ferrite (Photomicrograph 4.28). It has fine pearlite that is evenly distributed, and its carbon content is estimated around 0.60% to 0.70%. This bolo might have been cooled rapidly in air as evidenced by the apparent presence of some upper bainite in the microstructure, although no martensite was observed. This is a true steel which may have been quenched. Quenching would result in hardening but the low hardness reading indicates some reheating which would result in tempering. The average hardness of Artifact B-18-17 is 267 VHN.

4.4.8 Burial Ground 19

Burial Ground 19 is located in the Municipality of Minglanilla, Cebu. According to Guthe (1922-25), the
collection from this site consists mainly of ceramic sherds, fragments of a lower human jaw, clay beads and broken clay tubes, and iron implements that were associated with B-17, B-18 and G-82. The iron sample from this collection is Artifact B-19-20a, classified as Type 3.2 (small L-shaped knife, Figure 4.18).

4.4.8.1 Metallographic Data on B-19 Artifact

Observed in an unetched condition Artifact B-19-20a has a number of flattened slag inclusions, perhaps by hammering. When etched (2% Nital), the knife has an irregular distribution of grain size, with the grains varying from fine to intermediate to coarse (Photomicrograph 4.29). Grains of intermediate size were observed near the edges, followed by finer and then coarser grains. Pearlite colonies appear clearly at x400 magnification (Photomicrograph 4.30). Even in the oxide some discontinuous pearlite grain boundaries are found. The average hardness of this knife is 171 VHN. This is a mild steel with an estimated carbon content of 0.08%.

4.4.9 Burial Ground 64

The site of Burial Ground 64 is in Barrio Ticoy, Argao, Cebu. The materials collected from this site are a small unbroken dragon jar with two bone fragments of a
child and a flake of gold, miscellaneous sherds of celadon, greenish grey bowls, grey stonewares, and two iron bolos. The two iron artifacts are grouped as both Type 3.3 (square end bolos with the lengths of between 30 to 60 centimeters, Figure 4.19). These are identified as Artifacts B-64-14a, and B-64-14b.

4.4.9.1 Metallographic Data on B-64 Artifacts

Artifact B-64-14a has a number of slag inclusions, flattened perhaps by hammering, as observed in its unetched condition. The slag inclusions look very typical for wrought iron. After it was etched (2% Nital), the bolo showed a very coarse grain of size No. 2 1/2 ASTM and evenly distributed (Photomicrograph 4.31). It is definitely a wrought iron having virtually no carbon. The average hardness of Artifact B-64-14a is 117 VHN.

In an unetched condition Artifact B-64-14b has a number of slag inclusions which appear to have been flattened by hammering. When etched (2% Nital) this bolo has a fine grain size basically martensitic with substantial pearlite and some ferrite. There may be some bainite in it also (Photomicrograph 4.32). Bainite looks similar to martensite but is quite different in a sense that bainite forms isothermally or in slower cooling at low temperature and is not quite as hard as martensite. In
other words, there was quenching but it was not severe enough for complete hardening. Artifact B-64-14b has a high hardness reading with an average of 470 VHN.

4.4.10 Burial Ground 82

Burial Ground 82 is located in Barrio Capiyoan, Argao, Cebu. The artifacts collected from this site include ceramics of various kinds including green bowls, white fluted cups, greenish brown jars, grey glazed stonewares, two small gold ear-rings with circular bodies, gold beads, eleven beads of various kinds, one agate, highly polished stone amulets, an unbroken glass green bracelet which is triangular in cross section, and a complete but badly rusted iron spearhead. The iron artifact examined from this collection is classified as Type 1.2 (spearhead with rectangular tang in cross section, Figure 4.12) and identified as Artifact B-82-17. According to Guthe (1922-25):

One grave was found and excavated. The body was about six inches below the surface ... The small jar and the green bowl were inverted over the head. The three smaller vessels were near the feet. Beads around the neck. The green bracelet on the left arm. The top of the jar was on the surface.
4.4.10.1 Metallographic Data on B-82 Artifact

There are two samples taken from this Artifact B-82-17, and both have a number of slag inclusions which appear in the unetched condition to have been flattened by hammering. The samples were taken from opposite sides of the blade. Sample A is mounted in transverse section and Sample B in cross section. After these were etched (2% Nital), Sample A of Artifact B-82-17 showed a coarse grain wrought iron with little or no pearlite. The grains are equiaxed and evenly distributed over the entire field (Photomicrograph 4.33). Sample B on the other hand is fine grained and martensitic. There is also fine bainite observed under x400 magnification. It appears, then, that the Sample B side of the spearhead was case carburized and quenched (Photomicrograph 4.34). Case carburization can occur when the implement being forged is left in the charcoal bed of the forge for an extended period. During this period carbon diffuses into the outer surface of the implement and hardens it. The average hardness of Sample A is 122 VHN while that of Sample B is 514 VHN. The mean hardness of Artifact B-82-17 therefore is 309 VHN.
4.4.11 Burial Ground 84

The site of Burial Ground 84 is at Barrio Salagmaya, Ronda, Cebu. The artifacts associated with this burial are grey bowls; olive-green, crackled, glossy celadon wares; grey, glazed stonewares; brown jars; light blue and white bowls; and a fragment of a rusted iron knife. The iron artifact in question is Artifact B-84-13a, which is classified under Type 3.4 (medium knife with the length of between 12.0 to 29.9 centimeters, Figure 4.20).

4.4.11.1 Metallographic Data on B-84 Artifact

Artifact B-84-13a is remarkably free of slag inclusions as seen in the unetched condition. After it was etched (2% Nital), the knife shows its wrought iron character with virtually no carbon (Photomicrograph 4.35). It has very few pearlite colonies at the tip or along the blade. The grain size varies from fine to intermediate. At the heavy end, however, the grains are larger. Hence this knife must have cooled more slowly at this thicker end. Artifact B-84-13a has an average hardness of 184 VHN.
4.4.12 Burial Ground 85

Burial Ground 85 is located in Barrio Balanigan, Dalaguete, Cebu. The iron artifact from this site is Artifact B-85-19a, classified as Type 3.6 (knife with oval tip, Figure 4.22). It is associated with celadon wares, green bowls, brown bowls, grey wares, and blue and white wares. There were also some shell bracelets and other iron implements recovered.

4.4.12.1 Metallographic Data on B-85 Artifact

Observed in an unetched condition, Artifact B-85-19a has a number of slag inclusions which appear to have been flattened by hammering. Some slag inclusions have internal structures visible even under low power (x100) magnification. When etched (2% Nital), the knife is basically martensitic in microstructure with a small amount of ferrite. Some bainite is also observable under higher (x400) magnification (Photomicrograph 4.36). This knife must have been quenched and later tempered. Its average hardness is 543 VHN.

4.4.13 Burial Ground 89

The site of Burial Ground 89 is situated above the
mountains of Barrio Tulotulo, Consulacion, Cebu. The materials recovered from this site are mostly ceramics – such as green bowls, grey plates, a small globular brown jug – and seven fragments of iron. Among the iron artifacts selected as samples are Artifact B-89-8a, identified as Type 2.0 (dagger with long tang, Figure 4.14), and Artifact B-89-8b, classified as Type 3.4 (medium knife with the length of between 12.0 to 29.9 centimeters, Figure 4.20).

4.4.13.1 Metallographic Data on B-89 Artifacts

There are two samples from the same specimen B-89-8a, and both have number of slag inclusions which appear to have been flattened by hammering when observed in the unetched condition. Sample A was taken from the blade and Sample B was cut from the tang. Some slag inclusions remain intact within the oxide. Most of the slag inclusions have internal structures (dendritic), perhaps of some form of magnetite. It should be noted that some light colored idiomorphic crystals also were observed in the slag (Photomicrograph 4.37). When etched with 2% Nital, the blade (Sample A) of Artifact B-89-8a showed an evenly distributed fine grain size (Photomicrograph 4.38). It is mainly pearlitic in microstructure with an estimated amount of 0.10% to 0.15% carbon. In this sample there are some
equiaxed grains which are not deformed which indicates that it was fired uniformly above the critical temperature at about 750°C. The tang (Sample B), on the other hand, had a mixed austenite grain size to start with and now it has a mixture of coarse and fine grain pearlite (Photomicrograph 4.39). Its carbon content is about 0.30%, which is much higher than Sample A. It is hypo-eutectoid in composition and was probably heated to about 800 - 950°C, also much higher than the blade. There are some Widmanstätten structures observed within the coarse grains of prior austenite, and this suggests fairly fast air cooling along the tang. The average hardness of Sample A is 153 VHN while that of Sample B is 293 VHN, hence, this dagger has a mean hardness of 223 VHN.

As seen in an unetched state, Artifact B-89-8b has a number of slag inclusions which appear to have been flattened by hammering. When etched (2% Nital), the knife has a fine grain size with an evenly distributed pearlite and some patches of ferrite. It is nearly eutectoid but slightly hypo-eutectoid in composition (Photomicrograph 4.40). This knife was possibly quenched and tempered at the extreme end with some evidence of spheroidization. There is also some evidence of partly decomposed pearlite. Its carbon content is estimated to be high, in the order of 0.90% to 1.0%. Some of the spheroidized microstructures
suggest the possibility of cold working. The average hardness of Artifact B-89-8b is 290 VHN.

4.4.14 Burial Ground 93

Burial Ground 93 is located in Barrio Bulac, Bogo, Cebu. The iron artifact from this site is Artifact B-93-15, classified under Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21). It is associated with ceramics such as grey stonewares, grey green wares, blue and white wares, and greenish brown jars, some pieces of gold, fragments of shell bracelets, and a small soft grey sandstone, shaped like an adze, but according to Guthe (1922-25), "it was surely used as a whetstone."

4.4.14.1 Metallographic Data on B-93 Artifact

In an unetched condition the sample from Artifact B-93-15 has a number of slag inclusions which appear to have been flattened by hammering. Fine slag inclusions are also observed to have been dispersed mostly at the center and at the wide end of the sample. After it was etched with 2% Nital and viewed under lower (x100) magnification, one could observe the gradient of carbon distribution in the sample of Artifact B-93-15 (Photomicrograph 4.41). The darker side apparently has a higher carbon content than the
lighter side. There are martensite and islands of ferrite on the darker side while the lighter side is basically composed of fine pearlite colonies. This knife has an average hardness of 215 VHN.

4.4.15 Grave 71

The site of Grave 71 is in Barrio Camuran, Municipality of Barili which is four kilometers north of Tapet, on the Carcar – Barili Road, and on the west side of Cebu. The goods found in this grave were a carved gold ferrule, gold and glass beads, shell bracelet, a shark's tooth, an iron sword and knife, human teeth, a festoon-lip bowl, a dark brown jar, olive green bowls, white wares, and brown crackled plates. According to Guthe (1922–25), "the material was associated with only one skeleton, at a depth of about one meter, and covered an area of about two meters square." The iron artifact in question is Artifact G-71-18a, identified by Guthe as a "sword". It is classified here however, under Type 3.3 (square end bolo with the length of between 30 to 60 centimeters, Figure 4.19).

4.4.15.1 Metallographic Data on G-71 Artifact

Observed in an unetched state, Artifact G-71-18a is relatively very clean metal with virtually no slag
inclusions. After it was etched (2% Nital), this bolo showed a uniform distribution of very fine grains and is a medium carbon steel (Photomicrograph 4.42). It is basically martensitic with fine spheroidized carbide, which could have been the result of tempering. Islands of ferrite are also visible in the sample. Artifact G-71-18a has an average hardness of 464 VHN.

4.4.16 Grave 74

Grave 74 was located on the mountainside of Barrio Tapul, Talisay, near Linay, Cebu. It is reported that this was a grave of a single individual, associated with ceramics including green wares, and cream bowls, a fragment of a lead pipe, a number of iron fragments, and two small gold tube rings. There are four iron artifacts sampled from this site:

1. Artifact G-74-6a, classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20);

2. Artifact G-74-7a, classified under Type 1.0 (spearheads having diamond shaped tang in cross section, Figure 4.10);

3. Artifact G-74-8a, classified under Type 3.5 (small knife with the length of between 5.0 to 11.9
centimeters, Figure 4.21);

4. Artifact G-74-8b, classified as Type 3.1 (small pointed knives, Figure 4.17) and functionally these are suspected as knives used for working "pinya"\(^1\) cloth or fibers by the local people.

4.4.16.1 Metallographic Data on G-74 Artifacts

There are two samples from the same Artifact G-74-6a, and both have a number of slag inclusions which appear to have been flattened by hammering, as observed in an unetched condition. Both samples were taken from the blade: Sample A is from the middle portion; and Sample B is from the tip of the artifact. There are long slag inclusions in Sample A (Photomicrograph 4.43). There are less slag inclusions in Sample B. After both samples were etched (2% Nital), Sample A showed a uniform carbon distribution, and the carbon content was estimated at about 0.30%. It has very fine grain size and is covered with pearlite colonies (Photomicrograph 4.43). On the other hand, Sample B is mostly eutectoid to slightly hypo-eutectoid microstructurally. It is also pearlitic.

---

1. Pinya is a local term for pineapple (Ananas comosus), the tropical plant that develops from a spike or head of flowers and is surmounted by a crown of leaves. The leaves are used as fibers for clothing, rope, etc.
Prior austenite boundaries are visible at x400 magnification (Photomicrograph 4.44). Its carbon content would be approximately 0.65% to 0.70%. The average hardness of Sample A is 251 VHN while that of Sample B is 221 VHN. This knife, then, has a mean hardness of 236 VHN.

There are also two samples from the same Artifact G-74-7a, and both have a number of slag inclusions which appear to have been flattened by hammering as seen in their unetched state. Both samples were taken from the blade, adjacent to one another. Sample A is mounted in cross section and Sample B in transverse section. When etched with 2% Nital, Sample A reveals a fine grained steel, pearlitic in microstructure (Photomicrograph 4.45). It is estimated to have a medium carbon content in the range of 0.20% to 0.25%. Even under lower (x100) magnification, it is observed that there are faint bands of segregation (Photomicrograph 4.45). Sample B on the other hand shows basically the structure of a low carbon steel with an estimated 0.08% carbon. The grain size is intermediate and appears to be equiaxed. There is also a weld-like line which was compounded. In this thin band (Photomicrograph 4.46), the carbon content is higher, about 0.30%. This band of pearlite grains may have resulted from the presence of a thin band of phosphorus and manganese rich metal. Alternatively it could have been produced by superficial
carburization in the hearth prior to local welding. The average hardness of Sample A is 191 VHN while that of Sample B is 128 VHN. This spearhead, then, has a mean hardness of 160 VHN.

Artifact G-74-8a, as seen in an unetched state, has a number of slag inclusions which appear to have been flattened by hammering. It is mounted in transverse section. After it was etched this knife revealed a hyper-eutectoid steel with cementite particles in a fine grained matrix (Photomicrograph 4.47). This matrix, which is almost unresolvable even at x600 magnification, is probably a very fine grained tempered martensite or very fine pearlite. Coarse carbides must have come out just before quenching or rapid air cooling. There may have been some tempering done. The average hardness of this knife is 373 VHN.

In its unetched condition Artifact G-74-8b shows a number of slag inclusions which appear to have been flattened by hammering. Some slag inclusions have internal structures visible even under low power (x100) magnification. It was mounted in a transverse section. After it was etched (2% Nital) this pinya knife was shown to be definitely a low carbon wrought iron with an uneven distribution of grain size ranging from coarse to intermediate. It shows no pearlite (Photomicrograph 4.48).
Artifact G-74-8b has an average hardness of 140 VHN.

4.4.17 Grave 76

The site of Grave 76 is situated in the mountains directly at the back of Danso, Cebu. According to Guthe's (1922-25) fieldnotes, the site has various odd graves containing ceramics such as green bowls, brown wares, and grey wares, and also a badly rusted iron spearhead. The iron artifact taken from this site is Artifact G-76-11, grouped under Type 1.1 (spearheads having square shaped tang in cross section).

4.4.17.1 Metallographic Data on G-76 Artifact

Artifact G-76-11, as observed in its unetched state, has a number of slag inclusions which appear to have been flattened by hammering. Some slag inclusions have internal structures visible even under low power (x100) magnification. When etched (2% Nital), Artifact G-76-11 proved to be definitely a low carbon wrought iron with an uneven distribution of grain size (Photomicrograph 4.49). The grain size ranges from coarse to intermediate. There are no observable pearlite colonies. The average hardness of this spearhead is 114 VHN.
4.4.18 Grave 82

Grave 82 is located in Barrio Tabud, Municipality of Minglanilla, Cebu. "It is in the hilly country, near Grave 68" (Guthe 1922-25:fieldnotes). The materials associated with G-82 are mostly green bowls and six fragments of iron implements. Artifact G-82-6a is the iron artifact sampled from this site. It is classified under Type 1.2 (spearheads with rectangular tang in cross section).

4.4.18.1 Metallographic Data on G-82 Artifact

In its unetched condition Artifact G-82-6a has a number of slag inclusions which appear to have been flattened by hammering. After it was etched (2% Nital), the grain size of the spearhead was observed to be generally fine and evenly distributed over the entire area. It is basically martensitic with islands of ferrite, hence it must have been quenched (Photomicrograph 4.50). Artifact G-82-6a has an average hardness of 326 VHN. This comparatively low hardness for a martensitic structure indicates tempering.
4.4.19 Grave 111

The site of Grave 111 is in Barrio Talot, Carcar, Cebu. According to Guthe (1922-25), it was a single burial with the skeleton at full length. It was estimated at about twenty inches below the surface. A group of small unbroken deep ceramic plates were found around the body, but not on the skull. A bead chain was observed around the neck, consisting mostly of small glass beads in various colors, with six gold beads, and three agate beads. On one lower arm were a series of shell bracelets. Also associated with these materials were one polished stone implement and four iron fragments. There are two iron artifacts sampled from this site. The first is Artifact G-111-40a, and the other is Artifact G-111-40b. Both artifacts are classified as Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21).

4.4.19.1 Metallographic Data on G-111 Artifacts

Artifact G-111-40a has a number of slag inclusions running in one direction which appear to have been flattened by hammering when observed in its unetched condition. When etched with 2% Nital, this knife has a very irregular distribution of grain size. The grains vary from very fine to intermediate to coarse (Photomicrograph
4.51). It has virtually all types of microstructures including pearlite, cementite, martensite, bainite, and ferrite which are visible at x100. Depending on which field one is looking at, on the lighter side there is probably no carbon at all; whereas on the darker side, the carbon content is estimated to be 0.25%. Since the prior austenite grains were coarse, so too, is the martensite. There may be evidence of decarburization where on the opposite and lighter side the carbon is less. Artifact G-111-40a has an average hardness of 240 VHN.

In an unetched state the sample has a number of slag inclusions which appear to have been flattened by hammering. After it was etched (2% Nital), Artifact G-111-40b showed a fine martensitic microstructure that appeared to contain small spheroidized carbides (Photomicrograph 4.52). It was quenched from above the critical temperature of pearlite formation where the carbon content could have been roughly 0.20% to 0.65% and then tempered. This knife was probably a very successful tool, judging by its hardness. Its average hardness is 419 VHN.

4.4.20 Grave 114

Grave 114 is located in Barrio Biaong, Barili, Cebu. "This grave was found in a field, while plowing. Enough of the skeleton remained to say that it had been
buried at length, and that the pottery was on the upper part of it in the vicinity of the chest" (Guthe 1922-25:fieldnotes). Major fragments of two grey bowls with unglazed rings in the bottom were found along with a part of an iron implement. The iron artifact sampled is Artifact G-114-3, identified as a fragment of a long rectangular tang, and classified as Type 2.0 (dagger with long tang, Figure 4.14).

4.4.20.1 Metallographic Data on G-114 Artifact

Artifact G-114-3 in an unetched state showed a number of slag inclusions which appear not to have been flattened. Some internal microstructures on the slag inclusions are observable. After it was etched with 2% Nital, much of Artifact G-114-3 showed itself to be martensitic (Photomicrograph 4.53). The grain size ranges from fine to coarse. The martensite was tempered at a fairly low temperature. The average hardness of this dagger's tang is 358 VHN.

4.4.21 Grave 123

The site of Grave 123 is in Barrio Bulac, Dumanjog, Cebu. According to Guthe (1922-25), the burial was found eight and half inches below the surface. He reported that the arms were folded on the abdomen and that there were
shell bracelets on the right forearm. There was a large broken plate on the chest and an unbroken plate on the knees. These plates are of green celadon type. There were also two sherds of blue and white wares recovered. A spear was found in situ on the right hip. It is probable that this iron artifact, labeled as Artifact G-123-6 was misidentified as a spear instead of being a two-edge dagger. It is therefore classified as Type 2.0 (dagger with long tang, Figure 4.14).

4.4.21.1 Metallographic Data on G-123 Artifact

The sample from Artifact G-123-6 is relatively clean with few slag inclusions. Those visible appear to have been flattened by hammering when viewed in its unetched state. When etched with 2% Nital, Artifact G-123-6 is hypo-eutectoid in composition and has irregular carbon distribution. Carbon tends to be more concentrated at the middle than along the edges, hence it may have been decarburized on both edges (Photomicrograph 4.54). The center has an estimated carbon content of 0.40% while the edges have about 0.25% to 0.30% carbon. The specimen is eutectoid in composition at the center and there are some ferrite, pearlite, martensite and prior austenite grain boundaries present. This dagger had been quenched and tempered. The interior was all austenite before it was
quenched. There are some observable Widmanstätten structures even in the oxide. The edge is coarse grained and has been reheated to the point that the original microstructure has been destroyed. Artifact G-123-6 has an average hardness of 301 VHN.

4.4.22 Miscellaneous 1

These materials were collected from various barrios and municipalities in southern Cebu. They may have been mixed with B-25, which is in Barrio Salay, Ronda; B-26 in Barrio Butong, also Municipality of Ronda; B-27 in Barrio Bisaril, Boljoon; C-42, in the Barrio of Tabud, Alcoy; G-89, in Barrio Pogalo, also in the Municipality of Alcoy; and G-90, in Barrio Colansijan, Alegria. Most of the artifacts are ceramics such as celadons, green dishes, light grey bowls, "South China" blue and white plates, and brown wares. There are also a number of various iron tools and weapons. Among the iron artifacts sampled from this collection are the following:

1. Artifact M-1-26a, classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20);

2. Artifact M-1-26b, classified as Type 1.2 (spearheads with rectangular tang in cross section, Figure 4.12);
and

3. Artifact M-1-26c, classified as Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21).

4.4.22.1 Metallographic Data on M-1 Artifacts

Observed in an unetched condition the sample from Artifact M-1-26a is mostly oxide with only two islands of metal at the very end section. In these islands of metal, there are almost no slag inclusions. When etched with 2% Nital, this knife is almost eutectoid in composition with some patches of ferrite. It has a homogeneous distribution with a very fine grain size. Some colonies of pearlite are observable at x400 (Photomicrograph 4.55). This knife has an average hardness of 263 VHN.

The sample from Artifact M-1-26b in its unetched state showed some slag inclusions, but these do not seem to have been flattened. It is perhaps due to the sample having been mounted in a transverse section. After it was etched (2% Nital), the spearhead appeared to consist mostly of martensite and ferrite (Photomicrograph 4.56). On one side it is mostly ferritic with very fine grain size. On the other side, near the edge, it is almost entirely martensitic with a few patches of ferrite. This indicates
therefore that the spearhead was quenched, and the low
hardness of the martensite indicates it was tempered. The
average hardness of Artifact M-1-26b is 225 VHN.

The sample taken from Artifact M-1-26c is mostly
oxide with only a few minute islands of metal when observed
in an unetched condition. There are however, slag
inclusions found in the oxide (Photomicrograph 4.57). After
it was etched (2% Nital), the island of metals of Artifact
M-1-26c were mostly eutectoid in composition. There are
some "ghost structures" or relict pearlite appearing in the
oxide. It is probably pearlitic with fine grains, and
uniform in distribution. The average hardness of this
knife is 286 VHN.

4.4.23 Miscellaneous 6

These M-6 materials were also collected from
different barrios and municipalities in southern Cebu.
These collections were associated with B-40, in Barrio
Cangbanog, Dalaguete; B-41, in Barrio Algasí, Argao; B-42,
in Barrio Tabon, Sibonga; B-43, in Barrio Tolang, also in
the Municipality of Argao; C-26, in Barrio Mandaliquit,
also at Argao; G-105, in Barrio Cangaga, Sibonga; and
G-106, in Barrio Calauin, Argao. These were also mostly
ceramics such as green celadon plates, blue and white
wares, grey bowls, and grey stoneware jars. Brass and/or
bronze fragments were reported as well as a number of iron implements like spears, knives, bolos, and chisel. There are four iron artifacts included in this study and they are as follows:

1. Artifact M-6-51a, grouped under Type 1.1 (spearheads having square shaped tang in cross section, Figure 4.11). It was formerly identified as chisel, since what is left is a chisel looking implement;

2. Artifact M-6-52, classified as Type 1.2 (spearheads with rectangular tang in cross section, Figure 4.12);

3. Artifact M-6-53a, classified as Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21); and

4. Artifact M-6-54, grouped under Type 3.3 (square end bolo with the length of between 30 to 60 centimeters, Figure 4.19).

4.4.23.1 Metallographic Data on M-6 Artifacts

The sample from Artifact M-6-51a has a number of slag inclusions. Unlike the other samples noted, however, the slag inclusions in this artifact do not seem to have been flattened. Internal microstructures of the slag inclusions are also observable. When etched with 2% Nital,
Artifact M-6-51a has a very irregular grain distribution. The grain sizes range from fine to intermediate, from medium to coarse; at the edges, the grain size is very fine but at the middle, fairly coarse (Photomicrograph 4.58). It is definitely deliberately carburized, hardened, and probably tempered. At x400, one can observe some of the martensite forming near the center (Photomicrograph 4.58). If this artifact of tempered martensite was a chisel, then it would have been an unsuccessful tool because of low hardness due to insufficient carburization and/or overtempering. The average hardness of the artifact is 185 VHN, quite low if it had been a chisel. Thus, with this result of metallurgical analysis, it would be best to reclassify Artifact M-6-51a as a fragment of a spearhead with a square shaped tang in cross section.

There are two samples from the same Artifact M-6-52 and both have some slag inclusions, which appear to have been flattened by hammering when observed in an unetched state. Both samples were taken from the blade: Sample A is from the tip; and Sample B is from the middle portion of the artifact. Sample A is relatively clean with only 2 pieces of slag, whereas Sample B has few long slag stringers. When etched with 2% Nital, both samples A and B of this spearhead have tempered martensite with some patches of ferrite. The tip (Sample A) is fine grained
(Photomicrograph 4.59) while the blade (Sample B) has a coarser grain size (Photomicrograph 4.60).

In an unetched condition the sample from Artifact M-6-53a is relatively clean with few slag inclusions. Those present appear to have been flattened by hammering. When etched with 2% Nital, the knife is basically martensitic in its microstructure, which indicates that it had a homogeneous distribution of medium grain size prior austenite (Photomicrograph 4.61). This blade was quenched and tempered. Some very small patches of ferrite are visible as well. This would have made a very successful implement. This knife has an average hardness of 434 VHN.

The sample from Artifact M-6-54 is relatively clean with very few minute slag inclusions, which appear to have been flattened by hammering. Some slag is also found in the oxide when observed in its unetched condition. After it was etched with 2% Nital, this bolo was found to be basically martensitic in microstructure (Photomicrograph 4.62). It had a homogeneous distribution of fine to medium grained prior austenite. Some patches of ferrite are visible (Photomicrograph 4.62). Artifact M-6-54 has an average hardness of 397 VHN. It also was probably a very successful tool.
4.4.24 Siquijor Materials

One can not describe the island of Siquijor without mentioning its relationships to the whole Visayan region (Figure 1.1). The central Visayan region centers upon the island of Cebu, and includes all of Siquijor, Bohol, and the islands of the Camotes group, numerous smaller offshore islands, and the eastern side of the island of Negros, including the island of Negros Oriental and the two municipalities of San Carlos and Calatrava in Negros Occidental (Wernstedt and Spencer 1967:468). Siquijor is entirely ringed by coral reefs. The island contains a high and much dissected interior, and near the center reaches an elevation of 627.88 meters on Mount Malabohoc. Deep limestone deposits cover all of the island’s surface. Level land is limited to narrow river floodplains and deltas, particularly along the southern and northern coasts. Siquijor contains an area of 336.7 square kilometers (Ibid.:28).

There are 6 sites from Siquijor representing 14.63% of the total number of sites from the Michigan data. Each of these sites represents a single specimen or 8% of the sample collection under study from the Guthe iron materials.
4.4.25 Burial Ground 21

The site of Burial Ground 21 is in Barrio Datag, Larena, Siquijor. According to Guthe's (1922-25) fieldnotes, "it is located on a hill just back from the head of Larena Harbor on the left hand side of the flat, looking from the harbor." The materials from this site are mainly ceramics such as celadon sherds, green bowls, white wares, a brownish green dragon type jar, glass beads, a thin globular gold bead, a chunk of manganese ore, and a fragment of iron knife. The iron sample in question is Artifact B-21-17, which is classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20).

4.4.25.1 Metallographic Data on B-21 Artifact

Observed in an unetched condition, the sample from Artifact B-21-17 has a number of slag inclusions, which appear to have been flattened by hammering. When etched with 2% Nital, this knife shows itself to be definitely of wrought iron with an uneven grain size. The grain size ranges from coarse to intermediate. There are almost no observable pearlite colonies (Photomicrograph 4.63). It has an average hardness of 134 VHN.
4.4.26 Burial Ground 32

Burial Ground 32 is located in Barrio Bintangan, Larena, Siquijor. The specimens collected from this site were mostly blue and white sherds of bowls, and brown bowls with festoon-lip, and fragments of iron knife. The iron artifact sampled from this burial is Artifact B-32-8, grouped under Type 3.5 (small knives with the length of between 5.0 to 11.9 centimeters, Figure 4.21).

4.4.26.1 Metallographic Data on B-32 Artifact

There are very few slag inclusions in the sample taken from Artifact B-32-8, as seen in an unetched condition. When etched with 2% Nital, Artifact B-32-8 appears to be close to the eutectoid in composition. The sample is definitely a high carbon steel with an estimated 0.75% carbon content. It has very fine and uniform distribution of grain size (Photomicrograph 4.64). Basically, it is pearlitic in microstructure with a large amount of grain boundary ferrite - thus hypoeutectoid (Photomicrograph 4.65). This small knife has an average hardness of 346 VHN.
4.4.27 Grave 100

The site of Grave 100 is located in Barrio Calunasan, Maria, Siquijor. It was on the top of a small ridge projecting outward into the larger valley, just before the steep slope began. It was in rocky ground, and large stones had been piled on the spot to mark it. The materials collected from this grave are several sherds of white bowl with light brown marks, greyish white plates, a greenish dragon jar, dark blue and white wares, and a small thin iron knife, which according to Guthe's (1922-25) fieldnotes, looks obviously modern. The iron sample from this grave is Artifact G-100-7, classified under Type 3.2 (small L-shaped knives, Figure 4.18).

4.4.27.1 Metallographic Data on G-100 Artifact

In this sample of Artifact G-100-7, there are some slag inclusions, but they do not seem to have been flattened, probably because the sample is mounted in a transverse plane. When etched with 2% Nital, this knife is mostly fine grained and euctectoid in composition, though there are some medium sized grains present. Some pearlite colonies are visible at x400 (Photomicrograph 4.66). There are also some ferrite patches in the hypo-eutectoid zone. Artifact G-100-7 has an average hardness of 306 VHN.
4.4.28 Grave 101

Grave 101 is situated in Barrio Catamboan, Larena, Siquijor. It was on the top of a spur or hilltop. According to Guthe's (1922-25) fieldnotes, upon digging they found two green bowl sherds, four old human teeth which were still connected in the lower jaw, fragments of bottle glass, four fragments of iron implements, and several pieces of lopsided rings of lead. These materials were buried in the black earth, just below the surface and underlain by rotten limestone. "It was obviously a disturbed burial. the few bones seen were old and fragmentary and not in normal position." The iron artifact in question is Artifact G-101-7a, classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20).

4.4.28.1 Metallographic Data on G-101 Artifact

In an unetched condition the sample of Artifact G-101-7a shows a number of slag inclusions which appear to have been flattened by hammering. After it was etched (2% Nital), the knife showed an irregular distribution of grain size ranging from fine to intermediate to coarse. Basically it is pearlitic in microstructure. It is a mild carbon steel with an estimated 0.10% carbon content. Under
low (x100) magnification, there are observable band structures towards one end. These are probably some kind of band segregation. At a high (x400) magnification, some relief forming structures are visible inside some of the coarse grain boundaries (Photomicrograph 4.67). These are probably manganese segregation. Artifact G-101-7a has an average hardness of 150 VHN.

4.4.29 Grave 117

The site of Grave 117 is in Barrio Tacdog, Siquijor, Siquijor. The location was in an open flat field. There were two skeletons side by side with their bodies at full length. Their heads were facing to the east and their feet were pointing to the west. The associated materials were ceramics such as green celadons, brown jars, and greenish grey plates; native earthenware pottery; a small adze-like stone, which was probably used as a whetstone; strings of black beads and gold beads; and two pieces of iron implements. Artifact G-117-15a is the iron artifact sampled from this site. It is classified as Type 1.2 (Spearheads with rectangular tang in cross section, Figure 4.12).
4.4.29.1 Metallographic Data on G-117 Artifact

The sample of Artifact G-117-15a is mostly oxide with only a minute island of intact metal. Some slag inclusions are visible, even at the oxide zone, in its unetched state. When etched with 2% Nital, Artifact G-117-15a is revealed as basically of wrought iron with a carbon content of approximately 0.02% to 0.03%. It has equiaxed ferrite grains and some etch pits are visible (Photomicrograph 4.68). This tang of a spearhead has an average hardness of 120 VHN.

4.4.30 Grave 147

Grave 147 is situated in Barrio Lamancapan, Larena, Siquijor. According to Guthe's (1922-25) fieldnotes, this was a grave of a man found buried at length on his back. His head was facing east and there were two iron knives associated with it. Another artifact found during the excavation was a large green plate, probably a late type of celadon, with transparent glaze and an elaborate incised design on its interior. The grave was about ten inches below the present surface. The iron artifact analyzed from this site is Artifact G-147-2a, classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20).
4.4.30.1 Metallographic Data on G-147 Artifact

There are two samples from the same Artifact G-147-2a, and both have a number of slag inclusions which appear to have been flattened by hammering. Both samples were taken from the blade: Sample A is from the tip; and Sample B is from the middle portion of the specimen. There are less slag inclusions in Sample A. There are long slag stringers in Sample B. After Artifact G-147-2a was etched (2% Nital), Sample A was shown to be approximately eutectoid in composition and basically martensitic in microstructure. A few patches of ferrite are visible at x400 (Photomicrograph 4.69). The carbon content is estimated to be about 0.65% to 0.70%. Sample B, on the other hand, has a uniform carbon distribution and the carbon content is estimated as 0.30%. It has a very fine grain size and is covered with pearlite colonies (Photomicrograph 4.70). This indicates that the square end only was carburized, quenched and tempered. The average hardness of Sample A is 392 VHN while that of Sample B is 157. Hence, this knife has a mean hardness of 275 VHN.

4.4.31 Bohol Materials

In the Camotes Sea midway between the southern islands of Leyte and Cebu lies the island of Bohol (Figure
1.1). It has an area of 3864.28 square kilometers and nearly oval in shape. Wernstedt and Spencer (1967:27) have noted that "Large, low grade deposits of manganese ore are located on Anda Peninsula in the southeast."

From Bohol there are 4 sites studied comprising 9.76% of the 41 total number of sites from the Michigan data. Out of the 75 samples taken from the Guthe collection, there are 10 specimens from Bohol and these constitute 13.33% of the sample size.

4.4.32 Cave 11

The site of Sucgang Cave (Cave 11), is located on the south coast of Bohol, seven kilometers east of Loay and about 24.7 kilometers from Tagbilaran. This was one of the caves heavily worked by Guthe, judging from the considerable amount of fieldnotes and exhaustive stratigraphic profile descriptions he made during its excavation in February of 1924. Hundreds of boxes of materials were taken from C-11 ranging from imported ceramics such as blue and white wares, brown wares, green wares, light grey stonewares, greenish brown jars, etc. as well as native pottery, polished stones (celts?), shell bracelets, worked shells, animal bones, antlers, masses of beads of various colors and sizes, miscellaneous fragments of copper and/or brass, gold, and lead, and last but not
least, numerous fragments of iron (by the hundreds). These specimens were associated with burials of both young and adult individuals.

From the boxes of hundreds of iron artifacts from Sugang Cave, the following specimens were selected for this study:

1. Artifact C-11-400i, classified as Type 7.0 (cast iron vessel, Figure 4.26);

2. Artifact C-11-400j, classified under Type 1.0 (spearhead with diamond shaped tang in cross section, Figure 4.10);

3. Artifact C-11-400k, classified as Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21);

4. Artifact C-11-400L, classified as Type 3.4 (medium size knives having the length of between 12.0 to 29.9 centimeters, Figure 4.20);

5. Artifact C-11-400m, also grouped under Type 3.5 (small knife with the length of between 5.0 to 11.9 centimeters, Figure 4.21);

6. Artifact C-11-401b, classified as Type 4.0 (harpoons, Figure 4.23); and
7. Artifact C-11-401c, also classified as Type 4.0 (harpoons, Figure 4.23).

4.4.32.1 Metallographic Data on C-11 Artifacts

The sample of Artifact C-11-400i is relatively clean with almost no slag inclusions as observed in an unetched condition. When etched with 2% Nital, Artifact C-11-400i is a white cast iron whose main matrix is composed of cementite (Photomicrograph 4.71). It has lamellar pearlitic and little graphite. It must have been cooled rapidly. This cast iron piece has an average hardness of 632 VHN, the highest among the Guthe-Michigan collection.

In an unetched state, the sample from Artifact C-11-400j has a number of slag inclusions which appear to have been flattened by hammering. Some slag inclusions have internal structures visible even under low (x100) magnification. After it was etched (2% Nital), this fragment of a spearhead appeared to be basically wrought iron or a low carbon steel. It has a very irregular distribution of grain sizes ranging from fine to coarse (Photomicrograph 4.73). Some of its pearlite colonies are visible at x400 magnification. 137 VHN is the average hardness of this knife.
The sample of Artifact C-11-400k has a number of slag inclusions which appear to have been flattened by hammering. When etched with 2% Nital, one can easily distinguish the light and dark sides on Artifact C-11-400k under low (x100) magnification. There is definitely more carbon on the dark side. Carbon is beginning to diffuse on the lighter side. It is possible that this artifact consists of two welded pieces of low and high carbon steel. This knife is basically pearlitic and the pearlite appears to have been distorted (Photomicrograph 4.74). This could be due to cold working, i.e. it was forged after the pearlite had already crystallized. Artifact C-11-400k has an average hardness of 235 VHN.

In an unetched condition, the sample taken from Artifact C-11-400L is remarkably clean with almost no slag inclusion whatsoever. After it was etched with 2% Nital, Artifact C-11-400L showed a fine grain size with an irregular distribution of carbon. It probably started with a low carbon content. It was quenched, which produced martensite, and then it was tempered (Photomicrograph 4.75). The lath-like structures are tempered martensite. This knife has an average hardness of 249 VHN. The relatively low hardness test results for a martensitic structure indicate a high tempering temperature.

Observed in an unetched state, the sample from
Artifact C-11-400m is remarkably clean with almost no slag inclusions. When etched (2% Nital), Artifact C-11-400m appears highly carburized along the edge. This area has a quantity of fine pearlite and is basically eutectoid in composition. Some patches of ferrite are observed and there is a possibility of tempered martensitic and bainitic microstructures. The tempering could have been done at a high temperature as evidenced by the carbides in (Photomicrograph 4.76) and low hardness test results. This knife has an average hardness of 347 VHN. Quenching was probably done from above the critical temperature. It is very similar in structure to the sample C-11-400L.

The sample from Artifact C-11-401b, as it was observed in its unetched state, has a number of slag inclusions which appear to have been flattened by hammering. When etched with 2% Nital, this harpoon reveals a fine grained high carbon steel with an estimated carbon content of approximately 0.7%. Coarse pearlitic structures are present. Some ferrite was observed along the original austenite grain boundaries, its presence is perhaps due to its nearly eutectoid composition (Photomicrograph 4.77). There is a discontinuous network of ferrite outlining the austenite grains. Artifact C-11-401b has an average hardness of 322 VHN.

The sample of Artifact C-11-401c, in an unetched
state, shows a number of slag inclusions, which appear to have been flattened or hammered. When etched (2% Nital), Artifact C-11-401c appears to be a mild steel with carbon content ranging from approximately 0.08% to 0.1%, and pearlitic in microstructure. Its pearlite colonies are contiguous with one another across the field. It has a fine grain size on one side and is relatively coarser from the middle to the other side suggesting that there is more carbon on the side where the grain boundaries are finer (Photomicrograph 4.78). This harpoon has an average hardness of 121 VHN.

4.4.33 Cave 91

Cave 91 is situated on the Island of Sandigan, Loon, Bohol. "This cave is large, with very high ceiling and white wall, and has no dirt or guano inside, only a rock floor" (Guthe 1922-25:fieldnotes). The materials collected from this cave are blue and white plates, light grey bowls, blue green wares and what was identified as an iron spearhead, "probably a hunting spear." The iron artifact in question is Artifact C-91-6, classified as Type 2.1 (a two-edged sword, Figure 4.15), the only one from the whole iron collections of Guthe.
4.4.33.1 Metallographic Data on C-91 Artifact

The sample from Artifact C-91-6, in an unetched condition, has a number of slag inclusions which appear to have been flattened by hammering. Some slag inclusions have internal structures visible even under low (x100) magnification. When etched with 2% Nital, Artifact C-91-6 appears basically to be low carbon wrought iron. It has a very irregular distribution of grain sizes ranging from fine to coarse (Photomicrograph 4.79). There seems to be more carbon on the edge. Although there are no visible pearlite colonies, martensitic and/or bainitic structures are visible at x400 magnification along the edge of the blade. The average hardness of this two-edged sword is 141 VHN.

4.4.34 Grave 167

The site of Grave 167 is located in Barrio Limocon, Sitio Simang, Municipality of Valencia, Bohol. According to Guthe (1922-25), the artifact was found below the ground surface in a wooden coffin. A blue and white plate was over the face. "The kris, which is here called 'kalis' was also in the coffin." The iron artifact was identified as a "rusty straight Moro kris." This is Artifact G-167-2, and it looks more like a spearhead and it is therefore
classified as Type 1.1 (spearheads having square shaped tang in cross section, Figure 4.11).

4.4.34.1 Metallographic Data on G-167 Artifact

The sample from Artifact G-167-2, in an unetched state, is unusually dirty with a number of slag inclusions which appear to have been flattened by hammering. After it was etched with 2% Nital, Artifact G-167-2 showed a fine grain high carbon steel with an estimated carbon content of approximately 0.7% to 0.9%. It is basically pearlitic. Coarse pearlite structures are frequently observed (Photomicrograph 4.80). Few clear prior austenite boundaries are observed and this is due to the approximate eutectoid composition of the steel. There is a discontinuous grain boundary network outlining prior austenite grains. The boundary material is sometimes ferrite, sometimes cementite and sometimes both. This spearhead has an average hardness of 281 VHN.

4.4.35 Grave 185

Grave 185 is situated in Barrio Calonasan Norte, Loboc, Bohol. The materials collected from this site are celadon wares, two plain brass bracelets, and one rusted iron spear. The iron artifact sampled is Artifact G-185-5, classified under Type 1.0 (spearhead with diamond shaped
tang in cross section, Figure 4.10).

4.4.35.1 Metallographic Data on G-185 Artifact

Observed in an unetched state, the sample from Artifact G-185-5 is unusually dirty sample with a number of slag inclusions which appear to have been flattened and in bands. When etched (2% Nital), this spearhead is best described as a low carbon wrought iron with an approximately 0.08% to 0.1% carbon content and pearlitic in microstructure. It has fine a grain size on one side and is relatively coarser from the middle to the other side, suggesting that there is more carbon on the side where the grains are finer. There are several bands appearing at the middle section of the sample which suggests that the specimen might have been welded from a variety of wrought iron materials (Photomicrograph 4.81). Pearlite colonies appear to be more concentrated at the bands (Photomicrograph 4.82). Artifact G-185-5 has an average hardness of 159 VHN.

4.4.36 Surigao Materials

The province of Surigao is divided into north and south. It is located in eastern Mindanao with an area of 11,914 square kilometers (Figure 1.1). Generally, it belongs to the Pacific Cordillera region, consisting of
high and rugged mountain zone paralleled offshore by the deep waters of the Philippine Trough (Wernstedt and Spencer 1967:32, 517).

There are three sites studied from Surigao comprising 7.32% of the total number of sites included in the Guthe-Michigan collection. Nine iron artifacts were sampled from Surigao which constitutes 12% from the total samples size of 75.

4.4.37 Cave 5

The site of Cave 5 is on Dinago Island, on the east coast of Surigao, and very near the town of Placer. It is located on the east side of the small island of Dinago. According to Guthe (1922–25), this site is a fairly large cave which is both high and wide but not very deep. Its floor gradually sloped to the opening and it contains some earth and many rocks of various sizes which made digging difficult. At the back, the floor sloped more steeply toward the roof. Mostly, the cultural deposit in this cave came from the surface and absolutely nothing was found below the surface. It was dug with shovels, in this mixture of stone and earth to a depth of two feet, over a considerable area. Remains of coffin burials were found and many of the bones were in good condition. Guthe's assessment of the materials was that they were recent. The
associated artifacts were fragments of blue and white and celadon wares, native vessels and jars, shell bracelets, and pieces of iron. The iron artifact included in this study is Artifact C-5-27, identified as Type 1.0 (spearhead with diamond shaped tang in cross section, Figure 4.10).

4.4.37.1 Metallographic Data on C-5 Artifact

Observed in an unetched condition, the sample from Artifact C-5-27 has a number of slag inclusions which appear to have been flattened by hammering. Some of the slag inclusions have unusual internal microstructures seen even at x100 magnification. When etched with 2% Nital, this spearhead reveals an uneven grain size distribution and a variation from fine to intermediate to coarse (Photomicrograph 4.83). There are enough pearlite colonies present to refer to it as a mild steel with an estimated carbon content around 0.10%. It was probably air cooled since there are wide bands of ferrite present. Some of the carbide rims look like degenerated pearlite. Artifact C-5-27 has an average hardness of 160 VHN.

4.4.38 Cave 55

Cave 55 is Ilihan Cave, located in the Sitio of Ilihan, Barrio Santa Fe, Municipio of Carascale, Surigao. It is reached from Cantilan by one and half hours steady
walking for about 7 kilometers. Among the specimens collected were China wares such as olive celadon dishes, light green crackled wares, blue and white plates, large and heavy dark brown jars, dragon type green jars, etc. There were also a large number of native pottery sherds, shell and mother of pearl bracelets, clay pipes and beads, yellow, red, and large blue glass beads, fragments of gold and copper bracelets, and a number of iron implements, associated with human remains.

The iron artifacts included in this study are the following:

1. Artifact C-55-38a, classified as Type 3.5 (small knives with the length of between 5.0 to 11.9 centimeters, Figure 4.21);

2. Artifact C-55-50a, classified under Type 3.0 (big pointed bolos, Figure 4.16);

3. Artifact C-55-50b, classified as Type 3.3 (square end bolos having the length of between 30 to 60 centimeters, Figure 4.19);

4. Artifact C-55-50c, also grouped under Type 3.0 (big pointed bolos, Figure 4.16);

5. Artifact C-55-51a, classified as Type 3.1 (small pointed knives, Figure 4.17) and functionally these
are suspected as knives used for working "pinya" cloth or pineapple fibers by the local people;

6. Artifact C-55-51b, also classified as Type 3.1 (small pointed knives, Figure 4.17).

4.4.38.1 Metallographic Data on C-55 Artifacts

There is a small amount of slag inclusion in this sample from Artifact C-55-38a, which appear to have been flattened, perhaps due to hammering. On the average this knife is almost eutectoid in composition. It has a few pearlite colonies on one side and is hyper-eutectoid on the other side (Photomicrograph 4.84). The presence of martensite suggests that the sample was quenched and tempered at a lower temperature to get the spheroidization phase. There are also observable fine grain boundaries at the hyper-eutectoid area, suggesting that it was quenched from the austenite and cementite field. The sample is definitely a high carbon steel with an estimated 0.75% average carbon content. Artifact C-55-38a has an average hardness of 222 VHN.

Observed in an unetched state, the sample from Artifact C-55-50a, is relatively clean with a small amount of slag inclusions, which appear to have been flattened by hammering. When etched (2% Nital), Artifact C-55-50a is
virtually eutectoid in composition (Photomicrograph 4.85). It has coarse pearlite and the lamellae in the sample sometimes cut at a steep angle. It has been highly spheroidized as evidenced by the nature of the carbide even in the surrounding oxide. Spheroidization may have occurred during the reheating process or hot working just above the critical temperature of pearlite formation about 700°C. This pointed bolo has an average hardness of 269 VHN.

The sample from Artifact C-55-50b has a number of slag inclusions, which appear to have been flattened by hammering. Some of its slag inclusions have unusual internal microstructures as seen even under x100 magnification (Photomicrograph 4.86). Once it was etched (2% Nital), this square-end bolo was shown to be basically pearlitic but under the eutectoid composition. The edge of the blade is martensitic. Grain sizes vary from very fine to coarse (#3 - #4 ASTM). On the extreme side of the blade edge it is hyper-eutectoid with very fine grain boundaries and on the hypo-eutectoid edge there are coarse grains (Photomicrograph 4.86). The eutectoid zone shows no visible grains. Cementite is rarely seen but well defined ferrite grains are found. It is high carbon on one side and low carbon on the other side which suggests that it was case carburized and its carbon content is estimated to range
from 0.25% to 0.80%. The average hardness of Artifact C-55-50b is 201 VHN.

Viewed in an unetched condition, the sample from Artifact C-55-50c has a number of slag inclusions which appear to have been flattened by hammering. Most of the slag inclusions are concentrated on one side. Opposite this are some "ghost" microstructures, i.e. fine grain boundaries are observed in the oxide. After it was etched with 2% Nital, the cross section of Artifact C-55-50c revealed three distinct zones as seen under x100 magnification (Photomicrograph 4.87). From the edge it is coarse and dark, going to the middle it becomes grey and smooth, and at the other edge it is coarse and light. It has pearlite, cementite, ferrite, martensite, and Widmanstatten structures, and is on average of a eutectoid composition (Photomicrograph 4.88). It could be a cast iron welded onto a wrought iron at high temperature. This pointed bolo has an average hardness of 415 VHN.

Observed in an unetched condition, this sample from Artifact C-55-51a, shows a number slag inclusions, which appear to have been flattened by hammering. After it was etched (2% Nital), this pinya cloth knife appeared to be light on one edge and dark on the other, suggesting a gradient distribution of carbon (Photomicrograph 4.89). The lighter side had low carbon content and the darker side had
a higher carbon content. Apparently it was decarburized in the area now low in carbon, which reflects reheating. Alternatively this artifact could be a composite of welded low and high carbon steels. There is also the presence of dark lines, possibly some kind of band inclusions, at the high carbon area, which might possibly represent the segregation of manganese or phosphorous. At the middle it is eutectoid in composition. It has some colonies of pearlite at the lighter side and an irregular distribution of grain size ranging from fine to medium. Artifact C-55-51a has an average hardness of 232 VHN.

The sample from Artifact C-55-51b, as observed in its unetched state, has a number of slag inclusions which appear to have been flattened by hammering. Internal structures are visible in the slag inclusions even at x100 magnification. When etched with 2% Nital, Artifact C-55-51b may also be a welded piece of low and high carbon steel. It is light on one side and dark on the other side. Reheating could have caused the accumulation of more carbon in the low carbon area, which suggests decarburization. However, it has more pearlite than ferrite, and its fine pearlite structures are cut at angles where the lamellae look like martensite (Photomicrograph 4.90). The grain size (Photomicrograph 4.91) is very irregular, ranging from fine to coarse. This pinya cloth
knife has an average hardness of 259 VHN.

4.4.39 Cave 56

The site of Cave 56 is in Cabatuan, Lake Mainit, Surigao. There were few fieldnotes taken from this site. The materials collected from C-56 are celadon wares, light green jars, blue and white plates, native earthenware bowls, blue beads, clay pipes, iron harpoons, iron bolos, and a bracelet of bent, heavy copper or brass wire. The iron artifacts sampled from this site are Artifact C-56-25a and Artifact C-56-25b, which are both of Type 4.0 (harpoons, Figure 4.23).

4.4.39.1 Metallographic Data on C-56 Artifacts

Observed in its unetched state, the sample from Artifact C-56-25a has a number of slag inclusions, which appear to have been flattened by hammering. Internal structures in the inclusions are visible even at x100 magnification. After it was etched with 2% Nital, this harpoon showed itself to be a homogeneously distributed, coarse grain, low carbon steel (Photomicrograph 4.92). It has Widmanstätten structures appearing as parallel plates in crystallographic planes (Photomicrograph 4.93). The parallel bands of grains indicate that the steel must have been heated at a high temperature and cooled fairly
rapidly. The average hardness of this harpoon is 121 VHN.

The sample from Artifact C-56-25b is relatively clean with very few slag inclusions, which appear to have been flattened by hammering. When etched with 2% Nital this tang of a harpoon has revealed very fine ferrite grains almost uniformly distributed except for some areas. Spheroidized carbides are uniformly distributed in the microstructure and some of these carbides appear to be in chains (Photomicrograph 4.94). It could have been forged at or near the lower critical temperature, cooled slowly and not reheated or alternatively it could have been water quenched and over tempered. Artifact C-56-25b has an average hardness of 181 VHN.

4.4.40 Masbate Materials

The island of Masbate is located northeast of Panay and is the result of a juncture of the two major structural trend lines of the Philippines, thus forming an inverted V-shape island (Figure 1.1). One arm of the island is formed by the main northwest – southeast structural arc that supplies the alignment for the Eastern Cordillera of Luzon and Bondoc Peninsula. The other arm is formed by the second structural arc that trends northeast – southwest and reappears in the uplands of northeastern Panay (Wernstedt and Spencer 1967:31, fig. p. 448).
Of the 41 sites included in the study for the Guthe-Michigan collections, only one site or 2.44% is from Masbate. There are two iron specimens from the Masbate site which accounts for 2.67% of the total sample size.

4.4.41 Miscellaneous 2

M-2 site is not a burial nor grave but an ancient gold mining site located in the gold mining area owned by Paul Schwab and G.T. Gruiger on the shore of Port Barrera, near Rio Guinobatan, Aroroy, Masbate. According to Guthe (1922-25), at Schwab's district evidence of ancient workings have been found on the contour of the hillside and occasional holes resembling old tunnels. The men familiar with this site have estimated the ancient mines to be 400 years old. Old mortars and pottery fragments may be seen on the surface. A complete assessment of the site was given by Guthe, who wrote:

Schwab and his partner have set up a small plant for obtaining the gold by stamp mill and the amalgamation (with quick silver) method. They are working the refuse or reject dirt from the ancient mine with great success.

In the faces of their excavation the formation of the dump from the old mine can be studied. The entire dump appears to consist of relatively soft dark earth and pebbles varying in size from plain gravel to that of a man's head. A few larger stones occur. In this deposit are found the remains of human occupation described below. Below this deposit or dump, the undisturbed earth is of a brownish yellow clayey texture, which breaks away in chunks when worked with a trowel.
The deposit is not homogeneous, although regular stratification does not exist. There are irregular layers of earth, and others of gravel with almost no earth. In the same spots deposit of larger stones have accumulated. The gravel has somewhat the appearance of having been deposited by water, although this may be caused by the action of ground water only. In places the deposit is practically homogeneous, and no segregation of gravel and earth can be distinguished.

**Human remains:**

There is little doubt that the miners lived right where they worked and threw their living refuse out in the same place as their mine refuse. But they did not bury their dead in this soft deposit, for no human bones have yet appeared.

The evidences of human occupation consist of food remains, implements, and ceramics.

The largest mass of food remains are shells of several different edible kinds, mostly of the flat, thin bivalve type. Several animal bones occurred, among them deer horn, and boar's jaw. The latter is of a doubtful identification.

Two kinds of metal were found, iron and copper. The iron was a single small knife, of the bolo type with the rivets still in place. The copper was fragment of large implements or vessels of fairly hard thick material. 

Stones shaped by nibbling were fairly common. Larger stones, of hard material, unshaped, had holes of varying depths worn in them by the pounding of the ore. The hand stones,..., which were used with them were of various shapes, and in the great majority of cases, formed from pebbles and natural concretions. Occasionally a hand stone was from a fragment of a boulder. These two kinds of implements resembled the cruder Manos and Metates of the San Louis Valley, Colorado. Several kinds of rocks were used for these implements. One hallowed stone was found of softer material and a deeper hole, which may have been a grain mortar. These implements formed the same purpose as the miner's "bucking plate" of today.
Another use to which pebbles were put was as hammers. Sometimes they had nibbled surfaces, sometimes not, but they did have small concave pitted surfaces formed by hammering.

Most of the ceramic materials were Chinese. There was a noticeably small percentage of native pottery. A few pieces of native jars were seen and a native ware base with a foot! Also a small sherd of a cup sized native jar.

Most of the Chinese stuff was blue and white, and there were more fragments of large bowls than of small plates and bowls. Some had Chinese characters. Two plates were almost complete, both the cobalt blue and the washed grey blue color. This material greatly resembled the material from Daram and Laguinit, Samar. Two sherds of celadon - probably early Ming - were found, as well as one sherd of the covered dish said to be Siamese. A few of the "South China" crackled ware sherds appeared. ....

These fragments were scattered haphazard through the deposit. ....

There are two iron artifacts from this site that are included in this study. They are identified as Artifact M-2-31 and Artifact M-2-55a. Both are classified as of same type, Type 3.4 (medium size knives having a length of between 12.0 to 29.9 centimeters, Figure 4.20).

4.4.4.1 Metallographic Data on M-2 Artifacts

The sample from Artifact M-2-31 is an unusually dirty sample with numerous slag inclusions which, appear to have been flattened by hammering. Some slag inclusions have uncommon internal microstructures as seen at x400. An island of metal is also found caught in slag
(Photomicrograph 4.95). This may be a projection of metal into the slag. When etched (2% Nital), this knife is shown to be basically of low carbon wrought iron. Looking at the whole sample under low (x100) magnification, it has a very uneven distribution of grain sizes ranging from fine to coarse (Photomicrograph 4.96). However, the edge has a more regular distribution of fine grain size and some of its pearlite colonies may be seen at x400. Artifact M-2-31 has an average hardness of 151 VHN.

Viewed in an unetched condition, this sample from Artifact M-2-55a has few slag inclusions, in which appear to have been flattened, perhaps by hammering. After it was etched (2% Nital), the knife revealed its eutectoid composition. It has fine grains on one side and coarse grains on the other side. The presence of martensite and patches of ferrite indicates that the sample was quenched and tempered at a lower temperature and reheated enough to produce spheroidization. Martensite plates are visible in Photomicrograph 4.97. Some bainite is also present suggesting that it was fairly rapidly cooled (Photomicrograph 4.97). The average hardness of Artifact M-2-55a is 330 VHN.
4.4.42 Samar Materials

Samar is the third largest island in the Philippine archipelago (Figure 1.1). It is the largest island in the Visayan region and includes an area of 13,079.5 square kilometers (Wernstedt and Spencer 1967:25, 459).

There is only one site studied from Samar. It represents 2.44% of the total number of sites from the Guthe-Michigan collections, and two specimens from it are 2.67% of the whole sample.

4.4.43 Burial Ground 10

The site of Burial Ground 10 is located on the north road of Catbalogan, near the Barrio of Igid on the island of Samar. It is about one and a half hours by launch north of Catbalogan, by outside route. According to Guthe (1922-25),

About fifty yards inland from sandy beach begin holes from which earth had been taken to fill a road missing across the latter semicircular valley. In these fairly large holes, burial jars were found, which were said to have stone slabs as covers, which were grooved to fit tops of jars.

This burial site in Samar is one of the few sites ever published by Guthe himself (1938). He reported "ten undisturbed burials, five of which were those of adults
buried at length, and five of which were jar burials containing the remains of very young children" (Guthe 1938:29). He noted the valley floor was formed by an irregular stratum of black sandy loam, containing vegetal mold and many fine roots. This loam was 40-45 centimeters thick and was underlain by clean, light colored sand, in which occasional shells and fragments of native-ware jars occurred. He said that all the burials were found in the sand stratum underlying the darker sandy loam to the south in an area about ten meters long and nine meters wide and that the subsequent archaeological excavations were carried to a depth of about one and one-half meters. The depths of the burials were remarkably uniform, ranging from 70 to 113 centimeters. Guthe gave no definite date for the burials. However, he was quite convinced that they are of considerable antiquity because of their stratigraphic position.

According to Guthe (1938:31), "in burial number 4 a small piece of iron was found under the left ear, and in the right hand were the remains of iron and bone inlays could be identified." Some of these burials are associated with a number of small colored beads – white, red, yellow, orange, and blue. There was no mention of any imported ceramics that are associated with them. The Chinese ceramics he collected from the same site were taken from
the strata above the burials. One of the iron artifacts is grouped under Type 1.1 (spearheads having a square shaped tang in cross section, Figure 4.11). It is identified as Artifact B-10-28a. The second specimen, Artifact B-10-16a, is classified as Type 1.3 (it is only a blade of a spearhead without a tang, Figure 4.13).

4.4.43.1 Metallographic Data on B-10 Artifacts

Viewed in an unetched state, the sample from Artifact B-10-16a has a number of slag inclusions, which appear to have been flattened by hammering. When etched with 2% Nital, the blade revealed a generally uniform distribution of fine grain size with occasional coarse grains (Photomicrograph 4.98). It is basically pearlitic in structure across the field. It is a mild steel, and its carbon content is estimated to be 0.25% to 0.30%. Artifact B-10-16a has an average hardness of 258 VHN.

The sample from Artifact B-10-28a has a number of slag inclusions, which appear to have been flattened by hammering. Some of the slag inclusions have unusual, internal microstructures as seen at x200 magnification (Photomicrograph 4.99). After it was etched (2% Nital), Artifact B-10-28a showed an uneven grain distribution and its grain size varied from intermediate to coarse. There are some pearlite colonies present, hence it is a wrought
iron and the carbon content is estimated to be 0.10%. It was probably air cooled rather slowly since there are wide bands of cementite present in the ferrite grain boundaries. Some of the carbide rims look like degenerate pearlite. This fragment of a spearhead has an average hardness of 146 VHN.

4.4.44 Leyte Material

Leyte ranks eighth in size among the islands in the Philippine archipelago (Figure 1.1). It has an area of 7218.33 square kilometers, with a rugged mountainous interior (Wernstedt and Spencer 1967:26, 454-456).

There is also only one site studied from Leyte, and one specimen constituting 1.33% of the number of items from the Guthe-Michigan collections included in the study.

4.4.45 Cave 14

According to Guthe (1922-25), this cave (C-14) is not in a cliff, but rather it is situated inland from the beach, which is about a kilometer and/or forty five minutes walk west of the town of Calubian, Leyte. It is a wet cave, and it consists of several chambers. Most of the materials taken from it were native pottery, some plain and some with incised designs. Guthe noted that:
in cleaning the area about this large jar, a small iron chisel-like implement was found, pointed at one end. It was rusted, but in relatively good condition. The probabilities are that it is an old type of hunting axe. The natives did not know exactly what it was.

The artifact in question is classified as Type 6.0 (chisel, Figure 4.2), and it is identified as Artifact C-14-11. It is the only chisel from the whole collection considered in this study.

4.4.45.1 Metallographic Data on C-14 Artifact

In its unetched condition, the sample from Artifact C-14-11 shows a number of slag inclusions, which appear to have been flattened by hammering. Some slag inclusions have internal structures visible even under low (x100) magnification. When etched with 2% Nital, Artifact C-14-11 has a fine grain size and its grains are uniformly distributed (Photomicrograph 4.100). It is a low carbon steel with an estimated carbon content of approximately 0.3%. An attempt was made to harden the chisel, as is evident in its microstructure. It is composed of bainite, martensite, ferrite and pearlite. It was probably quenched but not quickly enough for the martensite to have been fully formed. In addition, it may also have been tempered. This chisel has an average hardness of 203 VHN.
4.4.46 Mindoro Material

Mindoro island is located southwest of Luzon and is separated from it by the narrow Verde Island Passage (Figure 1.1). It has a very regular oval shape without any deep coastal indentations and without fringing islets. It ranks seventh among the largest islands in the Philippines, with an area of 3,758 square miles (Wernstedt and Spencer 1967:22-23).

There is also only one site studied from Mindoro, and the one specimen constitutes 1.33% of the total number of the Guthe-Michigan collections included in this study.

4.4.47 Cave 83

The site of Cave 83 is located at Pocanil Point, near the Island of Pocanil just northwest of Buyallao Island, on the southeast coast of Mindoro, which is half way between Mansalay and Bulalacao. According to Guthe (1922-25), the floor of the cave is covered with a deposit of fine earth, almost dust, in which the specimens were found down to a depth of about 10 inches. Below this stratum was the same kind of earth, but redder in color and more tightly packed; it was about six inches deep, increasing to a foot and more localized in the center of
the cave. This stratum in turn was underlain by the solid rock. The materials obtained from this cave are multicolored beads, several jar sherds and polychrome plate sherds, blue and white "Surgiao" plate, native earthenware sherds, a spiral copper bracelet, and a small rusty iron bolo.

The largest part of the collection was examples of weaving, in cloth and rattan, without question Mangyan. Two skulls in fairly good condition were also taken out. The cave was very dry indeed, which accounted for the preservation of vegetable materials. Parts of rattan ties and Buri palm leaves were also found, as well as quantities of leaves, rotten cloth and broken bones (Guthe 1922-25:fieldnotes).

The iron artifact sampled from this cave is categorized under Type 3.4 (medium size knives with the length of between 12.0 to 29.9 centimeters, Figure 4.20) and is listed as Artifact C-83-6.

4.4.47.1 Metallographic Data on C-83 Artifact

There are two samples taken from Artifact C-83-6, and both have quantities of slag inclusions, which appear to have been flattened by hammering as observed in their unetched condition. Sample A was taken from the blade and mounted in transverse section; while Sample B was cut from the tip and mounted in cross section. Some slag inclusions are found even in the oxide. Most of the slag inclusions have internal structures including the dendritic form of
magnetite. After this knife was etched with 2% Nital, it revealed that Sample A has a very fine grain structure and the grains are uniformly distributed over the entire area (Photomicrograph 4.101). It is a low to medium carbon steel with an estimated carbon content of approximately 0.10%. On the other hand, Sample B has an irregular distribution of medium and coarse grain boundaries (Photomicrograph 4.102). It is basically low carbon martensite or bainitic-martensitic with some Widmanstätten structures. It must have been cooled fairly rapidly. Sample A has an average hardness of 155 VHN, while the hardness of Sample B is 133. The knife has a mean hardness therefore of 144 VHN.

4.4.48 Bukidnon Material

Bukidnon occupies north-central Mindanao (Figure 1.1). The Bukidnon–Lanao Highlands region consists of a series of plateaus, highland basins, hills, and volcanic ranges and peaks. It has a land area of 12,950 square kilometers (Wernstedt and Spencer 1967:557-558).

There is also only one site studied from Bukidnon, and one specimen, constituting 1.33% of the entire Guthe-Michigan collection included in the study.
4.4.49 Cave 32

The site of Cave 32 is in the high hill in back of the constabulary barracks in Maluko, Bukidnon, Mindanao. The specimens taken from this cave are blue and white plate and a greenish blue and white dish, associated with the fragment of an iron pot. According to Guthe (1922-25), they look very modern. The sample is identified as Artifact C-32-3 and classified as Type 7.0 (cast iron vessels, Figure 4.26).

4.4.49.1 Metallographic Data on C-32 Artifact

Observed in its unetched condition the sample from Artifact C-32-3 is remarkably clean with virtually no slag inclusions. When it was etched with 2% Nital, Artifact C-32-3 showed that it is indeed a cast iron with an unusual pattern of graphite distribution. It has a fine grain size and the grains are homogeneously distributed (Photomicrograph 4.103). Its dendritic structures look like ferrite (Photomicrograph 4.104). Carbide tends to stand up more in relief. There are cementite networks observed along the outlining dendrites and it does not seem to have any pearlite. It must have been air cooled. This cast iron has an average hardness of 213 VHN.
4.4.50 Davao Material

One of the largest lowland areas on Mindanao is the Davao-Agusan Trough (Figure 1.1). It has a 193.116-kilometer-long longitudinal trough, with a maximum width of nearly 48.3 kilometers, extending from north to south. It includes an area of approximately 28,749 square kilometers (Wernstedt and Spencer 1967:33-34, 523-524).

There is also only one site studied from Davao, and one specimen, constituting 1.33% of the total number of specimens of the Guthe-Michigan collections included in this study.

4.4.51 Cave 76

A burial was found in Cave 76, which is located in the district of Yangag, of the Barrio of Manurigao, at Bacul Point, Caraga, Davao, Mindanao. This cave contained burials of more than a dozen individuals, some of whom seem to have had intentionally deformed parietals. The materials taken from C-76 are ceramics, such as sherds of blue and white bowls, grey wares, greenish brown jars, and native earthenwares. There were also shell bracelets and other worked shells, and seven pieces of iron implements. Coffins were also found and according to Guthe (1922-25),
they bear resemblance to the Bohol coffins. The artifact sampled from this site is Artifact C-76-21a and it is classified as Type 5.0 (ferrule or rings of some kind used to hold the tang of spearheads or daggers or knives, Figure 4.24).

4.4.51.1 Metallographic Data on C-76 Artifact

Viewed in its unetched state the sample from Artifact C-76-21a is highly oxidized with virtually no metal left. Only one surviving minute island of metal was found in it. When it was etched with 2% Nital, the bit of metal discovered in Artifact C-76-21a appeared to be ferritic (Photomicrograph 4.105). It is not possible to characterize the nature of this artifact. Unfortunately the one surviving tiny island of metal found in this ferrule is not enough to take a microhardness test.

4.5 Summary

In this chapter the evidence of the presence of iron in the Philippines from the earliest possible date situated somewhere between 370 – 50 B.C. have been presented. Metallographically, the three Palawan samples are wrought iron with low carbon content. Although most of
the artifacts are in poor condition, relict pearlite or "ghost structures" are observed in the residual metal which permit some interpretation of microstructure. The earlier studies on iron artifacts in the Philippines suggest a more sophisticated metallurgical treatment in some of the low to medium carbon steel implements and tools from the Balingasay Site, Bolinao, Pangasinan, dated to ca. 14th to 15th century A.D. A steel cast fragment of perhaps a cooking vessel from China was found in a 10th century A.D. site of Sitio Maguirig, Cabaruan, Solana, Cagayan. This could suggest an early iron trade with China.

The Guthe-Michigan collection comprises the bulk of this study. There are 75 artifacts sampled from 10 areas constituting 41 sites in central Phillipine region. These are classified into 7 classes and 17 types of iron artifacts. Metallographic analysis was conducted on these materials and found out that: 28 of these artifacts (37.3%) are made of wrought iron and low carbon steel; 23 (30.7%) are of high carbon steel; 22 (29.3%) have medium carbon; and only 2 (2.7%) are made of cast iron. Most of these materials are carburized, quenched and hardened which suggest an improvement in iron technology, although this is expected since these materials date from the 10th to 15th century A.D.
Chapter 5

STATISTICAL ANALYSIS

This chapter will present the statistical description of the Guthe collection. The statistics are presented in tables that may be useful for future comparative studies. In addition, figures are added for a more effective visual representation. It is unfortunate that it is not possible to conduct a comparative analysis of these materials with any other iron collection since no collection of comparable size from the Philippines or elsewhere in Southeast Asia has yet been studied in this manner. Therefore, this study is an attempt to start the compilation of statistical data on iron artifacts in Southeast Asia.

5.1 Statistics of the Guthe Collection

The general distribution of artifacts by type among the Guthe collection is seen in Figure 5.1 and Tables 4.4 and 4.5. From these data one can easily note that the most
DISTRIBUTION OF ARTIFACTS BY TYPE

(Guthrie-Michigan 1922-25 Collection)

Figure 5.1 Bar-Chart Distribution of Iron Artifacts By Type
common artifact represented is the everyday, utilitarian knife. Type 3.4, which represents essentially medium knives with an average length of 17.58 cm comprises 17.3% of the total sample. Similarly, Type 3.5, small knives with an average length of 9.39 cm, constitutes 14.6%. If one adds artifact types together by class, for instance adding all the spearheads, (Types 1.0, 1.1, 1.2, and 1.3), the result is 19 spearheads or 25.32% of the total population, which is still lower than the figure for all the classes of knives. Together, all of these utilitarian knives (Types 3.0, 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6) comprise 35 items or 53.22% of the total sample.

Due to lack of stratigraphic notes in most cases, it is very frustrating to analyze the Guthe materials by period. Solheim (1964) also noted this very important limitation of chronological ordering in his study. In order to make the most of these iron artifacts, analysis was done by type and by site as well as metallurgical treatment. Chronologically, these materials are treated as belonging to the Period of Contact and Trade or the protohistoric period, ca. 10th to the 15th century A.D.

Some variables were directly measured or derived from each of the artifacts. They are therefore called primary variables. They are: site code, weight, maximum length, maximum width, maximum thickness, blade length,
blade width, blade thickness, blade angle, tang length, tang width, tang thickness, and the point or tip angle (Figure 5.2). After the metallurgical analysis was conducted, more primary variables were observed: the kind of iron, i.e. whether the artifact is made of cast iron, steel, or a wrought iron; and the hardness number. The secondary variables are the results of computations of values of the primary variables, such as the ratio of the blade length to the tang length and the relative mass of metal in the blade as computed by multiplying the blade length, blade width, and blade thickness to give a rough composite volume of metal in the blade in terms of cubic centimeters. The same method was used for the tang. Then the composite ratio was also computed by dividing the blade metallic volume with the tang metallic volume.

It should be noted that this is the very first attempt ever made to conduct statistical analyses of iron artifacts in Southeast Asia, hence this technique of analysis is experimental. It is hoped that such analyses will continue to be done in the future in order to arrive at a kind of "standardized" metal analysis similar to that achieved in lithic analysis (Bordes 1969; Dibble 1984; 1987a; 1987b) where another researcher can replicate someone else's work. In this case, the same type of measurement will be taken on the same point of reference
1. Maximum Length
2. Maximum Width
3. Maximum Thickness
4. Blade Length
5. Blade Width
6. Blade Thickness

7. Tang Length
8. Tang Width
9. Tang Thickness
10. Blade Angle
11. Tip or End Angle

Figure 5.2 Illustration of the Metrical Variables
and therefore, similar statistical results are to be expected.

5.1.1 TYPE = 1.0 (diamond shaped tang in x-section)

There are five artifacts (6.66%) of Type 1.0, spearheads with diamond shaped tang in cross section (Figure 4.10). Two of the five artifacts are from Cebu, two from Bohol and one from Surigao. One should note that these areas are geographically adjacent to one another. Hence, one should always bear in mind the high probability of direct contact among these sites during the 10th to 15th centuries A.D. All specimen of this type are of low carbon steel with an average hardness of 163.8 VHN (Vickers Hardness Number). Were they specifically made only as piercing tools or weapons? Although it is very difficult to positively identify what is a tool and what is a weapon among these spearheads, the function remains the same for both of them, which is basically piercing. The average angle of the point is 12 degrees; and the mean blade angle is 37 degrees. The average blade thickness is 0.45 cm. For Type 1.0, an inverse relationship was discovered between the blade thickness and its blade angle (r = -0.86603). The average composite ratio of the blade to the tang is 2.62:1 which means that for every 2.62 cc of metal for the blade, there is 1 cc for the tang.
Nevertheless, the ratio between the blade length and the tang length is 2.94:1. Descriptive statistics of Type 1.0 are tabulated in Table 5.1.

Table 5.1

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>163.8000</td>
<td>137.0000</td>
<td>191.0000</td>
<td>17.6794</td>
<td>5</td>
</tr>
<tr>
<td>Weight</td>
<td>112.3200</td>
<td>29.3000</td>
<td>237.7000</td>
<td>72.1571</td>
<td>5</td>
</tr>
<tr>
<td>Max-L</td>
<td>25.0600</td>
<td>15.6000</td>
<td>35.2000</td>
<td>7.8474</td>
<td>5</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.0200</td>
<td>1.9000</td>
<td>3.4000</td>
<td>0.5810</td>
<td>5</td>
</tr>
<tr>
<td>Max-T</td>
<td>1.2800</td>
<td>0.9000</td>
<td>1.6000</td>
<td>0.2315</td>
<td>5</td>
</tr>
<tr>
<td>Bld-L</td>
<td>20.4250</td>
<td>10.6000</td>
<td>26.7000</td>
<td>6.0330</td>
<td>4</td>
</tr>
<tr>
<td>Bld-W</td>
<td>3.3000</td>
<td>3.0000</td>
<td>3.4000</td>
<td>0.1732</td>
<td>4</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.4500</td>
<td>0.3000</td>
<td>0.6000</td>
<td>0.1118</td>
<td>4</td>
</tr>
<tr>
<td>Bld-A</td>
<td>37.0000</td>
<td>25.0000</td>
<td>61.0000</td>
<td>16.9706</td>
<td>3</td>
</tr>
<tr>
<td>Tng-L</td>
<td>6.6200</td>
<td>5.0000</td>
<td>8.4000</td>
<td>1.1250</td>
<td>5</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.3800</td>
<td>1.0000</td>
<td>1.8000</td>
<td>0.2713</td>
<td>5</td>
</tr>
<tr>
<td>Tng-T</td>
<td>1.1600</td>
<td>0.9000</td>
<td>1.4000</td>
<td>0.1855</td>
<td>5</td>
</tr>
<tr>
<td>End-A</td>
<td>12.0000</td>
<td>7.0000</td>
<td>17.0000</td>
<td>5.0000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-C</td>
<td>30.9115</td>
<td>15.9000</td>
<td>54.4680</td>
<td>14.7766</td>
<td>4</td>
</tr>
<tr>
<td>Tng-C</td>
<td>11.1816</td>
<td>6.7000</td>
<td>21.1680</td>
<td>5.4331</td>
<td>5</td>
</tr>
<tr>
<td>R=B/T</td>
<td>2.6180</td>
<td>2.2083</td>
<td>3.1818</td>
<td>0.3534</td>
<td>4</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>2.9438</td>
<td>2.1200</td>
<td>3.3571</td>
<td>0.4836</td>
<td>4</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>6.1113</td>
<td>3.5333</td>
<td>7.8529</td>
<td>1.6063</td>
<td>4</td>
</tr>
</tbody>
</table>

Max = Maximum    L = Length    A = Angle
Bld, B = Blade    W = Width     C = Composite (LxWxT)
Tng, T = Tang     T = Thickness  R = Ratio

Pearson correlation of coefficient test (PCCT) results has indicated that direct relationship can be established between the blade length and the blade width (r=0.94024) as well as the tang length (r=0.96967). As the blade of Type 1.0 becomes longer, there is a tendency for the blade to be wider and the tang longer. There is also a
direct relation between the blade width and the tang length $(r=0.84758)$. Aside from the inverse relationship between the blade thickness and its blade angle $(r=-0.86603)$, the blade thickness is also directly related to the tang width and the tang thickness $(r=0.83152)$. As the blade becomes thicker, the tang becomes wider and thicker too.

5.1.2 TYPE = 1.1 (square shaped tang in x-section)

There are only 4 artifacts (5.33% of the total sample) classified as Type 1.1, spearheads with square shaped tang in cross section (Figure 4.11). Two of them are from Cebu, one is from Bohol, and the remaining one is from Samar. Cebu and Bohol are adjacent but Samar is farther northeast. However, the Samar site is on the west coast and towards the south. Therefore, the Samar site then, would actually be within the maritime communications area of the Central Visayas a potential source of trade iron and ceramics.

Except for the Bohol sample, Artifact G-167-2, a medium carbon steel, all the rest of Type 1.1 are of low carbon steel. The Bohol sample seems to be a variant of this particular type. Artifact G-167-2 is the hardest with a VHN number of 281. It is also the heaviest, weighing 271.1 grams, and the longest with a length of 33.7 cm. Type 1.1 has an average hardness of 181.5 VHN. The average
The composite ratio of blade to tang among these specimens is 3.14:1; and the average ratio of the blade length and the tang length is 1.64:1. Artifact M-6-51a from Cebu remains a mystery as to whether it is a broken spearhead or an unused chisel. Its hardness, which is 185 VHN, appears too low for a chisel. If it was a chisel, it could not have been a very successful tool. Perhaps that is why it was not used after all. But if it was a spearhead, this hardness reading is acceptable for a successful tool or weapon. Table 5.2 shows other statistical data for Type 1.1.

Table 5.2

<table>
<thead>
<tr>
<th>Statistical Data of Type 1.1 (spearheads with square shaped tang)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Hardness</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Max-L</td>
</tr>
<tr>
<td>Max-W</td>
</tr>
<tr>
<td>Max-T</td>
</tr>
<tr>
<td>Bld-L</td>
</tr>
<tr>
<td>Bld-W</td>
</tr>
<tr>
<td>Bld-T</td>
</tr>
<tr>
<td>Bld-A</td>
</tr>
<tr>
<td>Tng-L</td>
</tr>
<tr>
<td>Tng-W</td>
</tr>
<tr>
<td>Tng-T</td>
</tr>
<tr>
<td>End-A</td>
</tr>
<tr>
<td>Bld-C</td>
</tr>
<tr>
<td>Tng-C</td>
</tr>
<tr>
<td>R=B/T</td>
</tr>
<tr>
<td>R=BL/TL</td>
</tr>
<tr>
<td>R=BL/BW</td>
</tr>
</tbody>
</table>

Max - Maximum
Bld, B - Blade
Tng, T - Tang
L - Length
W - Width
T - Thickness
A - Angle
C - Composite (LxWxT)
R - Ratio
From the PCCT, it was found that the maximum length is inversely related to the maximum thickness \( (r=-0.79650) \). This means that as the spearhead is made longer, its width becomes narrower, and vice versa. This is probably related to the piercing function of the spearhead.

5.1.3 TYPE = 1.2 (rectangular tang in x-section)

There are nine samples (12%) of Type 1.2, which are spearheads with rectangular tang in cross section (Figure 4.12). Eight of these are from Cebu and only one from Siquijor. Artifact G-117-15a from Siquijor is incomplete, the blade is broken, but the tang is complete and it measures 7.1 cm in length, 1.4 cm in width and 0.7 cm in thickness. It is basically a wrought iron and apparently has the lowest VHN number of 122. Artifact B-12-19a from Cebu has the maximum hardness of 399 VHN. Hence, the average hardness reading for Type 1.2 is 280.2 VHN. Consequently, the relative carbon content distribution for this type ranges from low to high. The mean composite ratio between the blade and the tang for Type 1.2 is 14.21:1; while the mean ratio of the blade length to the tang is 3.52:1. This means that this particular type has a tendency to have longer blades and shorter tangs \( (r=-0.76119) \). The average blade angle is 16.55 degrees;
while the average tip angle is 26.28 degrees. From the PCCT, it was noted that the blade length is directly related to the blade width \((r = .93314)\). It was surprising to find out too, that the blade angle is inversely related to the tang thickness \((r = -0.75668)\), though no explanation is suggested. Table 5.3 provides other descriptive statistical information for Type 1.2.

Table 5.3

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>280.2222</td>
<td>122.0000</td>
<td>399.0000</td>
<td>87.7076</td>
<td>9</td>
</tr>
<tr>
<td>Weight</td>
<td>74.8556</td>
<td>17.5000</td>
<td>128.4000</td>
<td>38.9535</td>
<td>9</td>
</tr>
<tr>
<td>Max-L</td>
<td>20.8444</td>
<td>8.3000</td>
<td>29.5000</td>
<td>7.3514</td>
<td>9</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.8444</td>
<td>3.1000</td>
<td>4.8000</td>
<td>0.5871</td>
<td>9</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.6222</td>
<td>0.4000</td>
<td>0.8000</td>
<td>0.1315</td>
<td>9</td>
</tr>
<tr>
<td>Bld-L</td>
<td>19.1143</td>
<td>15.0000</td>
<td>23.9000</td>
<td>3.5361</td>
<td>7</td>
</tr>
<tr>
<td>Bld-W</td>
<td>3.7889</td>
<td>3.1000</td>
<td>4.8000</td>
<td>0.5685</td>
<td>9</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.4111</td>
<td>0.3000</td>
<td>0.5000</td>
<td>0.0737</td>
<td>9</td>
</tr>
<tr>
<td>Bld-A</td>
<td>16.5556</td>
<td>11.0000</td>
<td>25.0000</td>
<td>4.6930</td>
<td>9</td>
</tr>
<tr>
<td>Tng-L</td>
<td>5.5750</td>
<td>3.1000</td>
<td>7.1000</td>
<td>1.1893</td>
<td>8</td>
</tr>
<tr>
<td>Tng-W</td>
<td>0.9889</td>
<td>0.7000</td>
<td>1.4000</td>
<td>0.2283</td>
<td>9</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.5222</td>
<td>0.3000</td>
<td>0.8000</td>
<td>0.1474</td>
<td>9</td>
</tr>
<tr>
<td>End-A</td>
<td>26.2857</td>
<td>20.0000</td>
<td>33.0000</td>
<td>4.3331</td>
<td>7</td>
</tr>
<tr>
<td>Bld-C</td>
<td>31.0401</td>
<td>15.3000</td>
<td>45.8880</td>
<td>11.0500</td>
<td>7</td>
</tr>
<tr>
<td>Tng-C</td>
<td>3.0425</td>
<td>1.2000</td>
<td>6.9580</td>
<td>1.6541</td>
<td>8</td>
</tr>
<tr>
<td>R=BC/TC</td>
<td>14.2124</td>
<td>8.1095</td>
<td>24.4085</td>
<td>5.2491</td>
<td>6</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>3.5218</td>
<td>2.6875</td>
<td>5.0851</td>
<td>0.8509</td>
<td>6</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>5.0532</td>
<td>4.6842</td>
<td>5.5116</td>
<td>0.2934</td>
<td>6</td>
</tr>
</tbody>
</table>

Max - Maximum  L - Length  A - Angle
Bld,B - Blade  W - Width  C - Composite \((L \times W \times T)\)
Tng,T - Tang    T - Thickness  R - Ratio
5.1.4 TYPE = 1.3 (blade only of spearhead)

There is only one sample (1.33%) of this type (Figure 4.13) from Samar. Actually, had there been more distinguishing features of Artifact B-10-16a, it could have been grouped with the other types and Type 1.3 would have been unnecessary.

5.1.5 TYPE = 2.0 (long tang dagger)

There are six artifacts (8%) of Type 2.0, long tang daggers (Figure 4.14), which were misidentified as spearheads in the Guthe collections; two of these are incomplete. The identification of these artifacts is based on the work of Hutterer (1973a) in Cebu. It is interesting to note that this particular type is found only in Cebu.

These daggers range from low carbon to high carbon steel: one in low carbon wrought iron, two of medium carbon steel and three in high carbon steel. As seen in Table 5.4, the lowest hardness reading among specimens of this type is 163 VHN (Artifact B-18-15), while the highest hardness reading is 412 VHN for Artifact B-6-8. The average hardness for Type 2.0 is 291.66 VHN. The mean composite ratio between the blade and the tang is 8.74:1; while the
mean ratio of the blade length to the tang length is 1.89:1. The average blade angle is 22 degrees; and the mean tip angle is 46.5 degrees. From the PCCT, direct relationship can be established between the blade length and the blade width (r=0.94949) as well as blade thickness and also the tang width (r=0.57735); between blade width and tang width (r=0.94772); between blade thickness and tang thickness (r= 0.87039); between blade angle and tip angle (r=0.94370); and surprisingly, between the tang width and the tip angle (r=0.85509).

Table 5.4

Statistical Data of Type 2.0 (long tang daggers)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>291.6667</td>
<td>163.0000</td>
<td>412.0000</td>
<td>81.8936</td>
<td>6</td>
</tr>
<tr>
<td>Weight</td>
<td>86.9333</td>
<td>14.9000</td>
<td>145.2000</td>
<td>47.2985</td>
<td>6</td>
</tr>
<tr>
<td>Max-L</td>
<td>25.6333</td>
<td>9.1000</td>
<td>34.0000</td>
<td>9.3600</td>
<td>6</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.5667</td>
<td>0.9000</td>
<td>5.3000</td>
<td>1.5997</td>
<td>6</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.5000</td>
<td>0.4000</td>
<td>0.6000</td>
<td>0.0816</td>
<td>6</td>
</tr>
<tr>
<td>Bld-L</td>
<td>21.3750</td>
<td>19.7000</td>
<td>23.0000</td>
<td>1.2417</td>
<td>4</td>
</tr>
<tr>
<td>Bld-W</td>
<td>4.5250</td>
<td>4.0000</td>
<td>5.3000</td>
<td>0.5540</td>
<td>4</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.3500</td>
<td>0.2000</td>
<td>0.4000</td>
<td>0.0866</td>
<td>4</td>
</tr>
<tr>
<td>Bld-A</td>
<td>22.0000</td>
<td>8.0000</td>
<td>50.0000</td>
<td>16.4165</td>
<td>4</td>
</tr>
<tr>
<td>Tng-L</td>
<td>11.4833</td>
<td>9.1000</td>
<td>14.3000</td>
<td>1.7430</td>
<td>6</td>
</tr>
<tr>
<td>Tng-W</td>
<td>0.8167</td>
<td>0.7000</td>
<td>0.9000</td>
<td>0.0898</td>
<td>6</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.4500</td>
<td>0.3000</td>
<td>0.6000</td>
<td>0.0957</td>
<td>6</td>
</tr>
<tr>
<td>End-A</td>
<td>46.5000</td>
<td>28.0000</td>
<td>78.0000</td>
<td>19.8809</td>
<td>4</td>
</tr>
<tr>
<td>Bld-C</td>
<td>35.0100</td>
<td>15.7600</td>
<td>48.7600</td>
<td>12.3985</td>
<td>4</td>
</tr>
<tr>
<td>Tng-C</td>
<td>4.2892</td>
<td>2.2050</td>
<td>6.8640</td>
<td>1.4217</td>
<td>6</td>
</tr>
<tr>
<td>R=B/T</td>
<td>8.7442</td>
<td>7.1474</td>
<td>10.6231</td>
<td>1.4899</td>
<td>4</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>1.8974</td>
<td>1.6250</td>
<td>2.2549</td>
<td>0.2272</td>
<td>4</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>4.7620</td>
<td>4.3396</td>
<td>5.2000</td>
<td>0.3274</td>
<td>4</td>
</tr>
</tbody>
</table>

Max - Maximum  L - Length  A - Angle
Bld,B - Blade   W - Width   C - Composite (LxWxT)
Tng,T - Tang    T - Thickness R - Ratio
5.1.6 TYPE = 2.1 (two edged sword or kris)

There is only one specimen of Type 2.1 kris or two-edged sword (Figure 4.15). This is Artifact C-91-6 from Bohol. It is basically a wrought iron or a low carbon steel with an average microhardness of 141 VHN. The composite ratio between the blade and the tang is 9.9:1; while the ratio of the blade length to the tang length is 4.47:1. Its blade angle is 9 degrees and the tip angle is 32 degrees.

5.1.7 TYPE = 3.0 (big pointed bolo)

There are only two specimens (2.66% of the total sample) of this Type 3.0. They are large and pointed bolos (Figure 4.16). Both of them are from the same site in Surigao. Artifact C-55-50a is a medium carbon steel with a hardness number of 269 VHN, and Artifact C-55-50c is a high carbon steel with a hardness number of 415 VHN. The mean hardness for Type 3.0 is 342 VHN. The average ratio of the blade length to the tang length is 3.61:1; whereas the average composite ratio between the blade and the tang is 12.28:1 as shown in Table 5.5. These pointed bolos have an average blade angle of 17 degrees; and the mean tip angle is 42.5 degrees.
Table 5.5
Statistical Data of Type 3.0
(big pointed bolos)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>342.0000</td>
<td>269.0000</td>
<td>415.0000</td>
<td>75.0000</td>
<td>2</td>
</tr>
<tr>
<td>Weight</td>
<td>285.7000</td>
<td>273.1000</td>
<td>298.3000</td>
<td>12.6000</td>
<td>2</td>
</tr>
<tr>
<td>Max-L</td>
<td>37.7500</td>
<td>37.0000</td>
<td>38.7000</td>
<td>0.8500</td>
<td>2</td>
</tr>
<tr>
<td>Max-W</td>
<td>5.1500</td>
<td>5.0000</td>
<td>5.3000</td>
<td>0.1500</td>
<td>2</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.7000</td>
<td>0.7000</td>
<td>0.7000</td>
<td>ERR</td>
<td>2</td>
</tr>
<tr>
<td>Bld-L</td>
<td>25.5000</td>
<td>22.0000</td>
<td>29.0000</td>
<td>3.5000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-W</td>
<td>3.9500</td>
<td>3.5000</td>
<td>4.4000</td>
<td>0.4500</td>
<td>2</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.6000</td>
<td>0.6000</td>
<td>0.6000</td>
<td>ERR</td>
<td>2</td>
</tr>
<tr>
<td>Bld-A</td>
<td>17.0000</td>
<td>10.0000</td>
<td>24.0000</td>
<td>7.0000</td>
<td>2</td>
</tr>
<tr>
<td>Tng-L</td>
<td>7.0500</td>
<td>6.1000</td>
<td>8.0000</td>
<td>0.9500</td>
<td>2</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.3000</td>
<td>1.1000</td>
<td>1.5000</td>
<td>0.2000</td>
<td>2</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.5500</td>
<td>0.5000</td>
<td>0.6000</td>
<td>0.0500</td>
<td>2</td>
</tr>
<tr>
<td>End-A</td>
<td>42.5000</td>
<td>35.0000</td>
<td>50.0000</td>
<td>7.5000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-C</td>
<td>59.4900</td>
<td>58.0800</td>
<td>60.9000</td>
<td>1.4100</td>
<td>2</td>
</tr>
<tr>
<td>Tng-C</td>
<td>5.0130</td>
<td>4.0260</td>
<td>6.0000</td>
<td>0.9870</td>
<td>2</td>
</tr>
<tr>
<td>R=B/T</td>
<td>12.2881</td>
<td>10.1500</td>
<td>14.4262</td>
<td>2.1381</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>3.6158</td>
<td>3.6066</td>
<td>3.6250</td>
<td>0.0092</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>6.6429</td>
<td>5.0000</td>
<td>8.2857</td>
<td>1.6429</td>
<td>2</td>
</tr>
</tbody>
</table>

Max - Maximum  L - Length    A - Angle
Bld,B - Blade   W - Width    C - Composite (LxWxT)
Tng,T - Tang    T - Thickness R - Ratio

5.1.8 TYPE = 3.1 (small pointed knife - pinya)

There are three specimens (4%) of Type 3.1, small pointed knife for processing pinya (Figure 4.17). Artifact G-74-8b is from Cebu, and both Artifacts C-55-51a and C-55-51b are from Surigao. It is interesting to note that Type 3.1 is absent from areas in between Cebu and Surigao, namely Bohol and Leyte, but this is perhaps due to inadequate sampling. Artifact G-74-8b has the lowest
hardness, with 140 VHN, and of low carbon steel. The rest are of medium carbon. Artifact C-55-51b has the highest hardness reading of 259 VHN among them. The mean hardness of these knives is 210.3 VHN. The average blade angle is 17.3 degrees; and the average tip angle is 37 degrees. The mean ratio of the blade length to the tang length is 1.43:1; while the composite ratio between the blade and the tang is 3.42:1. Table 5.6 provides a complete statistical data for Type 3.1.

Table 5.6
Statistical Data of Type 3.1
(small pointed pinya knives)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>210.333</td>
<td>140.000</td>
<td>259.000</td>
<td>50.9401</td>
<td>3</td>
</tr>
<tr>
<td>Weight</td>
<td>47.700</td>
<td>38.700</td>
<td>60.200</td>
<td>9.1196</td>
<td>3</td>
</tr>
<tr>
<td>Max-L</td>
<td>15.300</td>
<td>14.300</td>
<td>16.500</td>
<td>0.9092</td>
<td>3</td>
</tr>
<tr>
<td>Max-W</td>
<td>4.0333</td>
<td>3.2000</td>
<td>4.9000</td>
<td>0.6944</td>
<td>3</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.6000</td>
<td>0.5000</td>
<td>0.7000</td>
<td>0.0816</td>
<td>3</td>
</tr>
<tr>
<td>Bld-L</td>
<td>6.7000</td>
<td>6.5000</td>
<td>6.9000</td>
<td>0.2000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-W</td>
<td>3.2667</td>
<td>3.0000</td>
<td>3.5000</td>
<td>0.2055</td>
<td>3</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.4000</td>
<td>0.3000</td>
<td>0.5000</td>
<td>0.0816</td>
<td>3</td>
</tr>
<tr>
<td>Bld-A</td>
<td>17.3333</td>
<td>12.0000</td>
<td>20.0000</td>
<td>3.7712</td>
<td>3</td>
</tr>
<tr>
<td>Tng-L</td>
<td>6.1000</td>
<td>3.8000</td>
<td>8.3000</td>
<td>1.8385</td>
<td>3</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.0667</td>
<td>1.0000</td>
<td>1.2000</td>
<td>0.0943</td>
<td>3</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.5667</td>
<td>0.5000</td>
<td>0.6000</td>
<td>0.0471</td>
<td>3</td>
</tr>
<tr>
<td>End-A</td>
<td>37.0000</td>
<td>32.0000</td>
<td>42.0000</td>
<td>5.0000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-C</td>
<td>9.4650</td>
<td>8.5800</td>
<td>10.3500</td>
<td>0.8850</td>
<td>2</td>
</tr>
<tr>
<td>Tng-C</td>
<td>3.6600</td>
<td>2.2800</td>
<td>4.9800</td>
<td>1.1031</td>
<td>3</td>
</tr>
<tr>
<td>R=B/T</td>
<td>3.4230</td>
<td>2.3065</td>
<td>4.5395</td>
<td>1.1165</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>1.4321</td>
<td>1.0484</td>
<td>1.8158</td>
<td>0.3837</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>2.1348</td>
<td>1.9697</td>
<td>2.3000</td>
<td>0.1652</td>
<td>2</td>
</tr>
</tbody>
</table>

Max - Maximum  L - Length  A - Angle
Bld,B - Blade  W - Width  C - Composite (LxWxT)
Tng,T - Tang   T - Thickness R - Ratio
From the PGCT, it was found that the blade width is inversely related to the blade thickness \((r=-0.99340)\), blade angle \((r=-0.80296)\), and tang width \((r=-0.91766)\); but it is directly related to the tang length \((r=0.99708)\) and tang thickness \((r=0.91766)\). On the other hand, the blade thickness is inversely related to the tang length \((r=-0.99926)\) and tang thickness \((r=-0.86603)\); but directly related to the blade angle and tang width with the same value of \(r=0.86603\). The blade angle is also inversely related to the tang length \((r=-0.84615)\). The tang length is inversely related to the tang width \((r=-0.88462)\), but directly related to the tang thickness \((r=0.88462)\). Finally, the tang width is inversely related to the tang thickness \((r=-1.00000)\).

5.1.9 TYPE = 3.2 (small L-shaped knife)

There are also only three specimens (4%) of Type 3.2, small L-shaped knives (Figure 4.18). Two of these are from Cebu and one from Siquijor. Artifact B-19-20a from Cebu is a low carbon steel with a hardness reading of 171 VHN. The other two artifacts are of high carbon steel, with Artifact B-6-7, also from Cebu, having the highest hardness number of 343 VHN. The average hardness for these knives is 273.3 VHN. The mean blade angle is 12.6 degrees, and the mean tip angle is 68.5 degrees. The average ratio
of the blade length to the tang length is 1.64:1; while the average composite ratio between the blade and the tang is 2.25:1. A more descriptive statistical data are available in Table 5.7 for Type 3.2.

Table 5.7

Statistical Data of Type 3.2
(small L-shaped knives)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>273.333</td>
<td>171.0000</td>
<td>343.0000</td>
<td>73.9204</td>
<td>3</td>
</tr>
<tr>
<td>Weight</td>
<td>24.7000</td>
<td>23.5000</td>
<td>26.5000</td>
<td>1.2961</td>
<td>3</td>
</tr>
<tr>
<td>Max-L</td>
<td>14.1333</td>
<td>12.0000</td>
<td>16.1000</td>
<td>1.6780</td>
<td>3</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.3333</td>
<td>3.2000</td>
<td>3.6000</td>
<td>0.1886</td>
<td>3</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.4333</td>
<td>0.4000</td>
<td>0.5000</td>
<td>0.0471</td>
<td>3</td>
</tr>
<tr>
<td>Blk-W</td>
<td>1.8000</td>
<td>1.7000</td>
<td>2.0000</td>
<td>0.1414</td>
<td>3</td>
</tr>
<tr>
<td>Blk-T</td>
<td>0.3333</td>
<td>0.3000</td>
<td>0.4000</td>
<td>0.0471</td>
<td>3</td>
</tr>
<tr>
<td>Blk-A</td>
<td>12.6667</td>
<td>10.0000</td>
<td>15.0000</td>
<td>2.0548</td>
<td>3</td>
</tr>
<tr>
<td>Tng-L</td>
<td>5.9333</td>
<td>4.8000</td>
<td>6.8000</td>
<td>0.8380</td>
<td>3</td>
</tr>
<tr>
<td>Tng-W</td>
<td>0.8667</td>
<td>0.6000</td>
<td>1.0000</td>
<td>0.1886</td>
<td>3</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.4000</td>
<td>0.4000</td>
<td>0.4000</td>
<td>ERR</td>
<td>3</td>
</tr>
<tr>
<td>End-A</td>
<td>68.5000</td>
<td>52.0000</td>
<td>85.0000</td>
<td>16.5000</td>
<td>2</td>
</tr>
<tr>
<td>Blk-C</td>
<td>5.8480</td>
<td>4.6920</td>
<td>7.0040</td>
<td>1.1560</td>
<td>2</td>
</tr>
<tr>
<td>Tng-C</td>
<td>2.1173</td>
<td>1.1520</td>
<td>2.7200</td>
<td>0.6896</td>
<td>3</td>
</tr>
<tr>
<td>R=B/T</td>
<td>2.2335</td>
<td>1.8919</td>
<td>2.5750</td>
<td>0.3415</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>1.4993</td>
<td>1.4839</td>
<td>1.5147</td>
<td>0.0154</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>5.7353</td>
<td>5.4118</td>
<td>6.0588</td>
<td>0.3235</td>
<td>2</td>
</tr>
</tbody>
</table>

*******************************************************************************

Max - Maximum  L - Length  A - Angle  
Blk,B - Blade  W - Width  C - Composite (LxWxT)  
Tng,T - Tang  T - Thickness  R - Ratio  
*******************************************************************************

The PCCT shows an inverse relationship between the blade width and the tang length (r=-0.95632) and between the blade width and the tang width (r=-1.00000). The blade thickness is directly related to the blade angle (r=0.80296). The tang length is also directly related to
the tang width \((r=0.95632)\).

5.1.10 TYPE = 3.3 (square-end bolo length = 30-60 cm)

There are six samples (8%) of Type 3.3, square-end bolos with a length range of 30 to 60 cm (Figure 4.19). Five of these are from Cebu and one from Surigao (Artifact C-55-50b). These bolos have the most variable relative carbon content and hardness. They range from low carbon steel, with the minimum hardness number of 117 VHN, to high carbon steel with the maximum hardness number of 470 VHN. The average hardness reading, however, among Type 3.3 is 319.3 VHN. The mean ratio between the blade length and the tang length is 4.24:1; while the mean composite ratio of the blade to the tang is 8.83:1. The average blade angle of these bolos is 14.83 degrees; and their average tip angle is 146.66 degrees. Table 5.8 shows a more complete descriptive statistical information for Type 3.3.
Table 5.8
Statistical Data of Type 3.3
(square-end bolos, 30-60 cm L)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>319.3333</td>
<td>117.0000</td>
<td>470.0000</td>
<td>133.7543</td>
<td>6</td>
</tr>
<tr>
<td>Weight</td>
<td>330.0333</td>
<td>147.1000</td>
<td>662.9000</td>
<td>169.3354</td>
<td>6</td>
</tr>
<tr>
<td>Max-W</td>
<td>6.2333</td>
<td>4.6000</td>
<td>9.5000</td>
<td>1.7594</td>
<td>6</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.8333</td>
<td>0.5000</td>
<td>1.5000</td>
<td>0.3249</td>
<td>6</td>
</tr>
<tr>
<td>Bld-L</td>
<td>30.7500</td>
<td>19.1000</td>
<td>48.1000</td>
<td>10.0100</td>
<td>6</td>
</tr>
<tr>
<td>Bld-W</td>
<td>4.8500</td>
<td>3.8000</td>
<td>6.5000</td>
<td>0.8751</td>
<td>6</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.6500</td>
<td>0.4000</td>
<td>1.2000</td>
<td>0.2986</td>
<td>6</td>
</tr>
<tr>
<td>Bld-A</td>
<td>14.8333</td>
<td>8.0000</td>
<td>33.0000</td>
<td>9.5117</td>
<td>6</td>
</tr>
<tr>
<td>Tng-W</td>
<td>2.4000</td>
<td>1.5000</td>
<td>3.4000</td>
<td>0.5859</td>
<td>6</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.7000</td>
<td>0.4000</td>
<td>1.3000</td>
<td>0.2887</td>
<td>6</td>
</tr>
<tr>
<td>End-A</td>
<td>146.6667</td>
<td>79.0000</td>
<td>180.0000</td>
<td>47.1440</td>
<td>6</td>
</tr>
<tr>
<td>Bld-C</td>
<td>104.6583</td>
<td>34.2000</td>
<td>288.6000</td>
<td>84.2853</td>
<td>6</td>
</tr>
<tr>
<td>Tng-C</td>
<td>15.6897</td>
<td>5.2500</td>
<td>29.6660</td>
<td>10.4059</td>
<td>6</td>
</tr>
<tr>
<td>R=B/T</td>
<td>8.8382</td>
<td>2.3178</td>
<td>18.4286</td>
<td>5.5814</td>
<td>6</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>4.2483</td>
<td>1.1718</td>
<td>6.0886</td>
<td>1.8078</td>
<td>6</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>6.3969</td>
<td>3.8462</td>
<td>9.6200</td>
<td>1.8957</td>
<td>6</td>
</tr>
</tbody>
</table>

Max - Maximum
L - Length
A - Angle
Bld,B - Blade
W - Width
C - Composite (LxWxT)
Tng,T - Tang
T - Thickness
R - Ratio

From the PCCT, it was found that among these specimens, the blade thickness is directly related to the blade angle (r=0.79511) and the tang thickness (r=0.87006). Moreover, the blade angle is also directly related to the tang length (r=0.85747).

5.1.11 TYPE = 3.4 (medium knife length = 12.0 - 29.9 cm)

This Type 3.4, medium knives with the range length of between 12 to 29.9 cm (Figure 4.20) has the largest
number of specimens, 13 artifacts comprising 17.3% of the total samples. There are six from Cebu, three from Siquijor, one from Bohol, two from Masbate and one from Mindoro, covering generally the central Philippine region. These knives range from low carbon steel to high carbon steel. Artifact C-83-6 from Mindoro has the lowest hardness test number of 133 VHN, while Artifact M-2-55a from Masbate has the highest VHN number of 330. The average hardness number of Type 3.4 is 200.6 VHN. The mean blade angle is 11.46 degrees; and the mean tip angle is 139.8 degrees. The average composite ratio between the blade and the tang is 4.7:1; while the ratio of blade length to the tang length is 2.55:1. Descriptive statistics for Type 3.4 are found in Table 5.9. Surprisingly enough, the PCCT suggests that a direct realtionship can be established only between tang length and tang thickness (r=0.80806) among the variables measured.
Table 5.9
Statistical Data of Type 3.4
(medium knives, 12 - 29.9 cm L)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>200.6154</td>
<td>133.0000</td>
<td>330.0000</td>
<td>62.5097</td>
<td>13</td>
</tr>
<tr>
<td>Weight</td>
<td>60.6692</td>
<td>33.0000</td>
<td>88.0000</td>
<td>18.8488</td>
<td>13</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.7231</td>
<td>2.4000</td>
<td>6.0000</td>
<td>1.0177</td>
<td>13</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.5385</td>
<td>0.3000</td>
<td>0.8000</td>
<td>0.1389</td>
<td>13</td>
</tr>
<tr>
<td>Bld-L</td>
<td>12.6818</td>
<td>9.1000</td>
<td>16.7000</td>
<td>2.2611</td>
<td>11</td>
</tr>
<tr>
<td>Bld-W</td>
<td>3.2462</td>
<td>2.1000</td>
<td>5.3000</td>
<td>0.8793</td>
<td>13</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.4462</td>
<td>0.3000</td>
<td>0.8000</td>
<td>0.1216</td>
<td>13</td>
</tr>
<tr>
<td>Bld-A</td>
<td>11.4615</td>
<td>7.0000</td>
<td>18.0000</td>
<td>3.0030</td>
<td>13</td>
</tr>
<tr>
<td>Tng-L</td>
<td>5.3111</td>
<td>3.5000</td>
<td>8.4000</td>
<td>1.4325</td>
<td>9</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.8300</td>
<td>1.1000</td>
<td>2.8000</td>
<td>0.5292</td>
<td>10</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.4600</td>
<td>0.3000</td>
<td>0.7000</td>
<td>0.1356</td>
<td>10</td>
</tr>
<tr>
<td>End-A</td>
<td>139.8000</td>
<td>41.0000</td>
<td>180.0000</td>
<td>52.7083</td>
<td>10</td>
</tr>
<tr>
<td>Bld-C</td>
<td>17.1171</td>
<td>8.3720</td>
<td>28.7000</td>
<td>7.0370</td>
<td>11</td>
</tr>
<tr>
<td>Tng-C</td>
<td>5.2253</td>
<td>1.6800</td>
<td>16.4640</td>
<td>4.4090</td>
<td>9</td>
</tr>
<tr>
<td>R=B/T</td>
<td>4.7074</td>
<td>2.0126</td>
<td>7.7000</td>
<td>1.9034</td>
<td>8</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>2.5518</td>
<td>2.0000</td>
<td>3.6286</td>
<td>0.5405</td>
<td>8</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>4.2442</td>
<td>2.3019</td>
<td>5.3333</td>
<td>1.0394</td>
<td>11</td>
</tr>
</tbody>
</table>

Max - Maximum     L - Length    A - Angle
Bld,B - Blade     W - Width     C - Composite (LxWxT)
Tng,T - Tang      T - Thickness  R - Ratio

5.1.12 TYPE = 3.5 (small knife length = 5.0 - 11.9 cm)

Type 3.5, small knives with the maximum length of between 5 to 11.9 cm (Figure 4.21), constitutes the second largest number (11 specimens or 14.6%) in the collection studied. Among these artifacts, there are seven from Cebu, one from Siqijor, two from Bohol, and one from Surigao. The relative carbon content distribution of Type 3.5 ranges from low to high. Artifact B-7-25c from Cebu has the
lowest hardness number of 152 VHN, whereas Artifact M-6-53a, also from Cebu has the highest hardness of 434 VHN. The average hardness reading among these knives is 297.1 VHN. The mean blade angle is 13.36 degrees; and the mean tip angle is 113.8 degrees. The average ratio between the blade length and the tang length is 2.85:1; while the average composite ratio of the blade to the tang is 3.92:1, as seen in Table 5.10. The PCCT has revealed that a direct relation can be established between the blade length and the tang width (r=0.65433); between the tang length and tang width (r=0.60369); between tang length and blade angle (r=0.71759); and between tang length and tang thickness (r=0.80806) of Type 3.5.
Table 5.10
Statistical Data of Type 3.5
(small knives, 5 - 11.9 cm L)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>297.1818</td>
<td>152.0000</td>
<td>434.0000</td>
<td>87.8623</td>
<td>11</td>
</tr>
<tr>
<td>Weight</td>
<td>17.3182</td>
<td>5.3000</td>
<td>41.0000</td>
<td>10.0381</td>
<td>11</td>
</tr>
<tr>
<td>Max-L</td>
<td>9.3909</td>
<td>5.1000</td>
<td>11.7000</td>
<td>1.9723</td>
<td>11</td>
</tr>
<tr>
<td>Max-W</td>
<td>2.5000</td>
<td>1.2000</td>
<td>3.7000</td>
<td>0.7711</td>
<td>11</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.4545</td>
<td>0.3000</td>
<td>1.0000</td>
<td>0.1924</td>
<td>11</td>
</tr>
<tr>
<td>Bld-L</td>
<td>7.1091</td>
<td>4.5000</td>
<td>9.3000</td>
<td>1.5400</td>
<td>11</td>
</tr>
<tr>
<td>Bld-W</td>
<td>2.2818</td>
<td>1.2000</td>
<td>3.7000</td>
<td>0.8066</td>
<td>11</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.3091</td>
<td>0.2000</td>
<td>0.5000</td>
<td>0.0900</td>
<td>11</td>
</tr>
<tr>
<td>Bld-A</td>
<td>13.3636</td>
<td>9.0000</td>
<td>24.0000</td>
<td>3.9834</td>
<td>11</td>
</tr>
<tr>
<td>Tng-L</td>
<td>2.6000</td>
<td>1.8000</td>
<td>3.3000</td>
<td>0.5148</td>
<td>8</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.0750</td>
<td>0.6000</td>
<td>1.7000</td>
<td>0.3419</td>
<td>8</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.4250</td>
<td>0.3000</td>
<td>1.0000</td>
<td>0.2222</td>
<td>8</td>
</tr>
<tr>
<td>End-A</td>
<td>113.8182</td>
<td>38.0000</td>
<td>180.0000</td>
<td>54.9923</td>
<td>11</td>
</tr>
<tr>
<td>Bld-C</td>
<td>5.6236</td>
<td>1.4400</td>
<td>13.7640</td>
<td>3.9355</td>
<td>11</td>
</tr>
<tr>
<td>Tng-C</td>
<td>1.1999</td>
<td>0.3240</td>
<td>2.7300</td>
<td>0.6967</td>
<td>8</td>
</tr>
<tr>
<td>R=B/T</td>
<td>3.9240</td>
<td>2.1956</td>
<td>9.4163</td>
<td>2.2432</td>
<td>8</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>2.8586</td>
<td>1.6071</td>
<td>4.6500</td>
<td>0.9481</td>
<td>8</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>3.4532</td>
<td>2.1034</td>
<td>5.6000</td>
<td>1.2459</td>
<td>11</td>
</tr>
</tbody>
</table>

Max - Maximum  L - Length  A - Angle
Bld,B - Blade  W - Width  C - Composite (LxWxT)
Tng,T - Tang   T - Thickness R - Ratio

5.1.13 TYPE = 3.6 (oval tip knife)

There are only two specimens (2.66%) of Type 3.6, knives with oval shaped tip (Figure 4.22), and both of them are from Cebu. These knives have relatively high carbon content; Artifact B-7-25b has a hardness number of 380, and Artifact B-85-19a has a hardness number of 543 VHN. The average hardness for Type 3.6 then is 461.5 VHN. Although Artifact B-7-25b is much much bigger, longer, and heavier
(its dimension being 43.4 cc, and weighing 79 g.) than Artifact B-85-19a (with a dimension of 6.34 cc and weighing 11.8 g.), both have the same blade thickness of 0.4 cm, and a tang width of 1.3 cm. These knives have an average blade angle of 19.5 degrees, and a tip angle of 161 degrees. The mean composite ratio between blade and the tang is 3.21:1; and the mean ratio of the blade length to the tang length is 1.97:1. Table 5.11 provides more statistical description for Type 3.6.

Table 5.11
Statistical Data of Type 3.6 (oval tip knives)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>461.500</td>
<td>380.000</td>
<td>543.000</td>
<td>81.500</td>
<td>2</td>
</tr>
<tr>
<td>Weight</td>
<td>45.400</td>
<td>11.800</td>
<td>79.000</td>
<td>33.600</td>
<td>2</td>
</tr>
<tr>
<td>Max-L</td>
<td>11.400</td>
<td>6.900</td>
<td>15.900</td>
<td>4.500</td>
<td>2</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.100</td>
<td>2.300</td>
<td>3.900</td>
<td>0.800</td>
<td>2</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.550</td>
<td>0.400</td>
<td>0.700</td>
<td>0.150</td>
<td>2</td>
</tr>
<tr>
<td>Bld-L</td>
<td>7.550</td>
<td>4.600</td>
<td>10.500</td>
<td>2.950</td>
<td>2</td>
</tr>
<tr>
<td>Bld-W</td>
<td>3.100</td>
<td>2.300</td>
<td>3.900</td>
<td>0.800</td>
<td>2</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.400</td>
<td>0.400</td>
<td>0.400</td>
<td>0.000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-A</td>
<td>19.500</td>
<td>14.000</td>
<td>25.000</td>
<td>5.500</td>
<td>2</td>
</tr>
<tr>
<td>Tng-L</td>
<td>3.850</td>
<td>2.300</td>
<td>5.400</td>
<td>1.550</td>
<td>2</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
<td>0.000</td>
<td>2</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.500</td>
<td>0.400</td>
<td>0.600</td>
<td>0.100</td>
<td>2</td>
</tr>
<tr>
<td>End-A</td>
<td>161.000</td>
<td>142.000</td>
<td>180.000</td>
<td>19.000</td>
<td>2</td>
</tr>
<tr>
<td>Bld-C</td>
<td>10.3060</td>
<td>4.2320</td>
<td>16.380</td>
<td>6.0740</td>
<td>2</td>
</tr>
<tr>
<td>Tng-C</td>
<td>3.1200</td>
<td>1.3800</td>
<td>4.8600</td>
<td>1.7400</td>
<td>2</td>
</tr>
<tr>
<td>R=B/T</td>
<td>3.2185</td>
<td>3.0667</td>
<td>3.3704</td>
<td>0.1519</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>1.9722</td>
<td>1.9444</td>
<td>2.0000</td>
<td>0.0278</td>
<td>2</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>2.3462</td>
<td>2.0000</td>
<td>2.6923</td>
<td>0.3462</td>
<td>2</td>
</tr>
</tbody>
</table>

******************************************************************************
Max - Maximum  L - Length  A - Angle
Bld,B - Blade  W - Width  C - Composite (LxWxT)
Tng,T - Tang  T - Thickness  R - Ratio
******************************************************************************
5.1.14 TYPE = 4.0 (harpoon)

There are four specimens (5.33%) of Type 4.0, which are harpoons (Figure 4.23). Two of them are from Bohol, and the other two are from Siquiapo. It should be noted that Artifact C-56-25b from Siquiapo is incomplete. Three of these harpoons are of low carbon steel with an average hardness of 141 VHN. Artifact C-11-401b from Bohol is of high carbon steel with a hardness number of 322 VHN. Although it may be accidental, it is interesting to note that Artifact C-11-401c from Bohol and Artifact C-56-25a from Siquiapo have the same hardness number of 121 VHN. The average hardness for Type 4.0, however, is 186.25 VHN. The mean blade angle is 21.3 degrees; and the mean tip angle is 46 degrees. These harpoons have the average composite ratio of 4.09:1 between the blade and the tang; and an average ratio of 2.36:1 of their blade length to the tang length. Table 5.12 provides more descriptive statistical data for Type 4.0.
### Table 5.12

**Statistical Data of Type 4.0 (harpoons)**

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>186.2500</td>
<td>121.0000</td>
<td>322.0000</td>
<td>82.1139</td>
<td>4</td>
</tr>
<tr>
<td>Weight</td>
<td>76.3750</td>
<td>8.0000</td>
<td>169.5000</td>
<td>66.5276</td>
<td>4</td>
</tr>
<tr>
<td>Max-L</td>
<td>19.0500</td>
<td>12.3000</td>
<td>25.0000</td>
<td>5.7072</td>
<td>4</td>
</tr>
<tr>
<td>Max-W</td>
<td>3.3000</td>
<td>0.5000</td>
<td>6.5000</td>
<td>2.2683</td>
<td>4</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.8500</td>
<td>0.4000</td>
<td>1.3000</td>
<td>0.4031</td>
<td>4</td>
</tr>
<tr>
<td>Bld-L</td>
<td>9.1333</td>
<td>6.5000</td>
<td>12.3000</td>
<td>2.3977</td>
<td>3</td>
</tr>
<tr>
<td>Bld-W</td>
<td>2.8000</td>
<td>1.5000</td>
<td>4.2000</td>
<td>1.1045</td>
<td>3</td>
</tr>
<tr>
<td>Bld-T</td>
<td>0.5000</td>
<td>0.4000</td>
<td>0.6000</td>
<td>0.0816</td>
<td>3</td>
</tr>
<tr>
<td>Bld-A</td>
<td>21.3333</td>
<td>13.0000</td>
<td>35.0000</td>
<td>9.7411</td>
<td>3</td>
</tr>
<tr>
<td>Tng-L</td>
<td>3.8333</td>
<td>3.0000</td>
<td>5.0000</td>
<td>0.8498</td>
<td>3</td>
</tr>
<tr>
<td>Tng-W</td>
<td>1.1000</td>
<td>0.7000</td>
<td>1.3000</td>
<td>0.2828</td>
<td>3</td>
</tr>
<tr>
<td>Tng-T</td>
<td>0.8667</td>
<td>0.3000</td>
<td>1.2000</td>
<td>0.4028</td>
<td>3</td>
</tr>
<tr>
<td>End-A</td>
<td>46.0000</td>
<td>12.0000</td>
<td>81.0000</td>
<td>28.1780</td>
<td>3</td>
</tr>
<tr>
<td>Bld-C</td>
<td>13.9620</td>
<td>3.9000</td>
<td>19.9260</td>
<td>7.1556</td>
<td>3</td>
</tr>
<tr>
<td>Tng-C</td>
<td>4.4133</td>
<td>0.6300</td>
<td>7.1500</td>
<td>2.7628</td>
<td>3</td>
</tr>
<tr>
<td>R=B/T</td>
<td>4.0950</td>
<td>2.7869</td>
<td>6.1905</td>
<td>1.4969</td>
<td>3</td>
</tr>
<tr>
<td>R=BL/TL</td>
<td>2.3613</td>
<td>2.1667</td>
<td>2.4600</td>
<td>0.1376</td>
<td>3</td>
</tr>
<tr>
<td>R=BL/BW</td>
<td>3.6455</td>
<td>2.0476</td>
<td>4.5556</td>
<td>1.1335</td>
<td>3</td>
</tr>
</tbody>
</table>

**Max** - Maximum  
**L** - Length  
**A** - Angle  
**Bld,B** - Blade  
**W** - Width  
**C** - Composite (LxWxT)  
**Tng,T** - Tang  
**T** - Thickness  
**R** - Ratio

The PCCT had surprising results for Type 4.0. For instance, it was found that among these harpoons, the blade length is inversely related to the blade angle (r=-0.84965), but it is directly related to the blade thickness (r=0.98755), tang length (r=0.99243), tang width (r=0.77660) and tip angle (r=0.99119). The blade width is inversely related to the blade angle (r=-0.75593), but directly related to the tang width (r=0.83224) and the tang thickness (r=0.88415). The blade thickness is also
inversely related to the blade angle \(r=-0.92202\), but it is directly related to tang length \(r=0.96077\), tang width \(r=0.86603\), and tang thickness \(r=0.81088\), as well as the tip angle \(r=0.99969\). The blade angle, on the other hand, is inversely related to almost everything, like the tang length \(r=-0.77847\), tang width \(r=-0.99206\) and tang thickness \(r=-0.97421\), and also to the tip angle \(r=-0.91201\). The tang length is directly related to the tip angle \(r=0.96743\). The tang width is directly related to the tang thickness \(r=0.99485\) and the tip angle \(r=0.85321\). Finally, the tang thickness is also directly related to tip angle \(r=0.79594\).

5.1.15 TYPE = 5.0 (ferrule or ring)

There are only two specimens (2.66%) of Type 5.0, which are ferrules or rings (Figure 4.24) that were used to hold the tang of a tool or weapon when it was mounted or hafted on a wood or bone handle. Artifact B-6-9 is from Cebu and Artifact C-76-21a is from Davao. As expected from their function, both of them are wrought iron with an average hardness number of 142 VHN. Both artifacts have the same thickness of 0.3 cm, as seen in Table 5.13.
Table 5.13
Statistical Data of Type 5.0
(ferrules or rings)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>142.0000</td>
<td>142.0000</td>
<td>142.0000</td>
<td>0.0000</td>
<td>1</td>
</tr>
<tr>
<td>Weight</td>
<td>9.6000</td>
<td>5.8000</td>
<td>13.4000</td>
<td>3.8000</td>
<td>2</td>
</tr>
<tr>
<td>Max-L</td>
<td>2.0500</td>
<td>1.2000</td>
<td>2.9000</td>
<td>0.8500</td>
<td>2</td>
</tr>
<tr>
<td>Max-W</td>
<td>1.4500</td>
<td>1.2000</td>
<td>1.7000</td>
<td>0.2500</td>
<td>2</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.3000</td>
<td>0.3000</td>
<td>0.3000</td>
<td>0.0000</td>
<td>2</td>
</tr>
</tbody>
</table>

Max = Maximum L = Length W = Width T = Thickness

5.1.16 TYPE = 6.0 (chisel)

There is only one specimen (1.33%) that was positively identified as a chisel for Type 6.0 (Figure 4.25). This is Artifact C-14-11 from Leyte. It is of medium carbon steel with a hardness number of 203 VHN. The blade angle is 13 degrees, and as expected, the tip angle is 180 degrees. As mentioned earlier, due to their incompleteness, Artifacts B-10-28a and M-6-51a, both from Cebu, were misidentified as chisels but are now classified as Type 1.1 (spearheads).

5.1.17 TYPE 7.0 (cast iron)

There are two specimens (2.66%) of Type 7.0, which are cast iron pots or cooking vessels (Figure 4.26). Artifact C-11-400i is from Bohol and Artifact C-32-3 is
from Bukidnon. The Bohol specimen has a hardness number of 632 VHN, the highest among all the artifacts included in this study; while the Bukidnon specimen has a hardness number of 213 VHN. Hence, the mean hardness of Type 7.0 is 422.5 VHN. The average thickness of these cast iron samples is 0.35 cm, as shown in Table 5.14.

Table 5.14
Statistical Data of Type 7.0 (cast iron vessels)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std Dev</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>422.500</td>
<td>213.000</td>
<td>632.000</td>
<td>209.500</td>
<td>2</td>
</tr>
<tr>
<td>Weight</td>
<td>297.350</td>
<td>42.500</td>
<td>552.200</td>
<td>254.850</td>
<td>2</td>
</tr>
<tr>
<td>Max-L</td>
<td>14.550</td>
<td>9.100</td>
<td>20.000</td>
<td>5.450</td>
<td>2</td>
</tr>
<tr>
<td>Max-W</td>
<td>8.050</td>
<td>4.100</td>
<td>12.000</td>
<td>3.950</td>
<td>2</td>
</tr>
<tr>
<td>Max-T</td>
<td>0.350</td>
<td>0.300</td>
<td>0.400</td>
<td>0.050</td>
<td>2</td>
</tr>
</tbody>
</table>

Max - Maximum  L - Length  W - Width  T - Thickness

5.1.18 Variability Among Types of Iron Artifacts

To find out which among the types of iron artifacts analyzed has the widest range of variability in the different variables examined, the standard deviation (STD) of each variable from the different types was subtracted and added to the corresponding average (mean). Also, the coefficient of variation (C.V. = STD/mean) of each variable from the different types was subtracted and added to the corresponding average (mean). This is to show how much variation there is among the iron materials in the
Guthe-Michigan collection.

5.1.18.1 Variable = Blade Angle

Figure 5.3 shows a graphic representation of the variability of bladed artifacts in terms of blade angle. Type 1.1 spearheads clearly shows a wide range of 10 to 180 degrees, and this is due to Artifact G-167-2 from Bohol which has a blunt edge. The next most variable in blade angle are Type 1.0 spearheads and Type 2.0 daggers. The remaining types of bladed artifacts are consistent within the range of about 5 to 30 degrees of blade angle. It must be noted that blade angle may be influenced by volumetric expansion of the iron due to oxidation. Such expansion is not measurable.

5.1.18.2 Variable = Blade Length

Square-end bolos, Type 3.3, are most variable in blade length, as seen in Figure 5.4. Types 3.1 pinya knives and 3.2 (L-shaped knives) vary least being fairly uniform in blade length. Would uniformity in the size of blade length then suggest a specific function for these artifacts? Different types of spearheads, i.e. Types 1.0, 1.1, 1.2, and daggers Type 2.0, as well as pointed bolos (Type 3.0) overlap in blade length. This means that if one finds only a fragment of a blade, it would be very
VARIABILITY OF IRON TOOL TYPES
According to Blade Angle

Figure 5.3 Variability Chart of Blade Angle

VARIABILITY OF IRON TOOL TYPES
According to Blade Length

Figure 5.4 Variability Chart of Blade Length
difficult to positively identify to which specific type it should be categorized.

5.1.18.3 Variable = Blade Thickness

Figure 5.5 shows that Types 3.0 and 3.6 are the most homogeneous types among the knives in terms of blade thickness. Type 3.3 has the most variable blade thickness. This is expected, though, because these square-end bolos are multi-functional everyday tools that can also be used as weapons, as observed in the ethnographic present (Legaspi 1974b). Most of the iron artifacts are within the range of between 0.35 - 0.55 cm of thickness. Does this suggest a suitable blade thickness for iron working?

5.1.18.4 Variable = Blade Width

Type 3.3 (square-end bolos) has the widest blade width of all the iron artifacts. Types 1.0, 1.1, 3.1, and 3.2 have the least variability in blade width. Those with the most variability are Types 3.3, 3.4, 3.5, 3.6, and 4.0. Overlaps in blade width are detected between Types 1.2 and 3.0 and between 3.4 and 3.6. See Figure 5.6.
VARIABILITY OF IRON TOOL TYPES
According to Blade Thickness

Figure 5.5 Variability Chart of Blade Thickness

VARIABILITY OF IRON TOOL TYPES
According to Blade Width

Figure 5.6 Variability Chart of Blade Width
5.1.18.5 Variable = End Angle

Looking at point or tip angle in Figure 5.7, we see that Types 1.0, 1.2, 1.3, 3.0 and 3.1 have the least variability. Types 3.3, 3.4, 3.5, and 4.0 are the artifacts having the most variation. There are overlaps of tip angles between Types 1.1 and 1.2; 2.0, 3.0 and 3.1; and also 3.3, 3.4, and 3.6. This means that if one has only the part of the point to show, it would be very difficult to identify which among these types it belongs to.

5.1.18.6 Variable = Hardness

Hardness generally affects the function of the tool or weapon. If a particular type of tool has too low a hardness, it would not perform successfully according to its intended function, as this has been detected for some of the artifacts analyzed (see Chapter 4). Spearheads Type 1.0 have the least variability in hardness and these also have the lowest hardness among the different types. Type 3.3 have the greatest variability in hardness. Types 1.0, 1.1, 3.1, 3.4, and 4.0 have overlapping hardness, and so do Types 1.2, 2.0, 3.0, 3.3, and 3.5. Types 3.6 (oval tip knives) have the highest hardness range among the bladed iron artifacts, as seen in Figure 5.8.
VARIABILITY OF IRON TOOL TYPES

According to End Angle

Figure 5.7 Variability Chart of End Angle
VARIABILITY OF IRON TOOL TYPES
According to Hardness

Figure 5.8 Variability Chart of Hardness

DISTRIBUTION OF HARDNESS NUMBERS
(Guthe-Michigan 1922-25 Collection)

Figure 5.9 Bar-Chart Distribution of Hardness Numbers
Regardless of the type of iron artifact in the Guthe collection, the distribution of hardness numbers among the artifacts examined is presented in Figure 5.9. This graph is scaled in VHN from 100 to 650 and divided into groups of 50. It is noted that the majority of the samples are grouped into the 100 - 150 VHN and this reflects the low carbon steel as well as wrought iron artifacts represented in Figures 4.11 and 4.12 of Chapter 4.

5.1.18.7 Variable = Tang Length

Type 3.3 has the widest range of variability according to tang length, followed by Types 1.1 and 2.0. Interestingly enough, Types 1.1 and 2.0 also overlap in tang length, although their tang thickness and width varies considerably as we will see later. Types which also overlap with one another are the following: Types 1.2, 3.1, 3.2, and 3.4; Type 1.0 and Type 3.0. The type which has the least variance in tang length is Type 3.5. See Figure 5.10.

5.1.18.8 Variable = Tang Thickness

The type with greatest variability in tang thickness is Type 4.0 (harpoons), followed by Types 3.3 and 1.1. Type 3.2 is very homogeneous, having no variance as seen in Figure 5.11. Types 3.0 and 3.1 have the least
VARIABILITY OF IRON TOOL TYPES
According to Tang Length

Figure 5.10 Variability Chart of Tang Length

VARIABILITY OF IRON TOOL TYPES
According to Tang Thickness

Figure 5.11 Variability Chart of Tang Thickness
variability in tang thickness. Types 1.0 and 1.1 overlap, so too do Types 3.0 and 3.1, as well as Types 1.2, 2.0, 3.4, and 3.6.

5.1.18.9 Variable = Tang Width

Figure 5.12 shows that types with the greatest variability in tang width are Types 3.3 and 3.4. Type 3.6 is the most homogenous, and Types 2.0 and 3.1 have the least number of variants in tang width. Overlaps are observed between Types 1.0, 1.1, and 3.0; also among Types 1.2, 2.0, 3.2, 3.5 and 4.0.

5.1.18.10 Variable = Ratio of Blade Length over Tang Length

Looking at the ratio between the blade length and the tang length in Figure 5.13, we see that Type 3.3 stands out as having the most variability among these bladed artifacts, followed by Types 3.5 and 1.2. Homogenous types in terms of this variable are Types 1.1, 3.0, 3.2, and 3.6. Types 4.0 and 2.0 have the fewest variants. Types 1.1, 2.0, 3.1 and 3.2 have overlapping ratios between the blade length and the tang length, so does Types 3.4 and 3.5.

5.1.18.11 Variable = Ratio of Blade Length over Blade Width

Figure 5.14 shows the variability of bladed iron
VARIABILITY OF IRON TOOL TYPES

According to Tang Width

Figure 5.12 Variability Chart of Tang Width

VARIABILITY OF IRON TOOL TYPES

According to Ratio of Blad-L / Tang-L

Figure 5.13 Variability Chart of Ratio = BL/TL
VARIABILITY OF IRON TOOL TYPES

According to Ratio of Bld-L / Bld-W

Figure 5.14 Variability Chart of Ratio = BL/BW
tools according to the ratio of blade length over blade width. Type 3.1 is the least variant and is the lowest in the scale of this particular variable. It overlaps, moreover with Type 3.6. Types 1.0, 3.0, and 3.3 are most variant and each of these type overlaps with the others. Both Type 1.2 and 2.0 are comparable in ratio between the blade length and blade width. One can also group these artifacts into low, medium and high ratios. As noted, both Types 3.1 and 3.6 have low ratio; while Types 1.1, 1.2, 2.0, 3.4, 3.5, and 4.0 are in the medium ratio; finally, Types 1.0, 3.0, 3.2, and 3.3 are in the high ratio.

Low variance among the variables discussed could also mean that the artifacts in question suggest standardized pattern in manufacture. Those variables having high variance suggests the blacksmiths individual preferences in the artifacts they produce. However, since the sample size in this exercise is limited in number, the statistical reliability of this analysis of variance may have little significance. The highest number of artifacts included in this analysis is 13 for Type 3.4 (medium knives, 12 - 29.9 cm length), and there must at least be a hundred artifacts to have a significant result in the analysis of variance. Nevertheless, this is the direction we would have gone if we had had the available materials. This type of analysis could provide us with insights
regarding the organization of manufacture, e.g. production by individual smiths, craft centers, and mass production. In conjunction with other archaeological data, i.e. associated artifacts, such analyses may give us a better understanding into the social, economic and political organization of these early iron users.

5.2 Summary

The significance of the statistical study of the Guthe iron collection, lies with the descriptive value on each type of iron artifact analyzed. This study is an attempt to classify and characterize the Guthe-Michigan iron collection objectively using metrical variables so that other researchers can replicate the procedure utilized in this study on other collection of iron artifacts. It is unfortunate that so far there is no statistical data on other collections to compare with this material. If other iron collections were available, then we might be able to better define the iron industry in the Philippines and Southeast Asia. Based on such studies we could initiate

1. I would like to thank Professor Karl L. Hutterer for his suggestions here regarding the role of the analysis of variance and its implications in interpreting the organization of manufacture.
the beginning of a true comparative statistical study and a more sophisticated analysis of iron artifacts.

The relevance of the analysis presented in this chapter is that it serves as a model and future reference point for further analysis of other iron collections in the Philippines and elsewhere in Southeast Asia. This statistical study is not an end in itself but a means of achieving further classificatory schemes whenever possible (Rouse 1960). The purpose is to objectify attributes that can be recognized and measured with the same reliability, based on the replicability of the same methods and processes of the study. It is hoped that other researchers can therefore benefit from the statistical information provided in this study.
Chapter 6

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter consists of a short discussion of the problem of independent invention and diffusion as well as how these processes relate to the coming of iron in the Philippines. Responses to the hypotheses posed in Chapter 1 are presented. Conclusions based on the study of Philippine iron are formulated and recommendations for future research are made.

6.1 Discussion

As posed in the introduction, can the processes of independent invention and/or diffusion be identified as responsible for the development of iron metallurgy in the Philippines? Before we deal with this question, let us examine how the terms "independent invention" and "diffusion" have been treated by some scholars in the anthropological literature. This issue was the subject of much debate between diffusionists and evolutionists in the
early part of the twentieth century. For the extreme diffusionists, technological innovations for instance, arose only once in one area, and from there traveled to the neighboring areas and/or around the world. The extreme evolutionists on the other hand, believed that all societies are responsible for their own technological innovations, independent of other societies. Steward (1929:493) suggested that three criteria are to be sought, when the subject "independent invention" versus "diffusion" arises. He wrote:

"When a culture element is found in two or more localities (and it is assumed that the element is identical in each case), the probability that independent invention has occurred is:

1. Directly proportionate to the difficulty of communication between the localities.

2. Directly proportionate to the uniqueness of the element — the "qualitative criterion."

3. Inversely proportionate to the probability of derivation from a common ancestral culture."

According to Steward, the logical validity of proposition (1) lies in the fact that as communication is difficult, the chance of its having occurred to transport the element is small. Also the factors determining the difficulty of communication are: geographical accessibility and means of transportation, intertribal relations, and cultural receptivity. A measure of the difficulty of communication is the number of other culture elements
shared by the localities. Hence, other things being equal, each culture element common to the localities strengthens the probability that communication has occurred. As a supplement to proposition (1) then, Steward states that:

(1a) *The probability of independent invention is inversely proportionate to the number of traits shared by the two localities* - the "quantitative criterion" (Ibid.).

Under cultural receptivity and tribal relations, consideration would be taken that culture elements of different types diffuse with varying degrees of facility. A further supplement to (1) is:

(1b) *The probability of independent invention is inversely proportionate to the elapsed time since the appearance of the trait in either locality* (Ibid.).

That is, the amount of communication between localities is, other things being equal, a function of time.

According to Steward's (1929:494) principle (2), the uniqueness of a cultural element - that is, the probability of its being invented - is the most difficult problem to determine. "This will be decided by the investigator upon his experience and knowledge of the cultural setting and circumstances under which it may have been invented."

The solution to principle (3) depends partly upon the number of other culture elements which the localities
have in common so that (1a) may also apply in addition to the possible supplement:

(3a) The probability of derivation from a common ancestral culture is proportionate to the number of elements shared by the localities (Ibid.)

It also depends upon known factors of ethnic and linguistic relationship.

Applying Steward's (1929) now somewhat dated principles to the origins of Philippine prehistoric iron technology would demand more cultural data than what we presently have. For instance, although Solheim (1981) contends that as early as the Neolithic period, people from mainland Southeast Asia had been moving around the insular areas, we have no substantial, direct archaeological evidence of this proposition. In addition, there are as yet no C-14 dates or stratigraphic data to back up his contention.

Nevertheless, the linguistic evidence suggests that extensive movements of people from mainland Southeast Asia began as early as ca. 4000 b.c. (Goodenough 1982:53). The Austronesian (or Malayo-Polynesian) language family appears to be linked to the Thai-Kadai family of languages (which includes Thai, Lao, and some language pockets in Vietnam and southeastern China) in a superfamily, which Benedict (1975) has termed Austro-Thai. According to Goodenough
the geographic distribution of Austronesian languages extends from Madagascar in the western extreme, throughout Malaysia, Indonesia, and the Philippines, in enclaves in Vietnam and Taiwan, in pockets along the north coast of New Guinea, and through all the islands of the Pacific Ocean out to and including Hawaii, the Marquesas Islands and Easter Island at the eastern extreme. This represents movements of people over long distances at sea that took place in prehistory extending back considerably in time. Comparative linguistic research has been able to associate words relating to rice cultivation and metal tools with the parent language in mainland Southeast Asia (Blust 1976). If one accepts the linguistic evidence, it follows then that the diffusion of metal technology in Southeast Asia originated on the mainland and progressed to the insular areas.

Technically, it would be very difficult to prove independent invention in the case of Philippine iron technology because, in the first place, we still do not know the nature of the transition from stone to metal technology. Secondly, we are not sure yet of whether the transition was from lithics to copper/bronze or directly to the use of iron. As Barnett (1942:16) points out:

the process of invention states that the inventor through his insights into principles perceives the possibility of utilizing two different but familiar forms, to achieve the same function.
Colloquially, this would be a new way of doing the same thing.

In this instance one can replace the word "inventor" with the word "innovator" as the new development, the innovation, is based on a certain amount of prior knowledge. Barnett's idea fits well with the transition from the use copper/bronze technology for tools, implements and weapons to the use of iron for the same purpose. This is particularly true in the case of China (see Chapter 3), where casting techniques in bronze were transferred to iron casting.

For Kroeber (1940) invention was a form of "idea-diffusion" or "stimulus diffusion." To prove his point, he cited the invention of porcelain in Europe in the early eighteenth century.

Chinese porcelain had been coming to Europe for nearly two hundred years and naturally excited admiration. A definite goal was accordingly set: to produce porcelain without the heavy expense of import from China. The problem was to find the necessary materials at home and to develop the required technical skills. After a considerable period of conscious experimentation the kaolin deposits were discovered, first in Germany and then elsewhere in Europe, and the specific technologies needed were developed. The consequence is that we have here what from one angle is nothing else than invention. Superficially, it is a "parallel," in the technical language of ethnology. However, it is equally significant that the invention, although original so far as Europeans were concerned, was not really independent. A goal or objective was set by something previously existing in another culture; the originality was limited to achieving the mechanisms by which this goal could be
attained. If it were not for the preexistence of Chinese porcelain, and the fact of its having reached Europe, there is no reason to believe that Europeans would have invented porcelain in the eighteenth century, and perhaps not until much later, if at all (Kroeber 1940:2).

This scenario might have been similar with regard to the coming of iron in the Philippines. Iron technology had been in existence for many centuries in the Near East, China and elsewhere in mainland Southeast Asia before it became available it the Philippines. However, it is possible that in some areas like Palawan, Laguna, Manila, Cebu and Negros "parallel invention" of the use of iron could have occurred in response to the stimulus set by the coming of some finished product from China or Southeast Asia. Iron may have arrived in the Philippines as a finished product well before the local population learned to produce their own.

For a variety of reasons Southeast Asia has been a focal point in discussion of independent invention versus diffusion. However, these discussions have not been fruitful for the single reason that insufficient data are present to permit a useful dialogue. Anthropologists have realized that there is not much to solve with regards to this problem since both entail processes in culture change. It is far more satisfactory to investigate the processes of culture change per se. Change as such has been the subject in much of anthropological research, in
the fields of archaeology, ethnoogy, palaeoanthropology, biological anthropology and linguistics to name a few. Scholars have been focusing on the transition from one stage of cultural development to the other from as early as Lewis Henry Morgan's *Ancient Society* (1877). Of particular interest to us is the transition of technology from one society to the other, or the change in technology from one stage to another within the same society. For instance, in the transition from stone to metal-based technology or from copper/bronze to iron use, what cultural processes are involved? How does the society react and adjust to the new form of technology? Why do some societies reject a new type of technology while others easily accept it?

Fundamental to the answering of these questions is the concept of innovation, innovation as a source of technological change. For instance, in the case of metal technology, while copper and bronze technology had been in existence for centuries, this does not assume that a complete knowledge of iron technology existed. According to Pigott (1982b:21) the technology of iron, as an innovation, represented "a new line of development, a recombination of previously existing knowledge which resulted in an entirely new technological configuration."

It is difficult to view iron use in the Philippines as a product of processes of innovation. It is not as yet
clear whether the change was from a lithic technology to an iron using one or whether there was an intermittent copper-bronze technology between stone and iron. The archaeological data from Palawan (Fox 1970) seem to indicate the latter case. However, other areas in the Philippines do not seem to indicate the presence of copper and bronze, where iron is archaeologically excavated. The Philippines lacks a long, archaeologically substantiated record of sophisticated pyrotechnological activity involving metals other than iron. In certain areas, if not most areas of the Philippines iron may have been the first metal which local peoples learned to exploit.

6.1.1 Reply to Hypothesis 1

Hypothesis 1 states that:

If iron implements found in the Philippine archaeological sites were brought as trade goods in the form of finished products, then it may be possible to suggest the presence in their area of origin of a large industry capable of supplying iron artifacts for trade purposes. Since this would imply some form of mass production in certain centers, we may expect to find homogeneity of materials and regularity of forms, style, and metallurgical treatment. Among the iron artifacts found in the Philippines then, we might expect to find some homogenous patterning for each center in (a) morphology (form and style), (b) composition, and (c) metallurgical treatment (see Chapter 1.1.2.1).

As a response to Hypothesis 1 then, we could suggest China as a source of cast iron products like
cooking vessels, because of China's long pre-eminence in the production of cast iron. The other artifact classes including bolos, knives, daggers and spearheads which are wrought iron and therefore could be derived from local smithing but a foreign origin cannot be ruled out. However, it is not possible to scientifically pinpoint the particular place of origin of the cast iron artifacts presumably from China, in part because they have a wide range of variability in their microstructures. For instance, the cast iron fragment from Cagayan (71-Q-107) is comparable to a cast iron artifact from Bohol (C-11-400i) in terms of hardness but not in thickness. Nevertheless, Artifact 71-Q-107 has the same thickness as a Bukidnon cast iron artifact (C-32-3) although the latter is low in hardness. Morphologically, the form of these cast iron artifacts are quite similar but not their metallurgical treatment after casting. This means, as one might suspect, that there was certainly more than one source of cast iron in China and the probability is high that the Chinese manufacturers were not standardized in their production. Only direct comparative analysis with cast iron artifacts from China could begin to resolve this problem of origin of this particular class of artifacts found in the Philippines.
6.1.2 Reply to Hypothesis 2

Hypothesis 2 states that:

If iron was brought to the Philippines as a raw material in the form of wrought or cast iron and then processed and manufactured into finished products by local blacksmiths, then we might expect to find some degree of homogeneity in the composition of the artifacts, but not necessarily in their morphology and metallurgical treatment. In this case there may be significant regional differences within the Philippine archipelago reflected in artifact morphology and perhaps variability in metallurgical treatment (see Chapter 1.1.2.2).

I am inclined to favor Hypothesis 2 in this study for the following reasons. The ethnographic and historical record shows that raw materials in the form of cast or wrought iron were traded by the Chinese with the local inhabitants for forest products (see Chapter 2). The iron materials were then processed by the local blacksmiths for their needs into artifacts including everyday utility knives, bolos, spearheads, etc. Presumably this was the case in the late protohistoric period. Archaeologically, this is also most probable because the majority of the sites where iron is found are normally associated with ceramic trade wares from China from the 10th century A.D..

Archaeometallurgical analyses have shown that there is indeed a wide range of variability in morphology and metallurgical treatment among the types of artifacts from
different sites as seen in Figures 5.3 to 5.14. Even among the Type 2.0 (daggers) that come exclusively from Cebu, while they are morphologically homogeneous, they are quite variable in terms of their metallurgical treatment. This means that there is no apparent regularity in forging or treating the same artifact type except perhaps for some types like Type 1.0 (spearheads) and Type 3.6 (coconut knives). Homogeneity of metallurgical treatment was observed among Type 1.0 from Cebu, Bohol and Siquijor. Their hardness is relatively low (average of 163.8 VHN) because they are all made of low carbon wrought iron. Type 3.6 artifacts, on the other hand, have relatively high carbon contents with correspondingly a high average hardness reading of 461.5 VHN.

Regional variation in metallurgical treatment is observed among Type 3.1 (pinwa knives) where knives from Siquijor are relatively harder than those from Cebu; the same observation is true with Type 3.4 (medium knives), while the knives from Siquijor are homogenously wrought iron with low hardness readings (an average of 147 VHN), the Cebu knives have a relatively higher hardness reading of 217.3 VHN (average). Morphological regional variability is also observed among Types 3.1 (pinwa knives), 3.2 (L-shaped knives), 3.3 (square-end bolo), 3.4 (medium knives), and 3.5 (small knives). Most of the Cebu artifacts cluster in
the same form and style when compared with the remainder of the same types from different sites (see Figures 4.21 to 4.25).

Recycling is a problem in differentiating Hypothesis 1 from Hypothesis 2. Distinguishing iron traded as raw materials from iron traded as finished products is difficult if iron has been recycled. Since recycling is assumed to have occurred locally, whether the iron came in the form of raw material or finished product is no longer important because local blacksmiths transform it anyway. The morphology as well as internal structures of the iron would be changed completely.

6.1.3 Reply to Hypothesis 3

Hypothesis 3 states that:

If iron artifacts found in the Philippines were locally made from metal smelted from domestically mined ores, then we would expect to find inter- and intra-regional variability in artifact morphology, composition, and metallurgical treatment. We would expect to find some centralized mining, smelting, and iron working industries which should cluster geographically in regions where ores are found (see Chapter 1.1.2.3).

Hypothesis 3 is untestable in this study due to lack of the relevant archaeometallurgical data. These include the systematic collection of slags and their analyses which could be used to compare to the analyses of
individual iron artifacts, which frequently contain entrapped slag. These might assist in confirming whether or not these iron artifacts were smelted and manufactured locally or elsewhere. Nevertheless, the idea of regional specialization is still theoretically tenable as observed in Types 2.0 (daggers), 3.0 (pointed bolos), 3.1 (pinya knives), 3.2 (L-shaped knives), 3.3 (square-end bolos), 3.4 (medium knives), 3.5 (small knives), 3.6 (oval tip knives), and 4.0 (harpoons). Cebu might have specialized with Types 2.0, 3.3, and 3.6, while Surigao concentrated on Types 3.0 and 3.1, while Bohol and Surigao both had type 4.0.

6.2 Conclusion

This study is but a beginning of archaeometallurgical investigations in the Philippines. The research still has far to go and, while some goals may be unattainable in the Philippine context, we can, at least, aspire to the kind of detailed anthropological interpretation which Professor Heather Lechtman (1984; 1985) has achieved in her archaeometallurgical studies of metal use in the Andean region of South America. In her studies, Lechtman was able to demonstrate the role of metal technology in the propagation, maintenance and preservation of a major cultural tradition. Cultural components such as
those of socio-political, economic, religious as well as symbolic aspects of the culture were distinguished as factors giving rise to and shaping the copper-silver and copper-gold technology of the society. In turn, it is this copper-base copper technology which helped to maintain and preserve social status and to control human behavior.

6.2.1 Archaeological Evidence

In returning to the Philippine situation, it remains very difficult to say whether or not there is a real Iron Age in the Philippines based on the meager evidence this study has been able to bring together. At least we now have a foundation upon which to build our conception of the origin and development of metal use, particularly iron, in the Philippines. The pattern which appears, as in the case of other parts of the world, indicates that iron is first treated as a decorative and therefore precious metal, which only later became more and more a utilitarian one. This is supported to a certain extent by the earliest iron artifacts from Palawan (see Chapter 3) where Artifact 64-M-40 bears a mat impression (Figure 4.2) and Artifact 62-Tt-B-301 has a coiled shaped tang. It is very difficult to imagine a function for a coiled tang except perhaps for a decorative purpose. The mat impression on Artifact 64-M-40 suggests that it was
kept in a special container perhaps of ceremonial importance. Thus these two iron artifacts may have been decorative and precious and thus were considered as high status grave goods. Their origins will remain obscure until there is a systematic study of these materials in the Palawan area. To begin with it would be helpful for example, if ore bodies from the Palawan area are investigated in order to understand what types of raw materials might have been available to early metal working peoples there.

A comparison of the style and design of these iron artifacts with those of similar date found elsewhere in Southeast Asia would be very useful in establishing possible early contact or trade in finished products of iron. Such a comparison can also provide information about spatial distribution of types even if dates are not well established. Archaeological excavations of sites where these iron artifacts are found can establish temporal distribution of the materials in question. This is a step which scholars could take immediately.

If we consider the corrected dates of 370 – 50 B.C. (Fox 1970) to be correct for the early appearance of iron artifacts in the Philippines, we know little of what happened during the first millennium A.D.. There is little evidence available to demonstrate the role of early iron as
well as its technology among emerging Philippines societies. This again reflects the lack of research focused on archaeometallurgical problems in the Philippines. We need more excavation and, equally as important, various types of analyses to deal with the wide range of problems.

What do we know of the period following the first millennium A.D. in the Philippines? We know, at least, that between the 10th and 15th centuries A.D., there is overwhelming evidence of foreign trade among Southeast Asian societies both from the mainland and the island world (Hutterer 1977a; b). It is not immediately known what caused this surge and influx of foreign trade other than the desire to exchange goods that were not locally available. Where and how did the knowledge that there were other groups of people living in the neighboring islands develop? Although set in an earlier context, Solheim's (1981) main argument for the existence of the seafaring Nusantara, the hypothesized seafarers and trading population of Southeast Asia is that whenever opportunity was lacking in one place people tried to look for it somewhere else. But where did they come from and where were they going? We know little about this, but the archaeological evidence does show much similarity in cultural materials, such as ceramics (mainly porcelain), beads, and metals (i.e.
copper, bronze and iron), moving from one area to another during this time range. This is also supported by the close similarity of words used in various Southeast Asian regions as revealed by linguistic evidence (Goedenough 1982). Through comparative study, linguists have been able to reconstruct used words relating to rice and metal tools (Blust 1976) from the parent language of mainland Southeast Asia.

Technically, there is no Iron Age in the Philippines in the sense that this term is applied elsewhere in the Old World, for the simple reason that the social, political, economic and cultural conditions are different. Nevertheless, it can be argued that there were iron-using societies present in certain portions of the Philippines, as early as the 2nd half of the first millennium B.C.. Iron was most probably forged locally, although it is not certain that it was mined and smelted by the same group of people or even by other groups in the Philippines. There are reports of the possibility of early mining and smelting of iron in Negros by Tenazas (1973; 1974) and also during the later protohistoric period by Hutterer (1973a) in Cebu, and positively during the early historic period in Angat, Bulacan (McCaskey 1903). We can establish a better view of this scenario, if and only if, we conduct archaeometallurgical studies in these regions,
collecting especially evidence for mining and smelting.

The heavy use of iron tools and weapons is noted from the early 10th century A.D. onwards to the 15th century Solheim (1981). The main problem with analyzing iron artifacts is that they can be forged and forged many times. Unlike lithics, where one can trace their life history and reduction sequences (Dibble 1984; 1987a; 1987b), iron artifacts can be discarded or cached, refashioned and recycled over an extended period. It is possible that one would not exactly know how many times an iron artifact had undergone change in form, style, and function. Iron artifacts found in graves may only indicate their final form and style while there may well have been iron artifacts forged strictly for the purpose of being grave goods.

The results of current archaeological research in the Philippines (Junker 1987a; 1987b), indicates that metal, particularly iron, is very frequently associated with Chinese ceramics in burials. This suggests that trade is a major process behind the appearance of iron in many Philippine "Iron Age" sites. Previous research, however, suggests otherwise. Tenazas (1974) argued that iron was present stratigraphically below pre-porcelain deposits in Negros and Laguna. This means that the presence of iron can be argued for at least in these two regions prior to
the coming of full blown Chinese trade to the Philippines. While, no one cause can or will be pinpointed at this early stage in the research in attempting to understand the appearance of iron in the Philippines, one possible scenario involves a combination of the following factors: initial encounters with drift iron, cultural diffusion of artifacts and associated technology, and direct trade to Philippine populations eager to accept innovations from abroad and who were capable of producing technological innovations on their own once the technology was available.

6.2.2 Ethnographic Evidence

From the ethnographic and ethnohistorical records examined herein (see Chapter 2), a pattern has emerged on the supply and use of iron among Philippine people applicable at least during the early part of the 20th century and perhaps earlier. Iron as a raw material, i.e. in the form of wrought bar iron or even cast iron, was being supplied by Chinese and/or mainland Southeast Asian traders in exchange for forest products, gold, salt, beads, etc. These forms of iron, were then processed by local blacksmiths for primarily agricultural and everyday household tools, utensils, and weapons. For example various types of knives were commonly made which could
serve the dual functions of tool and weapon. Surpluses of these products were traded to other groups, and the diffusion of such iron materials was continuous. What we do not know from this pattern is where and how local blacksmiths obtained their knowledge of iron working technology, although we can assume that the technology, once obtained, was passed down from one generation to the next through the families of these craftsmen. Further questions may also be asked. Was iron mining and smelting developed and pursued by the inhabitants specifically in those areas rich in iron ore deposits? Why were the local peoples apparently so dependent on the foreign supply of iron as a raw material? These questions in turn lead to other issues:

1. Iron production, i.e. mining and smelting, is one activity, and iron working or, technically, blacksmithing is another. While some inhabitants may have had the knowledge of how to work imported iron they may not have known how to mine its ores and to smelt them to metal.

2. If some of these inhabitants knew how to mine and smelt iron, yet did not, then why not? Mining and smelting iron is very time consuming work which demands manpower and organizational skills for production on some scale. Perhaps, the quality of the locally smelted iron
would not compare well to the high quality material being traded by the Chinese who mass produced standardized implements and vessels. Given that there was a regular supply of high quality, finished iron goods coming in through trade, the locals may have become more and more dependent on it. Local production as a result may have suffered.

3. The Chinese, or for that matter any other foreign traders, appear to have exchanged only pots (cast iron) and wrought iron bars. Wrought iron bars are easier to pack and to transport than finished products. Furthermore, the cost of production under state organization in China may well have been so prohibitively high as to disallow working iron in shapes acceptable in Philippine societies, even if they understood what these shapes might be.

4. How far back in time can we safely project the model for trade as established via ethnographic evidence? Is it applicable in the pre-contact period before the Chinese traded iron with the local Philippine societies? Is the pattern of supplying iron in raw material form by traders and its processing by local inhabitants peculiar to the Philippines, or does the same pattern apply elsewhere in island Southeast Asia?
One problem in depending too much upon the anthropological interpretation of the ethnographic data in attempting to reconstruct the prehistoric record is continuity. For instance, while there is no mention of iron implements being used as burial goods in the ethnographic record, this is a relatively common practice observed in the archaeological record. Furthermore, one cannot ignore the possibility of selective sampling at work in both archaeological and ethnographic contexts i.e. iron artifacts in graves survive to the present while those in use were often recycled and were thus removed from the sample.

Nevertheless, at present, it is only the ethnographic record that provides us information on the coming of iron as imported raw material and its manufacture by local peoples for their own use. This merits further study in the field of local blacksmithing in the Philippines today. A number of things could be learned from contemporary blacksmithing technique such as heat and furnace conditions, fuel type and its cost, forging operations, metal treatment including carburization, and quenching. One can compare metallographically the microstructure of the present product with that of an archaeological artifact. After all microstructures of metals are beyond time and space if production technologies
are comparable.

6.2.3 Statistical Study

The potential for statistical study of archaeological iron artifacts shows some promise. In such studies one can objectively describe artifacts, groups of artifacts (types) or classes of types, assemblages, etc. in terms of their metric variables such as length, width, thickness, angles, and ratios, among other inherent characteristics. Such description can serve as a basis of comparison for other researchers so that a useful understanding of "types of iron artifacts" can be established. This would in turn standardize our definitions of the various types, size and shapes of iron implements, tools and weapons. For instance, when one speaks of a bolo, a definite shape, size and type should easily be understood.

Furthermore, one can also assess the power of exploratory statistics by testing hypotheses where relationships between variables derived from iron artifacts can be established. This can be done, if and only, if a complete data on chronology and provenience are present so that a time and space relationship of the major artifact attributes could be mapped out. For instance, among the class of spearheads, what is the relationship between the
tang to the blade? Does blade thickness have anything to do with tang thickness? Does the blade width influence tang width? Is blade angle related to tip angle? These data can provide some insights into the pattern or "mental template" which blacksmiths utilized in the production of finished iron tools and weapons. I tried to accomplish this analysis but was unsuccessful due to the limitation of the data. Otherwise, such a study might assist us in isolating inter and intra-regional cultural grouping based on artifact morphology and method of manufacture.

The Guthe iron collection has shown variability in form, style and metallurgical treatment as well as of function. The specimens sampled were typed accordingly. It seems that there does exist a pattern of regional variation among types of iron implements. Some areas may have been specializing in a particular type, as for instance, Type 2.0 (daggers) and Type 3.6 (oval tip knives) are only found in Cebu and nothing of this type was located in the other nine areas of Central Philippines. The bolo on the other hand, is found throughout the Philippines. Would this be a reflection of some local cultural identities within the mosaic and large picture of a "Philippine culture"?

One problem with the Guthe collection is that there is no analysis of the skeletal materials from the graves in
which the iron artifacts were found. A comparison between the types and amounts of iron artifacts and the information about the skeletal evidence would permit a better anthropological interpretation of the graves as a whole. Only a few skeletons were shipped to the University of Michigan while most were left in the Philippines. Analyses of sex and age patterns would be an advantage, for we know that and grave good pattern such as the iron implements are normally found near the body, behind the ear, adjacent to the arms and legs, and beside the stomach. Are these iron implements found in burials suggestive of social or political status, of economic power or religious significance or simply sex differences?

Based on observations in this study, it appears that the use of iron in the Philippines was primarily for utilitarian implements such as different types of knives and weapons including projectile points or spearheads for everyday life. Does this reflect in some way the nature of societies from the period in which iron was beginning to be used on a regular basis? Unfortunately, our data as it stands does not allow us to speculate at length about the nature of these societies or their social context. However, the mere presence of iron artifacts in graves may suggest that iron was used as a kind of high status grave good, since only a select number of burials contain iron.
As iron became more available, it played more and more a utilitarian role and thus it gradually became less and less a mere precious or ornamental material.

Judging from the number of the iron artifacts we have, one inference is that among the small groups of peoples using them, war and/or invasion were not consistent threats. Perhaps we have a situation akin to "the Peaceful Bronze Age" of northeast Thailand (White 1982). On the other hand, daggers and spearheads can be weapons of war (although they may also be used mainly for hunting) and protection. A case in point is the excavation of headless skeletons found in Calatagan (Fox 1959). Hutterer (personal communication) pointed out that this could suggest the presence of warfare which could fit with the level of socio/political development at this time.

The relative quantity of iron implements from sites in the Philippines covered in this study is not high. This in turn suggests that the rate of acquisition of iron was also not high. This may reflect also a small population. Consequently, a small population may not need a high volume of iron particularly if the need for iron is for nothing other than every day utilitarian usage. How many times do people change and discard their knives? Perhaps there was less demand for iron other than for everyday work. One may also add that, as I have observed in Philippine villages,
people frequently ruin, accidentally destroy, lose or throw away their iron implements.

Iron rusts quickly in Southeast Asian burials. Why do people bury their dead with their iron implements? Peralta's (1977) argument that after iron became abundant people could spare iron for grave furnishings is not completely convincing, because even today people still recycle old iron implements and scrap iron. Moreover, there is really no direct evidence of whether or not iron was indeed abundant in prehistory or even during the protohistoric period. Such determinations are yet before us.

6.2.4 Metallographic Study

We have learned from the metallographic study that the Palawan artifacts are made of wrought iron with a low carbon content as evidenced by the presence of relict pearlite or "ghost structures." When compared with the earlier studies (Dizon 1983) of iron from Pangasinan, Cagayan and Sorsogon, the Palawan materials are less sophisticated in their metallurgical treatment. Relative uniformity in metallurgical treatment has been observed among the Guthe-Michigan collection which constitute a larger sample from a later period. This suggests an improvement in iron technology through time.
There is no known iron casting industry in the Philippines even during the historic period, thus, the assumption remains that the presence of cast iron vessels in Philippine archaeological sites suggests trade relations between local populations and Chinese or other Southeast Asian peoples. Blacksmithing, on the other hand, must have been prevalent in the Philippines from early periods onwards. Various types of iron implements are observed in the major regions of the Philippines. As suggested by our statistical analysis, certain types of daggers, knives or spearheads are common in one region but not in other parts of the archipelago.

From the point of view of a craftsman such as a blacksmith, he can estimate the time of forging as well as the amount of iron needed for a specific tool or implement by knowing the volumes of each type. Perhaps, based on his limited supply of iron, he may be able to judge what implement should have priority for production. This may be particularly important in a small scale society. As Cyril Stanley Smith (1971) has pointed out, the man-hour input in the production of iron artifacts is relatively low compared to the amount of time and labor invested in forging the artifacts. Forging is tedious and time consuming work, and substantial man power is needed even for the small scale production of wrought iron material.
Based on our laboratory work to date, except for some regularity in shapes and sizes of some types, there seems to be no mass or even standardized production of iron implements in the Philippines. This suggests small scale wrought iron production at the level of the local smith and by a number of local smiths spread over the Philippines, each evolving his own local techniques to meet local needs and design preferences. This then is a means by which to look at iron in the Philippines for future research. It may stand up as a useful model or we may find, as is often the case, that future research will continue to evolve our understanding of just what impact the coming of iron did have on the multi-faceted cultural mosaic which we know the islands of the Philippines to be.

6.3 Recommendations for Future Research

In order to understand fully the evolution of iron technology in both mainland and island Southeast Asia, ideally, it would be best to conduct an inter- and multi-disciplinary research project for the period of the first appearance of metal. Planning should be done by specialists in various fields of disciplines including anthropologists, archaeologists, geologists, and metallurgists. The focus must be regional rather than
site-specific i.e., a proper consideration of the region as a whole with a systematic sampling strategy, as opposed to working only on designated sites where it is conducive to work. The above is, however, an ideal situation that assumes that funding is not a problem. Realistically speaking, particularly for the Philippine situation, the following suggestions are recommended.

6.3.1 Survey and Excavation

A geographical survey of selected districts of iron ore deposits is recommended to locate possible ancient iron mining and production sites. These would include Bulacan, Manila, Laguna, Sorsogon, Samar, Cebu, Negros and Surigao. Locations of present iron mining sites, in relation to known archaeological sites are good candidates for systematic explorations and archaeometallurgical investigations. That this strategy is successful has been made clear through the field work of Wertime (1968), Lechtman (1976), and Pigott (1984). Regional sampling is an important consideration in order to assess possible patterns of regional exploitation of resources and environment. If such a program is not possible, the least we can do is to begin by investigating sites where slag is reported to have been found, such as those sites reported by Tenazas (1968; 1973; 1974) and Hutterer (1973a).
Excavation of identified prehistoric iron working sites is necessary for the systematic recovery of archaeological evidence for production as well as the scientific dating of these sites. Radiometric dates are needed for the chronological ordering of technology as well as the cultural sequences. Stratigraphic data will be of a significant value for the reconstruction of site formation, site utilization and those of production.

6.3.2 Data Analyses

Metals, particularly iron artifacts, would be given special consideration for thorough archaeometallurgical analysis as has been demonstrated in this study. Among the analyses necessary are metallography, corrosion studies, elemental analysis, and slag and mineral/ore study. Trace element analysis of the slag inclusions should be made to compare them with the local iron ores found in the Philippines. All other associated cultural remains and ecological materials must be properly processed via archaeological methods. Statistical analyses should also be undertaken. In the future, we may also include in the analysis of variance, the variables of geographical location and metallurgical treatment.
6.3.3 Cross-Cultural Study

Contact should be made with mainland and island Southeast Asian museums or institutions in order to study their collections of iron artifacts as well as to implement archaeometallurgical analyses. Countries like Vietnam, Thailand, Malyasia, Singapore, Brunei, Indonesia and the Philippines are of prime importance in this venture. The southeastern provinces of China, including Hongkong, should be included in this project since they have been the trading partners of Southeast Asian nations. If sampling on the artifacts for metallography will not be permitted, at least, measurements should be made for an adequate statistical study.

6.4 Final Comments

The Iron Age is a technological stage with the largescale, wide spread use of iron as a material for everyday utilitarian tools and weapons, and not just for decorative or ornamental purposes. Its presence can imply, among other things, the existence of a complex social organization, where the society is differentiated not by sex or age alone but by various class distinctions,
segmented into groups i.e. food producers, farmers, workers, craftsmen, merchants, traders, military, public servants, religious leaders, etc. This kind of society assumes a complex political machinery, a system of religion, and an economic institution that deals with the control, distribution and redistribution of resources. Technology is also a system that operates within this complex whole. It provides the science and technical knowledge to manipulate the resources for the society.

To reiterate my basic conclusion, there is no real Iron Age in the Philippines but there may have been iron-using societies as early as ca. 200 B.C. at least in Palawan. This, however, does not mean that these were simple societies. They were perhaps at a different level of socio-economic-political complexity since the mere presence of iron in a society, whether it is derived by trade or not, can suggest some form of complexity. First, if iron is acquired by trade then this means that the society has an economic network that deals with the distribution and/or redistribution of what is being traded. Secondly, the mere maintenance, blacksmithing, forging and recycling of iron require some knowledge of its technology. Iron technology is not simple. It demands complex operation of a forge, pyrotechnological know-how, experience on the properties of iron and its practical uses
for the society.

Since iron technology is complex, knowledge of its processes becomes firmly embedded within societies which use iron. It involves many groups of people in a society including miners, blacksmiths, the local peoples who use their tools and weapons everyday. Thus, to conclude, the study of iron technology constitutes one mechanism by which an improved understanding of the socio-cultural complexity of pre- and proto-historic societies in the Philippines and Southeast Asia might be achieved.
APPENDIX

PHOTOMICROGRAPHS
Photomicrograph 4.1
64-M-40 (X400) Relict "ghost" pearlite

Photomicrograph 4.2
64-M-40 (X400) Slag inclusions
Photomicrograph 4.3
62-Tt-B-298 (X400) Ferrite and pearlite grains

Photomicrograph 4.4
62-Tt-B-299 (X400) Ghost structures - pearlite
Photomicrograph 4.5
62-Tt-B-301 (X400) Ferrite grains

Photomicrograph 4.6
62-Tt-B-301 (X400) Metal trapped in a slag
Photomicrograph 4.7
B-5-19 (X400) Fine lamellar microstructures

Photomicrograph 4.8
B-5-20 (X400) Coarse ferrite grains
Photomicrograph 4.9
B-6-7 (X200) Flattened slag inclusions, unetched

Photomicrograph 4.10
B-6-7 (X400) Martensitic structures
Photomicrograph 4.11
B-6-8 (X400) Fine grain martensite

Photomicrograph 4.12
B-6-9 (X100) Uneven ferrite grain distribution
Photomicrograph 4.13
B-6-9 (X400) Microhardness pyramid impression

Photomicrograph 4.14
B-7-23 (X200) Flattened slag inclusions
Photomicrograph 4.15
B-7-23 (X100) Uneven ferrite grain distribution

Photomicrograph 4.16
B-7-23 (X400) Pearlite colonies in bands
Photomicrograph 4.17
B-7-24 (X400) Spheroidized pearlite

Photomicrograph 4.18
B-7-25a (X400) Eutectoid composition
Photomicrograph 4.19
B-7-25b (X400) Flattened slag inclusions

Photomicrograph 4.20
B-7-25b (X400) Martensitic structures
Photomicrograph 4.21
B-7-25c (X100) Uneven grain distribution

Photomicrograph 4.22
B-7-25c (X600) Widmanstätten structures
Photomicrograph 4.23
B-12-19 (X400) Uniform grain distribution

Photomicrograph 4.24
B-17-33a (X100) Carburized edge
Photomicrograph 4.25
B-17-33a (X200) Martensitic structures

Photomicrograph 4.26
B-17-33b (X600) Fine grain, pearlite colonies
Photomicrograph 4.27
B-18-15 (X100) Uniform coarse ferrite grain

Photomicrograph 4.28
B-18-17 (X400) Austenite grain, slag inclusions
Photomicrograph 4.29
B-19-20a (X100) Uneven ferrite grain distribution

Photomicrograph 4.30
B-19-20a (X400) Pearlite colonies
Photomicrograph 4.31
B-64-14a (X100) Coarse ferrite grains

Photomicrograph 4.32
B-64-14b (X400) Martensite, bainite structures
Photomicrograph 4.33  
B-82-17 (X200) Coarse ferrite grains

Photomicrograph 4.34  
B-82-17 (X400) Fine bainite microstructures
Photomicrograph 4.35
B-84-13a (X100) Wrought iron, uneven ferrite

Photomicrograph 4.36
B-85-19a (X400) Martensite, bainite structures
Photomicrograph 4.37
B-89-8a (X400) Idiomorphic crystal on slag

Photomicrograph 4.38
B-89-8a (X400) Pearlite colonies
Photomicrograph 4.39
B-89-8a (X400) Pearlite colonies, uneven grain

Photomicrograph 4.40
B-89-8b (X400) Hypo-eutectoid composition
Photomicrograph 4.41
B-93-15 (X100) Gradual carbon distribution

Photomicrograph 4.42
G-71-18a (X100) Fine spheroidized carbide
Photomicrograph 4.43
G-74-6a (X200) Slag stringers in pearlite matrix

Photomicrograph 4.44
G-74-6a (X400) Spheroidized pearlite
Photomicrograph 4.45
G-74-7a (X100) Fine grain pearlite, steel

Photomicrograph 4.46
G-74-7a (X400) Compounded weld-like line
Photomicrograph 4.47
G-74-8a (X100) Hyper-eutectoid steel

Photomicrograph 4.48
G-74-8b (X400) Slags in coarse grain ferrite
Photomicrograph 4.49
G-76-11 (X100) Slags in coarse grain ferrite

Photomicrograph 4.50
G-82-6 (X400) Martensite, bainite structures
Photomicrograph 4.51
G-111-40a (X100) Uneven grain distribution

Photomicrograph 4.52
G-111-40b (X400) Fine martensite
Photomicrograph 4.53
G-114-3 (X400) Martensitic structure

Photomicrograph 4.54
G-123-6 (X100) Decarburized edge
Photomicrograph 4.55
M-1-26a (X400) Pearlite colonies

Photomicrograph 4.56
M-1-26b (X100) Gradual carbon distribution
Photomicrograph 4.57
M-1-26c (X100) Slag inclusion in oxide

Photomicrograph 4.58
M-6-51a (X100) Carburized edge
Photomicrograph 4.59
M-6-52 (X100) Fine grain, even distribution

Photomicrograph 4.60
M-6-52 (X400) Martensite, bainite structures
Photomicrograph 4.61  
M-6-53a (X100) Even distribution, martensite

Photomicrograph 4.62  
M-6-54 (X400) Martensite, bainite structures
Photomicrograph 4.63
B-21-17 (X400) Uneven ferrite grain distribution

Photomicrograph 4.64
B-23-8 (X100) Uniform grain distribution
Photomicrograph 4.65
B-23-8 (X600) Hypo-eutectoid composition

Photomicrograph 4.66
G-100-7 (X400) Eutectoid, pearlite colonies
Photomicrograph 4.67
G-101-7a (X400) Relief structures in ferrite

Photomicrograph 4.68
G-117-13a (X100) Equiaxed ferrite grains
Photomicrograph 4.69
G-147-2a (X400) Fine martensite structures

Photomicrograph 4.70
G-147-2a (X400) Pearlite colonies, fine grain
Photomicrograph 4.71
C-11-4001 (X100) Cementite matrix

Photomicrograph 4.72
C-11-4001 (X400) Lamellar pearlite & graphite
Photomicrograph 4.73
C-11-400j (X200) Uneven ferrite grain distribution

Photomicrograph 4.74
C-11-400k (X400) Pearlite colonies, fine grain
Photomicrograph 4.75
C-11-400L (X400) Uniform grain distribution

Photomicrograph 4.76
C-11-400m (X600) Tempered martensite, carbide
Photomicrograph 4.77
C-11-401b (X400) Eutectoid composition

Photomicrograph 4.78
C-11-401c (X100) Uneven ferrite grain distribution
Photomicrograph 4.79
C-91-6 (X100) Carburized edge, slag inclusions

Photomicrograph 4.80
G-167-2 (X400) Coarse pearlite structures
Photomicrograph 4.81
G-185-5 (X100) Uneven ferrite grain distribution.

Photomicrograph 4.82
G-185-5 (X400) Pearlite colonies in band
Photomicrograph 4.83
C-5-27 (X100) Uneven ferrite grain distribution

Photomicrograph 4.84
C-55-38 (X100) Carburized edge
Photomicrograph 4.85
C-55-50a (X400) Eutectoid composition

Photomicrograph 4.86
C-55-50b (X100) Hyper-eutectoid composition
Photomicrograph 4.87
C-55-50c (X100) Three-zone composition

Photomicrograph 4.88
C-55-50c (X400) Eutectoid, Widmanstätten structure
Photomicrograph 4.89
C-55-51a (X100) Uneven carbon distribution

Photomicrograph 4.90
C-55-51b (X400) Uneven carbon distribution
Photomicrograph 4.91
C-55-51b (X100) Uneven ferrite grain distribution

Photomicrograph 4.92
C-56-25a (X100) Coarse grain ferrites
Photomicrograph 4.93
C-56-25a (X400) Widmanstätten structures

Photomicrograph 4.94
C-56-25b (X400) Pearlite colonies
Photomicrograph 4.95
M-2-31 (X400) Metal in a slag inclusion

Photomicrograph 4.96
M-2-31 (X100) Uneven ferrite grain distribution
Photomicrograph 4.97
H-2-55a (X400) Martensite & bainite plates

Photomicrograph 4.98
B-10-16a (X200) Uniform fine ferrite grain distribution
Photomicrograph 4.99
B-10-28a (X200) Uneven ferrite grain distribution

Photomicrograph 4.100
C-14-11 (X200) Martensite, Widmanstätten structure
Photomicrograph 4.101
C-83-6 (X100) Uniform fine ferrite grain distribution

Photomicrograph 4.102
C-83-6 (X100) Uneven grain distribution, Widmanstätten structure
Photomicrograph 4.103
C-32-3 (X100) Uniform fine grain distribution

Photomicrograph 4.104
C-32-3 (X400) Dendritic structures, pearlite
Photomicrograph 4.105
C-76-21a (X400) Ferrite grain in oxide matrix
BIBLIOGRAPHY

Aga-Oglu, K.
1946 Ying Ch'ing porcelain found in the Philippines. Art Quarterly 9:315-326.

Aga-Oglu, K.
1948 Ming export blue-and-white jars in the University of Michigan collection. Art Quarterly 11:201-207.

Agrawal, D.P.
1971 The Copper Age in India. Munshiram Manoharlal. New Delhi.

Agrawal, D.P. and S. Guzder

Allchin, B. and R.

An Zhimin

An Zhimin

Banerjee, N.R.
1965 The Iron Age in India. Munshiram Manoharlal. Delhi.

Banerjee, N.R.
1983 Comments on "The issues of the Indian iron age" by D.K. Chakrabarti. Paper read at the International Seminar on Recent Advances in

Barnard, N.

Barnard, N. and S. Tamatsu

Barnett, H.G.

Barnett, H.G.

Barnett, H.G.

Barnett, H.G.

Barton, R.F.

Bay-Petersen, J.

Bay-Petersen, J.

Bayard, D.T.
1984 Some questions on Higham's revision of the mainland Southeast Asian sequence. South-East
Asian Studies Newsletter 14:5-8.

Bellwood, P.

Benedict, L.W.

Berger, R. and W.F. Libby
1966 UCLA radiocarbon dates V. Radiocarbon 8:467-497.

Bernard, H. and P. Pelto (Eds.)

Bewsher, R.A.
1956 Bisayan accounts of early Bornean settlements in the Philippines as recorded by Father Santaren. Sarawak Museum Journal 7:48-53

Bewsher, R.A.

Beyer, H.O.

Beyer, H.O.

Beyer, H.O.

Beyer, H.O. and J.C. De Veyra

Bjorkman, J.X.
Blair, E.H. and J. Robertson
1903-09 The Philippine Islands - 1492-1898 (54 Volumes).
Arthur N. Clark Co. Ltd. Cleveland.

Blumentritt, F.
1882 An Attempt at Writing a Philippine Ethnography.
Translated by N.N. Maceda (1980). University
Research Center, Mindanao State University.
Marawi City.

Blust, R.
1976 Austronesian culture history: some linguistic
inferences and their relations to the
archaeological record. World Archaeology
8:19-43.

Bondoc, N.
1983 A photograph report on the Aguit-it Vinson's site

Bordes, F.
1969 Reflections on typology and techniques in the

Bray, W. and D. Trump

Brick, R.M.; A.W. Pense, and R.B. Gordon

Bronson, B.
1985 Notes on the history of iron in Thailand. Journal
of the Siam Society 73(1&2):205-255.

Burton, L.M.
1979 Settlement and burial sites at Suatan, Butuan
City: a preliminary report. Philippine Studies
25:95-112.

Carroll, J.J.
1960 The word Bisaya in the Philippines and Borneo.

Chakrabarti, D.K.
1976 The beginning of iron in India. Antiquity
50:114-124.

Chakrabarti, D.K.
1983 The issues of the Indian iron age. Paper read at
the International Seminar on Recent Advances in Indian Archaeology, Dec. 10-14, 1983. Deccan College, Poona.

Chang, K.C.

Charles, J.A.

Chase, W.T.
1979 Solid samples from metallic antiquities and their examination. Proceedings of the 2nd ISCRCP Cultural Property and Analytical Chemistry.

Chase, W.T.

Childe, V.G.

Childe, V.G.

Childe, V.G.

Christie, E.B.

Christie, J.W.

Clark, G.
Clarke, D.L.  

Coghlan, H.H.  

Cole, F.C.  
1913 The wild tribes of Davao district, Mindanao. Field Museum of Natural History, Anthropological Series 12:49-203.

Cole, F.C.  

Cole, F.C.  

Conklin, H.C.  

Conklin, H.C.  

Daniel, G.  
1981 A Short History of Archaeology. Thames and Hudson Ltd. London.

Daniel, G. (Ed.)  

Desch, C.H.  

Dibble, H.  
1984 Interpreting typological variation of the middle paleolithic scrapers: function, style, or

Dibble, H.

Dibble, H.

Dinopol, D.

Dizon, E.Z.

Dizon, E.Z.

Dizon, E.Z.

Doran, J.E. and F.R. Hodson

Dunnell, R.C.

Dyson, R.H.
Eggan, F. et al. 1956  

Evangelista, A.E. 1962  
Philippines ... report. *Asian Perspectives* 6(12):46-47.

Evangelista, A.E., W. Ronquillo and R. Flores  
n.d.  
The Cabaruan jar burial: a site report.  

Fairservis, W.A. Jr. 1975  
The Roots of Ancient India (2nd ed., revised).  
The University of Chicago Press. Chicago.

Fergusson, G.J. and W.F. Libby 1964  

Forbes, R.J. 1950  

Ford, J.A. 1954a  
Comment on A.C. Spaulding's, 'Statistical techniques for the discovery of artefact types.'  

Ford, J.A. 1954b  

Ford, J.A. 1954c  

Foster, G.M. 1962  

Fox, R.B. 1953  

Fox, R.B. 1959  
Fox, R.B.

Fox, R.B.

Fox, R.B.

Fox, R.B.

Fox, R.B.

Fox, R.B.

Fox, R.B. and A.E. Evangelista

Fox, R.B. and A.E. Evangelista
1957b The cave archaeology of Cagraray island, Albay province. Journal of East Asiatic Studies 6(1):57-68.

Fox, R.B. and A.M. Legaspi

Fox, R.B. and J.T. Peralta
1974 Preliminary report on the palaeolithic


Glover, I.C. 1980 Ban Don Ta Phet and its relevance to problems in
the pre- and protohistory of Thailand. Buller
of the Indo-Pacific Prehistory Association
2:16-30.

Goodenough, W.H.
1966  Cooperation in Change. An anthropological
approach to community development. John Willey
and Sons, Inc. New York.

Goodenough, W.H.
1982  Ban Chiang in world ethnological perspective. In
J.C. White, Ban Chiang: Discovery of a Lost
Bronze Age. The University Museum, University
of Pennsylvania and the Smithsonian Institution.
Philadelphia and Washington, DC.

Gordon, D.H.
1950  The early use of metals in India and Pakistan.
Journal of Royal Anthropological Institute of
Great Britain and Ireland 80:55-78.

Gorman, C.F.
1969  Hoabinhian: a pebble-tool complex with early
plant associations in Southeast Asia.
Science 163:671-673.

Gorman, C.F.
1970  Excavations at Spirit Cave, north Thailand: some
interim interpretations. Asian Perspectives

Gorman, C.F.
1971  The Hoabinhian and after: subsistence patterns
in Southeast Asia during the late Pleistocene
and early Recent periods. World Archaeology
2:300-320.

Gorman, C.F.
1975  A priori models and Thai prehistory: a
reconsideration of the beginnings of agriculture
in Southeastern Asia. In C.A. Reed, ed., Origins

Gorman, C. and P. Charoenwongsa
1976  Ban Chiang: a mosaic of impressions from the
first two years. Expedition 18(4):14-26

Guthe, C.E.
1922-25  The University of Michigan Philippine
Expedition Field Catalogue 1922-25. Museum of
Ann Arbor.
Guthe, C.E.  
1927  The University of Michigan Philippine expedition.  

Guthe, C.E.  
1929  Distribution of sites visited by the University of Michigan Philippine expedition, 1922–25.  

Guthe, C.E.  
1935  Gold decorated teeth from the Philippine Islands.  

Guthe, C.E.  
1938  A burial site on the island of Samar, Philippine Islands.  

Harrisson, T.  
1962  Bisaya in North Borneo and elsewhere.  

Harrisson, T. and S.J. O'Connor  
Cornell University.  
Ithaca, New York.

Haryono, T.  
University of Pennsylvania.  
Department of Anthropology.

Hegde, K.T.M.  
1973  A Model for understanding ancient Indian iron metallurgy.  

Heine Geldern, R. von  
1937  L'art prebouddhique de la Chine et de l'Asie du sud-est et son influence en Oceanie.  

Heine Geldern, R. von  
1966  Some tribal art styles of Southeast Asia: an experiment in art history.  
In D. Fraser, ed., *The Many Faces of Primitive Art*.  
Prentice-Hall, Inc.  
Engelwood Cliffs, N.J.  
Pp. 165-221.
Henson, F.G. 

Heskel, D. and C.C. Lamberg-Karlovy 

Higham, C.F.W. 

Higham, C.F.W. 

Hill, J.N. and R.K. Evans 

Hodges, H. 

Hsia Nai 

Hutterer, K.L. 

Hutterer, K.L. 

Hutterer, K.L. 
Hutterer, K.L.

Hutterer, K.L.

Janse, O.R.T.

Janse, O.R.T.

Janse, O.R.T.

Janse, O.R.T.

Jenks, A.E.

Jocano, F.L.

Jocano, F.L.
1975 *Philippine Prehistory*. Philippine Center for Advanced Studies. Diliman, Quezon City.

Joshi, M.C.
Jue-ming, H.

Junker, L.

Junker, L.

Kehl, G.L.

Kijngam, A.

Knauth, P.

Knox, R.

Knox, R.

Krieger, A.D.

Kroeber, A.L.
Kroeber, A.L.

Kroeber, A.L.

Kurjack, E.B. and C.T. Sheldon

Lamberg-Karlovsky, C.C.

Leach, E.R.

Lebar, F.M. (Ed.)

Lebar, F.M. (Ed.)

Lechtman, H.

Lechtman, H.

Lechtman, H.

Lechtman, H.
1985 The significance of metals in pre-Columbian Andean culture. Bulletin of the American
Legaspi, A.A.  
1974a  

Legaspi, A.A.  
1974b  

Leuva, K.K.  
1963  

Li Chi  
1977  

Li, Xueqin  
1985  

Lowie, R.  
1940  

Lynch, F.X.  
1949  

Ma Chengyuan  
1980  

Maceda, M.N.  
1964  
Preliminary report on ethnographic and archaeological fieldwork in the Kulaman plateau, Island of Mindanao, Philippines. Anthropos 59:75-82.

Maceda, M.N.  
1965  
Maddin, R.; J.D. Muhly and T.S. Wheeler  

Mallowan, M.E.L.  
1936 1937, the excavations at Tall Chagar Bazar and an archaeological survey of the Habur region: second campaign. *Iraq* 4:91-154.

McCaskey, H.D.  

Meacham, W.  

Morgan, H.L.  

Moss, C.R.  

Muhly, J.D.  

Muhly, J.D.  

Muhly, J.D.  

Natapintu, S.  

Needham, J.  
Needham, J.  

Nguyen, P.L.  

Oppenheim, A.L.  

Pearson, G.W. and M. Stuiver  

Pearson, R.  

Peralta, J.T.  

Peranio, R.D.  

Peters, H.A.  
in press Chu Elegance in the Land of the Southern Barbarians.

Peterson, J.T.  

Peterson, J.T.  

Peterson, W.  
1972  Anomalous Archaeological Sites of Northern Luzon

Pigott, V.C.

Pigott, V.C.

Pigott, V.C.

Pigott, V.C.

Pigott, V.C.

Pigott, V.C., P.E. McGovern and M.R. Notis

Pigott, V.C. and A.R. Marder

Pleiner, R.

Pleiner, R. and J.K. Bjorkman
Possehl, G.L. (Ed.)

Possehl, G.L. (Ed.)

Possehl, G.L.

Potts, D.T.

Prakash, B. and V. Tripathi

Rausa-Gomez, L.

Roales, T.

Rogers, E.M.

Rostoker, W., B. Bronson, J. Dvorak and G. Shen

Rostoker, W., M.B. Notis, J.R. Dvorak and B. Bronson

Rouse, I.

Rowe, J.H.
1966 Diffusionism and archaeology. American Antiquity
31(3):334-37.

Rowlands, M.J.

Sahi, M.D.N.

Santaren, T.

Schmandt-Besserat, D.

Schofield, W.

Shaffer, J.G.

Sharer, R.J. and W. Ashmore

Sinha, K.K.

Smith, C.S.
1971 The techniques of the Luristan smith. In R.H.

Smith, C.S.

Snodgrass, A.M.

Solheim II, W.G.

Solheim II, W.G.

Solheim II, W.G.

Solheim II, W.G.

Solheim II, W.G.

Solheim II, W.G.

Solheim II, W.G.

Spaulding, A.C.

Spaulding, A.C.

Spaulding, A.C.

Stech Wheeler, T. and R. Maddin

Steward, J.H.

Steward, J.H.

Stuiver, M. and G.W. Pearson

Subrahmanyam, B.R.

Tenazas, R.C.P.

Tenazas, R.C.P.

Tenazas, R.C.P.
and Society 1:274-82.

Tenazas, R.C.P.

Thaplyal, K.K.

Tripathi, V.
1985 From copper to iron - a transition. Purattatva (India) 15.

Tuggle, H.D. and K.L. Hutterer
1972 Archaeology of the Subotan area, southwestern Samar, Philippines. Leyte-Samar Studies 6(2). Special Issue.

Tylecote, R.F.

Tylecote, R.F.

Tylecote, R.F. and R. Thomsen

Van Der Merwe, N.J.

Van Der Merwe, N.J.

Van Der Merwe, N.J. and D.H. Avery
Von Koenigswald, G.H.R.

Von Koenigswald, G.H.R.

Wainwright, G.A.

Waldbaum, J.C.

Waldbaum, J.C.

Wallace, A.F.C.

Wang, Teh-Ming

Wernstedt, F.L. and J.E. Spencer

Wertime, T.A.

Wertime, T.A.

Wertime, T.A.
Wertime, T.A. and J.D. Muhly (Eds.)

Whallon, R. and J.A. Brown (Eds.)

Wheeler, R.E.M.

Wheeler, T.S. and R. Maddin

White, J.C.

White, L.A.

Willey, G.R. and P. Phillips

Wilson, L.L

Woods, C.M.

Young, T.C.
1965 A comparative ceramic chronology for western Iran, 1500-500 B.C. Iran 3:53-86.

Young, T.C.
1967 The Iranian migration into the Zagros. Iran 3:11-34.
INDEX

An Zhimin 120
archaeological record 23
Argao, Cebu 234, 236
Aroroy, Masbate 286

"B.C." and "b.c." 29, 30
Bagobo 85
bainite 235
bainitic-martensitic 297
Balingasay Site (64-F) 166
Ban Chiang 133
bar iron 66
Barili, Cebu 243, 251
Barnett 351
Barrio Maguirig (71-Q) 171
Barrio of I gid, Samar 290
Barton 67
Bato Caves 152
Batungan Cave 153
Bayard 136
bellows 65
Bellwood 41, 134
Berger and Libby 151
Beyer 4, 31, 46
bimetallic (bronze and iron) 134
Binisitahan Site (V-79-L5) 174
Bisayas 78
blackamithing 72
blacksmiths 370
blade angle 332
blade length 332
blade thickness 334
blade width 334
Bogo, Cebu 242
Bohol 260, 267
Bohol materials 267
Bolinao materials 166
Bontoc-Igorot 64
Bronson 136
Bronze Age 6
broze and copper 165
bronzesmiths of the Shang dynasty 120
Bukidnon 297
Bulacao River, Cebu 220
Bulacan 87
C-14 date 54
Cagayan materials 170
Calatagan 373
Calubian, Leyte 293
Cantonese 128
Caraga, Davao 299
Carascale, Surigao 278
Carcar, Cebu 249
Case carburization 237
Cast iron 66, 143
Cebu 215
Cebu materials 215
Chakrabarti 109
Chalcolithic 38
charcoal fuel 90
Chang 125, 130
Childe 6, 57
China 116, 123, 136, 353
Chinese bellows 71
Chinese traders 69
Chinese "Iron Age" 119
Clarke 188
Classes and Types of the Guthe Iron Artifacts 192
Classification and typology 186
Cock's spur 226
Coghlan 142
Cole 67, 69
Conklin 67, 77
Conklin 67, 77
Consulacion, Cebu 239
Contact and Trade 26
Cortez Site (II-80-J) 173

Danao, Cebu 248
Daniel 24, 44, 90
Davao 299
diffusion 347
Dinago Island, Surigao 277
distribution of artifacts by type 302
Dumanjog, Cebu 252

Dong Son 133
Doran and Hodson 189
drift iron 54
Dunnell 188

Eastern Mediterranean 103
"emic" 187
"etic" 187
ethnographic and ethnohistorical records 366
Evangelista 36
Franklin 123
Ford 187
forge 71
forged hot 220
Fox 37, 53, 148, 159
Goodenough 41
Guthe 178
Guthe-Michigan Collection 177, 371
Hanunoo (Mangyans) 75
Hardness 336
Heine-Geldern 133
Henson 179
Hill and Evans 189
Hutterer 8, 19, 39, 42, 127, 133, 179, 215, 313, 345, 363,
364, 373
Ifugao 66
Igorot 66
Iliihan Cave 278
independent invention 347
India 108
Indian Iron Age 115
"Iron Age" 4
"Iron Age" in the Philippines 138
Iron Age 44, 45, 56, 57, 90, 379
iron and copper 287
Iron-Carbon Phase Diagram 154
iron mining and smelting 87
iron production 91, 367
Iron Technology 141
Jenks 64
Jocano 39, 51

Knox 220
Krieger 186
Kroeber 60, 352

Lagtan, Cebu 219
Lake Mainit, Surigao 284
lamellar microstructure 220
Larena, Siiquior 261, 262, 264, 266
lead 185
Lechtman 360
Legaspi 166
Leyte 293
Li 122
Loboc, Bohol 275
Loon, Bohol 273
Low 58
Low variance among the variables 344

Malayan forge 93
Malayan piston bellows 76
Maluko, Bukidnon 297
Manunggul Cave 149
Manobo 85
Maranao 84
martensitic structures 222
Masbate 153, 285
Masbate materials 285
McCaskey 62, 87
Meacham 126, 129
Metal Age 25, 132
Metal Age beads 165
meteoric origin 120
meteoritic iron 94
Michigan collection 301
Microhardness testing 20
Mindoro 295
Mindanao 82
Minglanilla, Cebu 230, 232, 233, 249
Morgan 56, 354
Moss 72
mother-of-pearl bracelet 227
Muhly 45, 104
municipalities in southern Cebu 254, 256

Nabaloi 72
Naga, Cebu 225
Near East 96, 44, 353
Needham 121
Negrito 79
Negritos 74
Neolithic 25
New Stone Age 25
New World terms 27
North China 117
Northern China 119
Northern Luzon 63
Nusantao 51, 363

Old Stone Age 25
ore preparation 90

pagan 61, 83
Palaeolithic 25
Palawan Materials 148
Pangasinan 166
pearlite colonies 224
Pearson and Stuiver 148
Peralta 373
Philippine Iron Age 48
Philippine iron ore 62
Philippine Metal Age 147
Peters 126
pinya 245, 279, 283
Pigott 8, 100, 354
Pigott and Marder 134
Pocanil Point, Mindoro 295
point or tip angle 334
Prakash and Tripathi 112
primary variables 304
procedures for metallographic examination 20
purpose of this dissertation 1
purpose of this investigation 10

Quenching 233

ratio between the blade length and the tang length 341
ratio of blade length over blade width 341
Recycling 358
reduction process 91
Relict pearlite 154
Ronda, Cebu 238
Rowlands 7, 58
Rostoker 121

Samar 290
Samar materials 290
Siquijor materials 260
Siquijor, Siquijor 265
smithies 65
Snodgrass 91
Solheim 4, 40, 48, 179, 350, 363
Sorsogon 152, 174
South Asia 105
South China 13, 125
Southeast Asia 118, 128, 132, 350, 351, 353
Southern China 125
Spaulding 187
spheroidized pearlite 227
statistical study of archaeological iron artifacts 369
Stech 103
Steward 58, 348
Subanun 83
Sucgang Cave (Cave 11) 268
Surigao 276
Surigao materials 276

Tadyaw Cave 157
Talisay, Cebu 230, 244
tang length 339
telluric iron 94
term Iron Age 145
Thailand 8, 9, 14, 134, 372
Thomsen 90
three-age system 24, 90
Tinguian iron-workers 71
Tinguians 88
trade 9, 365
trade iron 83
Type 1.0, spearheads with diamond shaped tang in cross section 307
Type 1.1, spearheads with square shaped tang in cross section 309
Type 1.2, spearheads with rectangular tang in cross section 311
Type 1.3, blade of spearhead 312
Type 2.0, long tang daggers 313
Type 3.0, big pointed bolo 315
Type 3.1, small pointed pinya knife 316
Type 3.2, small L-shaped knife 318
Type 3.3, square-end bolos 320
Type 3.4, medium knife, length =12.0 - 29.9 cm 321
Type 3.5, small knife, length = 5.0 - 11.9 cm 323
Type 3.6, oval tip knife 325
Type 4.0, harpoon 327
Type 5.0, ferrule or ring 329
Type 6.0, chisel 330
Type 7.0, cast iron 330

Valencia, Bohol 274
variability in the different variables 331

Waldbaum 96, 103
wave of migrations 46
welding 71
Wertime 95
Western Iran 99
White 7, 134, 372
Widmanstättten structures 229, 284, 297
Worcester 177
Wrought iron 143

Yueh people 127