Dissertation

By

AKO OKORO, John

UNIVESITY OF

GHANA

An investigation of iron smelting sites in gambage and the implications of the findings for iron age studies in Ghana

---

DECEMBER, 1989

THE UNIVERSITY OF GHANA

AN INVESTIGATION OF IRON SMELTING SITES IN GAMBAGA AND THE IMPLICATIONS OF THE FINDINGS FOR IRON AGE STUDIES IN GHANA

by

JOHN AKO OKORO

A THESIS
SUBMITTED TO THE DEPARTMENT OF ARCHAEOLOGY,
UNIVESITY OF GHANA, IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF MASTER
OF PHILOSOPHY IN AFRICAN ARCHAEOLOGY

DECEMBER, 1989

DECLARATION

I do hereby declare that this work with the exception of specified quotations and ideas attributed to specified sources, resulted from my own efforts and that it represents the true record of the goal that I set myself.

Candidate: (J. AKO OKORO) ....

December, 1989

Supervisors: (PROF. JAMES ANQUANDAH) .... Chairman.

(L.B. CROSSLAND) ....

December, 1989

ABSTRACT

The development of interest in Ghanaian history since the early 20th century has stimulated a demand that aspects of the Ghanaian culture and especially of production be revealed to portray the nation's great past and help project a greater future. "Traditional" (that is while we wait for more data to reddress this issue of how traditional is "traditional") iron production has proved especially attractive since it provided the chief metallic base for technologies, agriculture and industry of the Early Iron Age societies. Yet in spite of this, only a few smelting sites have been investigated. The large part of the data available on the industry is ethnological and dates to the late nineteenth and early twentieth centuries which represent the closing period of this industry due to competition from imported substitutes of iron and its products.

The data reveals that iron smelting was practised all over the country but there is not enough information to trace the history and development of this industry. The number of archaeological investigations so far conducted is woefully inadequate. Thanks to the reports by geologists, anthropologists and archaeologists in the early twentieth century and the ethnographic work by the National Museums in the 1970's, Northern Ghana is fortunate to have good ethnographic descriptions of smelting practices. The region, however, appears to lack known reconstructed archaeological remains (dated or not dated) and their underlying technological parameters.

The research in Gambaga has been able to characterize the iron technology of an area that has not received such examination and has established a base from

which future enquiries can develop. The main data was obtained from surface research, numerous excavations and destructions of smelting debris and in-situ structural furnace remains as well as from the analysis of iron ore, slag, pottery, charcoal, tuyere pieces and furnace wall fragments collected from the investigation. From the analysis of major elemental composition it has been possible to relate the iron ore and slag to different furnace forms. Both the induced draught furnace and forced draught type were recovered. The furnaces were buried in slag debris or below the ground and some had been preserved in a spectacular manner. The variety of furnaces recovered is different from ethnographic types reported from the Upper region of Ghana.

The investigation also focused on the blacksmith profession in the area. The main task of this thesis is to present the archaeological, ethnohistorical and ethnographical material from Gambaga as comprehensively as possible and to present significant new information for the interpretation of iron technology in Ghana. It is a necessary step for any future attempt at a more complete regional synthesis of the archaeological data on iron production in West Africa.

The importance of investigations of iron smelting sites whose data can be used for comparing data of other sites or the ethnographic record and for erecting a useful archaeological sequence of iron production and working in West Africa cannot be overemphasized at this stage. Before archaeological and also ethnographic projects on West African iron metallurgy, which are more "problem oriented" and of greater complexity can be undertaken, a general and broad familiarity with technological variations and distribution in the region must be acheived. This thesis is viewed as partially fulfilling this critical goal in the reconstruction of Ghana's technological past.

The thesis is divided into seven chapters. The first is devoted to a review of aspects of African iron metallurgical studies. Under this, a review of origins and devices for the technology is considered as well as the process and organizational activities involved in iron smelting. Issues raised here are necessary for an understanding of the archaeological and ethnographical interpretations discussed in other chapters. Chapter Two reviews the literature on the iron smelting industry in Ghana. Chapter Three consists of a brief description of Gambaga Escarpment, a description of my research in the Gambaga area, and summaries of data from the surface survey and excavation of slag mounds. The data on the excavation of smelting furnaces, the varieties recovered and the technological parameters of the Gambaga iron smelting industry is presented in Chapter Four. This chapter also contains the data on other archaeological finds like pottery, and smoking pipes analysed. Chapter Five looks at the blacksmithing occupation in Mamprugu. Chapter Six discusses important aspects of the smelting industry like the age, authors, location and distribution of the evidence. In the final Chapter the summary and conclusion on the results of the investigation and its significance in Ghana and West Africa at large are presented.

ACKNOWLEDGEMENT

I am sincerely grateful to the head, lecturers and staff of the Department of Archaeology, University of Ghana who have provided a stimulating and encouraging environment for me. I owe the opportunity and challenge of working in Northern Ghana to Dr. Frank Kense, Director of the Gambaga Archaeology Research Project who supervised me in the field, supported me financially and morally and shared his knowledge of African archaeology and history with me. I thank him for the numerous reference materials he made available to me and his interest in ensuring the successful completion of this thesis.

To the Nayiri, Na Mahamadu Gamni, chiefs, elders and people of Mamprugu I give my deepest thanks for allowing me the opportunity to see and learn about their culture and history. I want to thank Adam Ali Yahaya and Kennedy especially for their patience in explaining to me the customs of the Mamprusi people.

Thanks must also go to Mr. Abuga Avvaah, the District Administrative Officer and the entire staff of East Mamprusi District Administration for their assistance to my research in any way they could. A special mention must be made of Ben Cole, a U.S. Peace Corps volunteer stationed at Gambaga who assisted me greatly at various stages in the research.

I would like to acknowledge the Council for the Development of Economic and Social Research in Africa (C.O.D.E.S.R.I.A.) for financially assisting me during the period of the preparation and writing of the thesis. I hope that C.O.D.E.S.R.I.A.

will continue its support and interest in archaeological researches carried out in Africa and maintain the good relationship with the University of Ghana.

I also wish to thank my committee whose members have provided useful suggestions and encouragement in the writing of the thesis. These are Professor James Anquandah, and Mr. L.B. Crossland. I also greatly thank Professor Merrick Posnansky of the University of California, Los Angeles for sharing his immense knowledge of African archaeology with me. Mr. Osei Tutu and Mr. E.N.O. Quarcopoome, all in the Department of Archaeology, Legon are also mentioned and thanked for reading the drafts and making useful suggestions.

To Joanna Casey of the University of Toronto, Canada, I owe an enormous debt of gratitude that cannot be measured but must be recorded. Acknowledgement is also due to Brian Vivian, Kirk Collins, Claire Bourges and Carol Krol, all of the University of Calgary, Canada for their encouragement in the field work. Many thanks go to Dr. Nicholas David, Head of Department, University of Calgary for his special interest showed in my work and for the various materials he made available to me.

The production of this thesis has relied upon the expertise and assistance of a number of people who deserve my thanks. For their aid in analysis, I thank Dr. Kwame Kwakye, and Mr. E.O. Mensah of the Ghana Geological Survey Department, Mr. Arthur Peters and Mr. Y. Manu of the Department of Geology, University of Ghana, Legon for identifying, and analysing slag, iron ore and rock samples; Mr. A. Sambo of the Soil Science Department of the University of Ghana for analysing charcoal and soil samples.

In the production of the thesis itself, I thank Mr. Ishmael O. Sowah for the drawing of figures and maps; Bossman Murrey for the valuable technical support; Armah Tagoe, J.A. Quansah, S.A. Dankwah and Ebenezer Adjedu for their technical assistance. Richard R. Andoh and Joana Asiedu of the Water Resources Research Institute (CSIR), Accra deserve special thanks from me for the despatch with which they handled the typing and processing of the thesis.

The writing of this thesis and the entire graduate programme was undertaken during a period of difficult and demanding personal problems. If it were not for the unfailing support, encouragement and confidence of six people, I would not have been able to carry through the seemingly endless frustrations that a thesis brings. It is, therefore, to Dr. Frank Kense, Dr. Christopher R. DeCorse, Professor Merrick Posnansky, Professor James Anquandah, Dr. Kofi Agorsah and Joanna Casey that I dedicate this thesis with my greatest appreciation.

TABLE OF CONTENTS

Page

ABSTRACT i

ACKNOWLEDGEMENTS iv

LIST OF MAPS x

LIST OF FIGURES xi

LIST OF TABLES xiii

LIST OF PLATES xiv

CHAPTER ONE: ASPECTS OF AFRICAN IRON WORKING STUDIES 1

Introduction 1

A review of the literature on the origins and Devices of African iron smelting technology 2

A review of aspects of the processes and organization of African iron production 16

CHAPTER TWO: A REVIEW OF THE WRITTEN REPORTS ON IRON PRODUCTION IN GHANA 38

CHAPTER THREE: GAMBAGA ESCARPMENT: ARCHAEOLOGICAL CONSIDERATIONS

Description of the area 61

Research goals and Methodology - Archaeological survey 70

The disturbance and destruction of iron smelting sites 75

Iron smelting furnaces - the survey results 80

Excavation of slag mounds 85

Stratigraphy and features of slag mounds 93

CHAPTER FOUR: FURNACE EXCAVATIONS, DESIGNS AND THE UNDERLYING TECHNOLOGICAL PARAMETERS OF THE GAMBAGA IRON SMELTING INDUSTRY 97

Excavation of furnaces 97

Gambaga furnaces and other functional units 111

Chemical analysis of relics of the smelting evidence 120

Other finds from the investigation 128

CHAPTER FIVE: THE BLACKSMITHING OCCUPATION IN MAMPRUGU 144

Ethnic composition of the blacksmiths 145

Becoming a blacksmith 147

Blacksmithing Tools, Equipment and Ritual 150

Blacksmithing fuel 157

Workshops 159

Smithing devices and techniques 161

Items produced 166

The blacksmith as a ritualist and dispenser of herbal medicine 170

The blacksmith and his status in the community 172

CHAPTER SIX: DISCUSSION 178

The chronology and authors of the smelting evidence 178

Estimating the slag volume and the ecological impact of the iron smelting activity 188

Location of the smelting sites 195

Spatial distribution of the furnace varieties 200

CHAPTER SEVEN: SUMMARY AND CONCLUSIONS 202

BIBLIOGRAPHY 217

APPENDIX I: Brief history of Gballa 282

APPENDIX II: King list - Nayiris (Paramount Chiefs) of the Mamprusi State 285

APPENDIX III: Names of informants from Mamprugu 287

APPENDIX IV: Names of some blacksmiths interviewed in places in the Upper Regions of Ghana 291

LIST OF MAPS

Map	Page
1. Physiographic regions of Ghana	228
2. Topography of the Gambaga Escarpment and surrounding areas	229
3. Soils in Northern Ghana	230
4. Vegetation types of Ghana	231
5. Language map of Ghana	232
6. Linguistic groups in Northern Ghana	233
7. Area investigated showing the location and distribution of smelting sites and furnace varieties recovered from the excavation	234
8. Areas traversed by the 'Adites' in Northeast Ghana	235
9. Principal localities in Ghana mentioned in the text	236

LIST OF FIGURES

Figure — Page

1. Diagram of Zanlerigu furnace showing symbolism attached to the smelting apparatus 237

2. Achimota furnace plan and sections 238

3. SM.44 showing plan of slag mound destroyed by road construction 239

4a.Plan of the units excavated on F43, and F44 and trenches cut through the associated slag debris 240

4b.Plan of SM.47 showing trenches excavated on the mound 240

5. Plan of SM.1 mound and the excavated units 241

6. SM.15 Plan of excavation units and outline of furnaces and tuyere remains exposed through excavation 242

7. SM.27. Showing the smelting site and the excavation units 243

8. Stratigraphic cross sections of slag mounds 244

9. Stratigraphic cross sections of slag mounds 245

10.Furnaces with in-situ slag lump 246

11.Plan of furnaces (F10, 11, 12) as they were discovered on the surface 247

12.Plans and sections of furnace bowl bases without apertures 248

13.Plans and sections of Furnace bases with only slag hole in tact 249

14.Stratigraphic cross section showing furnace in-situ 250

15.Furnace excavation unit, stratigraphic cross sections 251

16.Type I and II furnace varieties 252

17.Type III furnace variety 253

18.Tuyere varieties belonging to the three furnace design 254

19.Rim forms of the three furnace varieties 255

20.Smelting furnaces from Upper Region, Ghana 256

21.Drawings of iron smelting furnaces in West Africa 257

22.Drawings of iron smelting furnaces in West Africa 258

23.Drawings of iron smelting furnaces in West Africa 259

24.Pottery forms and decoration from the smelting sites 260

25.Smoking pipes from the investigation 261

LIST OF TABLES

Table | Page
1 In-situ structural furnace remains recorded in the individual zones 83

2. Estimated slag volume of the Gambaga iron smelting sites 190

3. Composition of Gambaga smelting debris in percentage of total volume of slag 262

4. Summary of details on Iron ore mining sites discovered 262

5. Summary of details of the excavated slag mounds 263

6. Summarized data of furnaces excavated 264

7. Chemical analysis (Weight percentage) ores, slags, charcoal 265

8. List of some major iron items produced by the Mamprugu blacksmiths for the various sectors of the local economy 267

LIST OF PLATES

Plate		Page
1.	Surface of slag mound cultivated with millet and corn	268
2.	In-situ structural furnace remains: walls	268
3.	In-situ structural furnace remains: slag lump	269
4.	SM.15 showing the cleared surface of the mound and the unit to be excavated	269
5.	SM.44 slag mound destroyed by road construction	260
6.	SM1, Furnaces (F1, F2, F3) recovered from the excavation of the slag mound	270
7.	Furnaces (F10, F11, F12) showing remains as bowls bases without any aperture surviving	271
8.	F9: Type I furnace variety	271
9.	F43: Type II furnace variety	272
10.	F45: Type III furnace variety	272
11.	F45: Furnace interior excavation	273
12.	Tuyere varieties	273
13.	Slag samples	274
14.	Iron bloom being kept by aged blacksmiths	274
15.	Iron objects obtained from the investigation	275
16.	Interviewing aged blacksmiths in their workshop (Type A)	275
17.	Stone anvils	276
18.	Type 'B' blacksmith workshop	276
19.	Type '1' smithing devices and techniques	277
20.	Type '2' smithing devices and techniques	277

21. Type '3' smithing deveices and techniques 278

22. Blacksmith's son making a new tuyere in the workshop 278

23. Bullock ploughs produced by blacksmith 279

24. A variety of items produced by blacksmiths 279

25. Different clay vessels in Nalerigu brought from Garu in the Upper East Region of Ghana 280

26. Lithics recovered from the investigation 280

27. Shaped clay pieces (plugs?) recovered from the investigation 281

28. Plugs(?) found in-situ in the bowl base of furnace (F12) 281

CHAPTER ONE

ASPECTS OF AFRICAN IRON WORKING STUDIES

Introduction

African Iron Age studies have taken two quite distinct forms. One is largely cultural in perspective, emphasizing the economic, social and political aspects of iron-using societies and examining the cultural development of Iron Age communities in Africa since about the middle of the first millennium B.C. (Kense 1985:11). This results from the evidence that the Iron Age is the period during which the present cultural configuration in Africa was laid down. In many cases, the finds from an archaeological site can be compared with the modern material culture. An awareness of the cultural continuity has led to an interest in the use of ethnographic information, linguistics, and ethnohistory in the interpretation of archaeological remains. This has been particularly true of iron working. The principal interest of study has been focused on the ceramic material since that comprises the major element in the extant archaeological record.

The second interest of Iron Age studies has been a concentration on the technological aspects with iron production, as well as a concern with certain activities - economic, cultural and social - and environmental factors indirectly related to iron working. It is an attempt to understand the behavioral and technical complexities associated with the wide variety of technological variants in Africa. Although this reconstruction of African metallurgical development is the more recent of the two interests of Iron Age studies, it is gradually becoming one of the most important themes of historical enquiry. It has been a subject of fascination as well as of anthropological, historical and archaeological research. An important focus of study has been the conducting of demonstration smelts or experimental archaeological reconstructions of African iron production during which surviving iron smelters re-enact the different aspects of the process (Pole 1979, Todd 1974a, 1979; Todd and Charles 1978; Schmidt and Avery 1976; 1979; David 1988). One of the most important of such smelts with far - reaching consequences is the experiment carried out by Childs and Schmidt (1985) at Brown University, U.S.A. in 1975. This was a replication based on African ethnographic and technical evidence. By assessing and recording the technological significance of physical attributes, experimental reconstructions have provided vital clues which could be used to interpret archaeological phenomena, and data with which to compare and complement the historical and ethnological evidence. The discussion that follows examines the data on the origins of African iron working, the devices used, as well as the processes and institutions that govern or regulate the industry.

A Review of the Literature on the Origins and Devices of African Iron Smelting Technology

Central to the studies of the African Iron Age has been the concern over the origin of iron working. Different views have been expressed as to whether the knowledge of iron working was locally invented or was diffused in Africa; if diffused, along which route was it transmitted and/or carried throughout Africa over the last two and a half millennia? The early view was that iron technology was not developed indigenously in Africa. This led to a shift in focus of later research to the problem of determining by which means the knowledge reached and spread throughout the continent. Although extensive information was lacking, cursory observations, speculative ideas and self-fulfilling hypothesis accounted for many possible relationships viewed in the data. The literature on iron working demonstrates that it has been much more important to speculate on where iron production entered the continent (Tylecote 1975; Van der Merwe 1967) and what routes its diffusion followed (Oliver & Fagan 1975: Phillipson 1977).

The focus of investigation inevitably concentrated upon northern Africa, since this area was considered the probable point of contact between the iron-using Middle East and the Mediterranean World and Africa. Furthermore, as a corollary to this, initial research looked to developments in Egypt and the Nile Valley as these were considered the most likely centres of diffusion of new traits that had arisen in the areas to the north (Wainwright 1936, 1942; Leclant 1956). As such, these views merely reversed the pattern that had been proposed by early investigators such as Von Luschan (1909), Garland and Bannister (1927), and Kluseman (1924) that Africa and especially Egypt, was responsible for the discovery and dissemination of iron metallurgy to the Old World.

Dropping the primacy of Egypt in the origin of iron technology, the Nile Valley was considered as a primary channel through which the knowledge was refined and transmitted to the rest of Africa. The Nile Valley, after all, was viewed as forming a corridor between Asia Minor and Africa and the pre-eminence of Ancient Egypt over sub-Saharan Africa was accepted without question (Wainwright 1936, 1942; Leclant 1956). Meroe was seen as providing the vital link with the Meroitic culture accompanied by its Kushite rulers spreading to the Southwest after the break-up of the Kushitic State by the fourth century A.D. (Arkell, 1968).

Work by French scholars on the archaeology of North Africa especially the regions of Chad, Niger and Southern Algeria resulted in the presentation of alternate hypotheses for the diffusion of iron. By examination of ethnographic material across North Africa including camel saddles and weaponry and observations made on the rock paintings from scattered sites across the Sahara, Huard (1956) postulated two routes of diffusion from North Africa along which traits like iron working were passed to sub-Saharan Africa. Accepting the link through Meroe as one, he also hypothesized a route from the Gulf of Syrte (Libya) southward to the region west of Lake Chad. Earlier on, Mauny (1952) had already noted the geographical distribution of these peoples and had emphasized their potential for interaction with iron using Phoenicians and Carthaginians in the early first millennium B.C.

The notion that the sub-Saharan societies adopted iron technology as a result of contact, through, however, many intermediaries with North Africa remains largely unchallenged. The fact that there is little archaeological evidence to support the existence of iron technology in 'transit' from the desert region or that the supposed centres from which this knowledge was diffused has not produced much data relevant to iron production, seemingly had not concerned many of the theorists (Kense 1985:13). Lhote (1952) questioned the role of the Berber, pointing out that there was little ethnographic evidence demonstrating iron working skills by these desert peoples. He also suggested that it seemed more likely that iron working was discovered independently in West Africa, since many of the specifics related to the technology were quite different from anything known in the North. This idea of the independent discovery of iron production, while never widely accepted, certainly has found support from several scholars over the decades (Diop 1968; Keteku 1975; Andah 1983). While we can criticise the school of independent inventionism for lack of evidence, it shares the same draw-back as diffusionism. Largely based on speculation and theoretical guesses, neither of the schools of thought has produced concrete evidence to support its case.

A crucial element in the scepticism of the independent inventionist position has been the lack of evidence from sub-Saharan Africa for any tradition of metallurgical expertise prior to the appearance of iron. The greater part of Africa differs from most other regions of the Old World in that there was (except in Egypt and some other areas of northern Africa) no distinct 'Bronze Age' or 'Copper Age' during which softer metals, often including gold, were utilized when technologies of smelting iron had not yet been mastered. Especially in the sub-Saharan latitudes, iron was the first metal to be brought into use; the working of copper and gold began at the same time or somewhat later (Van der Merwe, 1974). The diffusionists believe that prior knowledge of copper technology or its alloys is a good basis for advancement to the more complex iron technology. Evidence from Do Dimmi in the Sekkiret area of western and central Niger in the form of two furnaces for copper working have been age-estimated to between the seventeenth and eleventh centuries B.C. (Calvocoressi and David 1979:9). If the wood used to age-estimate the slag associated with the furnaces is contemporary, then Do Dimmi represents the earliest evidence of iron production from West Africa to date. It also indicates that the appearance of iron was virtually simultaneous with the main period of copper production. Until recently, evidence of iron from Taruga in Central Nigeria indicated the earliest recognized Iron Age site from south of the Sahel in West Africa (Fagg 1969). With a large series of carbon and thermoluminescent age-estimates now available, this 'Nok Culture' site has been firmly 'dated' to between the sixth century B.C. and early first millennium A.D. (Calvocoressi and David 1979). Comparisons of the furnaces from here and those from further north as well as with later types known from the Mediterranean region would indicate the nature of the relationships and determine the indigenous character of the industry or the source of its origin.

Archaeological investigation carried out at the site of Daboya, along the White Volta River in northern Ghana, has demonstrated the replacement of a Terminal Late Stone Age component (Kintampo) by a tradition noted for a distinct pottery style and an obvious absence of worked stone material (Kense 1981). The latter component is interpreted as iron-using, although neither iron slag nor objects appear until several centuries later. This tradition has been age estimated to between mid-first millennium B.C. and the early first millennium A.D. and, therefore, represents the first well-established Early Iron Age culture in West Africa outside the Nok area (Kense 1985:17). A third sequence commencing just slightly later than the Nok and Daboya traditions, but overlapping with them is known from the appearance of iron working at Jenne-Jeno near the Upper Niger in Mali. Here, the earliest occupation of the large settlement dates from the last two centuries B.C. (Phillipson 1985:163).

From the first century B.C. to about the sixth century A.D. an increasing number of Early Iron Age sites have been identified in West, Central and East Africa to have exploited a variety of ecological niches, and showing successively greater cultural diversity between neighbouring communities. In West Africa, the more significant sites of this period include Rim in Burkina Faso, Hani at Begho and Abam (Bono Manso) in Ghana, Koro Toro in Chad, Samun Dukiya, Yelwa and Daima in Northern Nigeria and Casamance in Senegal. The clear implications of these dates are that the use of iron in the southernmost Sahara and adjacent northern savannah of West Africa dates back to the last few centuries B.C. and was widespread (Posnansky and McIntosh R. 1976).

The arguments on the origins and diffusion aside, recent multi-disciplinary researches by archaeologists, chemical engineers, technologists, ethnographers and archaeologists are beginning to accord to Tropical Africa its proper place in the field of world ferrous technology (David, N. et al forthcoming; Schmidt & Avery, 1978; Todd J. 1985; de Barros 1986). These studies have indicated the technical know-how and metallurgical capabilities of African iron workers in the production of cast and steel iron products superior to the iron items manufactured in European foundries of the time. These studies credit Tropical Africans with various technological devices for producing high furnace temperature reaching 1200-1700°C (Anquandah 1985:5; Childs, S. & Schmidt, R, 1985). A discussion of the devices is presented below.

Smelting Furnaces

One of the primary focuses of the study of African iron production has been concerned with the more technical aspects. Early interest in this direction focused on the types of furnace and bellows employed (Klusemann 1924; Cline 1937). This continued with renewed vigour once the archaeological record improved (Pearce 1960; Van der Merwe 1980: Kense 1981, 1983). Furnaces have been seen as the primary apparatus for smelting and as such have played a crucial role in determining the evolution, or origins and spread of iron working in sub-Saharan Africa. Where sufficient data has been lacking in the archaeological record it has been made up amply by ethnographic evidence (Kense 1983:4). The evidence available indicates not only an abundance of furnaces across much of sub-Saharan Africa but more importantly there is a great variety that remains difficult to explain. There has not been a given criterion that is acceptable to all whether based on form/shape, or function or the mode of operation of the furnace that is whether a natural (without the use of bellows) or forced (using bellows) methods of draught to raise the temperature of the furnace to the desired level to smelt the ore.

A variety of classificatory schemes for furnaces in Africa have been put forward by researchers (Klusemann 1924; Cline 1937; Coghlan 1956; Pearce 1960; Sassoon 1963; Tylecote 1965; and Kense 1983). Kluseman (1924: 121-9), in his study of African smelting furnace types distinguished the following forms: pit or hearth furnace; higher furnace; recent high furnace; high furnace with crucible;

and crucible furnace. This is evidently a classification that is too arbitrary to be warranted. This feature is reflected in the other schemes. Cline (1937) divided furnaces into large or small but without offering reasons for his choice of this criterion. Francis-Boeuf (1937:420) made a three-way division into shaft/pot/underground furnaces, but inaccurately summed up the processes used in West Africa as being of the Catalan type. Others created much confusion and are being rejected as being unsuitable for the African evidence. An example is the classification of furnaces into Bowl, Domed and Shaft by Coghlan (1956:87). There are schemes like dome-shaped, bowl-shaped, pot-shaped, pit, hearth, free standing, non-free standing, cupola, bottle- shaped, and bell-shaped. The list can be longer. While it reflects the infinite variations in the constructions to which African furnaces were subjected, one drawback about all these classifications is the overemphasis placed on the shape of furnaces alone. They all suffer from being inherently subjective without any guidelines to indicate where one particular form ends and the other commences.

It is very possible that some 'shaft furnaces' are so classified because of their visible shafts regardless of their possessing 'bowls' underneath which are hidden from view. Conversely, some time after abandonment, the shaft of such a furnace is liable to collapse, sometimes leaving no trace; and so an archaeologist finding only the foundations and subterranean pit, may describe it as a 'bowl furnace', may-be with minimal consideration of whether it possessed any superstructure, be it permanent or renewable for each smelt. So the same type of furnace may be placed in either of two basic categories, depending on one's approach and preconceptions.

Almost all investigators agree that African furnaces can be divided into at least, three main types characterized broadly as bowl furnaces, low shaft furnaces and high shaft furnaces. However, there is no consensus regarding the distinction of shaft furnaces into low and high. Whereas Kense (1983:48-49) emphasized the presence of a superstructure and/or bellows to distinguish between the types, Van der Merwe (1980:489-9) focussed primarily on size, the presence or absence of a slag tapping hole and the need for bellow to separate his categories. To Tylecote (1965:341), the essential difference in this classification is in the manner of blowing. Low-shaft furnaces have to be bellow-blown while the taller shaft furnaces may be blown by natural draught. Although this classificatory scheme moves the emphasis from superficial morphology towards the operation of the furnaces, it ought to be noted that this system (like the one it supercedes) is devised from early European archaeological evidence for which complete reconstructions and operating details have to be inferred. How well it will suit the superior African ethnographic and archaeological materials is not yet clear, either for classification purposes per se or for historical discussion (Sutton 1985: 165). No wonder there has been different classifications used by field archaeologists. Thus Schmidt and Avery (1978) classified the furnace constructed in the Kiziba division of Buhaya in northwestern Tanzania as a 'shaft-bowl type'. Similarly, Judith Todd (1985:91) who undertook a historical, ethnographic and metallurgical reconstruction of a pre-industrial bloomery process in the Diman region, southwest Ethiopia, recorded that iron was reduced in a forced draught, conical, nonslag tapping shaft-bowl furnace.

Tuyeres

Along with slag and furnace remains, the other most frequently preserved archaeological material is tuyere. Tuyeres are generally cylindrical-shaped tubes made out of hardened clay although they are often tapered at one end. Tuyere lengths vary and are of differing diameters. The most common method of making the tuyere is by moulding clay around a prepared wooden stick, so that it could be removed easily after drying (Kense 1983;53). However, modifications of this method include the piercing of the desired diameter by a sharpened stick through a solid mass of clay. Recent work has stressed the need to observe function as well as form, in particular whether (or how far) the tuyeres were inserted inside the furnace so that the draught is pre-heated before reaching the centre.

The function of the tuyere can be two-fold. It can either provide the intake of air from a bellow system into the furnace or it can regulate the air from a natural draught. Therefore, as Coghlan (1956:88) points out, the presence of tuyeres does not necessarily indicate the use of bellows at the site. An interesting distinction has been made by Chaplin (1961:55-6) that may clarify this ambiguity. He suggests that in the case of clay pipes or tubes being used without bellows, it would be more accurate to refer to them as tewels. Tuyeres on the other hand would be only those tubes through which air has been forced into the furnace through pipes attached to the bellows.

The value of the distinction gains support from the observation that often there is a separation between the clay tube (tuyere) and that piece which fits into the side wall of the furnace. This latter piece usually resembles a trumpet end (truncated cone shaped) and can be of varying width. As such, this piece would also seem to be a tewel, even though it is associated with the use of bellows. The important difference, however, would be that there are in fact two components possible in draught mechanism (Kense 1983:54). If tuyeres are used with bellows, the bellow nozzle is often affixed to the tuyere mouth by means of a series of one or more additional clay pipes that vary in length from a metre or more so that the bellowman can be positioned some distance away from the hot furnace. Sometimes too, the tuyere mouth is wide enough so that it can accommodate the insertion of two bellow pipes (Tylecote 1965:201).

Bellows

The provision of draught into the furnace is an essential element in the smelting process. Such a draught can be supplied naturally from the local wind blowing channelled through pipes without bellows or forced air from bellows or a combination of both. Like furnaces, the classification of bellows has been subjected to considerable culture-historical discussion (Luschan 1909; Klusemann 1924; Frobenius 1913; Cline 1937; Posnansky 1966). The classification has been based mainly on data derived from ethnographic investigations with very little information concerning bellow types in prehistoric times being available archaeologically. From this source there is available at least a general outline of the different bellow types that have been used in African smelting. Von Luschan (1909:24-37) listed four types: pump bellows, bowl bellows, bag bellows and skin bellows. This classification covers all the known types of bellows in Africa except that it does over-generalize in some respects (Kense 1983:50). Cline does make an ethnographic summary of the main types of bellows in Africa and concludes that these are: the drum bellows, the bag bellows and the concertina bellows (Cline 1937:102-6). The most important point that Cline derived from his classification is that the bellows demonstrated a significant distribution across the continent (Cline 1937:102). Below is a description of the bellows.

(a) Pump Bellows:

Apart from describing them as being cylindrical bowl bellows, Luschan (1909:33) did not indicate any other aspects of this bellow type but noted that they have been found in Madagascar and are probably associated with Indonesian smelting practices.

(b) Bowl Bellows:

The essential feature of this is a pair of vessels which may be of pottery, clay or wood (Luschan 1909:25, Davies 1967:238). These have a loose skin or leather diaphragm fitted over the chamber. They are operated by moving the leather covering up to inflate the chamber as air is sucked into it through an opening left along some point on the tuyere, or bellow pipes and down to deflate forcing draught out through the pipes into the hearth or furnace. By working on a pair, the air can be replenished while one chamber is being deflated of its air. The operation of the bellows is done with the hand but in Egypt the feet are used (Davies 1967:238). What Cline (1937:102) has described as drum bellows having a loose diaphragm fitted over a solid chamber would equate with the bowl bellows described above. Bowl bellows occur in Northern Ghana (Pole 1974a) and also among the Bassari of Northern Togo (Davies 1967:239). It has been found to have prevailed in the interior region of Central Africa; the Lakes region and on the West Coast from Cameroons to the Gambia (Cline 1937:102) and at Meroe (Shinnie 1985).

(c) Bag Bellows

This consists generally of a pair of wooden chambers, each with a cylindrical upper section of skin tubing attached. At the upper end of this tubing is a stick of sorts by which the blower lifts the tubing up and down to induce the draught. Cline's (1937:105) concertina type would be like the bag bellows which he recorded only from Northern Togo and Northern Benin (formerly Dahomey), Yoruba and Liberia. Bag bellows are found in North Africa and the Sahara, and like the skin bellows, are more easily trans portable over distances. They overlap occasionally with pot-bellows, for instance, at Atakpame (Togo) and in the Cameroons (Davies 1967:238).

(d) Skin Bellows

There are constructional differences between this type and the bag bellows although they both derive their air from skin woven into a bag of some sort. The skin bellows can be of varying sizes of animal skins that have been sewn together on three sides with the fourth side left open to enable the blower to open and shut the bellows as he pushes it up and down (Kense 1983:50). Cline (1937:102) recorded the domination of the skin bellows in the Horn of Africa, the Sahara, South of the Zambezi, and in a large part of East Africa. The general distribution of bag and skin bellows correlates closely with the penetration of Arabic/Islamic influence into Africa. This influence would predate century A.D. on the East Africa coast and be perhaps a century or later in Northern West Africa (Kense 1985:22). It is not known from the Zaire Basin region.

It needs to be emphasized that unlike furnaces, since most of the bellow types will not preserve archaeologically, a diachronic examination of bellows development is not easily undertaken (Kense 1985:19). The recovery of three clay pot bellows from one of the furnaces excavated in Meroe in the Sudan in 1969/70 has been reported by Shinnie (1985:33-34). These bellows are probably the oldest bellows discovered in Africa dated to the second century A.D. and therefore provide the main evidence from the antiquity of bowl bellows (although not necessarily constructed from clay) (Kense 1985:22). Those made from wood or wholly from leather or skin would have little chance of preservation.

Kense (1985:19) notes a classification of either bowl/drum bellows (made of wood or clay) or bag/skin bellows with important variations within them as being the widely accepted classification of bellows. For the purposes of this study and on the basis of the ethnographic data gathered during the field studies, a classification of bellows into a bowl/drum, skin, and bag would be adopted in order to maintain the important variations between skin and bag bellows. A discussion of bellows as they relate to blacksmithing in Mamprugu is presented in Chapter Five.

A Review of Aspects of the Processes and Organization of African Iron Production

Iron production is a complex process involving several stages of activity. This includes the mining of the ore, the breaking of the ore into the required sizes, the careful hand sorting of the ore to remove unwanted inclusions and the building of the functional devices like the furnace, tuyeres and bellows. In the actual process, the iron smelters knew when to stop the smelting without trying for impossible temperatures. Ritual was a vital element of the process. It is instructive to discuss aspects of iron production in order to reflect the behavioral and technical complexities as well as the technological variants in Africa. This, it is expected, would facilitate a better appreciation and comprehension of the technology of iron production, a process which Childs and Schmidt (1985) have referred to as a significant change towards technological complexity.

Iron Ore - A Basic Raw Material

Throughout Tropical Africa, the main source of iron ore is a ferruginous hardpan - the so-called laterite that is widespread in West Africa (Diop 1968). This occurs normally as surface outcrop or in sheets not far below the surface or more deeply buried by accumulated sediments or some other formation, for example, sandstone (Boeuf 1937:403). The thickness of the deposits varies from one to ten metres and the grade from 30% to 70% of iron (Boeuf.1937). In terms of the physical description, the ores are either nodular or in large lumps that are crushed into the required sizes.

Iron ores can be distinguished on the basis of their chemical composition into carbonate ores and oxide ores. Siderite is one of the carbonate ores. It is also called Spathic. It has a composition of $FeCO_3$. Coghlan (1956:14) quotes an iron content for this ore as 48% which is relatively lower than for the oxide ores but about the same as for the sulphide ores (Kense 1983:32). It is an ore type for which roasting is the best preparatory method. This serves to increase the percentage of iron present per unit volume. In the roasting process of the carbonate ores, the resulting chemical product is Fe_2O_3 (Tylecote 1965:190) so that this is a

critical point to be remembered when analyzing the ore wastes.

All authorities agree that the oxide ores have traditionally been the most important source for iron smelting (Eckel 1914:11; Forbes 1950:383; Coghlan 1956:14; Tylecote 1965:179-83) and that these appear to be the most widely distributed ores (Kense 1983:32). Eckel has distinguished three different groups within the oxide family, depending upon the ratio of Fe (iron) atoms to the O (oxygen) ones, and the amount of H_20 (water) present. The first is ferro-ferric oxides, and is exemplified by magnetite (Eckel 1914:23). Magnetite has the chemical composition of Fe_3O_4 and when pure has the richest iron content known. Coghlan (1956:14) gives the iron content as 72.4%. It occurs in sand and gravels of river beds where it can be easily collected and washed before smelting. It appears as a greyish to black mineral although it will turn to reddish brown upon exposure to air or water.

A second important oxide ore is Ferric oxide. It has no water content thus it is known as an anhydrous type (Eckel 1914:22). It is characterised by the common mineral haematite and has a chemical formula of Fe_2O_3. It's iron content stands at about 70% and thus is the second richest iron containing ore available (Coghlan 1956:14). This element has also been referred to as red haematite, specular haematite, colithic, chemalite or fossil ore (Eckel 1914:24) and is the most commonly found ore on all the continents (Kense 1983:33). The third group of ferric oxide is categorized as hydrous ferric oxides. These have retained water within their bond. On the basis of the H_2O content, hydrous ferric oxide are differentiated into groups. Limonite is the commonest name used for these. This has a chemical formula of $Fe_20_32H_20$ (Todd 1985:93). Limonite occurs in stratified formations, and is usually formed by deposition in swamps and lakes (Eckel 1914:47). Bog iron is one of its forms that is deposited as such (Coghlan 1956:15). Limonite ores have traditionally been called "Brown ores" so named because of their prevailing yellow or rusty-brown colour in soils, sands, clays, and sandstones (Coghlan 1956:15). Forbes has given a figure of 59.9% as the theoretical iron content for limonite, although the practical is considerably lower at 25-58% (Forbes 1950:381). Limonite iron content can also be improved through the process of roasting, thereby eliminating much of the excess moisture in the ore. As such, the resulting ore behaves much like the normal haematite (Kense 1983:34).

Obtaining and Preparing the Iron Ore

The smelters were skilful in locating exposed deposits richest in iron. They determined the quality of the ores by lifting and weighing them in the hand, a lump at a time, as they collected it. At Tiza, in the Upper West Region of Ghana, there are various areas within a radius of about six kilometres of the smelting site where the stone is suitable. The smelters in the past collected small amounts of ore from each place since they were not sure which would yield the highest grade of iron. The smelters remarked that the same procedure would have been used in former times until the location of the ores that yielded the best iron was established, when that site would have been used exclusively (Pole 1974a:24). This reflects the tendency of trial and error in the location of good iron ore sites for their continuous exploitation.

Several ways of mining iron ore have been identified, the use of each method being determined normally by the depth of location of the good iron ore in the geological formation in the area concerned. The most common method is by digging shallow open quarry that ranges in depth from 50cm to a few metres deep. Examples of the use of this method have been recorded at Chiana, Lawra, Garu and Zanlerigu in the Upper Region of Ghana (Pole 1974a:24) and in the Bassare Region of Northern Togo (de Barros 1985:151). Others come from the Darfur region in the Sudan Republic in Northeast Africa (Haaland 1986:54). By occurring in the form of surface outcrops, the ores are easily exploited without the creation of subterranean galleries. A second method of mining is by sinking vertical shafts in the shape of a cylindrical or truncated cone one to two metres deep arranged in groups of five or six. Examples are derived from Dedougou and Bobo regions in northern and western Burkina Faso respectively, in Fouta Djallon in Chad, and in the caves of Bougouni in the south of Bamako in Mali (Diop 1968:3). The last method to be mentioned is less common and involves the use of a curious system of wells and connecting tunnels. An example was found in Akpafu of northern Volta region of Ghana (Rattray 1916:432).

The iron ore obtained was transported in basket loads to the smelting site where they were prepared. The ore pieces were broken down or crushed into the required sizes and a careful hand sorting of the ores was undertaken to remove deleterious materials. The ore so sorted was not always pure for immediate smelting. They might contain too much water which has to be extracted. The process of removing preliminary impurities from the ore is known as roasting. This has been shown to have existed in early times (Forbes 1950:384; Tylecote 1965). Near Oyo, north of Ibadan in Nigeria, small and large nodules of haematite iron ore obtained from depths between 1.2 to 2.4m was first roasted on a wood fire and broken up with wooden pestles (Bellamy 1904). This indicates a careful preparation of the ore before it was smelted.

Roasting was done in the open and never in kilns (Tylecote 1956:340). It served two main purposes. First, that of driving off water or carbon dioxide from the ore and second, making the ore more friable (Tylecote 1956:340), thereby making it easier to reduce its sizes into the desired dimensions. Roasting will remove carbon (C) from the carbonate ores as Carbon dioxide (CO_2) and result in a ferrous oxide that is then ready for normal reduction (Kense 1982:32). The iron content in limonite ores (one of the major groups of ferric oxides which has retained water in its bond) can also be improved through the process of roasting, resulting in the elimination of much of the excess moisture in the ore.

From the Dimam region of south west Ethiopia, no prior roasting of the ore was carried out but the first charge (quantity of iron ore poured into the furnace fire through the top at a time) was placed in the furnace one hour before bellowing was began (Todd 1985:99). This might have served to warm the ore slowly and to drive out any excess water or carbon dioxide that it may have retained. It is interesting to note that limonite was the main ore used for smelting though mixtures of magnetite (Fe_30_4 - black) and limonite were also reduced (Todd 1985:93). Both ores were collected from surface outcrops with fire setting occasionally being necessary for the magnetite after which they were concentrated by hand sorting the alumino-silicate mineral impurities. They were then broken into fragments and dried in the sun.

It is an open question whether by spreading sizeable pieces of iron ore on the ground, the intense heat of the sun in Tropical Africa could result in its partial roasting. If this is so then the lack of mention of roasting as a way of preparing the ore in most of the written records on iron production in several places should not be taken to mean an obvious absence of the process especially where it can be determined that the ores are of a type that contain excess water like limonite ores. What the Dimam example indicates is the fact that iron producers in Africa, guided mainly by the empirical experience of uncounted generations, were in possession of a high level of metallurgical knowledge. That this is true is exemplified by the report from Koni, not far from Korhogo in Northern Cote d'Ivoire. Here, the Senufo smelters after mining the ore panned, crushed, and then formed them into balls before casting them into the furnace (Gardi 1969:25-40; Zacharias and Bachmann 1983, quoted in Pole 1985:148). This evidently suggests a detailed ore preparation process which allows a much higher yield than other forms discussed above. What it reflects is the variations in smelting processes are evident not only in furnace, bellow and tuyere forms and arrangement but more importantly too in the mining and preparation of the iron ore. Such variations and/or similarities need to be highlighted in ethnographic and, where possible, archaeological researches on traditional iron production in Tropical Africa.

Smelting the Iron Ore

It has been indicated earlier that iron does not occur naturally in sub-Saharan Africa. It readily combines with other substances to form iron compounds. In the natural state, these compounds are associated with non-metal materials and other metals in rocks known as ores. The processes of separating the iron-bearing material from the other substances and extracting the iron from the former are known as smelting (Pole 1974a). The processes are complex and a wide diversity of African smelting techniques have been summarized by Cline (1937).

The furnace structure in which the smelting is carried out and the tuyeres which direct air into the centre of the fire in the furnace are subjected to tremendous heat. This necessitates the use of refractory material with the following properties in their construction. It includes a temperature tolerance to a maximum of 1300°C, insulating effect, plasticity in expansion and contraction during thermal stresses without disintegration, resistance to fusion with slag or iron bloom, low heat conductivity to retain furnaces heat and building strength (Norton 1931). Clays high in alumina (Al_20_2) and/or silica (SiO_2) meet many of the above criteria with the latter being particularly good for insulation and building strength while alumina clays have many of the other properties (Norton 1931).

To achieve the high temperature required for smelting aided only by the natural draft of the clay-built furnace and usually by hand operated bellows is a major task in itself (Phillipson 1985:148). The charcoal deposited with the iron ore pieces in the furnace burns to release heat to smelt the ore and more importantly produces carbon monoxide (CO), an unstable gas that combines with the oxygen (O) reduced from the iron oxide of the ore as it is subjected to high temperature in excess of 900°C. The two combine to form carbon dioxide (CO_2) thereby reducing the ore to the metallic state, as the non-metallic elements known as gangue are separated from the iron compounds.

The charcoal was probably the most crucial factor in the smelting process because it was involved in the very chemistry of the reduction process (Goucher 1981:181). The attainment and maintenance of a specific chemical balance within the furnace is a necessary pre-requisite to the success of the process. Thus an over enthusiastic fanning from the bellows could make Carbon Monoxide (CO) recombine with the Oxygen (O) to produce carbon dioxide (CO_2) thus negating the whole process (Anquandah 1982). Mean temperatures for smelting is between 1000°C - 1200°C (Pole 1974:8). Traditional iron smelters were certainly not academic chemists but these rudimentary basic, secrets of iron technology were known to them (Anquandah 1982:67). For instance, it has been noted through experiments that the structure of the broad-based and narrow-tops of some furnaces was designed to lead out hot gases and so to reduce temperature and maintain an equilibrium of carbon monoxide inside the furnace. This precludes a combination of carbon monoxide to carbon dioxide to sabotage the entire smelting process (Schmidt and Avery 1978; Van der Merwe and Avery 1982; de Barros 1983). By producing iron which was steel-like if not actually a deliberate steel (Goucher 1981), West African smelters have made their mark technologically, an achievement accomplished through the use of long tuyeres to introduce air preheated to about 600°C into the combustion chamber (Schmidt and Avery 1978).

The charcoal and the iron ore aside, it has been noted that other substances are added to the smelting material to promote fusion. Such a substance is referred to as flux. Fluxing can be described as the process by which the smelting point (or free-running temperature) of an oxide or slag has been lowered by the addition of other compounds (Tylecote 1962: 186-7). By converting the non-ferruginous part of the ore - gangue - into a fluid slag, it assists its removal from the furnace (Tylecote 1965:341). Some of the more common forms of fluxes include magnesia, silica, lime and alumina (Eckel 1914:146).

In Nigeria, near Oyo, some of the slag was returned to the furnace (Bellamy 1904). This was the last slag to be tapped from the furnace which was highest in iron slag since it had been in close contact with the reduced iron and therefore could be almost saturated with iron (Tylecote 1965:341). Small fragments of iron slag from previous smelts were also included with the ore charge in the furnace in the Diman region of Southwest Ethiopia (Todd 1985:93). From a report on a re-enacted iron smelting process in the Gisgara area near Butare, Rwanda, some kind of weathered quartzite was ground into a powder and thrown on the fire yielding silica which served as a fluxing agent (Van Noten 1985:115).

In addition to a high iron content and the presence of elements like magnesia and silica, certain iron ores in Tropical Africa have been determined to contain as much as 12% of water which facilitates smelting without the use of limestone, a material which is a good fluxing agent but not available in the region (Forbes 1933:231). The use of botanical substances in the smelting process has been recorded. At Lawra, in Upper West region of Ghana, Pole (1974b:134), noted the addition of extra ingredients consisting of roots, stalks and leaves of certain plants together with some parts of the head of a dried mud fish into the furnace both through the tuyere opening and the top as the smelting was in operation. Without the addition of these extras, the smelters indicated that the iron could not be released from the stones (Pole 1974b:134). Van Noten (1986:106-107) witnessed a smelting in Madi north-eastern Zaire which was carried out in a depression dug in the ground with a piece of log placed in it below the charge. This was said to produce 'foam' to allow the 'stones' to be formed while chopped pieces of newly cut branches, and a hollow kind of wood produced 'liquid' and 'sap' respectively to help the smelting of the ore (Van Noten 1986:107).

Evidence of the use of "extra ingredients" consisting of botanical substances like leaves, bark, roots, stem, stalks together with zoological substances like bones, and fish heads, in the smelting process is not likely to be found in the archaeological remains of iron smelting. There is, therefore, the need for archaeologists, ethnographers and scientists conducting re-enacted iron smelting processes, using aged surviving smelters to pay attention to this aspect of the technology and have samples collected for analysis. It is in this direction that we can determine whether these plants were added mainly for their ritual value or for the purpose of serving as fluxes releasing vital elements to speed up the separation of the iron metal from the non-ferruginous elements in the iron ore. It should not pass without mention that such attempts to inquire into the minor details of traditional smelting technology like blacksmithing are sometimes treated with great suspicion or outright contempt making it difficult to be able to determine and separate a situation where the surviving smelters have forgotten such details from where they do not want to disclose them. Van Noten's (1981:111) attempt to know what happened to the variety of botanical materials that were placed in the furnace met with the refusal of the smelters re-enacting the process. Tact and diplomacy would be greatly needed in this exercise.

Slagging

Slagging is the process by which the impurities and other non-metallic oxides contained in most iron ores are removed from the ore during reduction (Kense 1983:39). Forming the most extensive remains from a smelting operation, slag largely consists of iron oxide and silica compounds (sand). When the temperature in the furnace is raised to about 1170°C, the fayalite compounds in the ore melt; they become fluid and move down away from the iron in the furnace (Kense 1983:39). The iron metal is not molten with the attainment of this temperature. It is held together by a semi-fluid slag rigid enough to prevent its sinking motion (Wynne and Tylecote 1958:348).

In Africa, the slag is allowed to drop into a pit if there is one, or to coagulate at the base of the shaft to be collected at the end of the process. In the case of more efficient furnaces it is "tapped" through a specially designed orifice at the base (Kense 1983:39). The drain hole is opened to allow the outflow of the molten slag that has collected inside the furnace after which it is plugged to keep the lower part of the furnace completely sealed. Tapping is more easily achieved if the furnace is inclined, or is built into a bank or anthill with a frontal opening at the base (Sutton 1985:173) or from a sloping interior furnace wall base opening into a pit.

Forging

The end result of every successful smelt is the production of a bloom, an irregular, heterogeneous mass of iron often with a thick tongue at the base indicating that it has been seated in the back and the base of the furnace (see plate 14). This product is not pure. It has a spongy-like texture and may contain up to 50% slag inclusion with charcoal pieces adhering to it on the outer face (Tylecote 1970:72). It can also be coated with furnace slag which needs to be squeezed out during consolidation (Todd 1985:94). Before a tool can be made from this iron metal it must be purified and consolidated by separating from the waste products - the slag - and brought to its desired shape.

Forging involves the reheating and hammering of the bloom which results in decarbonization. This raises the carbon content in the bloom. A variety of ways of dealing with the crude product have been observed to have been practised by different iron workers in different locations. In the Upper Region of Ghana, "forging involved the breaking of the bloom up into small pieces by placing it on a large stone anvil and hurling heavy pieces of granite at it; the slag and charcoal pieces were discarded and the iron fragments gathered together. They may be enclosed in a clay sphere or placed directly in the forge fire. The pieces are heated until tacky and begin to coagulate. At this moment they are removed from the fire and beaten gently with a light hammer, to remove more impurities and form the pieces into a solid lump (Pole 1975:15)".

In the Bassare Region of northern Togo, the bloom was broken up and crushed in iron crushing and grinding mortar of stone into bits and pellets separated from the slag. These were mixed with clay and vegetable fibre to form a ball and worked in the hearth at the forge to improve the purity and working characteristics of the iron (de Barros 1986:113). For strength, the practice of quenching and tempering was adopted by the Dimi Smiths in the Gemu Gofa province of southwest Ethiopia (Todd 1985:95). The end result is the raising of the carbon content in the bloom converting it into a steel iron, homogeneous and purer ready to be worked into tools, weapons and other items of iron.

Smelting and Smithing: A Distinction

The traditional iron industry has two broad components of specialized activities, namely smelting done by smelters and smithing by blacksmiths. Iron smelting is the production of workable iron metal from the naturally occurring ore and blacksmithing is the manufacturing of tools, weapons and other related items from iron. From the above distinction, iron smelters can also be referred to as iron producers and the forgers as blacksmiths. Before the introduction of iron bars and scrap metal imported from Europe, traditional smelting provided all the raw material requirements of the blacksmith in the form of a complete bloom or fragments sufficient to make iron items (Pole 1982). The smithing activity, therefore, started with the forging of the iron bloom produced by the smelting component of the industry into a form suitable for working.

One may ask why the need for this distinction. It is to enable us answer the question as to whether every blacksmith could smelt or all smelters could also smith iron, since a statement that the iron workers of sub-Saharan Africa are able to both smelt and smith (Boeuf 1937) is likely to carry the impression that every smelter is also a smith or else the working of the iron into items is always carried out by the same people who smelted. Historical and ethnographic accounts depict that in practice it is not always so. Iron working informants I talked to in

Mamprugu and in the Upper Regions of Ghana indicated that it was not automatic that every blacksmith in Northern Ghana knew how to smelt although they were very optimistic that most smelters might have known how to forge iron. Smelting, they indicated, involved more skill and expertise. It was also lengthy and very labour intensive processes often undertaken by a specialized group who had the know-how. This is in line with Pole's (1975:31) observation during a demonstration smelt at Chiana near Navrongo in the Upper East Region of Ghana, that, the blacksmith in charge of the demonstration was obviously more at home in his forge than at the furnace. This was because traditionally the smelts and the blacksmith came from different families and were distinct specialists (Pole, 1975:31). Such division of labour is well attested in sub-Saharan Africa. Bassare smiths of Northern Togo obtained iron bloom from their smelting counterparts (de Barros 1985:153). This internal division of labour was most highly developed in the western part of Bassare where smelting was done by the villages around the rich iron deposits with villages to the south where quartzite stone for anvils and hammers is abundant concentrating on smithing (Pole 1985a:153). In the same way, Yatenga was known for the quantity of bloom it produced and the Mossi, also in Burkina Faso, for the great skill of their smiths (Forbes 1933:232).

In the highlands area of northeastern Nigeria and northwestern Cameroon, the separateness of the smithing group has been noted. The smiths in Surkur in northeastern Nigeria were not necessarily smelters (Sassoon 1964). Vaughan (1973) spelt out in more detail the distinctiveness of the smithing group within Marghi society in Cameroon. Smelting could be done by any person and each family had its own furnace but only members of certain families were allowed to become blacksmiths. The smithing group was defined as much by their lack of farming skills as by their smithing activities. They were craftsmen, not just smiths. In the Nupe Kingdom in Nigeria, a similar division of labour was found. Iron producers were distinct from blacksmiths although some men were members of both groups (Nadel 1942:259).

The ethnographic account documents instances where the smelting activity has been carried out by farmers who delivered the product to the blacksmiths for forging and smithing. Examples can be derived from Surkur and also in Marghi society in Northern Cameroon. In the latter, the smelters were not smiths but were smelters (Vaughan 1973:175). Such farmers/smelters, like their non-smelting counterparts in the communities, represented a group of people who are on record as having been resistant to the introduction of imported wrought iron and manufactured iron items from Europe into Tropical Africa (Pole 1982). This was because tools made from local iron were usually said to be harder and longer lasting than those made from imported tools or scrap iron as my field work in northern Ghana showed. Three hoes were needed to complete work on their farms in the early 1970's whereas a hoe made of local iron would have lasted more than two seasons. It was the low quality of imported iron which prompted the smelters of Surkur to start smelting again in the early 1960s (Sassoon 1964:174) since they were in charge of the means of production. Similarly as a result of their dissatisfaction with the quality of the hoes the smiths made from imported iron, the process of smelting was resurrected by the farmers/smelters of

Marghi society (Vaughan, 1973:175; Pole 1985a:115).

Far from being 'pure', after the eighteenth century, much of the European iron had a high sulphur content due to the use of coal as fuel which seriously affected the quality of the smelted product and made it a poor substitute for the carbon steel or pure iron bloom from some African furnaces (Goucher 1981). It is, therefore, of little wonder that traditional iron production continued at low levels in Bandjeli in the Bassare region of Togo despite the presence of cheap imported scrap iron until 1951 when smelting was forbidden by the French as a deforestation control measure (de Barros 1985). In Dimam, in the northern part of the Omo Valley, South-west Ethiopia, the Dimi smiths found scrap steel to have higher strength and be more difficult to forge or repair than locally produced iron; thus as at 1973 they preferred to reduce the local ores than use imported scrap (Todd 1973:39-40). Did the widespread preference for local iron emanate mostly from its method of manufacture as Van der Merwe (1971) has noted. Pole (1982), mentioned nostalgia for old tradition as an equally important factor. The reason for the preference was therefore not only qualitative, it may have been conservative, a prejudice hinged on a regard for local material.

From the foregoing, it can be realised that in the past some tribes or groups within a given community specialized in smelting iron more intensively than others. Caillie (1830:318) indicated that in Sambatikila, blacksmiths of Sierra Leone imported iron from Futa Djallon. The basis of such specialization might have been due to the comparative advantage one group or family enjoyed over the other because of its proximity to, or control of, the source of iron ore, nearness to abundant and easily exploited selected tree species needed for making charcoal or a monopoly purely based on tradition.

Rituals and the Role of Women in the Iron Production Process

In this part of the discussion we shall examine briefly aspects of the systems of beliefs, rituals and regulations structuring the process of iron smelting and the relation of the iron workers to the rest of the community. This would be concluded with a brief discussion of the role of women in iron manufacture. Unlike the blacksmiths workshop or forge which is a public place where villagers are likely to meet to chat while observing the craftsman, smelting is confidential and is carried out away from the village. This was undoubtedly due to the desire to keep the technical process secret as well as to symbolic discretion (de Maret 1985:77).

The smelters themselves had special relationships with their furnaces. This cultural and natural status of furnaces is clearly expressed in the differing treatments that is evident in the ethnohistoric and ethnographic data available. Along with many, if not all iron producers, the terms applied to human bodies are extended to furnaces. Furnaces are described as having mouths, necks, bodies, bellies, navels, lower parts (genitalia)(Pole 1974a, David et al. 1988, also see Fig.1). Some furnaces are ornamented with breasts and considered as parturient women. This practice is reported among the Luba, Ruud, Tshokwe, Shona, Karenga all in Central Africa and in Rwanda (de Maret 1985:77), and also in Southern Tanzania (Sutton 1985:176). In Ghana, it is reported from Lawra and Zanlerigu all in the

Upper Regions (Pole 1974a,1974b). As shown by de Heusch (1982:382-486) pregnancy is assimilated to cooking, the child undergoing an intra-uterine baking.

Ritual practices are a part of the African iron production process. Various stages of the activity are preceded by rituals. At Lawra, in the Upper West Region of Ghana, the iron smelters were said to have begged the earth to allow them to remove the ore by the slaughtering of a fowl (Pole 1974a). And at Zanlerigu, when the ore was moved to the smelting site, a small branch of acacia is put on top of the pile and a ring of wood ash is put round it on the ground, marking a barrier, both for the spirits outside and those inside that may cause harm if they get out (Pole 1974a:26). Blacksmiths from the village of Tourma, in the Darfur province of Sudan, draw animals on the outside walls of the furnace (Haaland 1986:52-53). These were said to protect the furnace and the smelt from the evil eye. Similarly the shaft at Zanlerigu, Jefisi, Lawra, and Tiza in Northern Ghana are each marked with a cross in white ash all of which converged at the place of sacrifice (Pole 1974a:27). In the Mandara highlands in Cameroon, the furnaces of the Mafa was guarded by a pot in which sacrifice was made on the day of the smelt (David et. al. 1988:375).

Further testimony that special equivalence between furnaces and person is evident in the choice of furnaces to represent typical sacrificial content. The smelting operation at Jefisi is preceded by sacrifices of fowls and at Garu the dog was used (Pole 1974a:27). At Lawra, Pole (1974a:27), has recorded that "one male fowl was sacrificed on the 'navel' of the shaft. This is the repository of the agent through which the iron is smelted: it is as a result of this sacrifice that the necessary goodwill is released to allow the smelting to proceed. Another fowl is sacrificed on a small stone inset into the support at the back of the shaft in order to propitiate the earth. A third fowl is sacrificed next to the bellow pumps in order to bring the attention of the elders to the work that is about to start. A fowl and a guinea-fowl are sacrificed at the shrines of the ancestors; four small fowls are sacrificed at the cardinal points some way away from the site". The pouring of libation was mentioned as practised in Jefisi and Garu which also served the same purpose. At Garu, a libation of millet gruel is made on each side of the shaft, over an iron stake set in the ground (Pole 1974a:28). The rituals, it is important to note, were accompanied by incantations. In Bassare, in Togo, a teenage boy was positioned near the furnace and given several lashes on his bare back until he screamed and cried to signify the restoration of life into the furnace (Posnansky, personal communication).

Why all these attention to detailed rituals which sometimes involved the slaughtering of over half a dozen birds and the canning of children? Several answers can be given but one of the basic reasons is to be found in the very nature of the smelting process. It was lengthy, strenuous and risky. The smelters were particular about avoiding failure. A failure, according to contemporary smelters interviewed included instances where the bloom produced at the end of the smelt is too small or had no iron in it. They would not always attribute failures to physical factors. To the smelters activities and techniques associated with smelting are not always functional; they can be ritual (Van Noten 1986:117-

118) as well as supernatural. Rituals in smelting are meant to invite the help of 'unseen powers' in the undertaking or to show dead blacksmiths that they had not been forgotten and thereby dissuade them from interfering with any aspect of the work. It was also aimed at protecting the furnace and the smelters against 'evil' or wicked eyes that might obstruct the process (Pole 1974a). It was seen as a safety measure against serious accidents like the explosion of the furnace. In effect, ritual is explained as protective in intent or more precisely as apotropaic in that it warded off fate (David et. al. 1988:375) and it invited ancestor smelters to partake in the process to ensure its success and the well being of their descendants.

This leads to the next level in the analysis namely the role of women in the smelting process. Did women ever play a role in any aspects of the smelting of iron ore? One may easily assume that since there are many rituals, secrets and superstitions associated with the process, women would have no part to play in it. The ethnographic and ethnohistorical records reveal that women participated in various aspects in different smelting communities. In the village of Tourma in Darfur in Sudan, women performed the important task of crushing the iron ore into requisite sizes (Haaland 1986:54). Most smelting villages in Bassare had a sexual division of labour where the women generally did the mining, transportation, breaking of the ore into smaller bits and removing of impurities from them while the smelting itself was limited to the men (de Barros 1985:154-155). At Zanlerigu, Pole (1974a:32) gave an account of women participating in the pumping the bellows although only for short periods since it needed extra strength.

There were aspects of the ritual at Zanlerigu which was related to the welfare of women on the smelting site. This was meant to protect pregnant women passing near the shaft from the harmful effects of the structure which might cause them to have a miscarriage. This took the form of a ring of wood ash put around the shaft when it is completed (Pole 1974a:26). This is explained by the belief of the shaft as a woman from whom the iron would be born as a result of impregnation with air from the bellows, which are seen as male genitalia (Pole 1974a:21). For the fear of this belief being translated into reality on pregnant women, therefore, this ritual was performed. My informants in Chiana, Garu and Nakpanduri indicated that as a way out of this problem, the smelters preferred to use the services of old non-child bearing women as well as teenagers in tasks related to the actual smelting. These included participating in singing to the tune of traditional musical instruments like drums, guitar and castanets. Apart from this, women and children participated in the fetching of water, carrying of wood or charcoal to the site. In Garu, I was informed, as has been recorded by Pole (1974a:32) also that formerly the entire processes and activities related to the smelting of the ore could be performed by a blacksmith and his wife or wives (which was more often the case) and children especially where they were immigrants in the community.

CHAPTER TWO

A REVIEW OF THE WRITTEN REPORTS ON IRON SMELTING IN GHANA

The Iron Age has been a popular theme of study and research in Ghanaian archaeology since the inception of scientific archaeology in the country in the 1930's. A greater part of the research effort has, however, been on the economic, social and political aspects of iron using societies. Among the most popular areas of research are archaeological investigations into early trade, state formation and urbanism (Posnansky et al, forthcoming; Shaw 1961; Shinnie and P.C. Ozanne 1962; Bellis 1972; Agorsah 1976; Effah-Gyamfi 1974; 1978; Boachie-Ansah 1978; Kense 1981; Brempong 1987), ceramic studies and its significance in reflecting cultural development (Anquandah 1967; York 1968; Crossland 1973). Others have focused on mudwall structures (McIntosh 1974) and ethnoarchaeological studies of settlement and behaviour patterns (Agorsah 1983). An awareness of the cultural continuity accounts for the great use of ethnographic data, ethnohistory, ethnomedicine, ethnomusicology, written history and linguistics in the reconstruction of development in the iron age.

While we speak confidently of a Ghanaian Iron Age and use it as a formal historical epoch, it is in fact defined more by the lack of stone-working, its divisions by changes in pottery styles and emergence of complex urban settlements. We still know very little about the history of iron working (which provided the chief metallic base for the technologies, agriculture and industry of the early iron age societies) and not much more about the product.

Iron smelting is defunct across the length and breadth of Ghana although it has been witnessed in a few isolated places like Cherepong near Lawra and at Bellaw near Lambusie all in the Upper West Region during the last four or five decades (Junner 1935:441). A common explanation for the demise of iron production in West Africa was its inability to compete favourably with "cheaper" and "superior" substitutes of raw iron and manufactured products from Europe. This view was assumed to be due to the backwardness and inferiority of West African technology in the face of stiff competition. In her article, Candice Goucher (1981:179-89), showed the need for a more detailed examination of the demise of iron production in West Africa. She advocated a model in which ecological factors are emphasized. These centre on the enormous consumption of charcoal by the iron smelting process, leading to partial deforestation, in combination with a desiccating climate shift seriously curtailing the regeneration of the forest and endangering the future of fuel reserves. Initially, she indicated, the European iron import was neither 'cheaper' nor 'purer'. On the other hand, the increasing importation of European iron bars and other manufactured goods necessitated a certain amount of technological innovation such as increasing the furnace height, adaptive variations in the angle and number of tuyeres and the development of preheating, all aimed at providing advances in fuel conservation and manufacturing. An increased reliance on imported supplies of iron, she concluded, became a last resort when the technological advances could not provide a long term solution to the ecological devastation (Goucher 1981:109) in the absence of a laid down attempt at reafforestation.

Pole (1982:503-13) has proposed the consideration of factors like, labour input, price, the ritual value of local iron and the social organization of iron working groups vis-a-vis the imported iron products. In other words, he suggested that not only does traditional iron production require skill but more importantly it is lengthy and very labour-intensive. That local iron production was "killed" by imported ones indicates that there were difficulties facing the local production which therefore provided a safe ground for external competition. Whether this can be explained in terms of ecological or economic and social factors would be determined by the results of research on African iron metallurgy.

The decline of iron smelting was earliest on the coast (Pole 1974a:5) where iron was first introduced from the mid-seventeenth century (Flint 1974:387). Local smelting of iron became unnecessary in the Cape Coast-Elimina areas as early as the late seventeenth century although it continued until the late eighteenth century in the Accra Region and in parts of Western, Ashanti and Brong Ahafo Regions until the mid-nineteenth century (Pole 1974a:5). An explanation for this pattern of earlier abandonment in the southern and coastal areas than in the northern sector might be found in economic factors like the cost of transporting the iron in the form of manufactured goods, bars or scrap metal up north. This would have made the price of imported iron not too cheap compared to iron from local sources. The price of European iron increased as it went away from the point of production (Pole 1982:508). In 1819, bars of iron were sold in the markets of Salaga and Yendi at three times their Cape Coast price which would itself have been twice that in London (Bowdich 1811:331). Not until the beginning of the twentieth century did imported iron become sufficiently cheap and plentiful to outweigh the prejudices against it.

A detailed description of a smelting tradition was recorded in Akpafu Todzi in the Northern Volta Region of Ghana by Rattray (1916:431-435). He described the remains of an iron smelting furnace standing at a height of ca.2.2m and ca.90cm in diameter at the widest with a bottle-shaped neck. Down the centre of the furnace was a chimney c.46cm in diameter with what Rattray called doorway (slag tapping hole) at the base. This was used for lighting the furnace at the bottom (see Fig.20d). It was sealed with clay, leaving only a small duct for the molten slag to flow out. This suggests the use of plugs to block the duct when no slag was expected to ran off. The seal was broken off at the end of the process to remove the bloom (Rattray 1916:433). Air into the furnace was naturally induced through funnel-shaped tuyeres fixed into air inlet holes radiating around the base of the furnace. The air inlet holes varied between 5 and 7. The whole structure was covered by a flat mud roof resting on a cross pole supported by upright poles with the mouth of the shaft projecting above the roof (Rattray 1916:433-435). This served as a platform on which the smelters stood to charge the furnace, while serving as a protection over the furnace from rain and the sun. The construction of such a platform was necessitated by the height of the furnace. The mouth could be reached only by means of a ladder or steps.

Although Rattray does not indicate it in his article, furnaces such as he mentioned had been more fully described in an operation by Hupfeld (1899) who managed to witness what has been one of the last smelts of the hundreds of furnaces formerly in use in the Akpafu-Lolobi-Santrokofi area in the Northern Volta Region (Darkoh

1964). For the ore, the Akpafu smelters travelled some distance to mine it from a mountain (Rattray 1916:432). He noted two varieties of methods of obtaining the ore. In the first method, deep vertical shafts with side galleries running out of it were sunk into the mountain. The ore in this case was passed up in baskets from hand to hand by men standing in notches made in the shaft. The other method involved the running of winding tunnels or shafts into the side of the mountain. These had low entrances and extended to distances up to 45m or more. The ore was quarried with the use of a long stick shod with a piece of iron to prod the roof and sides of the shaft. The iron ore obtained was broken up into pieces although the required size was not recorded. The smelting process lasted for 12 hours. Once the charge had been burning for some time the operators could leave the furnace unattended, except for slag-tapping (Pole 1982:504). One person was appointed to keep watch over the furnace, to make sure the air inlet tubes did not become blocked and that the charge was not burning too fiercely.

The Akpafu iron production was not only an organized family industry but also it was done on a full time basis all the year round. Thus, they produced a larger quantity of iron than the smelting communities in Northern Ghana where iron smelting was done only during certain periods of the year with farm work taking precedence (Pole 1975:504). A diversity in the published report on Akpafu iron production makes it difficult to determine the output of the furnaces per smelt. A single piece of bloom recorded in 1972 weighed 24kg and was higher than the amount produced during a demonstration smelting in September 1973 which was only just over 3kg (Pole 1982:505). According to Pole, the discrepancy was the result of inaccuracies of the recreated smelting. Hupfeld's report indicated that at the end of the nineteenth century, blooms weighed about 4.5kg (Hupfeld 1899:175-94 quoted in Pole 1982). A bloom seen in the neighbouring village of Santrokofi by Pole (1982) weighed 7.2kg. but that appeared to contain a large amount of slag.

An interesting aspect of Rattray's (1916) report is the striking similarity noted in the architectural style of the smelters' homes and their smelting structure. Their huts were flat-roofed (with mud) instead of the conical grass-roofed houses typical of the Ewe. Their language is not Ewe but a remnant of some ancient tribal idiom (Rattray 1916:431). Cline (1937) in a survey of the literature on African metallurgy mentions the Ewe, but only to say that their iron is worked by the original inhabitants, that is, the Akpafu.

Junner (1935/36:36-37) who worked with the Gold Coast Geological Survey, witnessed smelting operations in the Lawra district in the 1930's in the towns of Cherepong and Bellaw. This enabled him to record valuable details on the smelting process. The furnace from Cherepong was cylindrical in shape with a height of 1.5m and a diameter of 30.5m. It was inclined at an angle of 70° to the ground surface and supported by mud bricks and 'swish'. It was open at the top. The furnace at Bellaw was similar in size and design but the sides were not built. Air was supplied into the furnace through a conical tuyere 15.4m and 17.8m diameter from bellows consisting of basin-shaped chamber (like a native drum) covered with a loose sheep-skin.

To operate the furnace, Junner's reports indicated that, small pieces of wood or bamboo were put in the bottom of the furnace and these were covered by a layer of charcoal and iron ore in a ratio of 1:3 of ore to charcoal. The ore used at Cherepong was scoriaceous surface iron stone and at Bellaw, red ferruginous laterite. These were broken up into 1/4 - 1/2 inc (.63 - 1.27cm) limps before being smelted. He also noted that the "lower part of the front of the furnace below the tuyere opening was pierced at intervals to let the slag run off" (Junner 1935/36:37). This implied that the slag was ran off at appropriate intervals as the smelting went on. Furthermore, the slag was run off from the same side of the furnace where the tuyeres were also located. His report also stated that the smelting of 25 calabashes of ore (and presumably, 75 calabashes of charcoal) took 10 hours on the average and produced a 9-12 pound (4-5.4 kilograms) bloom. Junner's work represents one of the earliest reports on iron smelting in Northern Ghana.

From Busie in the Upper West Region of Ghana, comes the description recorded by Cooper also of the Gold Coast Geological Survey in 1927, published by Davies (1967). The furnaces were 150cm high and 30cm across at the top each standing within a smithy which also housed the bellows which Copper stated were apparently made of wood. Tuyere pipes were made of loam mixed with straw and cow-dung and baked. Ore was said to be 'gritty yellow pisoliths, fluzed with soft dark pisoliths' (Davies, 1967:299). They were crushed with a heavy iron hammer, then with small quartz balls. Cooper did not give an indication of the charging ore sizes thus making it difficult to determine whether it was similar to those in other reported sites like Tiza and Gomperi in the same region. As the smelting progressed, slag was tapped from the hearth below the tuyere nozzle. The smelting gave about 10 pounds (4.5kg) of 'frothy iron containing bits of charcoal and slag' (Davies

1970:26). After smelting, the iron was beaten for about two hours, using cylindrical iron hammers in an open bowl hearth situated outside the smithy. The data from Busie suggests that the iron working practice was not different from that noted at Cherepong and Bellaw.

It is important to note that, the details on the smelting process aside, there exist some doubts on the description of the smelting apparatuses which according to Cooper were housed in a building. Except where it can be determined that the mouth of the furnace projected above the roof as was in the Akpafu example, it is difficult to imagine how the smelters could cope with the high temperature experienced in such an enclosed smelting house, not to mention the attendant carbon monoxide poisoning emitted from the process. Perhaps what we are dealing with is a discrepancy in the distinction between a smithing shop (the forge) and a smelting site. The forge is always enclosed under a roofed structure in Northern Ghana today as was in the past. Moreover, the description of the smith's hearth as an open bowl hearth by Cooper (Davies 1967) could have been no more than a hearth in the form of a shallow depression with a low mudwall surrounding it. This has been the typical blacksmith hearth in the Upper Region. The above examples show the immense benefit Ghanaian archaeology has derived from the field survey of the Gold Coast Geological Survey in the 1920s and 1930s.

Perhaps the most interesting and far reaching investigation into the traditional iron industry in Ghana was a detailed ethnographic and ethnohistoric field study inspired by anthropologists who were anxious to probe further the technology and the organization of the industry (Pole 1974a, 1974b, 1975). It was carried out in the

1970's in some selected villages of the Upper Region belonging to Lo-Dagaa, Isala, Kassena, Nabte, Bisa, Kusal, Frafra and Busanga linguistic groups under the auspices of the Ghana Museums and Monuments Board. This eventually occasioned the revival of the art of mining, furnace building, charcoal making and smelting for the purposes of recording and filming in six of the selected villages namely, Gomperi in Lawra (Lo-Dagaa), Tiza (Lo-Dagaa), Jefisi (Isala), Garu (Busanga), Chiana (Kassena) and Zanlerigu (Nabte).

Basically, the furnace consisted of a cylindrical shaft usually inclined at an angle of 20° from the vertical and had openings at the top and bottom with a height not more than 1.5m (Pole 1974a, 1975, 1985). The lower opening was provided with two holes; a nozzle called a 'tuyere' and below it at the very base of the shaft a space for the removal of the slag during the smelt (Fig.20). The air blast is supplied by a pair of clay bowl bellows each of which is connected via a pipe to the tuyere. All parts of the furnaces are made by the blacksmiths themselves out of clay used in making granaries or from a termite-hill (Pole 1975:14).

Significant differences in the construction and shape of these furnaces were noted. The furnace at Chiana has an upright shaft which widens near the base and uses two sets of bellows with the hole through which slag was tapped being opposite the holes into the tuyeres are placed (Fig.20d). The bellow bowls and the pipes leading from them into the tuyeres are made in one piece; the bowls being on a short pedestal. The bellows are operated in a seated position (Pole 1974a:14). This bellow arrangement was replicated in Garu. It was, however, different from that of Jefisi, Lawra and Tiza where one set of bellow bowls standing on a high pedestal necessitate that the pumper stand to operate them. Pole (1974a:38) observed at the end of the investigation that two related, but distinct, technological traditions were evident; one exemplified at Chiana, the other by the furnaces at the other five places.

The fuel is usually charcoal, sometimes supplemented by wood sticks or guinea-corn stalks. The charcoal is made by the smelters from preferred species of tree, the preference varying throughout the Upper Region (Pole 1975:14). The ore found in the area occurs in two forms; in the west around Lawra it is dug from 25-60cm below the surface in massive lumps, which are then broken up with hammers. Further east, from Jefisi onwards, a nodular type is found only a few centimetres below the surface with the nodules being seldom more than 2cm in any dimension and resemble peas; nevertheless they are usually broken up, revealing dark brown and yellow lustrous rings. From quantitative analyses carried out on both types of samples, it appeared that the latter nodular type was much richer in iron (average 50% by weight) than the massive type (25-35%). In both, the haematite has been deposited lateritically (Pole 1974a; 1975).

The temperature of the furnace at Lawra was measured, the results of which indicated that temperatures up to 1200°C can be obtained in the furnaces in Upper Region of Ghana. The results also indicated that the smelters of this region have a long standing tradition of being able to produce blooms weighing 2-3.5 kilograms after a 10-hour smelt. This was consolidated in the forge by the same people to make medium or high-carbon steel by a conscious process amounting to alloying iron with about 1-1.5% carbon (van der Merwe 1977: Pole 1985) for implements to be used by local farmers, hunters, carvers, butchers and warriors.

As far as the archaeological literature is concerned, Oliver Davies' (1967, 1971-73) field researches reported surface iron slag deposit, furnace wall fragments and tuyere pieces from all regions in Ghana. This evidently is indicative of former iron smelting activity, but up to now, there have been only a few archaeological excavations of iron smelting sites and little has been written about iron smelting in Ghana. It is instructive to examine the few archaeological excavations of iron smelting furnaces for which detailed reports exist.

R.P. Wild (1931), excavated what he termed an 'unusual type of iron smelting furnace' at Abomposu in Ashanti. The entire furnace was constructed in the form of a pit entirely below the surface of the ground nearly at the bottom of a valley where the inclination of sides had eased off to a completely gentle slope (Wild 1931:185). This is in contradistinction to the usual type of furnaces found all over Ghana which projected on the surface of the ground. He gave the dimensions of the furnace mouth as being 96.5cm deep near the middle and 53cm at the bottom. It is the first of its kind reported in Ghana to date. On the other hand, it is important to note that bowl furnaces are rare from this part of Africa (Pole 1974b: 264). Wild's evidence was rejected by Cline in his major review of 1937. Oral traditions collected in 1972 from Hani by Goucher (1981), in the Brong-Ahafo Region and from near Navrongo, in the Upper Region describing smelting without shafts do not constitute anything like a bowl-furnace tradition (Pole 1974b: 264). Although it might be too rash to conclude that the Abomposu furnace was not what Wild determined it to be, it is proper to keep it in mind in our classification of furnace. As I have already noted above, the terms "bowl" or "shaft" themselves have their shortcoming since they remain largely at the descriptive and subjective level and are difficult to correlate.

Shaw (1969) excavated a furnace at Achimota College in Accra in 1938. The evidence that led to the discovery of the furnace was the in-situ structural remains of the wall outline of the furnace in an area covered by slag, tuyere and wall fragments. The excavation revealed only the lower portion of the furnace. It was 30.5cm high, oval in shape, with a maximum interior diameter of 72.8cm and contained a large lump of slag which had never been removed (Shaw 1969:48). The presence of the slag lump within the pit and overlying the furnace lining clearly indicated that this was the actual furnace bottom. The smelting area of the furnace would have been at a higher level although none of this had been preserved (Shaw 1969: 54). Furnace features like the tuyere hole and the slag disposal hole could not be found from the excavated evidence. These had perhaps been destroyed after a period of time when the abandoned furnace stood exposed to the vagaries of the weather and perhaps disturbances by human beings and animals. Despite this, the presence of abundant tuyere fragments around the furnace (see Fig.2b) do not by themselves indicate induced or bellows blown draught. On the other hand, since the walls measured only about 7.6cm thick at the base, the furnace wall would not have reached a sufficient height to be an induced draught shaft furnace. One cylindrical clay tuyere measured about 30.5cm in length with an external diameter of about 10.1cm (estimated from Fig.4 - Shaw 1969:50).

Excavating at Beifikrom, located near Mankessim, in the Central Region of Ghana (see Map 8) in 1956, Nunoo (1970), obtained evidence of iron smelting in the form of the remains of furnace and tuyeres in addition to large quantities of local pottery. The furnaces (Nunoo did not state their number) were cylindrical and the dimensions of one are 45cm wide and 75cm high. He did not state whether the dimensions were the evidence before excavation or after. Moreover, whether the width of the furnace was taken to include the furnace walls cannot be determined. It was open at the top and had an opening at the front for kindling the fire and for the tuyere (Nunoo 1979:74). This description represents a small shaft furnace.

Archaeological excavation of three furnaces was conducted between 1964-66 at a site now built on at the University of Cape Coast in the Central Region (Penfold 1970). The furnaces were found together with slag and potsherds scattered on the surface. Most of the furnace remains Penfold excavated had been damaged with only their bases surviving. The first 'kiln' extended down to a depth of 60.9cm (Penfold 1970:8). The interior diameter of the second furnace was about 38.1cm. Both diameters closely tally with that from Achimota.

The wall thickness of the first 'kiln' was given as about 12.7cm (Penfold 1970:8) which made it thicker than the Achimota furnace. Both 'kilns' indicated the position of the tuyere holes to be near their base and to one side, even though the second furnace was only preserved to a height of 22.9cm. Only fragments of the third furnace lay preserved in association with large amounts of slag deposit.

There are also some difficulties in accepting the reconstruction of the furnace as illustrated (Penfold 1970:6). Ethnographic evidence provided by Rattray (1916:43), Junner (1935/36:36-37), Pole (1974a,1974b), Tylecote (1965:1975) and the results from my field excavations (1987-1988) indicated that the air blast, no matter the furnace type and whether naturally induced or bellow blown, usually enters from a slightly elevated point into the furnace, and that the slag must settle at the base of the furnace bowl or in a pit at the base. The position of the tuyeres on Penfold's furnace seems too low to be realistic. Furnace reconstruction as was done by Penfold should of necessity be supported by sufficient ethnographic and/or archaeological evidence.

Pole also challenged the interpretation of this structure as a bowl furnace (Pole 1974b). Although he did not specify what features separate a bowl furnace from a shaft type, he did point out that the usual height/diameter ratio for the former was less than 1:1. The Cape Coast furnaces, however, appeared to be about 3:2. According to Pole, therefore, these furnaces should be likened to those known for the Akpafu noted above. The "tuyeres" would have been used as slag outlets, thus accounting for the slag heap at one side of the furnace. If this is true then the removal of the bloom would be through the top or by opening a gap at the base of the furnace perhaps by widening the slag outlet hole. Such a damage to the furnace could be repaired before the next smelting.

This explanation, notwithstanding, the archaeological evidence did not reflect any sign of the destruction of the lower furnace walls. For this reason Kense (1983) suggested that perhaps the furnace was not utilized. This view is, however, defeated by the evidence of slag-encrusted "tuyeres" suggesting evidence of use. A group of sherds present eluded inclusion in Penfold's rough classificatory scheme on account of their undecorative and gritty texture (Penfold 1970:3-4). One piece even had layers of iron slag adhering to it. Kense's view (although he noted that there was no substantiating evidence) that these sherds may represent the fragments of a clay bowl bellow and thus provide a unique example of the bellows mechanism in prehistoric West Africa should not pass without comment. We need to ask ourselves whether bowl bellows used in the smelting process are repeatedly exposed to heat furnace fire or the molten slag and under what circumstances would slag (molten ones of course) get attached to these bowls. Fragments from broken jars and storage vessels used on the smelting site could be improvised to serve as a tool for scooping away accumulations of slag flowing out of the furnace slag disposal channel. In effect, such details should be noted in future archaeological and ethnographic researches carried out on iron smelting sites.

From the evidence obtained from the Cape Coast site, Penfold (1970) estimated the iron content of the iron ore to be 11.7%. Ore with an iron content of at least 20% may be exploited (Coghlan 1956:13) although it must be stressed that such ores would not yield enough crude iron after processing in the smelting furnace especially when the large amount of iron wastage into the slag is considered for the majority of 'primitive' furnaces (Kense 1983:31; Wild 1931; Tylecote 1962). To use such ores they should be suitably pre-heated (Tylecote 1962). The evidence from Cape Coast might therefore suggest the preparation of the ore through roasting.

One basic feature of the above reports on archaeological excavation is that their dating is usually unknown or it is based on oral tradition or association with historical materials. The Cape Coast site has been suggested to be the remains of a smelting tradition in Southern Ghana before the seventeenth century and probably operated by local smelters before the arrival of Akan-speaking groups in the area

(Pole 1974b:265). The Beifikrom and Asebu sites have been dated to the fifteenth century or earlier on the basis of the absence of European imports (Nunoo 1970:73). The need for the effective application of chronometric dating cannot be over emphasized especially where one is dealing with archaeological remains of iron working which may date to earlier periods.

The above specific excavations aside, archaeological evidence of iron smelting has been encountered in several places in Ghana on the surface or in excavations. At Begho, research by the West Africa Trade Project (WATP) 1970-79, directed by Professor Posnansky led to the discovery of evidence of a period of iron working at Atwetweboo unit dated to be second century A.D. (Posnansky and McIntosh 1976:161-95). With this date, the iron smelting site at Atwetweboo represents one of the earliest iron production evidence about smelting practices in the first millennium A.D. in Ghana. A total of twenty-six slag mounds, some more than 30m across and over 1.5m high, were recorded at the Dapaa site and studied by Candice L. Goucher (1979:1981). The mounds had arc-like configuration (Goucher 1981:182) which conforms to that described by Pole (1975) for the Upper Region of Ghana where it occurs as a result of the placement of several furnaces in a line when smelting. Of considerable technological importance is the revelation of a high extent of vitrification (indicating intense heat) of a near-complete tuyeres excavated at Dapaa. This suggested that tuyeres were extended more than 10cm into the interior of the furnace thus confirming a technology which utilized preheating of the air-blast (Goucher 1981:186). In another chapter the significance of this technological innovation which was first recorded in East Africa by Schmidt and Avery (1985) would be discussed when we analyse the tuyere remains recovered from the Gambaga excavation. Electron probe microanalysis and scanning electron microscopy with energy dispersive X-ray techniques used to characterize the slag and iron from the site of Atwetwebooso (literally meaning 'the place of iron stones'), indicated that a temperature of 1250-1300°C was reached in the reduction process (Goucher 1981:186).

Six slag mounds were discovered during an archaeological investigation into early Akan urbanism by Effah-Gyamfi (1978) at Abam, the industrial sector of the Bono Manso site. These ranged from 0.75m and 1.2m high and each about 25m across. Two of these mounds were excavated and were found to contain slag, and tuyere and daub (furnace wall) fragments (Effah-Gyamfi 1978:168-169). It was difficult to attempt any meaningful reconstruction of the structure used in the smelting process since no direct evidence of even a single in-situ structure was found (Effah-Gyamfi 1978:173). He also found what looked like a slag plug in the excavation of one of the mounds. More would be said on slag plugs when the archaeological finds from the Mamprugu investigation are discussed in a later chapter. The Abam site has been dated to the fourth century A.D. (Posnansky and McIntosh 1976:166). The Brong-Ahafo Region has therefore provided some of the earliest-known iron industries in Ghana (Anquandah 1982).

From A.D. 1400 onwards, iron working sites proliferate in the archaeological record (Anquandah 1985). Studies in ethnography and ethnohistory provide confirmation that traditional iron working was developed by most ethnic groups in Ghana. In Southern Ghana, among the notable technological centres were Tonsuo Sim in Denkyira, Edubiase in Adansi and Akpafu in Volta Region (Rattray 1916;

Daaku 1971 and 1970; Effah-Gyamfi 1978).

From the excavation of ancient rubbish mounds at Dawu-Akwapim, in the Eastern Region of Ghana, evidence of iron working in the form of haematite iron slag was recovered which has been suggested to be the residue of local manufacturing industries (Shaw 1961, Sutton 1981; Brempong 1987). The mounds have been age estimated to between the sixteenth and late seventeenth centuries and the chances that the evidence represents residue from the use of imported iron and scrap rather than local iron smelting is high. Moreover, there are no traditions of iron smelting technology in the area in the past (Okoro 1984; Brempong 1987). Similarly, there is evidence that the pro-urban settlements of little Accra area at the University Drama Studio site which traded pottery from Cherekecherete and dated to the fourteenth century A.D. possessed the skills of iron working (Anquandah 1982:68). More concrete evidence in the form of furnace remains, slag and remnants of tuyeres are needed to determine the ability of the people of the said site to actually turn iron ore into metal. Thanks to the Volta Basin Research Project, it is now known that about the middle of the first millennium A.D. there were large villages in the Basin that smelted and worked iron. The evidence in the form of slag at Owansane river site attest to iron smelting (Anquandah 1982:72). York (1968) recovered iron slag in large quantities in his excavation at the mouth of the Sheribong river (8°35'N, 0°54'W) also in the Volta Basin.

Surface surveys in Northern Ghana have provided a large evidence of iron smelting. At least over a hundred sites with evidence of iron furnace walls, slag, and tuyere remains were found from archaeological surveys. Moreover, a large number of settlement mounds with similar evidence have on excavation proved to be the domestic ruins of versatile iron working populace (Kense 1985:16; Anquandah 1982:74; Shinnie and Ozanne 1962). This might be due to the common occurrence of lateritic iron ore and wood for fuel in the seasonal rainfall which also implied that there were long period during the year when the dry conditions were suitable for iron smelting activity in the countryside. Major iron industrial centres which appear to have functioned from around the beginning of the fifteenth century have been recorded in almost all the major towns in Northern Ghana. In fifteen villages around Wa, there are large heaps of slag and tuyeres some measuring over thirty metres across. Five villages around Navrongo (especially Navere and Billaw) have a relatively long tradition as iron working centres. The old townships of Bole, Yeji, Tumu, Lawra, Jefisi are all marked by many slag mounds (Anquandah 1982:74). These are clues that iron working was widespread thanks to archaeological surface surveys.

Discussion

This brief review of the evidence on iron smelting has revealed that iron smelting was widespread all over Ghana. It shows that a large part of the data is ethnological comprising the numerous accounts by people with a variety of professional orientations; geologists, colonial officials and administrators, ethnographers, historians and anthropologists. These normally date to the turn and early decades of this century before the iron industries especially the mining and smelting side went into sharp decline. For the practices in the first millennium A.D.

(which are often recovered through archaeological surface surveys and excavations) practically nothing is known. Clues for reconstructions have had to rely on to the archaeologically recovered data and the ethnological data available.

Although iron smelting has ceased, the work by Pole and the Museum staff has revealed that the knowledge is still to be found stored in the memory of a few surviving iron workers who participated or witnessed the smelting process. A furnace built at one of the villages, Tiza, but not used, was transported to Accra and can be found on display in the National Museum. In four places, Lawra, Jefisi, Garu and Chiana, the furnaces were left standing with the objective of using them again to demonstrate to local people and visitors the blacksmiths' techniques (Pole 1974a:7). Laudable as this idea was, a visit to these places in December, 1988 and January, 1989 indicated that apart from Lawra, the furnaces in all the other villages had been destroyed without trace. No shelter were found, and if these existed, they were not maintained leading to their collapse. The location of the demonstration smelting sites close to or on the modern settled area made their destruction by human beings (especially children) and domestic animals like goats, sheep and donkeys, a matter of time.

The success of the Museum project had much to do with the availability of blacksmiths who were willing to recreate the processes they had either themselves learned as young men or had seen performed by their fathers (Pole 1974a:7-8). For this reason it was unlikely that recall of the details of the process was total (Pole 1974a:8). Three of the thirteen smelts reported were unsuccessful in producing iron. In the next chapters when we examine data from the Gambaga area, we shall discuss what light archaeology has thrown on successes and failures of smelts.

A very important point that Pole noted during his ethnographic research was that as the surviving blacksmiths die, the knowledge about iron production dies with them. Most of the blacksmiths with whom the Museum staff worked were in their 60's and 70's and cannot be expected to last for more than a decade (Pole 1974a:39) noted. This observation has been proved right. On my visits to four of the six villages where demonstration smelting activities were undertaken in 1971-73, all the blacksmiths concerned in Chiana, Jefisi, and Garu were dead but for one smelter still surviving in each of the settlements. These surviving smiths are now very old, no more practising the profession and displayed overt signs of having weak memory. At Jefisi, the surviving smith with knowledge about smelting is now blind and spends all his time in his room.

There are some few shortcomings associated with the use of the ethnographic documents by archaeologists, which emanate from the fact since most were conducted or recorded by people who were themselves not archaeologists, the focus of interest would not always match with what the archaeologist may want. Moreover, some information on smelting remains is from isolated iron smelting sites making it difficult to discuss their significance within a wider geographical or cultural perspective. There is also the need for caution in the use of ethnographic data as a result of the existence of variations in recording and in actuality.

An area of the ethnographic record that has suffered greatly from this problem relates to the weight of iron bloom per smelt. Since each individual (with only a few exceptions) estimated the weights of the bloom by hand it is not too easy not to associate the different weights to different levels of personal estimates rather than actual production outputs. Some examples would make this clear. The smelters of the Upper Region of Ghana, it has been recorded, smelted on a part-time basis producing iron bloom weighing 4-5kg in Cherepong (Junner 1935/36:37), 4.5kg in Busie (Davies 1976:26) and an average of 2.0-3.5kg from the villages where Pole researched (Pole 1975:11-39). Pole's 1971-73 demonstration smelting, therefore, produced less heavy iron at the end of the process. But whether the differences between his figure and that of Junner and Cooper are related to actual production results and not differences in estimates is open to debate. The situation is more disturbing when the Northern Ghana results are compared to those of Akpafu in Northern Volta Region. As indicated above there is a diversity in the published reports of Akpafu that makes it difficult to compare the efficiency of the Akpafu smelting furnaces and output levels to those of Northern Ghana. There is the extreme estimated weight of 24kg (Pole 1975:504) for a bloom seen in 1972 sharply contrasting with Hupfeld's weight of 4.5kg. recorded at the end of the nineteenth century (Hupfeld 1899).

The results of archaeological excavations reveal one basic problem with furnace reconstructions. To begin with the remains are invariably incomplete and commonly fragmentary which have resulted in the debate over proposed reconstructions, sometimes over the basic aspect of the style, let alone their functioning. Such essential issues as the relationship of a supposed piece of furnace base or wall to the original ground level remain quite unclear as was evident from the examples discussed. Again, a fair amount of such furnace sites - what are taken to be such -

remain undated which gravely limits the contrast with ethnographic examples which may be noticed. As it is, the Upper and, to some extent, Northern Regions for which there are good ethnographic descriptions and where there are surviving blacksmiths with knowledge of iron production, lack known archaeological remains that have been excavated. On the contrary, the lack of ethnohistorical or ethnographic data on smelting processes in the southern part of Ghana has accounted for the difficulty of accepting the reconstructions that are made.

The limitations, notwithstanding, the archaeological investigation of iron smelting in the Gambaga area which is the first of its kind in this part of Ghana, led to the recovery of furnaces which had been preserved in a remarkable way as well as data on details of the processes of iron production and apparatuses that were used. It indicates that at least in Northern Ghana, archaeology has a great role to play in the reconstruction of the iron technological history of Ghana.

CHAPTER THREE

GAMBAGA ESCARPMENT: ARCHAEOLOGICAL CONSIDERATIONS

The Escarpment derives its name from the ancient town of Gambaga (10°33'N 0°27'E). The first recognition of the Gambaga Escarpment as an archaeological site and the first report of the traces of ancient iron production in the Gambaga area must be credited to Oliver Davies (1970) who visited the place and noted a number of areas in and around Gambaga town where he observed archaeological material, some of which he collected. These included lithic artifacts like microlithic flakes, chert core and flakes as well as refuse from iron production. Since then Mamprugu (which is the name of the land) has been visited by anthropologists (Brown 1975), and historians (Illiasu, 1971, Davies 1984). An archaeological survey carried out on the Gambaga Escarpment during the summer of 1987 by me and other members of the Gambaga Archaeology Research Project (GARP), directed by Dr. F.J. Kense, clearly indicated the presence of a variety of extensive cultural material scattered about the towns of Gambaga and Nalerigu which are pointers to the rich archaeological potential of the Escarpment. It was on the basis of this visit that the decision to return to Gambaga for extensive surface survey and excavation as well as collection of ethnographic and oral tradition relating to the iron industry was taken by me.

Description of the Area

The Gambaga Escarpment lies in the northeast part of the Northern Region of Ghana. It is one of the outstanding relief features in Northern Ghana (Map.1). By

Northern Ghana is meant the present Upper and Northern Regions. This area exhibits a basic geographical, economic, cultural and linguistic unity at least in contrast with other parts of Ghana. The escarpment marks the northern limit of the Voltaian sandstone relief zone of Ghana which trends from East to West and is bounded on the north and south by scarps (Dickson and Benneh 1977:18). The north facing scarp rises sharply from the bed of the White Volta at sea level to a height of 520 metres above sea level 8 kilometres north of Gambaga. To the south the land slopes gently towards the Nasia river (Map 2).

Basically, the Gambaga Escarpment is made up of horizontal layers with the Voltaian sandstone forming the basic rock. The Voltaian sandstone is composed of gently-dipping or flat-bedded sandstones, shales and mudstones which, generally speaking, are easily eroded. The result is an almost flat extensive plain which is between 61m and 152m above sea level in that part of the basin south of the West to East flowing Black Volta and up to 183m above sea level in that part of the north of the river (Dickson and Benneh 1977:18). Thus towards the Southeast and Southwest margins of the escarpment, the land is periodically flooded by tributaries of the Nasia, Oti and Volta Rivers. The topography of the land on which Manprugu is located is marked by considerable local diversity from the flat plains along the Volta near Janga to the rugged sandstone ridges that runs southward from the Gambaga Escarpment. Such variations in altitude produce small but significant climatic differences. Grain harvests occur much earlier in lower-lying sections and rice and tobacco are cultivated in the riverine marshlands (Brown 1975:11). Such differences in agricultural productivity area reflected in the local market systems.

The importance of understanding something of the geological character of a region relates to the available rock and type of soils that develop from the parent-rock. Soils are a critical factor in the determination of vegetation cover and land use patterns and as such provide the archaeologist with some indications of settlement potential. They are also important in the identification of source areas for the differing clays used in pottery making so that the more detail available about the various soils in a region, the more accurate these identifications can be (Kense 1981:71). Unfortunately, examinations of the soils in Northern Ghana (interior savannah zone) is considerably less well known than for the remainder of the country (Brammer 1962:105) so that a "finely tuned" differentiation of soils is not yet possible (Kense 1981:71). Brammer distinguishes two major soil groups among nine types identified in Northern Ghana - the Savannah orchrosol (as red and brown, well-drained, friable, porous and loamy soils) and the Groundwater laterites/Ochrosol-Groundwater laterite intergrades (brown to yellow and grey silty or sandy). The Gambaga Escarpment is located in the former (Map 3). In all cases the soils are poor in organic matter and in nutrients. They are sometimes very acidic (Dickson and Benneh 1977:44). Throughout the region, there are laterite deposits often dotted among the other soils or lying at shallow depths below the surface soil or as surface outcrops. These are difficult to cultivate but their value for use in building houses (mixing the gravel with clay soils produces a lasting wall material) for flooring rooms and courtyards; (it is spread and then compacted by dampening and pounding), road construction and as a source of iron ore, the basic raw material needed in iron production, is immense.

The climate of Mamprugu is part of what has been distinguished as the Tropical Continental or Interior Savannah (Dickson and Benneh 1977:34). It has a single rainy season from mid-April to October with the peak from June to September. The rest of the year is absolutely rainless apart from occasional localized storms. Rainfall averages a little over 1000mm per year. Mean monthly temperatures vary from about 36°C in March to about 27°C in August. Relative humidities are high during the rainy season (70-90%) but may fall to as low as 20% during the dry season (Dickson and Benneh 1977:34).

Two large air masses are alternatively responsible for providing Northern Ghana with its weather patterns. The Continental Tropical air mass flows down from the Sahara and is hot in summer and cool in winter but always dry while the Maritime Tropical air mass is cooler but moisture laden (Dickson and Benneh 1977:27). As the belt of the ascending air (known as the Inter-Tropical Convergence Zone, ITCZ) into which these two masses flow, shifts north/south on annual cycle in response to wind and air pressure patterns, Northern Ghana comes under the influence of the two masses. From about May to October when the ITCZ is well north of Ghana, conditions are generally cloudy and cool with period of heavy rains, while November through March is a period for the harmattan with the shift of the ITCZ to Southern Ghana. This is characterized by dust and high temperatures between 30-40°C may be recorded during day time but may fall to as low as 10°C at night. Humidity comes down to 5-15% (Barker 1985:9).

The long dry season is the time for festivals and brings leisure and suitable weather for craftwork. Most funerals (for people who die during the rainy season) in the area are held in the dry season because there is not only the time but, more importantly, there is plenty of food available. Other dry season activities include the construction of new houses, re-roofing and maintenance of old ones. There is a marked difference between the humid tropical pattern of climate with two rainy seasons a year that prevails in the south and the single rainy season regime of the north. It is not only the amount of rainfall which is low but it also fluctuates. These fluctuations, which cannot be predicted, can create problems for the farmer. Unexpected prolonged dry spells may cause either complete crop failure or a reduction in crop yields. On the other hand, too much rain in a particular month or year may damage farmers' crop.

The vegetation type found over much of Northern Ghana is generally classified as Guinea Savannah Woodland or Interior Wooded Savanna (Dickson and Benneh 1977:37-8). Both suggest the mixture of grasslands and wooded areas and form a band between the forest to the south and the Sahel to the north (Map 4). Large trees which stand scattered on the escarpment include the baobab (Adansonia digitata), "dawadawa" (Parkia clappertoniana, or Locust bean), shea nut tree (Butryrospermum parkii), silk cotton tree (Ceiba pentandra) and a variety of Acacia species (Lane 1962:165-6). Others include mango (Mangifera indica), Fig tree (Ficus sp.) and mahogany (Khaya senegalensis).

Trees are very valuable natural resource to the people in Mamprugu. Many large trees especially silk cotton trees near settlements, are favoured and protected because they provide shelter from the sun and serve as focal points for family and community meetings and activities, shade for markets, reception for visitors and relaxation, thus becoming an integral part of the daily life of the people. Most trees are burnt into charcoal or used as fuel for cooking, blacksmithing, shea butter preparation in addition to providing rafters, beams, building poles and sticks for constructional purposes that range from houses, market stalls to kraals. The carvers also fashion a variety of items which include mortars, pestles, handles, stools and walking sticks from the wood of many trees.

The ground flora of the vegetation consists of an apparently continuous layer of grass some species of which reach a height of 3 metres (Lane 1962:165). A variety of grasses, including the tall elephant grass, are used for thatching houses and farm shelters and for making baskets, hats, and mats. When the grasses dry during the dry season, they become highly inflammable. Much of this is burnt off so that the vegetation appears to undergo drastic changes between the rainy and dry seasons (Kense 1981:77). The annual fires which sweep through the area have given rise to trees which are fire-resistant often characterised by possession of thick gnarled bark and ability to reproduce from dormant buds. After the fires have been set, fruit trees like "dawadawa" and mango produce new leaf, flower and bear fruits. A lot of trees growing in the wild also bear fruits during the dry season. These are gathered for sale in the markets. There is an enormous amount of local knowledge about the uses of trees and other plants cultivated or growing in the wild as sources of food, medicine, gum, rope, bark, fuelwood, building materials, tools, craft objects and musical instruments. Aspects of these as they relate to iron working will be discussed in Chapter Five.

The vegetational formation of Northern Ghana is largely man-made as Dickson and Benneh (1977:37-40) have observed. The traditional annual bush burning has combined with large scale tree cutting, livestock grazing, and over-cultivation to produce an open vegetation that can no longer regenerate itself. The high vegetation density of the Gambaga Forest Reserve, sacred groves near the villages, and near river and stream valleys, where there is a restriction on the use of forest products and cultivation prompting a reduction in the forest take-off, points to the potential of this zone for regeneration and parkland development.

The present-day occupants of the Gambaga escarpment seem well-adapted to the environmental conditions prevailing. The vast majority of the people are involved in agricultural production as their main productive activity. Estimates indicate that about 90% of all the male in the region are involved in food production. The main crops grown include grains (millet, guinea corn, maize and rice as a recent development in the flat river plains along the Birimi and Nasia rivers), legumes (groundnuts and beans) and roots (mainly yam). Sheep, goats, pigs and innumerable chickens, pigeons and guinea fowls are kept by most households while wealthier people own cattle and village chiefs or their sons own horses. The donkey has since a decade ago become a very important beast of burden in Mamprugu. Domestic animals constitute material wealth, the repository of labour and thrift. Some are sold to raise money for emergencies or other purposes. Where there is trade in animals, it is conducted by men. It is their preserve. They also own most of the animals. Most of the these animals are also the principal objects of sacrifice by means of which the people maintain their relations with their ancestor spirits and other mystical powers. In Chapter Five we shall examine the role domestic animals play in rituals connected with blacksmithing.

Specialized traditional occupations include spinning, weaving and dyeing of cloth, blacksmithing, wood carving and leather tanning. Others include the more "open" ones like brewing of pito, making of shea butter, soap, baskets, mats, rope and grinding stones. Trade is more or less an extension of the duties of women. Village markets, occurring every 3 days, facilitate, the circulation of goods between specialized occupational groups and between the people on the escarpment and those in the lower lying areas to the north and northeast. Although pottery is commonly used, the main sources of pots are from Kusasi and Konkomba settlements nearby.

The traditional Mamprugu economy relies on a broad base of a number of different activities, that albeit, with varying economic importance supports and complements each other. Crop agriculture, pastoralism, hunting and gathering, weaving, leather tanning, blacksmithing (which is examined in much detail in Chapter Five) wood carving and trade are all major branches of this economy with crop production being the most important today. However, unreliable rainfall, improper management of soils, deterioration and exhaustion means that the agricultural component is never secure and even a combination of agriculture and other activities does not always achieve economic security.

Much of the protein supply of the communities has been derived from game animals. Currently, hunting and trapping are only part-time occupations and are confined to both large and small game. Traditions that I recorded indicate that the environment has such animals as elephant (Loxodonto africana), leopard (Panthera pardus), buffalo (Syncerus casfer), baboon (Papio anubis), patas monkey (Erythrocebus patas) and antelope (Hippotragus equinus) among others. Many of these are still hunted. Modern hunters, however, complained of a decline in the game population. For example, reference is made to the antelope as being very common some few decades ago but now comparatively scarce.

Small game normally hunted include squirrels (Heliosciurus spp), grasscutter (Thryonomys swinderianus), duiker (Sylvicepra grimma), hare (Lepus zechi) wild guinea fowl (Numida meleagris), bush tailed porcupine (Antherurus africanus), giant rat (Cricetomys gambianus) and game birds.

Other economic activities include fishing which is carried out by Ewe, and Hausa fishermen who have settled on the Nasia and White Volta river banks. These specialists carry out their activities throughout the year. They use nets, and hooks or special fishing baskets. The fish caught is mostly sold smoked like game meat. A fair amount of activity still results from the collection of wood for fuel, charcoal burning and gathering of fruits both cultivated and from the wild.

The population on the Gambaga Escarpment is culturally and linguistically heterogeneous (Brown 1975:11). According to the 1970 Ghana Population Census Figures, the Mamprusis (one of the dominant ethnic groups in Northern Ghana) represented the dominant group. They formed 55.8% of the population of 125,350. Census data for 1984 do not include figures for ethnic groups but it is likely that the Mamprusi would form a greater part of the population of 141,742 recorded. The minority groups are the Bimoba, and Konkomba who comprise strong minorities in the eastern areas, while Frafra, Tampolensi, Busanga, Kusasi, Akan and Ewe are

---

[1]. Source: 1970 and 1984 Population Census, Census Office, Accra.

scattered throughout the area. Although the other ethnic groups maintain some independence in both cultural and economic activities, the Mamprusis provide holders of chiefly authority within the traditional system. All the ethnic groups, however, exhibit certain related cultural features despite the general differences that there are. Social organization is centred around the local partrilineage which acts as the basic corporate unit in Mamprugu society. Social cohesion is great among the people.

Broadly, three different kinds of religion are found to be practised in Mamprugu namely, Traditional African religion, Islam, and Christianity. A survey by Barker (1986:112) indicated that 85% of the people follow traditional religion, 13% are Muslims and 2% are Christians. Like the Akan, the Mamprusi also believe in a deity called Wuni as the Supreme God and creator and is used as the name of God by both Muslims and Christians, but in traditional religion the name is scarcely used except in exclamation and no worship is connected with it.

Research Goals and Methodology - Archaeological Survey

The first surface reconnaissance survey on the Gambaga Escarpment was undertaken in July-August, 1987. The aim was to examine the archaeological evidence which was pertinent to this enquiry. It was to assess the archaeological potential for the Gambaga area to produce sites that would yield significant data on the smelting activity that went on in this area in the past, so that by excavation of a number of the sites, the greatest possible evidence of the iron smelting technology could be obtained. On the basis of the promising results from this preliminary survey, more subsequent detailed surface surveys were carried out from February to June, 1988. The spatial distribution and location of the iron smelting sites and the sources of iron ore for smelting were among the goals the archaeological survey sought to investigate.

The Mamprugu region is much too large for me to accomplish an area of research larger than the one chosen given the difficulty of the terrain in several areas on the upper reaches of the scarp, the time and funds at my disposal. Instead, it was decided to limit the survey to an area approximately 48 km^2 that straddles a portion of the Gambaga Escarpment (Map 7 also see Map 2). The area is bounded on the southeast by the town of Nalerigu. The town of Gambaga was initially supposed to have been the southwest corner of the area but information from residents interviewed led to the discovery of several smelting debris in an area located about 3 km to the southwest of Gambaga.

It became evident that the large nature of the survey area would make it difficult to accomplish this aim using formal sampling techniques within a few short months when there would be no rainfall and vegetation cover would be low enough to facilitate surface observation.

The identification of the smelting sites was on the basis of smelting debris - slag, in-situ structural furnace remains, furnace wall fragments and tuyere pieces. Thus it is pertinent at this juncture to discuss the distinguishing characteristics of an iron production site. The evidence for ancient iron smelting can take several forms but slag is a basic index since every iron smelting process produces slag - the remains of the iron ore after it has been subjected to high reduction temperatures. The slag evidence may not necessarily be in the form of huge mounds but may also occur as low heaps or as visible surface scatters, since as we shall see below, erosion agents like running water and physical/biological disturbances like ploughing, road, school, house and dam construction by man, affect the preservation of the debris. The slag mounds may have remains of furnaces standing or projecting to various heights above the mound surface around the edges or on ground away from the slag accumulation. On the other hand, the furnace may be completely buried below the heap and may be recovered through excavation. The disintegrated pieces of furnace wall material and broken tuyere pieces may be mixed with the slag material indiscriminately, or lying about on the surface.

The ability to turn iron ore into a workable iron material is a complex technological process as we noted in Chapter One and it is quite distinct from blacksmithing. Not all societies in the past possessed this technology but almost all iron age societies in Ghana used items made from iron. This distinction is necessary because the mere presence of iron objects in an archaeological survey or excavation does not by itself automatically imply that the occupants of the site smelted iron. Even the presence of small quantities of slag in the excavation should not immediately be construed to represent iron production. This is because it might well be waste product from forging iron in the blacksmith's workshop.

Other pointers to iron smelting include abandoned mines with open shallow pits, vertical trenches or underground tunnels from where the ore was obtained. The evidence of rock drawings showing people with iron has been named as a feature for ancient iron smelting by Diop (1968:10), but this has a limitation. It may be very deceptive since like the presence of iron objects, all by itself, rock drawings are more representative of iron use, the actual production likely to be the work of other groups who possessed the technological skill.

Locating the Smelting Sites

For my first field work in July-August, 1987 and also in subsequent seasons in 1988, I located quite a number of the smelting sites primarily with the aid of local informants. These were derived from interviews conducted with farmers, hunters, charcoal burners, forest reserve guides, gatherers of fuel wood and fruits, herbalists, blacksmiths, teachers, traditional rulers and muslim leaders in the towns, villages and hamlets in the area of investigation. They were asked if they knew of any smelting sites on or near their area of activity in the bush which they would be willing to show me. From this it became evident that these people especially the farmers, were much aware of even the small quantities of slag and smelting debris on their lands.

The main survey technique used involved walking with three field assistants along the numerous paths and tracks that transect much of survey area and more importantly along the banks and in the basin of the main rivers and seasonal water courses. Since accessibility and visibility were important in the walking survey, I did most of it during the dry season when the grass was low or had been burnt over large expanses of land making it possible to see the sites from distances away and also facilitating a better study of the shape, height of the furnace remains and the slag accumulations. Survey in the rainy season, I realized, was not too productive compared to the dry season since the grass undergrowth made it virtually impossible to locate surface features of prehistoric smelting activity.

<u>The Survey Results</u>

At the end of the survey, a total of 122 known places of iron production in the research area consisting of one or several smelting furnaces were recorded in addition to 2 places of iron ore extraction. For purposes of facilitating a better discussion of the results from the investigation, the survey area has been subdivided into five arbitrary zones. This would also make for easy identification and location of the individual sites in addition to making it possible to compare and contrast the areas on the basis of the variety of evidence from the investigation. The sub divisions are as follows:-

(i) Zone 'A' or Gballa zone comprising the abandoned Gballa village settlement site and the forest reserve located to the south and southwest (Map 7).

(ii) Zone 'B' comprises the sites in the basin of the Fulani Kuliga seasonal water course. Fulani Kuliga is one of the tributaries of the northwest-southeast flowing Gambaga Kuliga river.

(iii) Zone 'C' consists of all the sites found on or near the main Gambaga - Nalerigu road.

(iv) Zone 'D' is made up of the sites along the Birimi river basin, from the Dam site to the headwaters.

(v) The last Zone 'E', is located approximately 3km south-southwest of Gambaga.

A breakdown of total sites recorded gives the following figures for the five zones 'A', 22; 'B', 15: 'C', 9; 'D', 63 and 'E', 13. As can be observed from the map of the survey area (Map 7), Zones 'A', 'B' and 'D' are located in Forest reserves where farming activities are prohibited. This might account for their higher figures since most of the sites can be preserved unlike those in the farming areas where Zone 'C' is found. For each of the sites, height, width and length of the slag accumulation were directly measured using a metric tape. The nature, extent and possible type(s) of surface disturbances that have affected the sites were also noted. The surface of the sites were carefully examined for cultural materials and iron working tools. Apart from pottery, which was the commonest surface cultural material recovered from the investigation, not much iron objects were surface collected. What was found was one iron working tool picked from the floor of a mine pit in Zone 'E', and two clay smoking pipe stems from the surface of two separate mounds in Zone 'D'. Two iron ore mining sites were found, one each in Zone 'B' and 'E'. More will be said about these sites in the next chapter.

<u>The Disturbance and Destruction of Iron Smelting Sites</u>

One factor that promotes the rapid destruction of cultural materials, especially inorganic substances in archaeological contexts in Tropical Africa, are the acidic soils.

Not only are they hostile to items like baskets, textiles and leather but also to iron implements. The iron materials are attacked by rust which reduces them into very fragile objects. Slag on the other hand is generally believed to preserve better under these conditions but whether the heaps and accumulations, especially with smaller ones, can be preserved on the site forever undisturbed is a different issue. Past iron smelting activities are represented by the debris of which slag forms the greatest percentage. As already stated, a basic clue for the discovery of indigenous iron smelting is iron slag and smelting furnaces. The preservation of these debris on the surface of the land on which they are deposited is, therefore, of paramount importance to the study of African iron metallurgy. For this reason one fo the aims of the surface survey investigation was to examine the various factors which in one way or the other contribute to the disturbance or total destruction of smelting sites.

A number of human activities like ploughing and cultivation of land, road, building and dam construction and natural agents of water, erosion and landslides of river valleys were identified as serious factors that affect or alter the original state of abandoned smelting sites. They may completely eradicate the site from the land surface. Below the analyzed results of the investigation are presented.

Constructional Activities

Five slag mound sites forming 4.1% of the total surveyed had been affected by the above. Two of these had completely been graded away by the construction of the Gambaga - Nalerigu road. Since the road had not been tarred, evidence of the smelting debris could be found in the form of slag, furnace wall and tuyere pieces compacted on the surface of the road clearly marking the base and outline of the slag accumulation. A further evidence of the above form of destruction was found in the Forest Reserve to the north of Nalerigu where the construction of a road through the forest to the villages of Dintigi and Bukperi had reduced one mound to its foundations. For the mound SM.44, the construction of the Gambaga-Nalerigu road had not completely graded it away. Instead, the 9m wide road cut through the mound leaving part of the mound as road cutting on either side of the road (Fig.3). The discovery of this site was by the Director of the Gambaga Archaeology Project, Dr. Kense while we were driving along the road. What provided the clue was the distinctive vertical slag cutting with tuyere pipes and furnace wall pieces marking the surface (Fig.9a). This was later excavated and the results are discussed below. The final mound recorded to have been affected is SM.46 located on the plot of the Nalerigu Primary and Junior Secondary School. This has not been graded away completely, rather the top has been reduced leading to the spread of the slag over a large area. It came as a great surprise to the teachers in this school when I informed them that the evidence represented iron smelting activity carried out on the site. Immediately the Headteacher, Mr. Isahaku Assani, volunteered to lead me to a spot in the Nalerigu forest reserve where he once saw "a small round clay wall feature projecting on the surface of the ground near a heap of a similar material as this". This turned out to be furnace, Fig.43, which was later excavated and has been donated to the National Museums and Monuments Board Upper East Region, Bolgatanga (Plate 9).

Farming Activities

Twenty-Seven (22.1% of total) slag mound sites were recorded as having suffered from the above. As expected, these are found located in heavily cultivated farmlands in zones 'C' and 'E' and in the area covered by the ancient Gballa settlement in zone 'A'. The disturbance of smelting sites by farming activities took two broad forms. First, the surface of the mound had been weeded with the hoe. On the edges, however, there is ploughing all round sometimes picking up to c.50cm of the edge of the mound. This has led to the spread out of the slag increasing the diameter of the mound while reducing the height. Some farmers indicated that they normally transplanted millet from other parts of the farm to the mounds. Through years of experiment, it has been determined that corn or millet seeds planted on the mounds directly do not always germinate and in the case of corn the transplanted ones die off easily if they do not get rain water for just a week. Millet is more hardy and drought resistant. An explanation for this can be found perhaps from the point that iron slag absorbs so much radiation heat from the sun which results in the quicker drying out of the moisture in the soil matrix thus depriving the cultivated crops of the needed soil water. Trees, shrubs and other plants growing on the mounds were found upon excavation to have roots extending into deeper layers of the subsoil.

The second disturbance took the form of deep ploughing to a depth of c.30cm of the surface of the slag heap. Smelting debris are widely scattered on the surface. Where the original height of the mound ranged between 40cm-60cm or more the net result of the continuous ploughing is the reduction of the mound to low ridges of the same height as the surrounding farmland. Moreover, the smelting debris becomes so mixed up in the soil that it is very difficult to discover such sites. In fact, I relied on farmers to discover most of such sites.

The seriousness of farming activities on the preservation of the smelting sites was evident from the analysed result which showed that none of the 27 sites affected in this way had surface evidence of in-situ furnace remain on or near the mound as was found in the case of those in the Forest Reserve and uncultivated lands adjoining to river valleys. The only evidence of furnaces and tuyeres were the remnants and pieces mixed with the slag and the surface soil. Thanks to the creation of the Forest Reserve where there is a ban on cultivation of the land, there are some well preserved smelting sites although such sites suffer from the most dominant agent of the destruction of smelting sites, running water.

Erosional Activities of Running Water

The action of running water can be as destructive as that of ploughing. A total of 70 sites (that is 57.4% of the total) had been adversely affected by this agent of erosion. These are all located in the Forest Reserve. This takes several forms. First, running water had cut a gulley through the slag heap and carried away a chunk of the debris in the process. In the second instance, running water had eroded away the slag and debris around the edges of the mound gradually reducing the size of the mound. Furthermore, some mounds had about a third of the accumulation wasted into the river valley with the collapse of the valley wall after heavy rainfalls experienced in the past. The slag is therefore found sprawled from the edge of the valley over the slopes downward into the valley bottom. This erosion can be effective in destroying the remains of furnaces that were buried under the mounds or were placed away from them. The final form of water erosion is where an entire mound together with the furnace remains have been eroded and reduced to a thin widely spaced surface scatter of smelting debris. The top soil in the area has been washed away completely after years of erosion, exposing the subsoil on which the smelting evidence now lies. The effectiveness of the above erosional activities of running water is explained, firstly, by the sloping nature of the land over which the water runs from upper locations on the escarpment into the river valley and secondly by the loose nature of the smelting debris accumulation.

Relatively Undisturbed Sites

A total of 20 (17.2%) smelting sites were found to have escaped serious destruction. These were located in the Forest reserves in zone 'A' and 'D' on relatively flat land surrounded by thick vegetation cover or right under large trees. These provided most of the evidence of in-situ furnace wall remains projecting to heights c.5-20cm above the present ground surface.

Iron Smelting Furnaces - The Survey Results

A total of 101 in-situ structural furnace evidence were recorded at the end of the archaeological research. Ninety-five of these were visibly evident on the surface of the ground at heights that vary from c.1-48cm. The surface evidence took two forms.

The first was in the form of outlines of the furnace wall remain after the collapse of the superstructure (Plate 2). These are heavily filled in with soil, and rubble of furnace wall fragments and/or slag pieces. Seventy-five (that is approximately 75% of the total) of the 95 surface furnace evidence were found to be of this form. It was not in all instances that the complete circular or oval shape of the remnants were found on the surface. Some of the projections represented half of the complete furnace structure. To be sure of the presence of walls below the trowel was used to dig along the lines where the remaining one were suspected to be buried and in all cases these were exposed. Some of these were selected for excavation as in the case of Fig.12 (see Fig.11).

The second surface structural furnace evidence was in the form of slag lumps and columns projecting above the land surface without any visible evidence of wall outline surrounding them. These had very distinctive features in that they were cylindrical and tapering with smooth sloping sides resulting from attachment with the interior walls of the furnace, now completely destroyed and eroded away (see Plate 3). A total of 17 of such remains were recorded. The remaining 6 furnaces were recovered from excavation of smelting debris. Five of these namely, F1, F2, F3, F7 and F8, were found after excavating the entire mounds of SM.1 and SM.15 in zone 'A'. The sixth furnace, F4, was discovered during the excavation of a 1mx1m test pit that was located 8m away from a nearby slag mound SM.10 in zone 'A'. This unit was excavated to recover data for the reconstruction of the past of the now abandoned settlement of Gballa (see Appendix I). It formed a separate aspect of the Gambaga Project.

Since most of the smelting sites were located close to river valleys, the furnace remains on these sites have been affected by the action of erosion. This is more pronounced in zone 'D' along the Birimi Valley where erosion is evident on the sloping lands adjoining the river valley on which the sites are located. In several places, the surface soil has been washed away exposing the subsoil. Furnaces and slag heaps on these lands are accordingly affected. It was, therefore, not surprising that all the 17 purely slag-column-furnace evidence were found in this area.

In terms of the location of the furnaces in relation to the mounds, the field data indicated that of the 95 surface evidence of furnace, 15 were located on the mounds; 69 were located either right on the edge of the mound or placed within distances up to 4m. Five others were located between 6-10m. The Gambaga evidence, therefore, showed that furnaces on smelting sites are not only likely to be found buried below debris without trace but also on the surface of the heaps, at the edges or at distances that can extend up to 10m away from the slag heap. This evidence was also depicted in the furnaces recovered from the excavation of slag heaps. As already stated above, three furnaces F1, F2, F3 were found in the excavation of SM1. F1 and F3 were exposed close to the edges of the mound, with F2 placed near to the centre (Fig.5). In the case of SM.15, the two furnace remains were located to the northern edge of the mound. None was found in the other parts of the mound (Fig.6).

What is the relationship between the total number of smelting sites and the number of furnaces recorded from the investigation? If we should assume that every slag mound is the result of smelting activity carried out in one or more furnaces then we should expect at least equality in the totals of furnaces and slag mounds recorded. The method adopted in the investigation was to compute only visible structural furnace remains. This would permit an objective presentation of the survey results while enabling us to examine the effect of on-going socio-economic activities and natural agents like weathering and erosion in the destruction of the archaeological record on the iron smelting sites. On this basis, only 43% (that is 52 sites) produced surface evidence of furnace structures. The break-down is presented in Table 1 below:

Zone	Total No. of Slag Mounds Recorded	Total No. of Furnaces Recorded	Average
A	22	12	1.8
B	15	15	1.0
C	9	-	-
D	63	63	1.0
E	13	5	2.6
TOTAL	122	95	-

Table 1: Furnaces Recorded in the Individual Zones

From the table certain features are evident:

(i) Zone 'C' yielded no surface evidence of furnace structural remain.

This is obvious since it is located in a farming area with evidence fo

(2) To determine the variety and nature of cultural materials that compose the slag mound.

(3) To obtain charcoal samples for dating.

(4) To determine whether any furnaces would be found buried in the slag mounds especially where the surfaces had been disturbed extensively. This goal was based on the assumption that furnaces whether preserved or destroyed existed where there were slag accumulation that can be determined to have resulted from iron smelting activity. The investigation was aimed at verifying the presence of furnaces in the slag heaps.

(5) Linked to this was the desire to determine the number of furnaces in the mounds and to relate the number to the sizes of the mounds.

<u>Methodology</u>

The surface of the mounds to be excavated were thoroughly examined for any evidence of surface materials like pottery, smoking pipes, bangles, rings and tools of iron or any other artifacts. The vegetation growing on the surface of the mounds and in the immediate surroundings were cleared with the aid of cutlasses or pulled out where they were likely to disturb the mound. This surface clearing was done in a careful manner to avoid any serious disturbance of any suspected features on the mound. All large slag pieces that were likely to obstruct the excavation process, furnace wall pieces and fragments of tuyeres were collected and gathered separately. In the case of furnace and tuyere fragments, the excavated remains were also examined closely for their forms and features like rims in addition to measuring their

extensive ploughing and levelling of slag heaps. Some of the sites have been graded away altogether during road construction. This shows how serious the effect of farming and constructional activities can be as far as the disturbances of smelting sites are concerned.

(ii) Zone 'E', in a farming area produced a fairly high average of one furnace for every 2.6 slag mounds perhaps because the sites were located far away from the modern settlement in an area with lots of surface outcrops of laterite rock. A higher number of surface evidence of furnaces could have been found in zones 'A' and 'B' but for the location of most of the smelting sites on sloping land near river valleys where erosion is very effective.

(iii) Zones 'D' and 'E' produced 63 and 15 furnaces from a total of 63 and 15 sites respectively. This immediately creates the impression that every single mound in the area had one furnace. This is not supported by the evidence available. The true situation is that some slag mounds produced more than one furnace evidence while others did not have any such evidence at all. The evidence might be buried under the slag mound or completely destroyed without trace on the surface.

What is the total number of furnaces actually in use in the survey area? This could best be determined with evidence provided by the excavation of a greater number of entire smelting sites and all the furnaces buried or located away from the slag heap. Moreover, most of the sites which had been graded, eroded or ploughed had lost their furnaces. If we assume that every single slag heap is the product of smelting, using at least one furnace, then the furnaces would be 122 (that is by multiplying the total smelting sites by one). However, the excavations of SM.1 and SM.15 shows that more than one furnace can be involved. This is corroborated by the structural remains of furnaces found on the surface of the sites. As many as four furnaces were counted for some sites on the surface (excluding those buried under the slag heaps). While more concrete excavation results are awaited, a conservative estimate of 370 furnaces (computed by multiplying the total smelting sites by a mean figure of 3 furnaces per site as well as making allowance for a minimum of unrecorded sites in the area surveyed) is suggested by the available archaeological data.

Excavation of Slag Mounds

The total area of excavation of slag mounds was 276.3m^2. Out of this, 216.7m^2 was made up of various excavation units undertaken on selected mounds (see Table 5). In all 8 mounds were excavated and these formed 7.4% of the total number of slag mounds recorded in the surface survey. The remaining 59.6m^2 area consisted of units excavated on smelting furnaces located on grounds away from the slag debris.

The aims and goals for the excavation were as follows:

(1) To obtain an idea of the actual depth of the mounds. That is, to ascertain whether the smelting debris were dumped into a hole or pit specially dug or one from which clay soil was collected to build furnace and other units or on the flat land surface.

(2) To determine the variety and nature of cultural materials that compose the slag mound.

(3) To obtain charcoal samples for dating.

(4) To determine whether any furnaces would be found buried in the slag mounds especially where the surfaces had been disturbed extensively. This goal was based on the assumption that furnaces whether preserved or destroyed existed where there were slag accumulation that can be determined to have resulted from iron smelting activity. The investigation was aimed at verifying the presence of furnaces in the slag heaps.

(5) Linked to this was the desire to determine the number of furnaces in the mounds and to relate the number to the sizes of the mounds.

<u>Methodology</u>

The surface of the mounds to be excavated were thoroughly examined for any evidence of surface materials like pottery, smoking pipes, bangles, rings and tools of iron or any other artifacts. The vegetation growing on the surface of the mounds and in the immediate surroundings were cleared with the aid of cutlasses or pulled out where they were likely to disturb the mound. This surface clearing was done in a careful manner to avoid any serious disturbance of any suspected features on the mound. All large slag pieces that were likely to obstruct the excavation process, furnace wall pieces and fragments of tuyeres were collected and gathered separately. In the case of furnace and tuyere fragments, the excavated remains were also examined closely for their forms and features like rims in addition to measuring their

thickness. For the furnaces, this helped in the estimation of the height of the collapsed superstructures.

Two excavation techniques were adopted in the field to achieve the above stated goals. The first involved the excavation of the entire mound. Four mounds were excavated in this way. The second involved cutting trenches of different dimensions across the mound with some running close to the crest. The excavations were controlled vertically by the changes in soil layers that is by peeling the layers rather than cutting through them. This was used to enable us follow the natural sequence of deposition and to derive an idea of the material remains and debris that composed the different layers. Attempts to sieve the excavated material met with serious difficulty as the slag and other debris made it impossible. This idea was, therefore, dropped and the hand trowel was used together with short wooden handled hoes and pick axes to carefully excavate, and search through the rubble to recover materials. The pits were dug until the natural sterile layer was reached. Below, a brief description of some specific sites has been presented with diagrams and plates as a way to describe further the excavation of the mounds.

<u>SM.1</u>

An 8m x 8m unit was set on the mound. This was further divided into 4m x 4m quadrants namely SW, SE, NE and NW (Fig.5). This sub-division was devised to impose some control on the excavation while facilitating an easy identification of the locations and provenance of the furnaces or any other cultural materials recovered. A datum point was fixed at a spot in the central part of the mound. A baulk of

30cm was left separating the northern quadrants from the southern ones. This made it easy to identify the changes in the soil layers while the excavation progressed. It also facilitated the drawing of stratigraphic cross sections running almost along the crest of the mound. To provide a quick idea of the presence of structural furnace remains, c.20cm of the top layers in all the quadrants were carefully excavated. This was fruitful since one furnace each (F1, F2, F3) was discovered in three of the four quadrants in the process as shown in Fig.5. The individual quadrants were then excavated one after another until the sterile layer was reached. While the excavation went on all furnace and tuyere wall pieces were sorted out and grouped separately. These were later closely examined for evidence of furnace and tuyere rims. Their wall thickness were also recorded and related to the structural remains. These are further discussed when we treat the excavation of furnaces in Chapter Four.

SM.15

A 5m x 6m unit was laid on the mound (see Plate 4). This was subdivided into four parts each measuring 2.5m x 3m. The quick excavation of the top 20cm of slag did not reveal any furnace structure. The two furnaces exposed were found in the northeast and northwest quadrants (Fig.6). This was after the excavation of c.75cm of the 90cm high mound. Lots of concentrations of furnace wall fragments and slag were encountered in the excavation but these turned out not to be structural furnaces. Neither were bases of collapsed furnaces found in the southern quadrants. The two recovered structural evidences were in all cases the remains of round bases of furnaces (F7, F8). More is said on these in Chapter Four. Tips of tuyeres, all coated with slag, were recovered from the excavation just as in the excavation of SM.1. The interesting thing is that some of the tuyeres were found near the furnace remains. The only two pipe bowl fragments from a total of four pipe remains obtained from the investigation were recovered in the northwest quadrant near the furnace remain, F7.

SM.16

This is located some 11m from SM.15. Placed some 2m to the north of the mound was a furnace structure projecting on the surface of the ground to a height of c.15cm. The excavation of this mound was conceived of after F9 was revealed as one of the spectacularly preserved furnaces recovered during the research period (see Plate 11). As has been elaborated in Chapter Four, after dissecting the furnace into approximately equal parts in order to examine the content it was found that the internal part of the furnace was completely occupied by a slag lump (Fig. 15a). Considered that this might indicate archaeological evidence of an aborted smelt, it was decided to excavate the associated mound to see if there were any furnaces buried inside the slag rubble and if there were any to determine the circumstances leading to the abandonment. This would also reveal whether an abandoned furnace was declared a spot where slag was deposited leading to the eventual burial of the furnace remains. Another aim was to recover all furnace wall remains and tuyere pieces, the former to help determine the height of the furnace wall thickness, the form of the rim and the latter to know the type of tuyere used in the smelting process.

A $3m^2$ unit was laid on the mound. This was subdivided along the North-axis into two units each 1.5m x 3m. This was done to enable an easier drawing of the stratigraphic cross section since the division line virtually cut through the crest of the mound. No furnace structure was found. While no pottery was found on the surface, the excavation yielded only 2 pieces.

<u>SM.27</u>

Although this smelting site was located in a Forest Reserve, encroachers had established farms some 100m to the south away from the site. For this reason it is quite obvious that in the not too distant future the whole area would be ploughed. After surveying the site carefully and plotting in the various features, it was decided to excavate one of the two furnaces located on grounds away from the slag rubble inside the eastern loop of the arc-shaped slag mound. After excavating the furnace, two trenches were laid all to the eastern part of the mound (Fig.7). Trench 'A' (5.8m x 2m) is basically an extension of the south wall of the $3m^2$ unit excavated around the furnace. The excavation recovered lots of charcoal mixed with the slag and other smelting debris. Some five pieces of pottery were also recovered. Getting nearer the northern part of the trench where it runs into the south wall of the unit on F.26 less but larger pieces of slag were encountered with typical flow structure mixed in sandy soil which had a high concentration of tuyere fragments and wall remains.

The excavation of Trench 'B' (2.5m x 2m) revealed that this part of the mound was composed of higher amount of tuyere remains than slag and furnace wall fragments. The tuyeres ranged from near-complete pieces to half sizes and others representing only the tips of the tuyeres. All the tips were heavily coated with slag. Lots of pockets of charcoal were encountered and most of these were near the tuyeres indicating perhaps that they were poured out of the tuyere holes or were attached to the tips of the tuyere that were extended into the furnace interior. In all, about 13 tuyere remains were found (counting was based on the slag coated tips). These were found to have been accumulated to a depth of 40cm from the surface. More will be said about tuyères from the investigation in Chapter Four. A close study indicated that only 6 pieces of furnace wall fragments were recovered from this unit which might suggest that this part of the mound was demarcated for the deposition of tuyeres removed from the furnace located a metre away.

SM.44

This is one of the two recorded sites which had been affected by road construction. As noted above, with the construction of the 9m wide road through the mound, what was left were remnants of the debris in the form of road cutting on either sides of the road. The base of the mound can still be found compacted on the surface of the untarred road (Fig.3). The following dimensions were estimated for the complete mound: Height, 1.5-2m; Length, 15m; Width, 10m. From the above figures it can be seen that the road cleared more of the mound to the southern part than the northern part. Moreover, the slag remains to the south of the road have been attacked by water flowing through the drain along the sides of the road which has cut away large portions of the smelting debris. On the other hand the vertical face of the 4.5m wide slag remain to the north of the road had clay tubes sticking out as can be seen in Fig.9a. The selection of this mound for excavation was to fully expose the tubes to determine whether they were remains of bellow pipes connected to in-situ structural furnace remains buried in the slag or were tuyeres. Principally, however, it was to salvage the remaining archaeological data on the iron smelting activity which the destroyed mound represents before the entire remains are cleared away through a possible expansion of the road in future (see Plate 5). The clay tubes were found to be the broken tips of tuyeres all encrusted with slag. No structural remains of furnaces were found. These might have been destroyed by the construction of the road.

SM.47

It is located on farmland. The land surrounding it has been ploughed extensively. Weeding and cultivation of bean and millet has been going on for years on the surface of the 1m high slag mound according to the farmer working on this farmland (Plate 2). An examination of the surface did not provide any evidence of actual furnace structures except for wall fragments. These were scattered especially around the eastern side where the nature of the accumulation of wall pieces might be a strong indication of one or several furnaces that were located some few metres away from the slag heap now destroyed as a result of years of ploughing. A large quantity of these pieces as well as those of the surface of the mound which included tuyere fragments were gathered and studied. Surface collection of pottery and iron ore pieces were also made.

A trench (A) 1m x 15m, trending east-west was cut across the southern part of the mound (Fig.4b). It cut through an area with a large concentration of furnace wall. The excavation yield a lot of pottery, a few wall and tuyere remains in the top soil that had a dense concentration of slag. Roughly at the centre of the trench, an area of heavy concentration of furnace wall pieces and few tuyere fragments was encountered. This started at a depth of c.50cm below the surface and became more plentiful in the next layer up to 80cm. Almost all the sizeable wall and tuyere remains were gathered, examined and measured. It was assumed that the furnace remain might be found below or near the spot so another trench (B), 1m x 6.63m was cut at right angle to the southern edge of the mound. The heavy concentration of furnace wall fragments were found not to be laid on or near a structural furnace remain.

<u>Stratigraphy and Features - Slag Mounds</u>

An understanding of the stratigraphy of a site as observed through excavated section is crucial for a reconstruction of the conditions and nature of deposition (Kense 1981). The level of interpretation of the archaeological material is highly dependent upon an adequate examination of the stratigraphic record. The excavation of the slag mounds was by natural levels that reflects observable stratigraphic condition thus there was no difficulty in recognizing stratigraphic changes during the excavation.

The surface of the mounds were bare during the dry season and even for the early part of the rainy season compared to the surrounding land. Grasses which grow on the surface wither off quickly with the lack of water from rainfall. The few plants growing on the surfaces have roots that penetrate through the top soil to the lower layers or right into the clay subsoil upon which the slag accumulation lies. This perhaps should explain why corn would not do well since it cannot withstand long periods of drought. The loose nature of the slag accumulation, which as we noted above might account for the ease with which running water can erode the smelting debris, might also promote rapid percolation of rain-water through the top soil to the lower layers of the mound. With continuous deep ploughing, however, the slag and its soil matrix is mixed up with the soils on the farmlands so much so that this poor water holding property of the debris is eliminated or minimised.

There is the lack of humus layer (without slag or other debris) in all the sections except for SM.15 (Fig.8a). This humus layer is found not over the entire mound but concentrated in a thin layer on about half of the mound. It needs to be recollected that this is one of the few relatively undisturbed mounds which might explain this feature. For all the remaining excavated mounds, disturbance especially from farming activities is suspected or has actually occurred on them possibly accounting for the mixing up of the humus layer with the smelting debris.

The distinguishing feature of the section is the depiction of two basic soil layers, one natural and the other depositional (Fig.8 and 9). The top soil on all the sites had a heavy concentration of slag and other debris. The dark brown loamy soil becomes increasingly sandy with a corresponding decrease in the slag concentration until the natural layer is reached. The excavation did not stop at the exposure of this layer, rather, it was continued through to depths of c.50cm to ensure that there was no smelting debris below it. The fragments and pieces of tuyere, furnace wall and also pottery continued to be found throughout the excavation. An attempt was made to collect and gather as many of these as possible not only from the surface but also from the excavation. This method necessitated the exercising of the greatest caution in the removal of any furnace or tuyere fragment. This also retarded the pace of excavation but it paid in the sense that for most of the structural furnace remains found, the tops were exposed in the top soil. The three furnaces in SM.1 (F1, F2, F3) were uncovered together with a number of slag coated tuyere tips after c.20cm depth of excavation of the top soil in the four quadrants of the 8m x 8m unit. Their bases were, however, planted firmly in the clay subsoil as it was in the case of F7, F8 on SM.15.

Only two slag mounds had two layers of slag and smelting debris concentration whereas all the other had one as noted above. These are SM.16 (Fig.8c) and SM.47 (Fig.9b). This evidence might suggest that these witnessed two different periods of smelting activity. Evidence of pits, or hearth were not found in the stratigraphy. Charcoal and ash on the other hand formed a fairly common compound of each unit not as hearths or in specific concentrations but generally scattered throughout much of the slag deposit.

From the foregoing, the slag heaps were places for smelting debris, thus they contained slag, charcoal, ash broken tuyeres, furnace wall remains laterite and sandstone rock pieces and odds and ends such as pottery. It is appropriate, therefore, to attempt to assess the proportion of these various items on the basis of the excavated evidence (see Table 3). It may seem surprising that pieces of tuyere are more than the percentage of the furnace wall remains. This is due to the fact that although a small component of the furnace, almost every single smelt required the use of at least a new tuyere. The used ones were prised out of the tuyere inlet and dumped on to the slag heap being formed away from the furnace.

In fact the percentage estimate seems to be on the conservative side since parts of the tuyere especially the tips were fused and incorporated into the slag. The tuyere pieces tend to be more widely mixed in the stratigraphy. Most of the rest remained unbaked and were dissolved by the rains to be incorporated in the debris or washed away.

The furnace wall fragments in the mounds seem to have resulted from the collapsed furnaces after abandonment or fragments from parts broken and repaired while the furnaces were in use. It is not possible to carry this issue of maintenance further because there is a persistent vagueness in the literature on whether furnaces, in part or in whole, needed repair or reconstruction between smelts and some more elaborate examples were in fact used more than once. The mixing of the furnace wall material could therefore be accounted for by pieces left following maintenance or from the effect of past ploughing activity. In two of the excavations (Fig. 9b and 8c) concentrations of wall remains in slag debris were exposed at depth of c.50cm from the Datum line perhaps indicating a deliberate deposition of wall remains from the collapse and repair of the furnace while in use.

CHAPTER FOUR

FURNACE EXCAVATIONS, DESIGNS AND THE UNDERLYING TECHNOLOGICAL PARAMETERS OF THE GAMBAGA IRON SMELTING INDUSTRY

Introduction

This chapter focuses on the exterior and interior excavation of structural remains of furnaces. It also throws light on the variety of evidences and furnace types recovered. The tuyeres obtained from the excavation are analysed for their forms and functional significance and together with the data from analysis of ore and slag the technological practices represented by the smelting debris are examined. The other cultural materials like ceramic are presented. To conclude this chapter a brief discussion is presented on a number of shaped clay pieces which were obtained from the investigation.

Excavation of Furnaces

A total of 15 furnaces, representing approximately 15% of the total of 101 furnaces recorded from the archaeological investigation, were excavated. From these, 5 were exposed as a result of the complete excavation of mounds. The furnaces were buried under smelting debris without any trace on the surface. They are as already indicated above, F1, F2, F3, all from the SM.1 site and F7, F8 from the SM.15 site. One other furnace F4, was not buried under debris. It was exposed from the excavation of a test unit located 8m from the associated mound SM.10 in the Gballa settlement site in zone 'A'. Its discovery came as a surprise since there was no evidence of either fragments of furnace walls or tuyere pieces or structural furnace remains on the spot where it was found. Moreover, it was exposed at a depth of c.60cm below the surface. The test unit was not actually aimed at excavating a furnace; it was to recover cultural material for the reconstruction of the history of the Gballa abandoned site (Appendix 1). With the discovery of this furnace structure, the excavation was undertaken by my crew and myself during which the entire remains were exposed, studied and drawn.

The remaining 9 furnaces were selected from the surface survey. An area of 59.6m² was covered in the excavation of these furnaces.

Excavation Strategy and Results

Whether exposed through the excavation of slag mounds, or from a unit excavated on a structural evidence visible on the surface, the excavation and recovery of furnaces was very slow and challenging although the results were not only fascinating but also rewarding. Since one of the goals of the excavation of slag heaps was to recover furnaces buried, extreme care was taken in excavation although we were using pick axes, mattocks and digging hoes. The procedure of excavating in quadrants (in cases where entire mounds were excavated) was very useful since it enabled excavation work to be concentrated in one part of the excavation unit at a given time. Also as the excavation proceded it became clear that the first impression of a furnace structural remain could easily be mistaken for a piece of wall fragment to be removed like the many other pieces found in the debris. Extra caution was therefore taken in the removal of any piece of wall fragment.

When a structural remain was exposed in one quadrant the excavation was temporarily halted. The outline was drawn within the quadrant in the plan of the excavation unit on the mound. To ensure that the exposed furnaces were not unduly disturbed or destroyed by the excavation of the slag and other debris, a 60-100cm radius around the furnace was demarcated and left unexcavated and the mound excavation proceded to the sterile layer. All furnace wall fragments in the quadrants were collected and gathered for measurement of their thickness and for evidence of furnace rim design or form. With the remaining parts of the heap excavated to sterile, attention was then focussed on the furnace structures. The trowel and brush were the main tools used to carefully expose the furnace walls to its base. This strategy had three main advantages:-

(i) The pattern of deposition of wall materials and tuyere pieces around the furnaces could be seen in perspective. This was evident in the excavation of F3. On the Southeast side of the structure, near the slag tapping hole, was found a concentration of wall fragments. These were carefully excavated and after examining and measuring the pieces it was revealed that these were remains from the collapsed superstructure with all thickness similar to the existing structure but also with variation in the thickness between 6-8cm. This suggested that the furnace wall reduced in thickness with height.

(ii) The unit around the furnace could be excavated to depths below that reached for the other parts of the quadrant in which the furnace was found. The aim was to determine how far the furnace base was placed below the floor level of the slag accumulation. From the SM.1 excavation, the bases were reached between 20cm-40cm below the sterile level reached for the mound. This deeper excavation produced no slag (Plate 6).

(iii) The third advantage was that the soil material on which the furnace bases were seated could be examined. One of the three furnaces on SM.1, F1, was found to be standing on a layer of gravel that interestingly did not extend throughout the unit, but concentrated precisely at the base of the furnace. This might suggest that before the construction of this particular furnace the gravel was laid to provide a firm base for the structure. The two remaining furnaces in the same mound were placed on a clay soil.

We have so far described the excavation of furnaces that were buried inside slag debris without evidence on the surface. Before we examine further the nature of the remains that had survived after their abandonment, a brief description of some specific excavation units on furnaces that were not buried under slag but were located either on the edges of the mound or some distance away and were visibly evident on the surface is presented as a way to describe further the excavation of furnaces.

F9

This is located in zone 'A' of the survey area in the Forest reserve to the south of the Gballa village site. It was discovered as an in-situ structural furnace remain projecting c.15cm above the ground surface. It was placed some 2m away to the north of the mound SM.16 which was later excavated.

After recording its dimensions, a 2mx 2m unit was set on it. The excavation was carried out in a careful manner since all fragments of furnace wall were to be collected for analysis. More often than not the hand trowel was used to excavate closer to the walls in order to prevent the impact of the digging from affecting the structure adversely. All wall fragments gathered from the excavation were examined and measured and related to the thickness of the broken levels of the structure. While the latter measured 8cm, the majority of the collected wall pieces ranged in thickness between 4-7cm. This clearly indicated that they are fragments from the collapsed walls of the structure. The discovery of the furnace rim fragment provided a unique opportunity to determine the nature of the lip of the furnace.

F10, F11, F12

These were all found on one smelting site. They were located 4m to the north of SM.17 in zone 'A'. They were discovered after a thorough search had been made all over the site on which erosion is clearly evident since the land slopes into the valley of a stream placed 8m from where the furnace remains are. They were hardly visible on the surface of the ground since no slag was found on the spot where they were located. They projected to heights between 3-5cm above the ground surface. A 2.5m x 2m unit was set on them after the plan of the furnaces had been drawn (Fig.10). The excavation recovered a number of wall fragments and very few slag pieces. The furnace remains were revealed as lower bases of the collapsed furnaces as would be discussed below.

Details of Furnace Remains Excavated

The details of the features on the excavated furnace remains have been summarized in Table 6. A glance at the figures shows that some of the furnaces namely (F1, F2, F3, F4, F7 and F8), had nothing for their heights above the surface of the modern ground prior to their excavation. This is because they were completely buried without any trace inside smelting debris or in the case of F4, below the land surface. For the remaining furnaces (F9, F10, F11, F12, F26, F43, F44, F45, F46), there was evidence of the wall of structural remain of the furnaces projecting on the surface to heights between 1-24cm. F34 was hardly visible on the surface projecting only 1cm above the land surface and placed at a distance of 2m from the slag heap on the site. The almost bare landscape facilitated its discovery since not a single piece of slag was found on the spot of the furnace. These had been carried away by running water.

The furnaces excavated varied in terms of the height of the structural remains and features that have been preserved. A first group of six of the furnaces (F4, F7, F8, F10, F11, F12), were found to be in all cases bowl-like saucer-shaped furnace bases. These had external diameters ranging between 40-75cm along the longest axis and 40-60cm across. The depths measured from the collapsed height to the bottom of the bases was between 11-25cm. The walls were on the average 8cm thick on the broken heights (Fig.13 also see Plate 7). Apertures such as the tuyere hole and the slag hole were absent. The structure of the remains and the archaeological evidence on the other furnaces shows that the hole for the tuyeres were placed at a higher level on the shaft and so were lost with the collapse of the superstructure of the shaft which originally stood much taller. The sloping nature of the bases strongly suggests that the slag was led out of the furnace through a spout at the base of the furnace.

A second group of furnace remains (F1, F2), were found to be bowl bases like the first group but these had the slag tapping hole, always placed at the very base of the furnace, intact (Fig.14). The tuyere holes were absent since they had heights similar to the first group. Their diameters and wall thickness were also the same. A third group of structural furnace remains (F3, F9, F26, F43, F44) had both the tuyere and slag ducts intact (Fig.16 also see Plate 12). The external diameter and wall thickness of the this group is the same as the other two as is revealed in the table. On the other hand, the presence of the tuyere inlets on these remains means that a greater part of the shaft had been preserved since the tuyere ducts were measured to be placed at heights between 35-55cm from the furnace bottom. Excluding the heights projecting on the surface of the ground, these furnaces had between 50-100cm of their structure buried in the ground.

The last group of furnaces distinguished are (F45, F46). These displayed morphological features quite distinct from all the furnaces in the earlier groups (see Plate 10). Their walls measured 13-14cm on the broken heights. Their external diameters along the longest axis are 128cm and 144cm respectively and 91cm and 103 across. These had 10 air inlets radiating around their bases at height of c.30cm from the furnace bottoms. The preservation of the third and fourth group of furnace remains is often remarkable and the shaft of some of them are virtually complete. The reason for the spectacular preservation seems to be a combination of the robust bowl and shaft construction firmly implanted in the lateritic subsoil with subsequent filling and covering by alluvial soil or slag debris, the former only recently being reduced in thickness by further erosional process revealing the parts of the shafts.

The determination of the depths of furnace below the ground surface was facilitated by the method of excavating one half of the units to the base of the furnace at a time. Such deep excavation enabled other archaeological features to be seen in th stratigraphic across sections cutting as it was through the furnaces. A few specific examples should explain this further. From Fig.14, it can be seen that the basic subsoil in which the furnace bowls were planted are yellowish or reddish clay soils. However, the 15cm of more soil immediately near the furnace bases is a pinkish or reddish brown clayey soil compacted with a tendency to encrust the furnace base wall. This has been baked by the heat from the furnace walls. It is difficult to excavate with the hand trowel which is the most suitable tool for working close to the furnace wall in order to ensure a minimum of destruction or disturbance. Another problem with this soil is that since it has assumed a colour almost similar to the furnace wall, extreme caution had to be used in trying to separate the outline of the furnace wall from it during the excavation.

Furnace Unit Excavations - Stratigraphic Cross Sections

For all the furnaces excavated, sections were drawn of the four walls of the units. These revealed certain salient features that have been described below with the aid of specific examples (Fig.15). The top soil was dark brown humus or alluvial layer with lots of root activity. These often contained few charcoal and slag pieces and fragments of furnace wall remains. The latter are often found within close distances from the furnace remains. The units excavated were deliberately extended to between 1-2m from the furnaces to make room for excavation of the furnaces to their bases. This also made for easy photographing of furnace features deep in the excavation unit.

The subsoil was normally a reddish or yellowish red clay soil. It was compact when dry and sticky when wet; either way it was difficult to excavate. The bases of the furnaces are planted into this layer which ensured a firm support. It contained no charcoal, no slag and no furnace or tuyere remains. Cutting through this basic soil layer often in two contiguous walls was a very dark brown soil. This was sandy and loose thus easy to dig. It had a very high concentration of charcoal and ash. Few slag pieces were found in this layer. It extended to distances up to 2.5m or more from the mouth of the slag disposal hole which are placed on the opposite side of the tuyere hole. The location of this evidence on the side of the slag duct depicts an archaeological evidence of a roughly rectangular pit dug next to one side of the furnace base in order to collect the slag flowing out of the furnace. With a width of approximately 2m, this trench would have been wide enough for one man to go through to open a vent on the furnace, plug the tapping hole or collect the slag running out of the slag disposal hole. This pit evidence was not clearly found in the excavation of the furnace buried inside slag mounds. The relevance of this evidence would be discussed further when we examine aspects of the smelting technology that the archaeological excavation recovered.

Furnace Interior Excavations

Observations were made on the furnace contents to determine the nature and composition of materials that filled the furnaces at the top, the interior and the apertures. Surface observations revealed different materials like loose sandy or alluvial soil, broken pieces from the collapsed superstructure of the furnace, and slag pieces. Examination of the tuyere holes revealed that they contained soil mixed with slag and charcoal pieces. The slag was often in the form of small pieces or nodules that were easily mistaken for gravels. In none of the tuyere holes were pieces or complete tuyere pipes found. This might imply that the tuyeres did not break inside the holes or inside the furnaces. It might also suggest that whether the process was successful or not the seals were broken around the tuyeres and the latter removed from the air inlet.

The soil in the slag duct was also loose, sandy and very dark brown or black in colour. It had plenty of charcoal pieces larger than those found in the tuyere holes. The top c.20cm of debris in F9, F43, and F44 were mainly soil without any slag or furnace wall remains. These might be alluvial soil deposited by running water. It was below this level that wall remains and charcoal pieces were found. The former were all gathered together with those recovered from the excavation of the units near the furnaces. They were examined for their shapes and measured for their dimensions. The estimated of the smallest measured recovered wall thickness is found in Table 6. These represent the thickness of the upper parts and some are actual rims of the shafts (Fig.19). Together they provided very important clues for determining the approximate heights of the furnace shafts and the nature of the rim.

Apart from charcoal, slag and furnace wall remains, the study of the contents produced iron ore pieces. This was particularly true with F46 and might be the result of erosion from the surface of the site into the furnace remain. However, this explanation does not fully answer what was found in F45 in the form of lots of iron ore pieces together with numerous partially reduced chunks of ore and uncombusted charcoal. These were at the bottom and sides of the interior walls especially below the air inlets radiating around the furnace base. The condition of the ore could mean either that only a short period of reduction actually occurred during the operation or that much more ore was introduced into the furnace than it was capable of effectively reducing

The furnaces were also split vertically into two along their longest axis. These cut through the slag disposal and air inlet on the opposite sides of the furnace. One part was removed leaving the other half standing. This exercise permitted the documentation of the nature of the furnace interior and the positions of the content and the drawing of sections of the remains (see Plate 11). Furnaces (F4, F10, F11, F26, F44 and F46) contained no slag, only a few pieces of charcoal in clean sandy soil mixed with furnace wall fragments. Presumably, they had been cleaned out in antiquity ready for another smelt which was never in fact undertaken. It was difficult to determine the nature of the furnaces found inside slag debris since their content can easily be the result of infilling with debris from the heaps. This might not reflect the actual condition in which they were last abandoned. However, the evidence in the form of slag and charcoal pieces in a matrix of loose humus soil strongly suggested that these had been cleaned after the last smelt.

It was revealed that, from the interior, the bases of all the furnaces except for F45 and F46, had been constructed into a slope along the line of the air inlet through to the slag tapping hole with an adjoining platform. The slope is such that any molten slag that accumulated inside the furnace would flow out freely anytime the slag duct was opened. Thus the smelters deliberately constructed sloping interior base wall profiles to facilitate the smooth draining of the molten slag. These bases were found to be made of hard well baked clay almost indistinguishable from sandstone. There is no break in the continuity of the wall from the interior which is remarkable for its smoothness. It is this smooth continuous surface of the interior which introduces a perplexity when the construction of the furnaces is considered. The thickness of the wall thins out at the bottom of the furnaces from 8cm to 3cm. The furnaces might have been built of coils of fine grained daub. The interior might have been plastered with a thin layer of daub mixed perhaps with ash from wood, leaves, or roots to produce a hard and smooth surface material. Such a constructional feature and the thinness of the wall at the bottom of the furnaces might have technological implications that cannot be determined easily from the archaeological evidence.

Another unique archaeological find was in the form of discrete slag lumps firmly attached to the furnace interior and sometimes extending through the slag duct in a continuous form for distances away from the furnace. The furnaces that produced this evidence are F3 and F9 (Fig.10). It became evident early in the excavation that all structural features were to be saved. With this in mind no slag block was pulled out from any part of the unit without first cleaning and brushing the soil around it and examining it closely. The F3 slag mass was found to be overlain by a concentration of wall fragments near the base of the furnace near the slag disposal hole. Careful cleaning revealed that it extended from the slag duct and after splitting the furnace into two this was found to be stuck firmly to the interior floor of the furnace. Since the slag occupies the lower part of the furnace and not the entire interior, there have been problems with the interpretation of what it tells about the last smelt that was carried out after which it was abandoned. This is made more complex with the absence of similar evidence on the other two furnaces (F1 and F2) found in the same mound. A possible explanation might be that it was perhaps realized by the smelters that a removal of this slag material would have led to the eventual destruction of the furnace base thus it was abandoned altogether and a new one(s) built nearby in the form of F1 and F2.

A splitted F9 revealed that the whole interior from the bottom to a height of c.60cm was completely occupied by one slag lump. This has assumed the shape of the furnace interior wall (Fig.10b). Earlier on, the excavation of the unit near the slag hole had revealed a compact slag layer stuck firmly to the ground as in the case of F3. This was connected to the interior slag mass as one unit through the slag duct across the floor of the excavation unit into the south wall (plate 8). The part in the unit measured 15-22cm wide and 12-18cm high. The surface was jaggeded as in the case of F3. This feature might reflect an archaeological evidence of an aborted smelt leading to the complete blockage of the furnace interior by slag. Its association with a furnace using a single line of tuyere arrangement gives weight to an observation made by Nicholas David during a re-enacted iron smelting in

Cameroon, that, "the advantages of furnaces with a single tuyere as compared to the more common African types with several tuyeres penetrating the furnace from around the base included the delivery of air to the centre of the fuel ensuring even combustion and lesser investment or labour since only one bellowsman is needed at a time. On the other hand, there is a significant risk of failure since if the tuyere breaks the smelt is aborted (David et. al 1989)".

Particular technical and ritual care in tuyere construction and in its positioning on the furnace was therefore needed. From Tiza, in Upper West Region of Ghana, Pole (1974a:19), recorded that "the tuyeres were made of the same type of clay as the furnace. On the other hand, the bellow pipes were made by a man other than a blacksmith and were made of pottery clay". Furthermore, at Lawra and Jefisi, in the same region, care was taken to align the axis of the tuyere hole with that of the pipes so that there was the least impediment to the flow of air (Pole 1975:19). Particular attention was paid in the fitting of the tuyere pipes into the air inlet. The smelter with the greatest knowledge was entrusted with this work since the positioning of the tuyere in the hole and especially the angle its axis makes with that of the shaft was crucial (Pole 1974a:28). This furnace like all the others had no archaeological evidence of tuyere pipe fitting inside the air inlet that could have shed some light on how the tuyere could have been a cause of the aborted smelt. Moreover, except for fragments of the tuyere, no complete or near complete ones were found in the excavation of the mound near this furnace. We cannot rule out the effect of decay or decomposition or erosion of the tuyeres into the river valley nearby especially, if they had been dumped on the edges of the slag heap. The aborted smelt may be seen as a reflection of the inability of the smelters working with this furnace to have brought together the various factors needed to produce sufficient reduction conditions in the furnace to ensure a successful smelt.

GAMBAGA FURNACES AND OTHER FUNCTIONAL UNITS

The available archaeological data suggested the existence of three furnace varieties. The distinctions are based on a combination of the morphological features both on the exterior and interior of the excavated structures. They are amplified further by the differences in their functioning and underlying technologies evident from the results of the analysis of the functional units like tuyeres as well as the ores and slag which are examined under separate headings.

(i) Shaft-in-bowl Furnace (Type Variety I)

This is the shortest of all the types recorded with an estimated maximum height of 1-1.2m measured from the bottom of the furnace bowl. It consisted of a bowl with rounded base which widened in the first 40-50cm surmounted by a short pronounced tapering cylinder. It had an external diameter of 70-90cm at the widest (measured along the longest axis) and tapers to 40cm at the oval shaped mouth. The wall measured 8-10cm in the body and thinned to 4cm at the mouth. From the outside, the furnace had two walls with the shaft seated inside the bowl base giving it its shape that has been described as "shaft-in-bowl". It had one air inlet (tuyere hole). To the side opposite where the air inlet was located was a slag hole at the base of the furnace (Plate 8 also see Fig.16a).

(ii) Bowl-Shaft Furnace (Type Variety II)

This was a tapering shaft cylinder surmounted over a bowl with a round base. It was 1.5-1.8m high from the bottom of the furnace with an external diameter of 50-60cm at the mouth and 60-90cm at the widest base, measured along the longest axis. The wall was 8cm thick in the body thinning to 5cm at the mouth. It had air inlet and slag hole arrangement like the type 'I' furnace. Two size modes and shapes of slag hole were noted for this type of furnace (Fig.16b). There is one group (F1, F2, F3, and excavated from one smelting site) which had slag holes that were wider (30-35cm) than high 10-18cm) (see Plate 6). The holes had a flared shape and contrasted with the oval shaped slag holes of F43 and F44. These measured 30-35cm wide and 30-35cm high (see Plate 9).

On the basis of results from the analysis the tuyeres recovered and discussed below, the type II furnaces were the most dominant. As many as 11 (73%) of the 15 in-situ structural furnace remains excavated were of this type.

(iii) Tall 'Naturally-Induced' Furnaces (Type Variety III) F45, 46

These were a tall tapering cylindrical shaft over a bowl base. They attained an estimated height of 2.5-3m. The maximum diameter was 1.4-1.6m (approximately 1.1m maximum interior diameter) and 80cm at the mouth. They had a wall 13cm thick near the base and 8cm at their mouth. Evenly spaced around the base were 10 air holes into which naturally induced draught were introduced into the furnace through clay tuyeres as will be discussed below. This type of furnaces have been described as Tall 'naturally-induced' furnaces. Examples are F45 and F46.

In addition to these air holes, these furnaces had a specially constructed oval shaped orifice that was located on the side opposite to where the slag was led out of the furnace. It was placed at a height of 1.2m on the furnace shaft (measuring from the furnace bottom), and 15cm above the air inlets (see Fig.17 and also Plate 10). The significance of this hole on the furnace would be examined below when we discuss more features about the various furnace types.

Slag Disposal and Bloom Removal

The archaeological evidence indicates that all the furnaces excavated were tapped of their slag separately during the smelting. For the type 'I' and 'II' furnaces, their bases had been slanted downwards to form a spout that opens into a roughly rectangular pit that originated 2m or more away from the furnace base. The slag holes were delicately modelled and formed part of the overall construction. These furnaces, therefore, seem naturally streamlined for the outward flow of slag into the scoop.

Specially constructed holes for slag tapping were not found on the type III furnaces. To drain out the slag, vent holes were made by breaking away part of the base wall on one side of the furnace. Removal of the bloom would have been through this side by breaking open a wider gap. From the evidence on the two furnaces belonging to this type, these openings measured 60cm high and 35-40cm wide. This would have been large enough to facilitate the easy removal of the iron bloom. The ensuing damage done on the lower part of the furnace could have been repaired after the furnace had cooled by filling it with fresh clay. The archaeological evidence indicates that such a repair would have been carried out only when the furnace was going to be used again. The other possible channel for removing the bloom might have been through the orifice on the shaft. Sutton (1985), noted that tall furnaces sometimes have such apertures which served not for draught but as channels for charging the furnace with iron ore and charcoal, stoking the fire, cleaning the furnace of debris and for removing the bloom.

The evidence from the examination of the interior walls of the type I furnaces revealed a narrowing of the slag hole to a 3-5cm gap, approximately 20cm into the interior of the furnace base (see Fig.16a). These constricted passages would have been perfect valves for controlled slag disposal even if the entrance of the slag hole were not sealed and the slagging was done continuously as the smelting went on as in the case of the smelting process at Chiana (Pole 1975:30). On the other hand, the narrow nature of this passage in the slag hole, and the absence of any breaking (deliberate or by natural agents) on the walls from the interior and on the entrance of the slag holes or on any other side of the base, argues against the withdrawal of the bloom through the slag hole. The height of the furnace, however, does make it reasonable to suggest that the iron bloom could have been removed through the mouth of the shaft. Where the size was such that it could not go through the narrow mouth, part of the wall at the top of the shaft could have been broken away to make for more room. The cleaning of the debris inside the furnace could also have been done through the top. This would have foretalled any damage to the delicately constructed slag hole. Moreover, the damage done could have been repaired before the next smelting simply by putting on new coils of clay.

The removal of the bloom from the type 'I' furnaces would have been by two possible ways; through the slag hole and through the mouth of the shaft. Old iron blooms I observed from old blacksmiths in Northern Ghana (see Plate 14) and photo documentation of what Pole (1974a:36, Plate XXIV) recorded, showed a tongue-like semi-hemispherical mass. These were produced from shaft furnaces one metre or so or less. The blooms measured 30-50cm long, 20-30cm wide and 5-10cm thick. Iron blooms of this dimension or slightly more could easily have been removed through the slag hole of the type 'I' furnaces. Close examination of the preserved slag holes did not show evidence of disturbance neither were there any evidence of breaking of the base walls. This should reflect the architectural skills of the smelters to construct the slag hole to given dimensions to serve as channels for draining slag and removing the iron bloom. This could also have served as a suitable passage through which the furnace were cleaned as the ethnographic evidence from Chiana suggest (Pole 1974a).

<u>Tuyeres</u>

Tuyeres are important functional units of the furnace. Basically, they play the role of providing a medium for the intake of air from a bellow system or from natural draught into the furnace hearth fire. The excavation of near-complete tuyeres and lots of the tips and fragments has made it possible to determine their form and functioning. The latter is very important since it throws light on the smelting techniques of the Gambaga iron smelters.

Three tuyere varieties were categorized. These are related to the different furnace varieties. The first variety was a massive cylindrical clay tuyere with length measuring 30-35cm and wall 5.5-6.5cm thick. The wall thickness was uniform for the individual pieces analysed. The external diameter was 20cm both at the mouth (the end that received the air supply) and at the tip (the lower part that was in contact with the furnace fire). The bore diameter was also massive measuring 5-6m for the greater length of the tuyere from the tip. It widened to 17-19cm at the mouth (Fig.18a). These were the only tuyeres for which decoration was found on their surfaces. This was in the form of grooves (possibly made with the finger tips) running in straight lines from the mouth to the tips. These furnaces are associated with F9, and F26 that is the 'shaft-in-bowl' furnaces.

The next tuyere forms were also cylindrical. These had external diameters of 11-13cm both at the tip and at the mouth. The length was estimated to between 35-40cm. The wall measured 3-4cm thick, and were smaller than the first variety. The bore was massive and measured 5-6cm from the tip through three quarters of the length widening to a 11-13cm diameter at the mouth (Fig.1). These tuyere forms were associated with the following furnace remains (F1, F2, F3, F4, F7 F8, F10, F11, F12, F4, F43, F44). This made it the most plentiful tuyeres recovered from the excavation. The evidence of association between this tuyere form and the above remains therefore provided a clue in the identification and categorization of the furnaces especially where the structural remains were in the form of bases without any apertures surviving. On this basis, type 'II' furnaces formed the majority of the excavated furnace structures.

The third group of tuyeres are associated with the type 'III' furnaces (F45, F46). They were different from all the other tuyeres recovered in several ways. They had lengths estimated to betwen 50-60cm. They tapered in their external diameter from 11.5-12.5cm at the mouth to 5cm at the tip thus had a tapering cylindrical shape. Their walls measured 1-2cm thick. The bore diameter also tapered from 12cm at the mouth to 2cm at the tip (Fig.18c).

Furnace Draught Mechanisms

The smooth bore of all the tuyeres is indicative of their use for an efficient transmission of air into the combustion chamber but a question that needs to be answered is the kind of draught mechanism these tuyere varieties transmitted. This question arises because all tuyeres are channels for directing draught into furnaces but the draught can be naturally induced from the blowing wind or one produced from a system of bellows and sometimes a combination of the two. The height of the type I and II furnaces and the single level air inlet arrangement argues against their being induced furnaces. The massive bore measuring 5-6.5cm at the tip and 11-13cm at the mouth makes them suitable for the directing air supplied from bellows into the furnace interior.

A more intriguing problem related to the type of bellows possibly used. Information gathered from reports by people who witnessed smelting in the late 19th century and early 20th century and from demonstration smelts carried out in the Upper Region in Ghana in the 1970's portray the clay bowl bellows as being the well-known (Wild 1931; Junner 1936; Cline 1937; Pole 1974a, 1974b; 1975). The available archaeological evidence indicated the absence of clay bellow pots and pipes either in complete forms or in fragments. On the other hand, if the smelters used leather or skin bellows either in the shape of sleeves or bags there was the minimal chance of finding these on the sites because Tropical African soils are acidic and they poorly preserve organic matter. This problem cannot therefore be answered properly on the basis of the evidence from the sites investigated. Future research should focus on this issue. My ethnographic study in blacksmithing communities in Mamprugu showed that the sleeve-shaped skin bellow is the predominant bellows used. This leather equipment (and also where the leather is laced on top of clay pot bellow) are always removed from the workshops even if the latter was one of the rooms on the compound. Since they are portable and easily transportable, these items where they were used on the smelting sites being investigated would have been carried away from the site at the end of the smelting process.

For the type III furnaces, the shape and length of the tuyeres and the evidence of a multiple level air inlet arrangement makes it reasonable to suggest that they were naturally-induced draught furnaces. Induced draught tuyeres according to Tylecote (1968) all seemed to be more than 60cm long with thin walls. In Bassare country, the Banyeri used furnaces that stood at 3-3.5m high and contained 7-9 openings for tuyeres (Hupfeld 1899; Tylecote 1956:342 also see Fig.21b). Furnaces about 2m high used by the Ba-Ushi in Northern Zimbabwe had 9 openings into which were plugged 40-80 tapering (from 5cm at the upper end to 3cm at the lower end) 60cm long tuyeres through which air was admitted into the furnace (Barnes 1962). Accounts on the source of draught for "tall" furnaces can be contradictory. In at least one region, the Tanganyika-Nyasa corridor, it appears that the draught arrangement may be flexible depending in effect on the breeze (Sutton 1985:169).

In West Africa, smelting furnaces near Bamako, Mali which were about 3m high were air blasted by means of goat-skin bellows operating through openings at the base of the furnace (Forbes 1933:231). Most of the ethnographic reports, however, indicated that tall furnaces standing up to 3 or 4m tall generally relied on self-induced draught than on bellows. No evidence of bellow bowls were found in the archaeological research of sites with tall furnaces. This might add to the increasing picture of the use of a naturally induced draught for the type III furnaces which distinguishes them from the possibly below blown type I and II furnaces.

The functional significance of the tuyeres recovered is evident in the definitive physical attribute of slag flow coating and encrusted heavily on the tips as well as display of evidence of reduction and vitrification (Plate 12). This showed that up to 12cm of the tuyere ends were extended inside the furnace interior. This confirmed a smelting technology which utilized preheating of the air blast. In other words, by positioning a long portion of the tuyere inside the furnace, air forced through the tuyere became preheated within the confines of its hot clay walls. This is similar to the practice of the Dimi in Southwest Ethiopia (Todd 1985:92). Data collected by Avery and Schmidt (1979) from measuring temperature profiles along the tuyere during a reconstructional Haya smelt in Tanzania did not only confirm that temperatures up to 1400°C could be easily attained, but more important technologically, in many African bloomery processes, placing the tuyeres inside the furnace can preheat the air by up to 600°C significantly raising furnace temperatures over those in cold blast bloomeries. Archaeological evidence from the Rugomora Mahe site of West Lake suggested that preheating may have been practiced in

Tanzania 2000 year ago (Schmidt 1974; Schmidt and Avery 1978).

The significance of preheating is directly related to the temperature in the furnace. In an African furnace it has been asserted that the amount of heat generated by fuel combustion was often approximately equal to the temperature of gases escaping out the flue (Schmidt 1985:126). This left very little heat for smelting. Preheating provided the additional heat needed to attain and maintain smelting conditions and it affected efficiency.

reheating could have constituted a significant technological innovation to African iron production industries with the smelted product being an intentional steel (Goucher 1981). This technique was patented in Great Britain only in the second quarter of the 18th century (Hyde 1977 quoted by Goucher 1981) when the industry was provided with significant savings in fuel as high temperatures produced more complete combustion, raised the potential furnace temperatures, speeded up and therefore increased production (Goucher 1981). By providing additional heat to attain and maintain the suitable reduction temperatures, preheating may not only have improved the efficiency of the smelting process but also it could have affected the impact of man on forest resources by requiring less charcoal and so less wood. Goucher has suggested that the full development of the preheating (fuel-conscious) innovation in the first millennium A.D. may also have been a response to the ecological degradation and deforestation associated with large scale iron production (Goucher 1981:186).

CHEMICAL ANALYSIS OF RELICS OF THE IRON SMELTING INDUSTRY

Iron Ore, Types, Sources and the Composition

Two main ore types were found from the investigation. The first was a nodular haematite ore. It was directly associated with the type I and II furnaces. The other one was lighter in weight, and consisted of lameller ferruginuous ore, reddish brown in colour. It was associated with the type III furnaces. Before we discuss the results of the analysis of their chemical composition we shall first treat the sources of the ores.

Two areas of ore extraction were recorded from the surface survey. These had their surfaces punctuated by dozens of pits and open trenches of different dimensions (see Table 4). They revealed that the smelters mined to shallow depths ranging from a few centimetres to a maximum of 2 metres below the surface of the laterite outcrop. This was similar to the evidence from Lawra and Jefisi where the ore was dug from 20cm to 2m below the surface (Pole 1975:14). Found lying on the floor of these pits were lumps of laterite of different sizes and physically different from the nodular type of ore that was the basic rock material composing the sites. These might have been embedded in the laterite formation and were discarded perhaps because of their low iron content. On the other hand, where they were of the required iron quality, they might have been broken into smaller sizes and the selected ones carried away. A piece of tapering cylindrical iron hammer, with part of the head flaked, was found on the surface of OM.2 in zone 'E' which has been suggested to have been put to use in breaking the extracted ore pieces into smaller sizes (see Plate 15a). More is said about this tool in the latter part of this chapter and in Chapter Five when we discuss the range of tools found and used in the blacksmiths workshop today.

It is very possible that other mines were missed in the survey. Others too might be located outside the area surveyed. This observation might explain the source of the ferruginuous ore found to have been used in the type III furnaces. The source might be found some distance perhaps kilometres away from the Birimi Basin where almost all the type III furnaces are located. This observation is supported by the ethnographic reports from other areas. The ore site at Chiana was about 16km away from the former smelting site (Pole 1974a:24). Contemporary informants in this village told me in 1988 that it was this problem of long distance of transportation that made some smelters migrate to the village of Kayoro in order to be nearer the source of the ore. The ore used in smelting in Darfur in Ethiopia was sometimes taken from a distance of 13 km away from the smelting village (Todd 1985). This suggests that the nearness to the ore sources might not have been a critical factor in these situations.

The type of smelting technique adopted (which also dictated the size and quality of bloom produced from any smelting activity) was dependent both on the iron content, the nature and composition of the non-metallic or impurities in the iron ore used. A chemical analysis of samples of iron ore from smelting sites, furnaces, and ore mining locations were carried out by the Geological Survey Department of Ghana and is presented in Table 6. From the data the mean iron ore content for the ore from the OM.1 and SM.27 site (on which a type II furnace was excavated) is about 56%. The similarity in the chemical composition of these two samples supports the view that the ore used on the SM.27 site was mined from the OM.1 site which was located some 800m to the southwest. The iron content compares very much with the average of 50% obtained for the ore at Lawra and Jefisi (Pole 1985) which were also nodular haematite ore smelted in bellow blown shaft furnaces.

A figure of 48% iron content for the ore sample from F45 (which is one of the tall naturally induced furnaces excavated) reflected its lamellar ferruginuous laterite type, characterized by lighter weight. This result might imply that the tall furnaces utilized ores that were of a lower iron content. The provenance of the analysed samples (that is collected from the interior excavation of the furnace) might mean that it had in some way been affected by the furnace heat, although this was not visibly evident, and thus might have increased the iron content. While more research will clarify this, the association between the lower grade ore and the tall naturally induced furnace is very striking. It gives an archaeological support to ethnographic and ethnohistoric accounts from other smelting centres in Africa that smaller furnaces usually employed rich or concentrated ores while the large and tall ones seem designed to utilize poor quality ores by the means of a long slow smelt (Sutton 1985:169-170).

In Bassare country in Togo, two furnace varieties were noted to have been in operation; a 3.5m tall shaft at Bassare and a 2.5m shaft at Banyeri. The iron workers themselves explained the differences in types to the quality of the ore; given that in both places a bloom of similar size was in demand, the amount of ore required at Banyeri was less than that needed at Bassare, therefore, the furnace could be smaller (Pole 1985:150). In the Futa Toro region in Senegal, Raffaenel (1856 quoted in Pole 1985) noted that smaller furnaces employed rich ores.

What the archaeological evidence could not prove was whether there were any preliminary roasting or treatment of any of the ores (especially the ferruginuous ores) before being used for smelting. Such treatment would have improved the iron content of the ore concerned thereby increasing the true yield of iron from the ores. The lower grade of ore used by the Banyeri was prepared carefully before they were used (Pole 1985:150). The attention paid to ore preparation was a very important element that made it difficult or improper to determine the industrial efficiency of furnace varieties that have been excavated and based on analytical results from ore samples. A study of the lag from the smelting sites with the I and II furnace designs shows that these normally had shiny surfaces with flow structure. This is not so with the Tall furnace sites (see Plate 13). These differences in the waste products from the iron extraction process might be accounted for by the differences in the type of ore and perhaps the additives and smelting techniques used. Re-enacted and experimental smelts would be of immense help in providing information to cross check these archaeologically observed features.

The best indications of a good ore is one low in silica (SiO_2) lime ($Ca0$) and Magnesia ($Mg0$) (Tylecote 1965). The percentages of these elements was very high and greater present in the ferruginuous ore from F45. This provided a reason that might have accounted for the use of this ore despite the lower iron content. The ores analysed were phosphorus containing. The inclusion of this element in the ore was a substance which adversely affects the quality of iron (Eckel 1914:155). But since the percentage was low the smelting operation though itself simple would have removed the greater part of this porous material (Wild 1931).

Chemical Analyses of Slag and their Significance

Samples of slag were collected from the excavation of the mounds and the furnaces for analysis of the weight percentage of their chemical composition (see Table 7). A glance at the figures reveals that the slag had a high iron content of about 40%. This implies that the slag that ran off the furnaces was not composed of mainly waste matter but rather it contained a high amount of iron oxide that was lost. This affected the yield of iron bloom from the smelting considering the amount of iron oxide compounds that the ore contained as discussed above. The average yield of iron from the smaller furnaces in Gambaga should be between 25 and 40% and that for the tall furnace about 15% or more. This shows a high yield for the smaller furnace which might reflect the technical efficiency of the furnaces supplemented by the use of a richer ore.

Forbes (1933:235), noted a "very great loss of iron in the slag" as a basic defect of the Dedougou furnaces in Burkina Faso. He did not indicate the loss in quantitative terms but the observation should reflect a situation that might not be too different from the Gambaga smelting technology. Wasted iron on a relatively large scale has been identified as a shortcoming of African smelting process. Wild (1931:188) attributes this phenomenon to the result of reoxidation of the reduced iron under inefficient conditions within the furnace. With such a high percentage of wastage it was therefore important for the smelters in Gambaga to utilize ore that had high iron content. On the other hand the ethnographic records shows that the iron rich slag was not all lost or thrown away as we noted in Chapter One. Rather it would have been returned in the slag to the furnace again and used as a flux for subsequent charges. Reports from the Dimam region in southeast Ethiopia indicate that small fragments of the slag from previous smelts were included with the ore charge in the furnace (Todd 1985:93). In Oyo, up to 6.8kg of slag was used as flux in a 73.5kg. of charge of ore in a smelting process that produced an output of 31.8kg of crude metal (bloom) and as much as 45.4kg of slag (Tylecote 1965:348). The addition of old slag to the charge served to decarbonize the iron reduced from the ore (Wild 1931:188). The observation of the interior of F45 revealed that a good deal of the slag at the bottom and base walls of the furnace was ore that had by-passed the reducing zone and had merely been melted rather than smelted. The composition of these would not be different from the slag and if put back could have absorbed some gangue to give a slag of lower iron content thus reduce the loss of iron.

The results given by the analysis shows that the differences in ore and probably smelting techniques was reflected in the chemical composition of the waste and possibly in the type of bloom produced. The slag showed increases in the percentage of lime (Ca0). This was significantly higher in the smaller furnace ores than in the tall furnace. Since the ore does have only small quantities, the source of this additional lime in the waste might be traced to alkali oxides in the ore, or flux supplied from the charcoal fuel, the tips of the tuyeres and from other organic and/or inorganic matter which were not evident in the archaeological data. In Chapter One we noted the variety of materials that are added into the smelting furnace as flux to promote the rapid fusion by lowering the smelting temperatures needed to run out the non-metallic components of the iron ore. An elemental analysis of charcoal samples from different excavated units was undertaken by the Soil Science Department of the University of Ghana. The results presented in Table 7, indicated that the charcoal used in the smelting process contained high percentages of lime (CaO) and alkali (K_20) which may have served as flux and thus explained a possible source of the additional lime evident from slag analysis.

The silicon ($Si0_2$) content in both slag samples were higher than in the ore showing increases of 89.2% in F26 and 64.5% in F45. The slag was essentially a silicate of iron. The results also showed that the slag had a high refractory index and a low lime/silica ($Ca0/Si0_2$) ratio of 0.15 and 0.04 respectively. The more refractory the slag, the higher the furnace temperature required to produce a fluid slag (David, forthcoming). The viscosity and melting temperature of such alumino-silicate slag as was found in Gambaga can be lowered by the lime (Ca0) or alkali oxides (K_20) either present in the charcoal or the flux deliberately added or by the incorporation of wustite (Fe0) (Todd 1985;97-98; David, et.al. 1989).

Sulphur (S) is also a very detrimental element in iron production and ores high in sulphur were not used by African smelters (Tylecote 1962:191). It required removal through roasting prior to the actual smelting (Eckel 1914:28). The analysis showed that the ores used in the smelting sites in Gambaga were virtually devoid of sulphur. By implication, it would have eliminated the need for roasting. The comparatively high alumina (Al_20_2) and Silica ($Si0_2$) of the samples proved that the iron ore was derived from the alteritic formation which caps the underlying rocks in many parts of the country and can be found as surface outcrops on the Gambaga

Escarpment. It also showed that the gangue (the non-metallic elements) was alumino-silicate. The high lime and Manganous oxide in the F45 ores is striking. Another feature that contrasted the ferruginous ore form the nodular haematite ones was reflected in the lower water content as well as materials (probably organic matter) lost on ignition at 1000°C. Explanation of these differences was problematic. Perhaps the ores used for the individual furnace designs were connected with production for specific iron bloom qualities, using different techniques (additives, length of production time, fluxing and forging technology).

OTHER FINDS FROM THE INVESTIGATION

Under this we shall examine all other cultural materials recovered from the archaeological research. The few materials included iron items, ceramics, smoking pipe fragments and lithics. Another find in the form of shaped clay pieces most of which had slag encrusted on them will be discussed.

Iron Items

(a) Ring:

This was found on the surface of the slag accumulation on the SM.61 site in zone 'D' on which F45 and F46 were excavated. It is complete but partly rusted. It has angular sides of 0.4mm on one end of the circle and thinned out to 0.2mm at the end. It measured 2cm in internal diameter (Plate 15b). Aside from the thumb, this diameter could have fitted onto only the last finger of an average sized man. However, if the gap in the circle is not the result of rusting then it could have been expanded to fit perhaps tightly on any of the fore fingers. Another possibility is that it might have been worn by a teenager possibly a boy working with the master smelters on the site.

(b) Arrow Head

This was found in the excavation of a furnace F44 in zone 'D' mixed in a layer of ash, charcoal and pebble shaped slag pieces extending from the slag disposal hole c.60cm below the ground surface. Its presence in this archaeological context posed problems of interpretation. It might have been an arrow that dropped into the slag pit at the base of the furnace after having been shot by a hunter at an animal. The effect of rusting was more evident on the tail of the object. The barbed head is a feature that links it with what is still used in Mamprugu and Northern Ghana in general (see Plate 15c). They are effective hunting weapons. Today in Mamprugu, there is the plain arrowhead which is not used for hunting animals but is used on ceremonial occasions and is of purely aesthetic value my informants indicated.

(c) Iron Hammer

This was found on the surface of one of the pits in an ore mine site, OM.2, in zone 'E'. It did not show much sign of rusting (Plate 15a). Its presence on the site presented problems of interpretion since, as we shall see in Chapter Five, it was a tool for forging iron bloom in the past and used today in the blacksmiths workshop as an important tool for hammering to extend the length of iron pieces. Perhaps the flaked off nature of the head might indicate that it was discarded as a forging tool and put to use as a harmmer for breaking the lumps of iron ore into pieces for easy transportation in baskets to the smelting sites.

CEREMIC FINDS

(a) Smoking Pipes

Four smoking pipe fragments were found. Two of these were pipe stems and were surface collected. The other two were pieces from the bowls. These were recovered from the excavation of the top soil of the SM.15 site in zone 'A'. These pieces have been described not because it is intended to make any conclusions or suggestions on them. This is because the sample is small, fragmentary and from surface collection or in the top soil of slag mounds that have been walked upon for years since their abandonment. More excavated evidence is needed before these pieces can be worked into the material aspects of the culture of the smelters concerned.

Pipe Stems

(i) One of these (Fig.25a) was cylindrical in form with a maximum external diameter of 2.7cm and a length of 3.3cm. The collar was angular and tappered from the maximum external diameter of 2.7cm to 1.9cm at the tip. It had traces of red slip probably from a solution of red haematite. It was plain.

(ii) The second piece was also cylindrical with an external diameter of 1.7cm and a length of 3.2cm. The bore diameter tappered from 1cm at the mouth to 0.7cm at the stalk-end which was slightly curved. It had an angular collar.

The surface treatment suggested thorough burnishing and painting with a red slip. The body was plain (see Fig.25b).

Pipe Bowl Fragments

(i) This was characterized by an everted lip which was rounded (Fig.25c). The body was carefully burnished but red slip was present on it. Decoration was in the form of three parallel horizontal grooves separating ridges with single horizontal lines of dotted impression.

(ii) This lacked the everted rim. It was not well burnished as in the case of (i) but it had red slip. It was also burnished with a band of three horizontal lines of dotted impressions. Barely visible at the lower end of the fragment and separated by 1cm of plain body was another band of decoration which appeared to be similar to that below the rim. A zonal fashion arrangement of decorated bands interpersed with plain undecorated surface is suggested (Fig.25d).

(b) Pottery

Pottery was the most numerous of the material aspects of the smelting evidence investigated. These were recovered both from surface collection and from excavation. The field data, however, indicated that only eleven smelting sites yielded pottery on the surface. This worked up to 9% of the total sites recorded. Two mounds SM.16 and SM.58 did not produce any pottery on the surface but upon excavation pottery was recovered. In no instance did the excavation of mounds fail to produce some pottery. This implies that surface observations of slag mounds or smelting sites might not be sufficient basis for determining the material composition.

In all, a total of 204 potsherds from excavated sites were collected from the investigation for analysis. This analysis is meant to be preliminary pending the undertaking of more excavation and recovery of more sherds. The sherds were generally fragmentary with 64% measuring 0-5cm and 29% measuring 5-12cm on their longest axis. The sherd thickness ranged between 0.5cm-1cm (44%) and 1-2.2cm (56%) thick. For purposes of this brief analysis, five elements were examined. These included fabric, vessel form (based on a study of the rim and base forms) surface treatment and decoration. The functions of the recognizable vessel forms have been suggested (based on ethnographic observations made) to reflect possible use on the smelting site. Since all the pottery tradition known from West Africa was hand made, differences between hand techniques are rarely discernible thus methods of manufacture was not a variable.

Clay Texture and Fabric

A study of the fabric of selected samples by Mr. L.B. Crossland, a Lecturer at the Department of Archaeology, Legon, partly with the aid of a microscope revealed two basic clay materials that were used. There is on one hand the use of rough grained residual clay. These clays are tempered with quartz fragments. Potsherds with this clay fabric are nrmally more than 1cm thick. The other clay used are fine grained possibly obtained from an alluvial lateritic source with tempering of an organic matter possibly grass or millet stalks.

Vessel Forms

On the basis of the study of rims and base forms the following vessel forms were identified.

(a) Jars with everted rims: These were hemispherical in shape becoming narrow at the neck from where they were separated from the rounded lip by an angle that curved outward (Fig.24a).

(b) A second group of everted rim vessels with a long slightly everted neck separating the rounded limp from the vessel's lower part. All the above jar forms had walls more than 1cm thick.

(c) Open bowls with thin walls measuring 0.5-0.7mm. The rims were incurved slightly creating a restricted orifice. These were mostly plain, burnished and red slipped. These had either flat or rounded bases. The lips exhibited slight thinning in relation to the vessel wall. The shoulder areas were typically rounded (Fig.24d, e, f). One base sherd of what looked like an open vessel was found. Such vessels are today used to serve groundnuts. The walls are thick about 1.2cm and the bases are thick and pronounced. The decoration of rouletting was not found on the base but on the body of the vessel. The lip was also round as the ethnographic examples indicated (Fig.24g).

(e) Large jars and storage could not be distinguished from the rim forms available but their presence was strongly suggested by the presence of body sherds with thickness of about 1.5 to 2.2cm. These sherds were also numerous perhaps indicating that they were the remains from a few large pots that were used to store water on the smelting site.

<u>Surface Treatment and Decoration</u>

All the sherds were burnished possibly by rubbing the surface with smooth surfaced objects. These have bodies that were either smooth or shiny and slippery both inside and outside. The sherds showed signs of slipping with the majority of them being red-slipped, although these exhibited a considerable range in colour like brown and grey variations. This might suggest the use of a variety of clay mineral suspension for the purpose of slipping. Surface study revealed that the application of slipping on the whole body and rims. Slipping was executed both in the inside and outside of the vessels. None of the vessels had a black fabric colour to suggest that, in addition to the original firing, the vessels in question were possibly later subjected to more heat and smoke produced in the process of being used for cooking. This perhaps suggests that the vessels used on the sites were mainly for storage of food, water and possibly nuts like groundnuts and fruits (domesticated and wild). This would also suggest that food might have been cooked and brought to the site by the smelters or their children and wives.

About 20% of the body sherds were plain and belonged to both large storage vessels and thin walled open bowl vessels. The main decorative technique observable was rouletting. These look like cord roulettes which were either twisted or knotted. They are executed in an oblique or horizontal or wavy fashion. Most of the large vessel sherds are decorated with rather hapharzard veins of large roulette impressions. Evidence from the analysis indicated that the rouletting was limited to the body of vessels. The rims were normally plain. All the decoration were on the exterior walls of the sherds.

Discussion

The excavation revealed the use of pots on the smelting sites. Since these were excavated from the slag mounds, a close study was made on all the sherds to see if any had evidence of layers of slag coating or encrusted to the surfaces to suggest their use for scooping away slag accumulations as has been suggested by the evidence from the excavations at the Cape Coast smelting site (Penfold 1970) and discussed in Chapter Two. The result was negative.

Contemporary informants and the ethnographic accounts available indicated that pottery was used for storage of liquid and solid material. However, mention was made of the use of gourds and calabashes, the latter as a measure for iron ore and charcoal pieces to be used in charging the furnace. Gourds are planted in settlements in most Mamprusi villages today and are preferred for carrying water to farms and hamlets since they are lighter in weight. Their preservation in the archaeological context, however, is poor and like and baskets might not easily be found in the archaeologial excavation, but their use was attested in the ethnographic and ethnohistorical data.

The ethnographic investigation indicated that pots have been and are being made for everyday use and for every conceivable economic and social activity. There are enormous jars for brewing and storing pito (the local beer) and water; smaller jars for fetching water and storing pito and shea butter; measures in which pito is sold; water coolers; domestic cooking pots of different sizes; food serving bowls; ingenious pots for holding water for ducks and chickens; vegetable grinding bowls; circular patty-pans for frying corn-cakes (maasa) ritual pots - the list is endless (see Plate 25). There is a high degree of flexibility in the use of pots. Any pot may be used as needs dictates. For example all spare vessels are full of water after heavy rains regardless of the shape or usual purpose. The oral traditions available indicate that the smelters would have used any of the household pots rather than any special vessel forms.

To the various markets on the escarpment are sent large quantities of the various pots listed above. Pots are not made in Mamprugu. This has been so for generations. The catchment areas for pots is in the Kusasi, Busanga, Builsa and Konkomba country lying in the flat landscape along the north face of the Escarpment. Retailers buy pots (these have already travelled some 10 or 20 kilometers from their village or origin) in bulk from Bawku, Garu, Bolgatanga and Walewale to sell to local customers. The pots being traded from these sources today lack the roulette decoration observed in the pottery from the excavation. The modern pots are burnished and slipped but they sometimes have thick red slip selectively applied to certain parts of the pots. The decorative categories included single horizontal bands, consisting of a zig-zag, parallel diagonal or curvilinear lines most often bounded above and below by horizontal lines. Since all the pottery from the smelting sites exhibited a remarkable degree of similarity in the form, fabric and ornamentation of the ceramic material, a suggestion that can be made is that the pottery making industry was in the hands of a certain specialized community who served as a common source of pottery for the smelters or that the potters (possibly the wives of the smelters) shared a common cultural tradition. This observation calls for a thorough study of the various sources of pottery to distinguish the individual cultural distinctions dictated by the traditions of the different ethnic groups whose pottery find their way to the Gambaga Escarpment. The size of comparative collections was small thus vessel forms and decoration may have to await more excavated data to make a complete assessment possible.

LITHICS

A few stone artifacts were recovered all mixed with the smelting debris. These have been divided into sub-groups.

(a) Rubbing Stones

These were flat rectangular fine grained sandstone pieces. Their surfaces and sides (except for the broken edges) are smooth and polished which suggests that all the parts were put to the same use (see Plate 26b). This feature of polished surfaces and sides might be due to these stones serving as smoothed surfaces and sides for frequent use in rubbing the surfaces of certain objects or structures on the smelting site. Things that can be suggested to have needed smoothening and polishing and for which there was archaeological evidence included the furnaces which have smooth interior walls. The exterior wall surfaces also were smooth although these these have been obliterated to a lesser extent by the effect of beating and splashing by rain water coupled with fissures and cracks resulting from expansion and contraction under the sharp diurnal temperature changes experienced on the Gambaga Escarpment. The other smelting device that can be mentioned are the tuyeres. These also had smooth walls.

The act of meticulously burnishing the surfaces and exterior walls of the furnaces can be likened to the practice of burnishing pots to give them shiny, smooth land slippery surfaces. Such repeated and deliberate rubbing of the surfaces of the furnaces with these stone tools would have achieved on the former, surfaces devoid of open and conspicuous pores - a condition which would have ensured a minimum of heat loss through the furnace walls and thus enhance the rapid and successful attainment of high reducing temperature in the smelting process.

(b) Hammers and Anvils

This second group of stone artifacts were roughly rectangular sandstones, fine grained and of a feldspathic variety. Their entire surfaces are marked by one or more artificial depressions. Two varieties were noted: smaller ones with roundish edges and larger ones which have two or more such depressions (see Plate 26a). These stones have been designated as hammers and anvils on the basis of the depressions on their surfaces. These it is suggested were due to their being used as hammers or anvils to work on iron pieces with rounded or pointed ends for use perhaps in an activity related to the production process. The impact of such bipolar punching would have been the creation of the depressions. The smaller pieces would have served as hammers and the larger ones as anvils since the former are more handy. They might have been used for working of pieces of bloom on the site after the latter had been dragged out of the furnace and broken into sizable chunks with heavier iron hammers. Their use in breaking iron ore into smaller pieces can also be suggested. The evidence of flaked of parts on the large pieces and breaking of the smaller pieces vertically across the depressions might suggest an impact from hammering.

Stone tools have been identified as forming part of the tool kit of iron workers (de Barros 1985; Warnier and Fowler 1979:344). These in the form of anvils, hammers and chisels were sometimes made from quartzite. Obviously one may agree with the view that quartzite or granite rock could have served as iron working tools because they are metamorphic and of harder material. What needs to be considered, however, is that we are dealing with material items of a people and as such we should not lose sight of the environmental setting within which they operated. In the case of the evidence from Gambaga, the use of sedimentary rocks as rubbing stones, hammers and anvils is a reflection of an effective utilization of the environment. Sandstones form the basic rock on the Gambaga Escarpment. The question of the effectiveness of the stone type use as hammers and anvils would be answered when we consider the hardness of the material being worked. Where the requisite rock material was not available locally, they were imported from other places as can be seen in the case of the use of granite and quartzite stone anvils in the blacksmiths workshop today in Mamprugu and other places in Northern Ghana. More directly relevant to this reconstruction of local smelting industry is that the use of stone tools as anvils, and hammers might be archaeological evidence of the working of the bloom on the sites. This is supported by evidence from Bamessing and Babungo in the grassfields in Cameroon, where anvils of stone with craters were put to use for hammering of the bloom on the site after it has been removed from the furnace (Warnier and Fowler 1979:344).

Shaped Clay Pieces - Plugs?

One interesting archaeological find recovered was in the form of shaped clay pieces with slag coating or encrusted on parts of their surfaces. Sixteen whole pieces and fragments were collected for analysis. The pieces were recorded from the investigation of 12 of the 122 sites mapped as well as from inside three of the furnace remains excavated namely F10, F11 (all on the same SM.17 site) in Zone 'A' and F43 in Zone 'D'. None of the sites in Zone 'E' yielded surface evidence of these pieces.

Two main form varieties were identified from the analysis. The first, 'A' took the form of cylinder shaped pieces 16-20cm long and 5-6.5cm in external diameter. They were flat on one end with the lower part of the other end extended in one direction. The base on this end was rounded making it difficult to stand the pieces on this end. A closer look at the form portray what might perhaps be a rough model of a human leg (see Plate 27a). The other variety 'B' had the appearance of the lower trunk of a human with rounded features. The top were flat with a diameter of 4-5.5cm. They had external diameters of between 10-12cm at the widest lower part. The bottom on this side was curved giving them the shape of an open thigh (see Plate 27b).

A study of the fabric reveals that they were all made from the grained alluvial clay sediment. However, tempering with organic material (possibly grass) was noted for the variety 'B' pieces.

What do these pieces say about the people and the smelting technology that is being investigated? The study of the surfaces showed that they were either covered with a thin layer or smooth surfaced slag or heavily encrusted with slag giving them a rough appearance. The slag evidence were often found covering up to a third of the surfaces. None of them was completely covered all over. The surfaces of the flat ends often had no slag. The slag evidence makes it reasonable to suggest that they were used as plugs to block vents cut at the base of the seals covering the slag hole to run out the slag whenever it was judged that the lower part of the furnace interior was full of the molten material.

There is a lack of detailed information accompanying most descriptions of smelting operations of the use of slag plugs which does not allow us to know what materials were used for plugging. The few data available mostly obtained from reports from demonstration smelts depict a diversity in what was used for plugging. In Garu, Jefisi, Zuarungu and Lawra, Pole (1984:28 1975:15) noted that each time the slag was tapped the hole was reblocked with small pieces of charcoal and white ash. The Mafa smelters in Northern Cameroon, blocked the vent with old tuyeres and rocks (David, et. al. 1989). In Chiana, shaped slabs of clay were used at one time to block the inlets of the tuyere in which the bellow pipes are placed (Pole 1974a:32), and at another point to block up the slag hole when the furnace fire was left overnight to continue burning with draught supplied by the high wind through the tuyeres (Pole 1974a:36). While the use of the clay pieces to block the slag hole was well known, the reason for the plugging of the tuyere holes was not explained. This, therefore, adds another dimension to the problem of determining the possible function(s) of these materials. More intriguing is the relationship between the diameters of the tuyere bore holes of the type I and II furnaces (discussed above) which measured 5-6.5cm and that of the flat ends of the clay pieces which was between 4-6.5cm. Did these pieces serve as plugs for the tuyeres?

The available archaeological evidence presents a number of complications due to the recovery of some pieces from inside furnace base remains (F10, F11 also see Plate 28) and a well preserved furnace structure (F43). An examination of the content of the bowl bases revealed that they were mainly alluvial soil deposited by running water which had completely eroded away the top soil in the area where these furnaces were found. The clay pieces might have been deposited together with the alluvial soil and later compacted inside the furnace bases after being eroded from the sides of the slag mound nearby. Pieces of slag and the clay plugs(?) were noted to have been eroded into the valley of a stream nearby. The presence of the pieces in the furnaces might therefore not be a reflection of their original context. Moreover, the observation of the interior wall suggested that these furnaces might have been cleaned of their slag after the last smelt possibly in preparation for another smelt that was never undertaken.

This explanation does not, however, solve another problem which was created by the finding of the most complete cylindrical "leg-shaped" clay piece inside F43. A scooping and examination of the soil inside the slag hole from the entrance to 20cm

into the furnace interior base yielded nothing. But when the furnace collapsed in the process of its removal by the personnel of the National Museum for display at Bolgatanga this piece was found in the soil inside the base. The undertaking of this act in my absence ruined my chance of observing things for myself. But as a result of the presence of one of my hardworking and intelligent field assistants, Adam Ali, the provenance of the piece was noted although not photographed. Did this serve any ritual purposes like warding off fate and evil forces thus reflecting something about the cosmology or ritual practice of the smelters? Does this explain the suggested anthropomorphic nature of the pieces and if so why the choice of the leg or the lower trunk of a human? To find answers to these and other problems, I carried some of the pieces with me to Garu and Chiana but in these places the only people who were known for having ever smelted had no idea what these pieces were. In all cases, however, these were aged men whom I realized were not seeing what they were being shown to them because of problems with their eye sight.

From the foregoing, we can suggest that these pieces were functional units of the smelting furnace playing important roles in the iron production process just like the tuyeres and bellows. They might have served as plugs for the slag hole and possibly for the tuyere bore. It is suggested also that these might have been associated with some mythical or ritual function that accounted for their placement inside the smelting furnaces. While the surface evidence of slag crustings and coating supports their use as plugs it is an open question whether their ritual significance is represented by their anthropomorphic forms? More ethnohistoric, ethnographic and archaeological information is required to address these issues in greater detail.

CHAPTER FIVE

THE BLACKSMITHING OCCUPATION IN MAMPRUGU

Introduction

The discussion in this chapter is based on data derived from ethnographical and ethnohistorical investigations carried out in Mamprugu between July-August, 1987 and particularly from February - December, 1988. With iron smelting defunct in the area, it is only blacksmithing that provides data for a better understanding of aspects of the organisation and societal basis of the industry. My objective was to collect ethnohistory on the blacksmithing profession in addition to capturing whatever knowledge was still available on iron smelting. A total of twenty-five people who were blacksmiths from eight major towns and villages were interviewed most often in their workshop (Plate 16). Ten other blacksmiths from outside Mamprugu were also interviewed. Information on the occupation was also derived from interviewing non-blacksmiths in Mamprugu. Most of the informants were always very helpful and cooperative. Few had a ready narration to tell but the most of the information had to be collected by putting prepared questions. The line of investigation I followed has therefore conditioned the type of information obtained.

The ethnographic investigation was equally interesting and it involved observing blacksmiths at work forging iron items, children pumping the bellows and breaking charcoal into smaller pieces. Several photographs were taken showing the making of tuyeres and the arrangement of tools in the workshop. I also visited places like Garu near Bawku and Chiana near Navrongo all in the Upper East region; Lawra, and Jefisi in the Upper West region of Ghana. These are places where the staff of the National Museums and Monuments Board worked in the early 1970s. The information gathered from these places provided data for comparative analysis with the Mamprugu evidence. Below is the result of the non-archaeological aspect of my research in which a variety of issues on the form, nature and organization of the blacksmithing activity are presented.

Ethnic Composition of the Blacksmiths

The linguistic heterogeneity of the population of Mamprugu is reflected in the ethnic composition of the blacksmiths today. Eighteen (68%) of the sample interviewed can be grouped under a Hausa/Mamprusi class. Forming the majority of the blacksmiths, these people trace their ancestory to Hausas (mostly men) who migrated from Hausaland in Northeastern Nigeria or the Lake Chad area to Mamprugu to practice their profession. This has been dated to the eighteenth century (Levtzion 1968). According to the tradition, the Hausas married mostly Mamprusi women. The present people speak Mampruli as their first language and call themselves Mamprusis although they continue to acknowledge their Hausa identity. They are all Muslims.

The remainder of the sample consisted of three Dagombas, one Frafra, one Busanga, one Bimoba, all ethnic groups found in Northern Ghana; one Krachi and one Brong all belonging to southern Ghana ethnic groups. Apart from the Bimoba, all the others are immigrants from regions outside Mamprugu who moved in to share in the favourable market demand for items of iron that prevails in Mamprugu. There is a high degree of geographical mobility of blacksmiths from places like Walewale and Gambaga (which have the highest number of blacksmith workshops - eight and five respectively) to other places like Sakogu and Nakpanduri. There is no restriction whatsoever on the movement of blacksmiths within the area and others from locations outside Mamprugu are cordially welcome no matter their ethnic identity or religious belief. The blacksmith is called machire which is a Hausa term; the Mampruli term saaba, is less commonly used to refer to the blacksmiths. This reflects the impact the Hausa blacksmiths have made on the smithing tradition in Mamprugu today.

The blacksmiths in Mamprugu are not segregated from the main villages as is the case in most villages in Northern Ghana (Pole 1985:15). In Lawra, in the Upper West Region, for example, the blacksmith's quarter is separated both geographically and socially from the main village; the rest of the community knowing nothing about the work. The nearest situation to that in Lawra is found in Walewale where the workshops of four related Hausa/Mamprusi blacksmiths are found in one area together with their compounds and families in the Muslim quarter of the town. The three non-Mamprusi blacksmiths in Walewale are located in other parts of the town, but all close to the market. The workshops of all the blacksmiths in Gambaga were found in the Muslim quarter but they were not grouped together.

Religion and ethnicity are interrelated in the present sample of blacksmiths. The majority of the blacksmiths interviewed are Muslims. They make up 18

(72%) of the total sample. These are either Mamprusi, Hausa or Dagomba. Twenty per cent of the sample are Traditionalists comprising of one Mamprusi, one Frafra, one Krachi, one Bimoba and one Busanga. An Akan from Atebubu in Brong Ahafo Region was the only Christian in the sample (2%).

<u>Becoming a Blacksmith</u>

Blacksmithing is a specialized occupation throughout Mamprugu and is performed only by men. The skill and knowledge required for blacksmithing is passed from father to son and identity as a blacksmith is ascribed at birth. The community categorises a son as a blacksmith if his father has the occupation. The identity as blacksmith does not impose restrictions on intermarriage between smithing and non-smithing families. Religious similarity was a far more important consideration. Three of the blacksmiths interviewed were not the sons of smiths but had mothers who came from families where blacksmithing was the primary occupation. Both were trained by their maternal grandfathers or uncles to ensure that the profession remained within the family. In all three cases, soothsayers and diviners directed them to become blacksmiths. Such prophesies are taken seriously by traditionalists as was the case with the two blacksmiths who practised traditional religion. The Akan Christian working at Walewale narrated that although it was divined that he should become a blacksmith to keep the profession in his mother's family, he decided, instead, to learn leather bag-making. After acquiring that skill and working for some time he realized that he was incurring debts and having other problems. Eventually, he underwent training to become a blacksmith at the mature age of twenty-two. He used a relatively short period of six months to learn the skill from his aged uncle. He concluded that blacksmithing is in his 'blood' and he is happy with the profession.

It is the desire of every master craftsman that his skill should remain in his bloodline. All sons in a smithing family will be trained as blacksmiths. Although not all the sons will become practising blacksmiths, the majority stay in the profession. No child of any of the blacksmiths interviewed had ever refused to learn the skill. As a sixty-five-year-old blacksmith from Nakpanduri, Jaana Ziafro (see Appendix III) remarked:

> "They are born and raised in it... I, for one, became a blacksmith because that is the family profession which I acquired and specialized in at a tender age and have been so since".

In blacksmithing as with other crafts, it became evident from the investigation that traditional education, learning and training are an integral part of the life of the people in Mamprugu. Such traditional education is dynamic and over the generations evolves new forms and content adapted to the needs of the people and to the changes which have occurred in their environment and in the world around them. Rooted deep in African culture, traditional education imparts a broad range of essential social and economic skills which have enabled the people to survive and maintain a sense of personal worth and community cohesion.

The essential elements of traditional education in blacksmithing are verbal instruction, observation and experimentation. In this direction, blacksmiths begin training all male children between the ages of about seven and ten years when they are able to do minor jobs such as blowing the bellows, setting the hearth fire and lending a helping hand. When they are above sixteen years they are capable of doing more strenuous jobs. Although blacksmithing is an exclusive male profession, teenage daughters occasionally help in the workshop by blowing the bellows and breaking up the charcoal into required sizes.

In theory, smithing is not the exclusive property of any clan or family and is not institutionalized in Mamprugu; however, in reality the control of blacksmithing is quite restricted. Anybody may become a blacksmith whether he is from a smithing family or not, however, the success rate of outsiders entering the profession is low. In the interviews, instances were repeatedly cited where people from outside blacksmithing families had become apprentices but abandoned the training after less than a year.

To the old blacksmiths, everything the children need to become smiths may be found in the workshop so they do not see the need to send them to school. Of all the blacksmiths interviewed, only four (16%) had received western education. They are all between twenty-five and thirty years of age; two are traditionalists, one Muslim and one Christian. Three of them terminated their education at the primary school level and one holds a Middle School Leaving Certificate. This low percentage of acceptance of western education among the blacksmiths is primarily due to a fear expressed by most older blacksmiths that children who receive western education will look down upon blacksmithing and will quit the profession for 'office work'. A second concern is that with all the children at school the blacksmiths will have nobody to help with the minor yet essential jobs in the workshop such as blowing the bellows, lifting and holding objects and running errands. Some old blacksmiths have started to send children to school if they can be assured of help from others in the family. This is a recent phenomenon and as Mama Sumani of Walewale put it:

> "To become an expert blacksmith was the ultimate goal of every young male son in the family. Today, the school going children still show interest in the work and with the introduction of the Junior Secondary School (which emphasises vocational training like weaving and metal working) and the shift system, we can at least dispense with their services for some hours till they return from school."

There is, however, a desire by all Muslim blacksmiths to arrange for group studies of Arabic by the children and some teach their children and grandchildren themselves in the night and on Fridays.

Blacksmithing Tools, Equipment and Ritual

Many types of tools and equipment are used in the workshops of blacksmiths in Mamprugu. These include tongs, chisels, screwdrivers, sticks (for clearing the air passage of the tuyere), stone and iron anvils and iron hammers of various sizes with or without handles. While all the tools have a practical function, the iron hammers without handles, zeri (Hausa) and the stone anvils satanga (Mampurli) have historic and magico-religious aspects which link the blacksmiths of today with those of the past. The iron hammers originated before the availability of imported hafted hammers and are preferred even today for many blacksmithing tasks. It is a tapering iron cylinder about 30cm in length with a larger end about 5cm wide and a small end about 2cm wide (Plate 15a). In the past, they were used to beat and stretch heavy iron pieces and the narrow end is used to widen the hafting elements on iron tools such as hoes. The zeri is preferred over imported hafted hammers because it is heavier and because there is no risk of the head becoming loose or the handle breaking or cracking as with the hafted ones. The latter are best suited for working less heavy metals or plates, and for smoothing the rough surfaces of heavy metals.

The unhafted iron hammer represents an old iron forging tool that has been used for centuries by the blacksmiths. The present-day smiths fashion them easily from heavy iron bars and each possesses at least one in his workshop. These are similar to stone hammers of varying weights which Jeffreys (1952:51) observed being used in both the initial and final stages of forging the bloom in several places in Africa. Northwest of Yatenga in the Lake districts of the Niger bend, Desplanges (1907:28) noted that once the bloom was obtained from the smelting furnaces it was taken to nearby forges and worked on granite or sandstone anvils with unhafted (iron) hammers. From Madi in Rwanda, van Noten (1985:110) recorded that heavy traditional iron hammers, almost cylindrical in shape were used to beat the bloom in the process of forging.

Stone anvils derived from granite or heavy quartzite prevail throughout Mamprugu (Plate 17). They are used alongside imported iron anvils or improvised ones made from scrap such as rail rolls, engine blocks, crankshafts and cylinder heads obtained from tractors, trailers, heavy duty trucks and earthmoving machines. Even today the stone anvil is preferred over the improvised iron anvils when heavier iron pieces are to be forged. Twenty-one

(84%) of the blacksmiths interviewed possessed the stone anvil. All of these are Hausa/Mamprusi or other immigrant blacksmiths whose ancestors have settled in Mamprugu some generations ago. The blacksmiths who did not have stone anvils were the three Dagomba and the Akan. One of the Dagombas claimed that such an anvil, in the custody of the head of his family, was meant for him and will be handed over to him after the performance of a ritual. The only Akan blacksmith in the sample recounted that the stone anvil had been used in his place of origin in the past. He is also one of the only two people who possessed the imported anvil. The other person who had the imported anvil is a Bimoba in Nakpanduri, a specialist in the manufacture of locally made guns like the Akan. It is interesting to note that although this Bimoba blacksmith no longer uses the stone anvil in the smithing process, he still keeps it near the smithing apparatus in the workshop.

The stone anvil is the most sacred and most respected of all the items in the blacksmith's workshop. They are heirlooms which are passed from father to son and their origins are mythical. Myths of origin vary but the satanga is effectively accorded a telluric origin. One version has it that the stones are the result of shooting stars or meteorites falling into rivers from where they are collected by persons with magical powers. Another version states that they fall from the sky into the bush where they are found by persons who have the "eyes" to see and collect them after the performance of certain rituals. Some of the blacksmiths interviewed knew only that they are brought from far away on the backs of donkeys.

The stone anvil provides the link between the living iron workers and their ancestors which is the basis of the magico-religious aspect which characterises blacksmithing today in Mamprugu. It is the focus of all ritual associated with the craft. Both Muslim and Traditionalist blacksmiths perform rituals to the ancestors through the medium of the satanga. Such rituals are made when the blacksmiths experience low or no demand for their product, when they face repeated difficulty in forging items, and when there are major or repeated accidents or injuries occurring in the workshop. Principally, the satanga is consulted to ensure the success of the business but its help is also elicited in family matters such as illness, deaths, attacks by evil forces or bad dreams.

The religious beliefs of the blacksmiths determine the type and nature of sacrifice that is rendered to the stone anvil. The dominant form of Muslim ritual involves the use of cow milk into which maasa, a local millet cake is mashed. Part of this mixture is poured onto the stone and sometimes also onto the tuyeres while a verse of the Koran or other incantations are recited. The remaining part is given to children. This ritual is followed with the giving of alms. Other Muslims slaughter fowls in addition and pour the blood on the ground some metres away from the shop. 'In all these I pray to Allah', one Muslim blacksmith in Nakpanduri commented. By directing the ritual to Allah, the Muslims are able to distinguish between what they call ancestral worship which is incompatible with Islam and what they consider to be a prayer to Allah. This probably reflects an attempt to comply with Islam's aversion to representational gods. The Muslim blacksmiths are convinced that the prayers to Allah and the amulets are suitable substitutes for the detailed traditional sacrifice.

At Walewale, one of the two major Muslim towns in Mamprugu, the Muslim blacksmiths do not perform any ritual that focuses on the satanga. As one blacksmith, Abu Mahama stated:

> "Everything relating to the blacksmith occupation or ritual is dealt with through the use of the Holy Koran because we are devout Muslims... all we consider the satanga today is that it is a good anvil not a god nor do we attribute it with any powers."

As a reflection of this, one of the Muslim blacksmiths agreed to release one of his stone anvils to me for analysis. He, however, insisted that he would like to have it back. The views expressed by these Muslims do not in any way reduce the importance of the stone anvil. None of those who perform the rituals, whether the Islamic or traditional way, doubted the vitality and power inherent in the stone anvil and the positive results that the rituals bring. The comment of one Muslim blacksmith, Adam Meijeda (Appendix III) in Gambaga sums it up:

> "The ritual I perform works otherwise there would be no need for me to waste my time and money ... Whatever the problem, my iron working ritual is capable of solving it."

Sacrifices by the traditionalists are made both to the satanga which is considered a god, and to the ancestors who passed the technology on to them. A sixty-five year-old blacksmith Jaana Ziafro in Nakpanduri summed up the general view of the traditionalist blacksmiths:

> "The satanga is my small god; it is very powerful. I like and trust it so much that I regularly perform rituals for it."

Unlike the Muslims, traditionalists often consult diviners and soothsayers to determine the cause of problems and the kind of sacrifice needed and to which of the ancestors it should be directed. When a sacrificed animal dies after a struggle and lies on its back, the ancestors have accepted it; when it lies on its side it has been rejected. Dogs and fowls are sacrificed by some, others sacrifice these together with goats. The blood and tail of the dog are offered onto the satanga. Kola is chewed and the liquid spat onto the stone. Another blacksmith at Nakpanduri indicated that he sacrifices goat, fowl, guinea fowl and a dog to his stone anvil which is located near his smithing apparatus though it is no longer in use, since he owns an imported iron anvil. All the heads, blood and livers of these animals are placed on the stone anvil accompanied by incantations or utterances.

A similar picture is projected in other regions outside Mamprugu. The stone anvil is seen as the embodiment of all the power, technology and ingenuity of blacksmiths, linking the living and the dead from whom the skills are inherited. In Garu, near Bawku in the Upper East region of Ghana, the dog features together with the fowl as principal ritual animals. One old Busansi blacksmith in Garu, Jaafo Asana, hinted:

> "Only this stone needs a dog; the dog is a special animal offered only to the sanbaja (Busansi)."

One Bimoba blacksmith in Garu performs a more complex ritual. He uses a red cock and a dog. After slaughtering them, he places the liver and feathers of the tail on the stone anvil and pours the blood on the surface of the latter. The ritual is accompanied by utterances in which he calls upon as many ancestors as he can asking for their guidance, protection and help in the solution of problems that confront him at the time. After preparing and eating the meat, the skull of the dog together with some of the bones of the fowl left after consumption are offered to the stone anvil.

Animal sacrifice plays an important role in rituals relating to blacksmithing and Pole (1974a) has observed the use of fowls in rituals related to smelting as well in Northern Ghana. The blacksmiths stated that animals are kept in their homes for the purpose of sacrificing them to gods and ancestors and this is a major part of the importance attached to domestic animals. Blacksmiths interviewed stated that they rarely buy an animal to sacrifice. The role of the dog is even more important than that of the fowl. In Mamprugu, the dog has to be included in any major ritual; and whenever it is used along with other animals, it is the dog which is the principal sacrificial animal. The dog is regarded as the most powerful of the domestic animals. The dog's characteristics of vigilance, clairvoyance and alertness are regarded as attributes which can rejuvenate the power inherent in the stone anvil. In addition to being used in blacksmithing rituals, the dog features centrally during the installation of the Nayiri. During the oath taking ceremony, the meat from a dog, a cow and the donkey upon which the King rode to his lodging place, are used to prepare dugurugu, the courting food (Drucker-Brown 1975:154-155). Under normal circumstances Mamprusis are forbidden to eat the flesh of dog and donkey (as well as horse).

Blacksmithing Fuel

Charcoal, bugum saala, is the main fuel used by the blacksmiths in Mamprugu. It is made by the blacksmiths or by charcoal burners from a few preferred species of trees. All trees and shrub species may be used as fuel for domestic purposes if efficiently dry. The burning properties of the different tree species vary widely and the blacksmiths place an emphasis on wood that produces charcoal that has a high calorific value, and burns without smoke or sparkle. Any wood that produces such charcoal is categorised under the name langbenga, a Mampruli term that refers to woods that are hard, durable, immune to termites and borers and are therefore the best woods for a number of constructional purposes. These woods also burn at high temperatures and produce the best charcoal for blacksmithing. There are two preferred types of hardwoods; these are termed Naziri and Bomni, their botanical names being Prosopis africanus and Burkea africana respectively.

In addition to their high heat and non-sparkling properties, these have the added advantages of producing little or no ash. Thus the hearth can be used continuously for a number of days without any problem of ash accumulating. This reduces the need to clean the hearth frequently. The blacksmiths indicated that this removes the problem of the unattended hearth fire burning out and reducing into ash.

Naziri is also an important resource for reasons in addition to charcoal making. Its hardwood is much sought for making mortars, pestles, hoe and axe handles and most importantly house posts. It is also an important medicinal plant and is protected from cutting and burning in and around settlements so that its medicinal benefits may be reaped. Almost all parts of the Naziri plant are used. A decoction made from the roots is used for toothache, the leaves are good for toothache and various head ailments, and a combination of leaves and bark is used for rheumatism (also recorded by Irvine 1961). Chewing sticks made from Naziri are said to cure "worms between the teeth". Bomni, by contrast is only used for chewing sticks.

Every qualified blacksmith in Mamprugu knows how to make charcoal. The specific wood needed for making the charcoal is obtained some kilometres in the bush while in the past few decades the blacksmiths claimed that these trees were growing around the villages. The local deforestation around the villages as a result of their exploitation for domestic, industrial and constructional purposes has increased the inconvenience of firewood collection and an increasing number of the blacksmiths are forced to cut trees from the restricted government forest reserves created on the escarpment or to request charcoal burners to produce charcoal from special wood. Otherwise they arrange to buy the preferred trees on other peoples land and use it themselves. Large scale charcoal production is necessarily done in the bush to forestall the problem of transporting the large quantity of logs needed to the village. To burn charcoal, sticks of selected trees species of hardwood are cut in short lengths and piled up into a heap on the flat ground surface. The sticks are covered with grass and banked with soil, and air holes are made at the base. The wood is lit at the bottom and allowed to burn slowly.

Suppressed burning is important in the process. At the beginning of the dry season when the harmattan wind is prevailing and the humidity is low, the fire tends to burn more quickly but towards the end of the dry season it is necessary to leave the fire to smoulder for a longer time before covering it.

The process of charcoal making on the average takes four days. Water is used to quench the fire at the end of the process. Not all the wood are always burnt in the process and those pieces left are gathered and used to form the base logs on which the fresh or partially dry logs for the next burning are piled. There is no specific period for charcoal burning - it is determined by the trend of smithing activity. When the blacksmiths need more time to work in the shop they order charcoal of specified wood from people who produce charcoal as a supplement to farming. It was estimated that on the average a blacksmith uses about one kilogram of charcoal per day when there is brisk business, such as during the period preceding the farming season. In the larger towns like Nalerigu, Walewale and Gambaga, charcoal is the preferred form of fuel because the larger populations and extensive farmlands means that people must travel far for firewood. Thus it is easier to purchase charcoal from the sellers. In the small villages, firewood is still the preferred fuel. This factor also accounts for the higher demand in the larger settlements for such items produced by the blacksmiths as coal pots constructed of scrap plate which are fuelled by charcoal.

Workshops

Two different varieties of structures used as blacksmiths' workshop were identified. The most common one took the form of a conically shaped thatched canopy supported by posts with all the sides open or with between one and three sides covered with a mat woven from grass (see Plate 16). This serves to block the sun's rays. These workshops, I have referred to as type 'A'. They are normally placed between 4 and 12 metres away from the compound in the direction of the compound gate or door way. They are rectangular in plan and measure on the average between 3.5m and 5.5m. Seventeen (68%) of the twenty-five workshops were of this type which makes it the most popular one. Fifteen of these shops contained what has been referred to as type 'I' smithing apparatus discussed below. The remaining two use the type '3' apparatus. To prevent running water from entering into the shop, a low embankment is made along the line of the posts. There was one case in Nakpanduri where a low wall 40cm high and 20cm thick has been constructed as an outer wall.

The second category of workshop, type 'B', are mudwalled, thatch roofed and consist of one of the rooms on the compound (Plate 18). They formed the remaining eight workshops. They are rectangular in shape except for one at Nakpanduri where the only Busanga smith in the sample population has a circular shaped workshop. In Garu, in the Upper East region of Ghana, this type of workshop was the only one that I discovered in the three blacksmith villages that I visited. There is, however, a distinction that I noted. The circular shaped workshop in Nakpanduri consisted of one of the rooms of the compound while in Garu the workshop was always separated and placed at some distance from the compound in much the same way as the type 'A' workshops discussed above. The type 'B' workshops have two doorways, one facing the compound while the other faces outside. The doorways have no door fixed on them and they serve as avenues to and from the house although the compounds have specially made entrances.

The shops have between one and two tiny windows for ventilation. Compared to the type 'A' workshops, ventilation is poor. They are really warm especially in the afternoons and are not bright enough inside. However, owners of these workshops have no fear for the rain even if it comes in the form of storms. This workshop contrasts with mud-walled smithing shops found in Chiana and Lawra. Here, the shops are attached to the backwall of the compound and can only be entered from outside. They have mud floored roofs and are usually at a lower level than that of the compound itself and could be entered and walked inside only in a crouching position since they are not higher than 1.2m.

Smithing Devices and Techniques

Three different smithing devices and techniques were identified in the investigation. The first type '1' has air supplied by a pair of goat skin bellows that has been woven into a sleeve of some sort. Different sizes of these were found in the individual workshops but all have been sewn together on three sides with the fourth side left open in order for the blower to open and shut the bellows as he operates them. The air is forced out of the bellows through a metal tube fitted to the lower end. The bellows are to be found lying on the ground from where they are operated to pump air through a short tuyere which directs it to the centre of the hearth (Plate 19). The latter consists of a shallow depression in the ground. The blacksmith works in a seated position. He sits on a stone block or log. The distance from the blacksmith's seat to the hearth is such that he can lift the iron being forged from the hearth with a locally made pair of revetted iron tongs and hammer it on the anvil of stone or iron that is placed nearby all in a seated position.

At the end of the day's work, the bellows are removed because they is easy to refix them to the hearth and they are portable to carry. The fact that there are no locked doors to the workshops might account for this need to daily take away the skin bellow to prevent their being stolen since it is a very vital piece of equipment.

The statistics indicated that as many as twenty-two (84%) of the twenty-five blacksmiths in the sample used this type of smithing apparatus and technique. This figure included all the Hausa/Mamprusi smiths (17), the Frafra (1), the Dagomba (3), and the Krachi (1). It is therefore the most common and popular apparatus of blacksmithing used. The whole process of making an item can be carried out by one person working on the bellows and seeing to the hearth and doing the hammering and shaping of the item all in a seated position. This is most suitable and convenient for the aged blacksmiths. Most often, however, they prefer to have a younger person pump the bellow while they concentrate on the forging.

The second type of device and smithing technique (type 2) is somewhat different from that discussed above. The hearth, also a shallow circular depression is found not on the ground but on top of a rectangular structure that has mud-walled vertical sides and is mud-roofed. It stands at a height of c.1.3m and c. 80cm wide and 1.5m long (Plate 20). A single large bag bellow produces the draught. It is made up of leather covering a pair of wooden chamber to form a bag to which a cylindrical tube is attached. The bellow is suspended between two poles and is operated normally with one hand in a standing position. On top of the pole is a bar to which is rivetted a stick on which is attached one end of a taut string or chain with the other end fitted to the bellow bag. By lifting up and down this stick, the bag is compressed and expanded accordingly to induce draught into the hearth through a tuyere that is embedded in the platform structure.

Like the type '1' device, when the bag is deflated it becomes a flat thing that is portable enough and easy to carry. It is removed at the end of the day's work. It has the added advantage of an individual smith being able to carry out the activities of operating the bellows whiles attending to the hearth fire. The anvils mostly used with this apparatus are imported ones and are placed on a log at a height almost like the hearth.

On the basis of the sample interviewed, two people, one Bimoba and an Akan were found using this type of apparatus. The Akan indicated this to be the typical apparatus in his home town, Atebubu in the Brong Ahafo region which he introduced on his settling at Walewale. The Bimoba man adopted the technique from Sefwi Wiaso in the Western region of Ghana where his father lived for several years until his eventual return to Nakpanduri his hometown. My investigation in the coastal regions of Ghana shows that it is typical with the Gas, Ga-Adangbes, Krobos, Nzemas and Ewes. It also prevails in the forest regions of Akwapim. The presence of this type of smithing apparatus might, therefore, be an introduction of Southern Ghana smithing cultural trait into Mamprugu. In none of the towns and villages in the Upper Regions did I find this type of apparatus. Its use has, however, been reported from Northern Togo, Northern Dahomey (presently Benin), Nigeria, and Liberia (Cline 1937:105; de Barros 1986).

The third type of apparatus (Type '3') has air supplied from a pair of bellow bowls/pots laced on top with animal (most often goat) skin. The hearth is a shallow circular depression surrounded on three sides by a low clay wall. The bellows are connected to the hearth through the tuyeres by means of clay pipes that are attached to the bowl with the end placed inside the tuyeres. They are about a metre long (Plate 21). The pumping seat consists of a pair of stools each made from a log with a hole at each end in which a forked stick is secured. Two people are always needed to do the smithing. There is a pumper who sits on a log or raised stone structure behind the bowls often with one foot between them. A second man positions himself near the hearth with the stone or iron anvil near him. He does the forging. The need for two people to operate this apparatus and work the iron brings into focus the services of the teenage sons and grandsons of the blacksmiths. At the end of the day's work, the leather covering the bellows is removed leaving the pots and the connecting clay pipes. The former are permanently fixed in the ground. Only one blacksmith in the sample, a Busanga in Nakpanduri, uses this apparatus. He comes from Nogunyiri, a tiny village near Bawku in the far north-east corner of Ghana on the border with Burkina Faso. He described this device to be the typical in his hometown which his father introduced when he settled in Mamprugu. The Type '3' smithing apparatus and smithing technique is, however, the dominant type in Garu in Upper region where three (all Busanga) of the four blacksmiths visited used the above. The fourth blacksmith in Garu, a Bimoba, uses the Type '1' apparatus. At Chiana, near Navrongo in the Upper West region the Type '3' apparatus was the dominant one. At Lawra and Jefisi, a modification of the Type 'C' can be found. The bellow bowls are embedded in an earth bank which has been built around the clay pipes leading to the tuyeres. This latter is not a separate structure but is moulded in one piece with the bank; nevertheless there is a gap between the ends of the pipes and the tuyeres. The bellows are operated in exactly the same way as those in Nakpanduri, Chiana and Garu except that the pumper sits on the part of the bank behind the bowls, often with one foot between them (Pole 1975).

We conclude this discussion on smithing devices with a look at the construction of the clay or mud units since it might provide clues to the construction of the smelting furnace or the functional units. The clay for the tuyeres of Type 'A' apparatus, the raised platform of Type 'B' and the bellow pot, pipes and tuyere is the same as used in making granaries. It is derived from termite mounds. The clay is crushed and all extraneous materials are removed. It is mixed with water and puddled. A number of materials are used as temper. These include droppings from donkeys, chopped grass and kapok in that order. The mixing is done on a wooden board or a metal sheet. The temper serves to absorb moisture from the clay without causing cracking both during the air drying and during the firing itself.

The bellow pots, pipes and tuyeres are made by the blacksmith themselves and not by any other man who makes them as a means of livelihood (Plate 22). It is one of the jobs that beginners are engaged in thus every blacksmith can make them just as he can burn his own charcoal.

The tuyere is the most frequently replaced part of the smithing apparatus especially for the Types '1' and '3'. Referred to as bachinwuta: (Hausa, literally meaning firemouth) it gets damaged when a piece of the part of tuyere and in contact with the fire is broken as a result of cleaning the channel of tuyere of any impediments like charcoal pieces or slag lumps obstructing the smooth air passage with a piece of stick (one of the tools used in the shop). A haphazard stoking of the charcoal fire resulting in striking or knocking of the tuyere end is another cause. The broken tuyere can sometimes be re-used when the broken off part is reconstructed with fresh clay and allowed to dry. Most often, however, there are spare tuyeres always available in the workshop.

Items Produced

Blacksmiths in Mamprugu manufacture iron, weapons, and equipment of all kinds used in the agricultural, constructional, hunting and gathering, carving and fishing sectors of the economy as well as for personal adornment and use or as attachments for other objects (see Table 8 also see Plate 23). The form the smithing industry has taken is determined principally by the requirements of their various customers. Most of the uses to which the objects or items are put are regulated to a great extent by the climatic conditions prevailing at a particular time of the year and not by the traditions of the specialists who maintain the industry. The coming of the rain marks the great demand for agricultural implements and the blacksmiths can be found turning out large quantities of all the hoes, axes and ploughs needed. With the planting season over, toward and during the harvesting period, hundreds of knives are needed by the people. After harvesting, everybody (except those who have the money to buy) has to go to the bush to cut grass and the sickle becomes one of the main items produced. The building of new houses and the maintenance of old ones goes on throughout the dry season, and tools for digging clay and gravel soils as well as locks and hinges have a high demand. The dry season is also the time of extensive hunting and not only should the blacksmiths produce locally made single-barrelled guns but should repair old traps and make new ones whilst turning out large quantities of spears and tanged arrow heads.

The blacksmiths recounted that in the past when there were lots of inter-tribal wars, large amounts of spears, arrow heads, javelins and long swords were produced in large quantities. Today, however, the javelin, long swords and horse stirrup are produced only on request. There is also a drastic reduction in the demand for iron rings and bangles (for the arm, wrist and leg) due to availability of copper, silver and brass substitutes. What has kept the demand for some of these is their use in juju for personal protection.

The blacksmiths furthermore recalled that there was much specialization in the items produced by individual blacksmiths in the past than it is today. The items for which specialization of some sort is evident today is in the making of local guns and bullock ploughs. Not every blacksmith manufactures these items. Only six (24%) blacksmiths of those interviewed are involved in the making of ploughs. There was a similar situation in Garu where two of the four blacksmiths talked to did not produce ploughs at all. With locally made guns five (20%) produced it and these are located in or near the towns of Gambaga, Walewale, and Nakpanduri. There is no restriction on any blacksmith in the manufacturing of any item for which there is the demand and this might explain the reduction of specialization since, as the blacksmith asserted there is an increase in the number of smiths.

There is no separation between blacksmithing and for that matter any other economic activity on one hand and farming on the other. Almost every adult no matter his profession or craft specialization, engages in farming during the rainy season to produce at least sufficient food to feed his family for the period lasting till the next harvest. In this sense farming in Mamprugu is a basic economic activity. After harvesting, there is no serious farming activity and everybody continues with his craft or profession. Seen in this light, neither the view that local craftsmen (in Mamprugu) supplement their farming income by practising their skills (Davies 1984:11), nor the assertion that iron workers of Northern Ghana both smelt and smith on a part-time basis (Pole 1985:115) can be seen as applicable in Mamprugu. Smelting, rightly stated, could only have been done at certain times of the year, that is, during the dry season when there would be no farming activity and climatically there were no rainstorms, thunder and lightning to pose any danger to the lives of the smelters. Smithing on the other hand, is a year round activity in Mamprugu. Almost all the blacksmiths interviewed insisted that smithing is their main occupation throughout the year. They do farm as everybody does to produce enough food for their rather large families and not for sale. Where they cannot get time for their smithing activities, they hire labourers to do the job of ploughing, sowing, weeding, harvesting, shelling and storage for them.

Throughout the year there is demand for the products of the blacksmith, a demand level that is regulated by the climatic conditions as well as the social and economic activities that result therefrom. Most recollect times in the past when blacksmiths were normally given gifts of farm produce by people for whom they had rendered some service. There was only one such case that I observed in Gambaga when two basket loads of corn had been given to this blacksmith. The reduction in this practice might be due to the increase in the cost of producing food items because of poor soil fertility and high cost of fertilizer and other inputs, making it difficult for people to be able to produce what is even sufficient for them much more in excess of such targets. In fact the blacksmith by participating in agricultural and pastoral activities are economically better off than most of the people in the towns and villages since they spend less of their earned incomes from smithing on food.

The Blacksmith as a Ritualist and Dispenser of Herbal Medicine

Traditional education in blacksmithing includes the acquisition of knowledge about certain plants and their medicinal value as well as the spiritual powers and physical properties of the tools, equipment used and the slag produced in the workshop during the forging of iron or those resulting from ancient iron smelting. Almost all the blacksmiths interviewed were pre-eminent herbalists or ritualists that are of a Traditionalist or Islamic sort depending on their religious inclination. The knowledge is acquired during the training process and the community is aware of the blacksmiths possession of this knowledge. Among the most popular cases which the blacksmiths can treat is scald. The surface of the burn is first washed with a decoction made from the leaves of some trees into which a piece of slag produced in the hearth in the workshop is dropped. Next the bark of the shea tree, taanga (Butyrospermum parkii), Dawadawa, dua, (Parkia clappertoniana) and sinsibi gbetule (Lannea spp.) are dried and pounded into a powder. A piece of workshop slag is also ground into a powdery form and mixed with the bark. This is applied on the surface of the scald for up to a week when it heals.

A second popular case treated involves deep cuts resulting from metal objects like knives, bicycle spokes and hunting or agricultural tools. This is treated with the same medicine as in the case of burns. In four instances, the blacksmiths showed me prepared powdered stuff which they had with them in their workshops as a kind of first aid. The others indicated that they could readily collect the herbs and prepare them when the need arose. This might imply that the cases discussed above are among the most common accidents associated with blacksmithing. It is also a common and sometimes very fatal accident in the homes especially involving children. Due to the special role the slag pieces plays in these medicines, the blacksmith is duly recognized as the only ritualist equipped to undertake the treatment. For this reason it has become an accepted practice in the communities to refer serious cases involving scalds and deep cuts to the blacksmith for treatment. In a society where many people prefer to use local medicine for treatment, the significance of this aspect of the blacksmith profession is readily perceived and appreciated.

Every blacksmith interviewed knew of this medicine and has treated some people in the community. However, almost all of them were reluctant to discuss the details of their knowledge in herbal medicine especially when it comes to mentioning the names of the plants or substances involved. This reflects their desire to forestall the secrets of their knowledge from 'leaking' out. This was more evident with the treatment of haemorrhoids or piles for which five blacksmiths indicated their capability but none of them would mention the names of the trees, leaves, roots or bark involved. The main ingredient is said to include roots of selected plants that are boiled in water into which a piece of workshop slag is put. This decoction is used to wash the surface of the swellings of vein or veins at or near the anus. The pile contracts and the patient is cured. The compound of one Adam Awudu, a Hausa blacksmith in Gambaga is reputed as a haemorrhoid treatment centre in Mamprugu.

The few pieces of slag produced in the hearth of the blacksmith in his workshop are always kept since some members of the community are noted for requesting for them to be used as one of the many items needed for making 'juju'. One of the most commonly referred 'juju' is the 'knife medicine' which is said to make one impenetrable by iron weapons in case of an attack. In some cases the blacksmiths are specifically requested by these people to go to the bush and pick a piece of slag produced from traditional iron smelting for a fee. These are given to the 'jujumen' for the performance of the rituals for medicine. Slag from the workshop hearth is used as a purifier of the local black ink used for writing Koranic verses on wooden slates. The ink is made from the leaves of blackberry tree, nyaringa, (Vitex doniana) or the seeds of bagarua, (Acacia nilotica). The piece of slag is dropped into the ink solution and boiled for some time. The product that results is said to be bright and shiny and stays longer on the slate. Charges for treatment or services by the blacksmiths are moderate. The traditionalists may demand a fowl and some kola to pacify the gods and ancestors and to ask for their help. To the traditionalists, therefore, this serves as a means of getting fowls for the performance of rituals necessary for the well-being and the success of their blacksmithing occupation.

The Blacksmith and His Status in the Community

By producing all the basic tools of procurement, production and construction, the blacksmith is the friend of everybody in the community. He is respected in every town or village in Mamprugu. He is a public figure but not close to the political power although he plays an important part by forging the symbols of political power. Smithing brings wealth as well as social and symbolic prestige. Data shows that smithing in Mamprugu is well rewarded. This work puts the smith at the origin of most socio-economic circuits. He provides the tools and equipment used in agriculture, hunting, fishing, carving and butchering. As one blacksmith in Walewale puts it 'we the blacksmiths are respected because we forge the hoes and traps necessary to get food'. The prestigious aspect of the smith's occupation seems to originate in the technical, symbolic and ritual efficiency demonstrated by the smiths. There is clearly evident in all those interviewed a satisfaction of being a smith.

This reflects the variety of benefits associated with the smithing occupation. Like a kind of technological 'big man' the smith emerges from the group. This ranks him among the other specialists: chiefs, hunters, herbalists, butchers, barbers - who also have a special position in the people's mind. The relationship between the various specialists is also interesting. The smith in Mamprugu is regarded as a magician (a creative and ingenious specialist) but his power is essentially aimed at technological and to a less degree spiritual influence.

This picture of the status of the blacksmith in Mamprugu is a reflection of the situation in most communities in Northern Ghana. At Tiza and Lawra, in the upper West region of Ghana, the status of the blacksmith is high. Pole's (1975) account indicates that the blacksmiths supply chiefs for their districts. The institution of chiefship was introduced in the early days of colonial rule in these areas and the selection of the blacksmiths shows that they were prominent members of the local community.

The blacksmith in Tiza was an accomplished xylophone-player and dispenser of herbal medicines both highly regarded specialist activities (Pole 1975). The blacksmith in the Dagari-speaking area formerly had an important part to play in ritual activities. The forge is likened to, but not identified with the earth shrine; and the smith shares some of the functions of the earth-priest, for instance, in invoking supernatural punishment on those who persist in armed conflict (Goody 1967:91). The blacksmith's special position derives from his association with the earth both in deriving iron from it in the past and in producing tools which enable the whole community to benefit from its fertility. This evidence from Northern Ghana compared to evidence from Diman in Ethiopia provide interesting contrasts. According to Todd (1985:91), the manufacture of iron was restricted to members of the blacksmith caste, a despised group with status higher than the tanner but much lower than the rest of the population. As at 1973, when she carried out her research, traditional smiths were servants of the chief. They were not permitted to own or inherit land and cattle (only sheep and goats) and were provided with grain, staples and meat in return for their iron work. They could only intermarry with other members of the blacksmith caste and were forbidden to enter the houses of ordinary and royal Dimi.

Overview

Iron working activities, the institutions governing them and the structures and devices used have been described among other aspects from Mamprugu. Variability was noted in terms of religious and ritual practices, the structures and items produced. These descriptions, though varied from each other are similar to other, descriptions in the literature in Ghana and elsewhere in West Africa. There are differences which are significant from the cultural point of view since they do indicate individual (ethnic) preferences in the solution of a common technical problem - manufacturing iron items for local use in the communities.

The importance of the activities of the blacksmith is evident both in his status in the society and in his role as a "spiritualist" and a dispenser of herbal medicine. In the determination of the type of tree species used and the assessment of the impact of the iron smelting industry investigated, the ethnographic data has been very valuable as will be noted in Chapter Six.

The variability observed can be attributed to the heterogeneity of the blacksmithing population. When it comes to determining the authorship of the Gambaga smelting evidence, the ethnographic data cannot provide direct answers. This issue was always addressed in the oral traditions collected and it was continuously revealed that none of the blacksmiths could say whom the iron workers were although they were aware that the evidence for smelting existed in several places in Mamprugu.

The Mamprusi do not work iron. Where a Mamprusi is a blacksmith he has become so because his father or mother married into a family which has blacksmithing as the main occupation. The Hausa, who form the dominant group of the blacksmith population, are immigrants who settled in Mamprugu not more than two or three centuries ago. The oral traditions shows that the ancestors of the Hausa smiths came to Mamprugu as blacksmiths and not smelters. The Bimoba blacksmiths in Mamprugu can be considered as a "floating" class of blacksmiths. They do not have identified smithing structures and devices of their own. They use any of the types be it the Southern Ghana or Hausa or Upper region type. This group has settled in Mamprugu for long but they do not claim ancestry from smelters in the past.

The only group in the lot which had been noted to have been present in Northern Ghana as iron smelters and smiths are the Busanga. It was, therefore, not surprising that the few aged Busanga smiths and non-blacksmiths interviewed knew how to smelt or had actually seen the process. The homeland of the Busanga is in Burkina Faso and the bulk of them are concentrated in several places in the Upper East region of Ghana. Their language, Bisa, belongs to the Mande family (Barker 1986:304). They are an intrusive element in most places where they are found. Their presence in Northern Ghana according to their tradition, dates to about the second half of the 19th century (Pole 1975). In Garu, a predominantly Kusasi area, the blacksmiths are all Busanga, who performed the demonstration smelt in this village in the early 1970's. These had migrated approximately 80 years ago from Burkina Faso (Pole 1975:32).

This picture in the Kusasi area is what is presented in Mamprugu. It is an immigrant group which is providing the blacksmiths. This feature accounted for the great caution in the use of any of the present day bellows systems as directly applicable to the archaeological evidence. Moreover, evidence from Lawra, Zanlerigu and Jefisi shows that the bellows used in smelting and smithing are not interchangeable (Pole 1975:35). These limitations in the ethnographic data show that ethnography conducted on modern blacksmithing societies can only be used for direct historical projections only when the link between the ethnicity of the present and the past iron workers is established. This aside the investigation into the profession of blacksmithing as it exists today gave insights into the cultural and religious background of the practitioners while depicting the complexity of Africa's technological history. Its usefulness as a reference material cannot be disputed.

CHAPTER SIX

DISCUSSION

This chapter is devoted to examining the chronology of the smelting evidence as well as the identity of the iron workers whose technological expertise is depicted by the remains. Other issues discussed include the impact of the smelting activity on the ecology, the location of the sites and the spatial distribution of the furnace type varieties.

THE CHRONOLOGY AND AUTHORS OF THE IRON SMELTING EVIDENCE

From the preceding chapter, it was noted that none of the blacksmiths interviewed in Mamprugu and who were shown photographs of the furnace designs had any recollections as to who were responsible for the smelting evidence investigated in the Gambaga area. None claimed ancestry, direct or remote, from the people concerned. The oral traditions from non-blacksmiths in Mamprugu and blacksmiths visited in the Upper regions of Ghana could not provide answers either. For possible clues, therefore, recourse to a critical study of the available data on the settlement of the Gambaga Escarpment and northeast Ghana in general was adopted.

The oral traditions and most of the written accounts on the Escarpment and also for most of the Northern region has been dominated by the history of the Mossi-Dagbani or Dagbamba as they are referred to by Davis (1984; also see Brown 1975; Barker 1986). This large entity consists of Mamprusi, Dagomba, Mossi and Nanumba ethnic groups. Linguistically, these belong to the south western Oti - Volta of the Central - Gurma sub group of the Niger - Congo family (Naden 1988:44 also see map 5). They share the same history and trace their origin to the east of Fadan Gurma in the northeast part of Burkina Faso led by one mythical "red hunter" named Tohaijie. There are many different versions of the story of the red hunter and his bold exploits but all agree that his grandson was Na Gbewa who is recognized as the first Nayiri (Paramount Chief) in Mamprugu and Ya-Na in Dagbon.

According to the oral traditions, Gbewa was succeeded at Pusiga by his eldest son Tusugu. When Tusugu died, the Dagbamba left Pusiga and settled at Gambaga where the remaining sons of Na Gbewa quarrelled, split up and each founded a separate dynasty. Sitobo founded the Dagomba state, Yantuare, founded the Mossi Kingdom and the youngest, Tohogo founded the Mamprusi state. The actual date for the settlement of the Dagbamba in Northern Ghana is a subject of controversy among historians. Whiles Davis (1984:62), has suggested a late 14th century date, others like Boahen (1966: 55) and Fage (1978:97-98), date it to the second half of the 15th century and the early 16th century.

As far as Mamprugu is concerned, and on the basis of the evidence available, the Mamprusi are the dominant and ruling class but they do not work iron as was noted earlier on. This therefore, demanded that the nature of the settlement prior to the coming of this group is examined. Investigation by the G.A.R.P. (1987-89) led to the discovery and excavation of Kintampo Neolithic sites. This cultural phase represents the earlier evidence for food production, using stone adzes popularly called Nyame Akuma in Twi, and settled community life in Ghana dated to the late second millennium BC. It therefore, provided evidence of the antiquity of agriculture in Mamprugu. The ethnicity of the authors of this culture is not known but it is hoped that from the analysis of the evidence available it may be possible to determine the contribution of the Kintampo agriculturalists albeit a long time in the past to the present day make up of the population and culture on the Escarpment.

Like the evidence of the early agriculturalists, the lack of knowledge on the makers and age of the slag mounds and smelting debris is suggestive that the evidence bears the stamp of antiquity. This has been confirmed by the single radio carbon date estimation I have so far obtained. It is based on charcoal from a sealed context at a depth of 50 cm in the slag layered and relatively undisturbed mount of SM.16 in zone 'A'. The mound has been dated to 460 $\pm$ 90 (AECV - 710C) B.P. MASCA calibrated, this is 1490 $\pm$ 90 A.D. This date might not fully address when the industry started. Data on this might not be easily forthcoming because early smelting operations were probably conducted on a scale resulting in relatively small slag mounds or surface scatters. Many or most of these deposits have subsequently been ploughed through, eroded or buried by later sediments. Future excavations and the submission of more charcoal samples for radio carbon dating or Thermoluminescence (TL) samples for analysis may address this issue favourably.

For the purposes of this analysis, the A.D. 1400-1500 date range, examined in the light of ethnohistorical and written accounts, suggests an iron production industry that dates prior to the arrival of the Dagbamba and which ceased generations or perhaps centuries ago which is why there are no recollections in the area today of the authors or the age. This confirms ideas and views held by earlier anthropologists and historians that Northern Ghana had been settled prior to the coming of the Dagbamba. Rattray (1932 preface xii), rightly noted that despite the oral tradition which reflect the movement of these immigrant rulers, "......the majority of the tribes who inhabit the Northern Territories were ...... residents on or near the localities where we now find them centuries before the ancestors of those whose name many of the tribes now bear had arrived in this part of Africa". These early settlers were living in scattered clan settlements under the religious and social leadership of the tendana, the "custodian of the land" (Davis 1984:113). These settlers are normally presented as agriculturalists practising crafts like potting. There are normally no mention of their iron working abilities.

Thanks to Tamakloe's (1931) 'Brief History of the Dagomba' it is now known that "there is an almost forgotten tradition among the present Dagbamba people that their country was formerly inhabited by giants whom they called 'Kondor' or Tiawomya' or 'Adites' This extinct race of giants were said to have been so extraordinary in stature that if hawks swooped down on their chickens they simply had to rise up and snatch them back. They were so tall that the least of them was 90 feet (32.8m) .... the industry of the Adites was iron smelting and smithing (Tamakloe 1931:1-3)". The description of the people as giants and the fantastic dimensions given is suggestive of reference to iron workers who might have been a caste or guild of hereditary workers regarded apparently by their agriculturalist neighbours as magicians or sorcerers probably by reason of their mysterious skills in extracting iron from stones. This superstition may be encouraged by their possible practice of working at night.

The data indicates that "since iron stones (iron ore) were not to be found in a limited locality, the iron workers found it necessary to wander about from place to place and interspersed themselves in the country between the Kulpene (Kulpawn), the White Volta and the Daka rivers (Tamakloe 1931:1)" This suggests that we are dealing with a group of iron workers who, moving in families under local heads, settled either among the agricultural communities or in other separate places to produce iron and iron products for the local economy. The factors in an area that would have attracted such people would have been the availability of iron ore, fuel wood for charcoal, water for the constructional and smelting activities and the market for their product. The Gambaga Escarpment attracted the activities of these people as the archaeological evidence suggests. Clays are in abundance and are found in the river valleys and several hundreds of ant-hills. Laterite rock which was not seen anywhere north of the cliff is found extensively in the rest of the Reserve where it forms many hillocks and ridges. The highest points on the scarp are usually laterite. Tree growth is very excellent due to the availability of streams and rivers which hardly dry out for most of the year. For the market, the evidence of the antiquity of agriculturalists has been noted above.

What the archaeological investigation in the Gambaga area recovered were possibly the remains of the activities of these iron workers who preferred to conduct most of their activities in the bush on the escarpment. These were the industrial sites. On the other hand, the 'Adites' "established towns at Gunayiri in Karaga District and Yogo (vogo) in Safulugu District.... and those who settled beyond the Oti rivers were the progenitors of the Konkomba race@ (Tamakloe 1931:1-2). In addition to these known towns, "large kitchen middens, refuse of iron stones (slag) and aged baobab and kapok trees which mark the sites of one time flourishing and populous towns are sufficient proofs that the Dagbamba was once inhabited by some huge and industrious people" (Tamakloe, 1931:1).

The coming of the Dagbamba to Northern Ghana led to changes in the demography and settlement pattern. The incoming people have been described as an all-male warrior band who had a strong authority structure so they imposed their chieftaincy on the earlier communities (Barker 1986:112,; Davis 1984:113). Since they were few they could not administer the whole area themselves (Davis 1984:128) so they left the social structure and religious practices of the earlier settlers under the leadership of the tendana intact. This was likely to have been made on condition that the acephalus groups did not raise any opposition to this "foreign rule". It would not be unreasonable to suggest that the iron workers (since they were the producers of the most effective means of production and destruction) would have been a possible source of danger or threat to the Dagbamba especially where attempts to bring them under the control of the new authorities was met with their refusal. In Mamprugu, for instance the oral tradition indicates that those tendanas who led their people to resist were killed and replaced by loyal members of the invading force (Davis 1984:128). Dagomba state, made war against the "Adites" killed the entire body of fetish priests and appointed its people in their stead (Tamakloe 1931:3). The traditions mentioned the names of as many as thirty villages where the tendana were slain (Davis 1984;128). The defeat of the acephalous communities, be they iron workers or agriculturalists was due to the fact that the Dagbamba had horses at their disposal and an organized troop of cavalry (Fage 1959:37), which gave them the advantage of speed in attack, in pursuit, and in escape, over fighters on foot (Davis 1984;120).

Traditionally Sitobo was accompanied by six of his brothers when he left Gambaga, but Tusugu was alone in establishing his stage (Davis 1984:128). This relative difference in the size of Sitobo's contingents might be indicative of an anticipated threat to be posed by some of the earlier occupants of the land. The brutal destruction of these people may be suggestive of stiffer resistance by these "Adites" are possible authors) named by Dagbon oral traditions, the area they traversed together with the area of smelting evidence investigated in the Gambaga area are indicated in Map 8.

Other questions that remain to be answered relate to the date for the attack and sacking or possible decimation of the "Adites". Whom do we consider as the descendants of these people in Northern Ghana and when possibly did the smelting industry in the Gambaga area cease operating?. Tamakloe (1931:3), dates the attacks to about the year 1416 A.D. On the other hand the reign of Na

Sitobo whom Na Nyatse succeeded has been placed in the early 1400's and by others in the early 1500's (Barker 1986:172). All these dates are derived from oral traditions which explains the complications involved. The reliability of orally determined chronology diminishes as it extends further back into the past.

Broadly, however, the dates suggested, fall within the range that can be determined for the settlement and early history of the Dagbamba which is between the second half of the 15th to the early 16th century. The abandonment of the smelting activity might have happened any time within this period. This view is corroborated by the evidence from the only abandoned settlement site, Gballa, (see Appendix I), found in the area investigated to the north-northeast of Gambaga. This site had lots of iron smelting debris which have been ploughed and cultivated for generations. The oral traditions and records at the Mamprusi Traditional Council in Nalerigu shows that this village was founded in the early 18th century and abandoned in the 1970's by Mamprusis. These found the iron smelting evidence on their arrival and do not know the authors. It is therefore reasonable to suggest a terminal date of early to mid 16th century for the abandonment of the smelting activity. The reasons for this can best be answered by a multiple of causes like possible attack and annihilation or sacking as the written document indicates or abandonment due to ecological reasons as will be discussed below. This second view is equally applicable like the first because since a great deal of raw wood is needed to produce the charcoal needed for iron smelting and smithing and because wood supplies are inevitably exhausted at some point, movement of the iron workers from one location to another is highly possible.

If the early abandonment of major iron production on the Gambaga Escarpment is maintained, it might imply that we should be able to determine the sources for iron for the people in Mamprugu from there on. Iron bloom could have been obtained from the Gur-Mossi and Bisa ethnic groups in the Upper regions of Ghana. Other sources would have been from Yatenga and the Mossi of Burkina Faso who are on record as having had considerable iron production activity even at the beginning of the 20th century (Diop 1968). By obtaining the bloom from other sources the blacksmiths in Mamprugu would have worked them into iron items. The Hausa blacksmiths who are the earliest immigrant blacksmith group in Mamprugu came to the area as smiths and not smelters as the oral tradition recounted indicates (Chapter Five).

An analysis of the oral traditions and ethnohistorical accounts of the Bassare in Northern Togo by de Barros (1988:95), showed that by about 1900, Bassare iron was being traded throughout most of Togo, Northeast Ghana and part of Western Benin. This is later than the date suggested for the abandonment of Mamprugu major iron. Perhaps a suggestion made by de Barros (1986:165) that the leap in the production of Bassare iron production during the late 16th to 18th centuries is probably due to the emergence of the neighbouring states of Dagbamba, Mamprusi and Gonja during the 15th and 16th century might be relevant here.

We conclude this discussion on the authors and chronology of the iron smelting evidence by determining who the descendants of these "Adites" might be. This would reveal a number of new research potentials that future investigation should tackle. The social and political organization described for the "Adites" reveals that they had no kings except for the fetish priests who exercised more or less sway over their fellow subjects (Tamakloe 1931:3). This is the typical organization that existed and has been maintained by the tribal groups in Northern Ghana even after the introduction of chieftaincy by the Mossi-Dagbani and Gonja ethnic group, colonial rule by the British and the present day political structures.

Manoukian (1952) mentioned the ancestors of the present day Tampolensi, Vagla and certain Isala groups and some Konkomba groups as among those who had occupied much of Northern Ghana some 500 years ago. Apart from the Konkomba, the other linguistic groups are Gur-Grusi (west) and closely related to each other and to the Chakali and Deg (Barker 1986:191, also see Map 6 and 7). These are located in the Tumu district to the Burkina Faso border with a "tail" reaching southwards as far as the border of Northern region of Ghana (Barker 1986:190). Traditions of migration into the area differ from clan to clan but suggest origins from Mossi, Mamprusi, and Dagomba country (Barker 1986:162). Rattrey (1932), had earlier on noted that "only a few Isala clans had a common origin, the scattered units which form the tribe being drawn from most part of every point of the compass". Would the Sisala be the descendants of these pre-Dagbamba iron working communities? The iron working prowess of the Sisala group at Jefisi had been shown in the 1970 demonstration smelts. However, the furnace type and the other functional units do not relate it to that of the Dagarti in Lawra. Further historical and archaeological research is needed in several Sisala settlements to determine whether there are other smelting communities in this area with evidence similar to that of Gambaga.

Tamakloe (1931-2), suggests a connection with the Konkomba by stating that the "Adites" who settled beyond the Oti rivers were the progenitors of the Konkomba. Tait (1961), quotes a Konkomba oral tradition that they formerly stayed around Yendi together with the Bekwon but the Dagbamba came from Tamale and Kumbungu and drove them out ... The Dagbamba had horses and were stronger. The Bekwon fled across the Oti river and the Konkomba tribes settled around Saboba. This has been dated to the reign of Na Sitobo which would place it at any time between the early 15th and early 16th centuries (Barker 1986). Reference to iron-smelting in the analysis of the Konkomba society given by Tait are conspicuous by their absence: it is likely that at the time of his field work, smelting had already been defunct in the vicinity for a number of years. I have unfortunately not had the opportunity to travel to Konkomba country and across the Oti River to the Togo side to areas where the Bekwon should be found to survey the land and examine the oral tradition on this issue. Future research is urgently required in the Isala and Konkomba, Bekwon and other areas in Northern Ghana especially in the technological sphere.

ESTIMATING THE SLAG VOLUME AND THE ECOLOGICAL IMPACT OF THE IRON SMELTING ACTIVITY

For each of the sites surveyed and counted, the heights, widths and lengths of the slag accumulation were directly measured using metric tapes. From this, it has been possible to make a rough assessment of the slag volume for the smelting evidence investigated. In Chapter Three, the effect of constructional and farming activities as well as running water in the destruction of smelting debris was discussed. The impact was clearly evident in that the slag mounds on 28 smelting sites, representing 23% of the total sites recorded, could not be measured in any way. This is because the debris has either been graded away completely or has been levelled and spread on the farmland through ploughing or else what remains is a thin scatter of debris on land that shows signs of having been subjected to serious erosion and degradation.

Almost all the sites have been affected by the above natural and human agencies which have altered the shapes of the mounds although the majority were roughly rectangular in plan. From the results obtained, the highest mound (SM.24) stood at 2.2m and covered an area of 728m^2 respectively. This gives a volume of 72m^3 of smelting debris per mound. The calculation of the slag volume for the 122 sites was based on the above measurement and the volume formula determined for typical slag mound shapes was based on the simple dimensions of length, width and height. The mounds were, therefore, viewed as three dimensional segments with flat bases (as the excavation revealed). The summarized data is presented in the table below:-

Zone	Number of Slag Mounds	Volume of Smelting Debris in Cubic Metres
A	22	1,584+
B	15	1,080+
C	9	648+
D	63	4,536+
E	13	936+
	122	10,000 +

Table 2: Estimated Slag Volume of the Gambaga Smelting Site

In determining the total slag volume, a conservative estimate of the minimum amount of unrecorded slag in each production zone was incorporated into the final total. It must be pointed out that the actual quantity of debris may be twice larger since the slag and smelting debris have accumulated over a long time probably centuries and most of ploughing, constructional and erosional activities by man and nature respectively have eradicated both large and small slag mounds.

The figures do not tell us anything about the average yearly output of the individual smelting sites at a given time. No data, oral tradition, ethnohistorical or written records is forthcoming that can be used to determine the efficiency of the Gambaga furnaces which should make it possible to determine the iron output. Further work has been planned to be carried out in the near future into this aspect of the industry. During this period, more dates would be obtained to make it possible to establish a firm chronological framework for the iron production evidence. Furthermore, the total weight of slag could be determined experimentally by using a given suitable ratio as has been done for the smelting evidence at Hani, Begho in the Brong Ahafo Region of Ghana (Goucher, 1981).

That the industry relied on charcoal fuel has been established archaeologically. Charcoal, we noted in Chapter One, is a very important raw material needed in the smelting process because it is involved in the chemistry of the reduction process by producing carbon monoxide to react with the oxygen from the iron ore to promote the reduction. It is also the main source of heat needed for the chemical reactions that go on inside the furnace. Information from blacksmiths interviewed and the ethnohistorical and ethnographic accounts indicates that the number of preferred savanna species suitable for the smelting and forging of iron is extremely limited. Burkea afraicana, Proscopis africanus, Acacia species and Zizyphus mucronate have been widely reported as the most suitable (Irvine 1961, Goucher 1981). Jobson (1923:164 quoted in Goucher, 1981) writes that there was only one kind of red wood from which the charcoal for smelting could be made in Gambia. This means not every tree suitable for use in the making of charcoal for the iron industry. The species selected are slow burning, dense hardwood, usually with high alkali and silica contents and a granular structure ensuring the packed charcoal's permeability in the charge (Goucher 1981:81), high calorific value and burn without smoke or sparkle. The alkali and silica elements contained in such wood charcoal are released as flux to catalyse the reduction process as has been suggested for the Gambaga industry on the basis of chemical analysis of the relics of the smelting evidence in Chapter Four.

The ethnographical accounts available on Northern Ghana shows that the choice of specific trees for the two different components of the iron industry (smelting and blacksmithing) can either be the same or different and is more reflective of ethnic preferences in obtaining the desired heat temperature required for the processes. In Chiana, (a Kassena settlement), "Teyor" (Bauhinia refescens) was mentioned as being the best charcoal wood for both smelting and smithing. In Garu, the Busanga blacksmiths prefer Prosopis africanus for smelting but for smithing it is considered too strong. The wood of the shea - tree (Butyrospermum parkii) for instance is mentioned as being unsuitable for smelting in Tiza (a Lo-Dagaa settlement) and Jefisi (an Isala settlement) which is only 16 kilometres from Tiza the same tree produced charcoal for smelting (Pole 1974a:22).

In Mamprugu, no specific information could be obtained on what tree species was used for smelting from the blacksmiths talked to. The species preferred for smithing charcoal are Prosopis africanus and Burkea africana as was noted in Chapter Five. This evidence presents a number of complications and since none of the modern day blacksmiths could say who the authors of the archaeological evidence were nor did any one claim ancestry to this group, a direct projection into the past can only be conjectural and would need to be corroborated by other evidences.

What is of considerable importance in this discussion is that, since the making of slag consumes prodigious quantities of fuel, the smelting activity would have led to intensive exploitation of preferred species which may have had severe ecological implications considering the structure of the flora, and soil types, rainfall and other climatic conditions that prevail in this part of Ghana. With the absence of restriction on the use of forest product until the establishment of the Gambaga Forest Reserve, an increasing iron production would have prompted an increasing forest offtake of specific tree species. When this happens, sooner or later a point will be reached where the exploitation exceeds regeneration creating an imbalance between forest regeneration and offtake. In this case, a rapid increase in deforested zone around the production centres as the pressures to supply specific charcoal fuel for iron production and also for blacksmithing and a variety of domestic purposes, would have demanded the eventual exploitation of younger species thus interfering with the replacement of cut trees and leading to rapid deterioration of the soil and to soil erosion problems. The long term effect would have been a sparse ecological zone unable to regenerate itself.

This discussion only tries to draw attention to a possible chain of systems of implication following from iron production. To establish which chains are actually applicable in the Gambaga area would require more comprehensive ecological observation and the availability of an estimate of the yearly forest offtake. Study of Goucher (1981:182) at Hani in the Brong Ahafo Region of Ghana has revealed that whatever species of trees were suitable for charcoal making tend to be slow-growing. For example, replacement of two Burkea africana trees will require more than 20 years of growth. For this reason, she noted rightly that, the amount of trees exploited by iron smelters in the past probably could not have been replaced during their life time.

Evidence available indicate that the Gambaga Forest Reserve was established in 1948 (that is long after the smelting activities has ceased) to protect the topography from "injury or destruction in order to protect the headwaters of the streams flowing north and south from the Escarpment...[1]" Referring to the injuries which the vegetation had been liable, the record singled out man as having carried out the greatest damage to the vegetation by felling and firing the trees, clearing the land for farming and farming the land to exhaustion so that conditions were established to cause accelerated erosion and impede the recolonization of woody vegetation. The record contains an inventory of the tree species prior to the creation of the reserve which show that "such species as Burkea-africana, Detarium senegalensis, Erythrophleum gineense and Lophira alata are a few of the constituents which either do not occur or are very rare south of the scarp". The iron smelting sites are located in this part of the escarpment. The old slag mounds are pointers to an intensive exploitation of trees for fuel alongside other domestic activities like house building. This also reflects the impact of the charcoal-burning industry in Mamprugu which derive its raw material largely from the south face of the scarp. The mention of <u>Burkea africana</u> in the list of endangered tree species is very interesting since it portrays that perhaps the use of this tree species in iron production in Gambaga area dates to the very beginning of the industry. It adds to the written and ethnographic account that this is among the most preferred species in sub-Saharan Africa.

---

(1) All the information from Colonial records cited on the Gambaga Forest Reserve were obtained from File No.R.214 sub-file No.2 at the Forestry Department, Head Office, Accra.

It has been stated above that for a quantitative presentation of the ecological impact of the smelting activity, a wider scope of research on the escarpments is called for in addition to more chonometric dates. The abandonment of the Smelting evidence in the Gambaga area especially if only a

few species were exploited leading to rapid felling of such species or to political reasons resulting from confrontations between the iron producers and the Dagbamba in the formative era of these nation states. These views expressed are conjectural and have to await further investigation.

LOCATION OF THE SMELTING SITES

One of the goals which the research set itself was to determine the spatial distribution of smelting sites and especially the relationship between the smelting sites and ecological factors like the ore deposits, watercourses and wood for charcoal. These are important factors which should determine the particular place where a smelting site would be located.

From the data presented in Map 7, most smelting in the surveyed area were concentrated water courses or in the basins of the main rivers. These were sometimes placed right on the edges of the valleys. Local informants stressed the importance of water in the smelting process. It is needed for puddling the clay to make and repair furnaces and other units like the tuyeres and bellow bowls, pipes and clay plugs where they are used. Water is used during the making of charcoal and for dampening the latter before it is poured into the furnace upon the established fire (Forbes 1933:234). Water is also poured into the furnace at the end of the process to cool the furnace as the evidence from the Gemu Gofa Province of south west Ethiopia shows. It indicates that at the end of the smelting, the furnace content were left until morning when one of the smiths poured a gourd of water into it ... (Todd 1985:93). In the villages of Lawra, Tiza, Jefisi, Zanlerigu and Garu, water was brought in several buckets to the site and as soon as the white hot interior of the shaft is exposed, water is thrown at the base of the shaft and over the charcoal scattering smuts of soots into the air, most of the water scattering immediately turns to steam escaping up the shaft (Pole 1974:35-36). Other personal uses of water were for drinking (for which the smelters would have taken large quantities since they were working near fire and for most of the time in the sun), for washing and cooling the body. Where food was cooked on the site, water was needed. The problem of the sun brings in an observation made during the survey that some smelting might have been done near or under large trees for shade. Dry tree stumps near the smelting sites as well as the location of mounds under shade provided by large trees today support this view.

Unless there was a serious deforestation as in most parts of the escarpments that fall outside the forest reserve, the availability of wood for charcoal could not be a factor in the location of iron smelting sites. The river sources would be suitable areas for tree growth as the evidence from the headwaters and basins of the water courses in the forest reserve show. This brings back the issue of water not for smelting but in promoting the growth of trees. Proximity to river sources, therefore, should have had two advantages, the availability of trees for charcoal fuel and water for the smelting processes. The presence of water one can propose was therefore a primary factor affecting not only the location but also the localization of the smelting sites on the Gambaga Escarpment.

The data on the location and distribution of the sites indicated above by emphasizing the proximity of water needs to be expanded further as far as the period of the year when smelting is carried out is concerned. The pattern of short, heavy downpour of rain as it pertains in this part of Ghana coupled with its highly seasonal nature results in most water either soaking quickly into the ground or else running off very rapidly. Almost all the rivers on the escarpment are, therefore, seasonal. One may, therefore, ask whether the smelters did their work at the time of the year when water was readily available in the streams which is the rainy season? Before we answer this question let us examine other features of the water resources on the escarpment.

For the periods in 1987 and 1988 when I was in Gambaga, I paid particular attention to observing and determining how long the water courses and rivers had water running in their valleys. It became evident that if the rivers depended entirely on rainfall for their water supply, there would have been no water at all in a weeks after the rains have ceased. But the escarpment serves as a source of springs which supply the streams with water well into the dry season. A few of these rarely dry up as a result of the underground water supply that they receive. It was, therefore, not surprising that as at the end of February, (that is after almost 5 months of dry harmattan weather), water was still to be found in the form of small pools in the valley of the Gambagakuliga river although the upper course had long been dry.

It is pertinent to note that even if the rivers and watercourses dry up completely they tend to conserve the water in the underlying rock. This was evident when a test pit dug into the dry valley of the Birimi river hit water at a depth of 70cm and water continuously flowed into the pit. This feature of the water sources has improved the performance of wells and water holes which are the important sources of water for the villages on the escarpment. A study revealed that most of the wells are dug in or near the bed of a dried-up river and the water in the bottom gradually replenishes itself as it is drawn off. Local informants indicated that because of the seasonality and unpredictability of rainfall, a high premium is placed on a dependable water supply when choosing a settlement site in Manprugu which confirms Bate's (1962) observation that a major concern for most peoples of Northern Ghana is the availability of a continuous supply of water.

Field dåta indicated that the long dry season that might last for six or more months is the time for festivals, and brings leisure and suitable weather for craftwork like weaving, spinning and wood carving and dyeing in Northern Ghana. This was also the favourable time for iron extraction and smelting operations (Pole 1974a). This was because there will be no rains to disturb the activities. The blacksmiths in Northern Ghana started preparation for smelting at the beginning of the dry season and continued to smelt throughout it sometimes exclusively working smelted blooms into tools in the wet season. While the undertaking of smelting in the dry season implied that it would not have conflicted with agricultural activities, the ideologically expressed reason was, however, that the smelters expose their life to danger when they smelt at a time when thunder and lightning occur. In fact the belief in the destructive powers of thunder and lightning is so strong and real in Mamprugu that one dare not walk on a path during rainfall for fear of being struck and killed by lightning which is said to follow paths when it strikes.

Furnace-building would normally have taken place at the beginning of the dry season when the harmattan is blowing and the humidity may be as low as 10% (Pole 1974a:16). Such climatic conditions would have facilitated the quick drying of the furnace and other units whiles ensuring strong winds suitable for effective draught especially for furnaces that relied on naturally induced draught. During a demonstration smelt at Chiana in 1971, Pole (1974a:36), recorded that when it was getting dark, the smelters removed the bellow pipes from the tuyere yet the fire continued to burn into the night because of the high wind. With the absence of farming activities, the heavy labour for transporting ores, firewood, charcoal, water, clay soil and dry millet or guinea corn stalks would also have been available in abundance and cheaply too.

Dry stalks of millet or guinea-corn, the ethnographic and ethnohistoric data indicates, were very important fuel material in the smelting process. At Jefisi, the stalks of guinea-corn are used at the start of the smelt (Pole 1974:29), while the Dimi of southwest Ethiopia lit dried grass inside the furnace inside the furnace for some minutes before charcoal was added (Todd 1985:93). In Darfur, in Sudan the bottom of the furnace is filled with stalks of wood and millet and set on fire (Haaland 1985:56). The dry harmattan condition is the factor making available these dry combustible materials. The process of setting such fire was more technological. It was meant preliminarily to warm the furnace by driving off all residual water absorbed by the furnace walls which by expansion during firing could cause the furnace to crack or break. Thus the warming gave the furnace walls good resistance against cracking under the strain of sudden thermal shocks generated by the furnace hearth fire.

SPATIAL DISTRIBUTION OF THE FURNACE VARIETIES

A look at Map 7 reveals that it shows the location of all the smelting sites surveyed and/or excavated. The information on furnaces is restricted only to those that have been excavated and their associated slag mounds. For the remaining furnaces recorded from the visual observation on the smelting sites, their classification into type varieties cannot be made at this stage of the research if we are to have a true picture of the evidence in Gambaga. These structural remains are buried below the surface of the ground but for a few centimeters of their walls projecting above. Until they are excavated, their type variety, real forms, whether in the nature of a bowl base with or without apertures, or a well preserved furnaces cannot easily be determined from the surface evidence.

The furnace structural remains excavated (15 of them) represents just a fraction of the over 350 estimated (most of which are buried inside slag heaps) for the area for them to be used as basis for classifying the observed remains. There are both major and minor variants of furnace styles that are yet to be revealed by further excavation. For instance, during the survey, it was noticed that the wall thickness of the type I and II furnace remains were the same for most of sites, but the excavation revealed that there were marked differences in the design that argued against their being lumped together. In the case of the type III furnaces the thicker walls and wider maximum and minimum internal and external diameter served to distinguish them from the others. Only two of these were excavated. They were from the same site SM.61. Further excavation of other remains are needed.

When the excavated evidence of the furnaces is seen against their distribution (Map 7), there does not seem to be any concentration of a type variety in one given locality. They were contiguous to each other sometimes separated by a distance of only 15-30m. Given the variety in elements and the spatial locations, it is reasonable to suggest that the smelting evidence might have been the result of very esoteric activities in a number of localised smelting sites. This suggestion has to be corroborated by more evidence especially from dated examples. For the present, however, this would be one way to explain such different furnace shapes and designs in so small an area. The full story must await further research and will doubtless prove much more complex.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

The archaeological, ethnohistorical and ethnographic investigation at Gambaga in 1987-88 has revealed the site to be one of the richest iron smelting sites reported from Ghana. Not only has Gambaga yielded substantial evidence of well-preserved furnaces and other smelting devices, but it has also provided evidence of their underlying technological attributes which has made it possible to obtain great detail about the smelting industry.

The data gathered on blacksmithing is significant for its new information for this surviving component of the iron industry. Given the socio-economic importance of iron products in Mamprugu, adequate institutional mechanism for transmission of skill of iron technology as well as for maintenance of a regular supply of iron products from specialists possessing the skills have become critical issues. The association of the blacksmith occupation with a caste-like identity can be seen as such an institutional mechanism serving both needs. By introducing their children to the occupation at a very early age, the respect and dignity of the identity of the blacksmith profession is inculcated in the youth. Such skills in blacksmithing, acquired through socialization within the family units, provide them with an occupational asset that the members can fall on at any time in their life. At the same time, the stigma minimizes the interest of people of non-blacksmith identity to take up this occupation and thus it serves to limit entry into this profession.

Today, the blacksmiths supply mainly hoes, ploughs and axes used in cultivation, plus weapons such as knives, guns, arrows and spears. Since the demand for their product is determined principally by the climatic conditions and the requirements of the various customers but not by the traditions of the specialists, there is competition and a reduction in specialization. Despite this, the position and status of the blacksmith is unlikely to alter significantly since it is more related to his crucial role as a supplier of tools and other essential items of iron, a ritual specialist and a dispenser of herbal medicine than to the production of iron. For this reason, while imports of iron tools, machinery and scrap iron have tended to kill Ghanaian smelting, they have helped maintain and even develop smithing in industries in many towns and villages in Mamprugu in particular and Northern Ghana in general. Motor car springs, rods, and plates are a favourite source of scrap wrought-iron obtained from the regional capitals of Tamale and Bolgatanga.

Though the finished imported goods compete with the products of the local blacksmith, the evidence suggests that the smiths would continue to stay in business due to the constant need for repairs or for "intermediate" improvisations on trucks, buses, trailers, motor cycles, carts and other vehicles. An added advantage which was evident was the ability of the smiths to react fast to changes in the climate. This combined with the preferences for more versatile styles of tools, weapons, ornaments and ritual items for rural use has guaranteed a reliable demand level for the produce of the blacksmiths.

Although the studies of the African Iron Age have been concerned with the origins of iron working, at this stage of my research, however, no statements can be made about routes of diffusion of the smelting technique into the Gambaga area, nor can any contribution be made to the diffusionist/independent inventionist controversy about the introduction of iron smelting to West Africa which has been going on since the turn of the century as was discussed in Chapter One. More concrete data in the form of further excavations and a large series of radiocarbon and thermoluminescence date estimations are needed for an effective determination of how far back the industry dates. This would forestall any speculative ideas and self-fulfilling hypothesis on whether the smelting technology at Gambaga originated from other smelting tradition in West Africa that date earlier or it is a technology that evolved and developed within the ecosystem in which the evidence has been found today.

The single radiocarbon age estimation (A.D. 1490 $\pm$ 90) obtained so far is significant. It has given additional evidence to explain that the industry bore the stamp of antiquity. In Mamprugu, as in Dagbon, the written histories and oral traditions on the settlement history of the area in pre-Dagbamba times reveals an emphasis on the agriculturalists living under priests and land owners (Brown 1975, Davis 1984). The smelting evidence from Gambaga suggests that the Dagbamba did also have to contend with iron smelters and blacksmiths. It has been suggested that the oral traditions of the Dagbamba which refer to attacks leading to abandonment of whole settlements (Tamakloe 1939:1-3) were attempts to bring into subjugation groups which were autochthonous or had settled in Northeast

Ghana earlier and who refused to come under "foreign" rule. An iron working group in this area would have been the producers of the most effective means of productions and destruction and thus would have been powerful. Such a group would have been attacked if peaceful means of bringing them under domination had failed. This perhaps is what happened to the "Adites" who, so far, are the only smelters and smiths whose presence and operational activities in Northeast Ghana tallies with the available archaeological and ethnohistorical evidence.

The above conclusion is one way to explain the forgotten, confused and fragmentary accounts on the iron production evidence. The ruling body in most parts of the Northern region of Ghana are the Dagbamba and the Gonja who could only have succeeded in establishing their authority after subdueing all local opposition. These groups introduced the institution of chieftaincy into Northern Ghana. Since then, chieftaincy has provided the machinery for proper organization and preservation of historical traditions. Most often than not, the function of the traditions recounted are meant to support the established political authority for example by explaining the greatness of the ruling class in every sphere while relegating that of the minorities.

The task of the official historian is to preserve and transmit orthodox versions of state history (Phillipson 1985:8). In Mamprugu, there are the lungsi (royal drummers) who play the hour-glass shaped talking drums and perform at functions for the chiefly gates to which they are attached. Most importantly, the lungsi maintain the annals of the ruling dynasty, they are the traditionists of Mamprugu (Davis 1984:xiv). Other custodians of information are the elders and officials at the Nalerigu palace and Traditional Council. The muslim community also have vital information but these relate to economic and socio-religious changes that have marked the last two centuries. After interviewing several people in Mamprugu, it became evident that there appears to be no group that claims autochthonous origin or ancestry from an ethnic group that ever produced and worked iron.

Despite the fragmentary evidence about the antiquity and authors of the iron smelting evidence, the investigation has revealed an industry that displayed a remarkable degree of iron production craftmanship evident not only in the furnace forms and designs but also in the underlying technological processes. The descriptions of the furnaces was made possible by the relatively large amount of sites or remains excavated in the survey area as well as by the unique state of preservation of furnaces and tuyere pipes. This is explained partially to the robust construction, by the subsequent filling and covering by alluvial soil or slag debris. But for the radiocarbon date estimation, and the ethnohistorical data obtained, the evidence could well have been considered as being only a century or so old. The correction of this view underscores the need for researchers on smelting sites to endeavour to record local lore about the industry while noting the variability of the authority of such information no matter who provides it. Chronometric dates are invaluable in such researches. When these are done, we shall be avoiding some of the basic shortcomings of early archaeological researches on iron smelting. Due to the inadequacy of evidence on the chronology and authors and insufficient data used to reconstruct most furnaces form these smelting activities, attempts to make meaningful comparisons among the excavated sites have to be deferred if conclusions on the subject are not to be highly speculative.

From the descriptions and photographs, it can be seen that three different furnace type varieties were recovered from Gambaga. These were all made in the form of bowls surmounted by shafts that are erect and tapering. They had maximum interior diameters between 70-80cm for the forced draught types and between 90-100cm for the naturally induced type. Their bases were planted into the laterite clay soil and the shafts between 1-4m for the different types would have stood free. They had no buttresses, nor creepers or steps. The absence of these features, which have been reported on ethnographic examples in West Africa, from the excavations might be due to the use of notched poles or erected platforms for access to the mouth to charge the furnaces especially where the height of the shaft mouth above the ground (type II and III) suggests that without such a facility the charging would have been awkward. From Bassare in Togo and Akpafu in northern Volta Region the use of notched poles and platforms respectively have been recorded (Pole 1985:158-163 also see Fig.21a, b, c).

The Gambaga furnaces were connected to one side of the bottom by a tunnel or pit (approximately 2 metres or so long, 1 metre wide and 40-8ocm deep) to catch the molten slag drawn out at specific intervals through their streamlined lower interior walls that open into a slag hole. This slag tapping facilities recovered in Gambaga furnaces fits them into the normal design noted for some West African furnaces (Sutton 1985:173; Pole 1985:142-163).

Within the overall similarity, many differences in detail have been described as can be seen by comparing the drawings and photographs of the furnaces and tuyeres. These variations in smelting devices are matched by two broad ore types: a nodular heamatite ore and a lamellar ferruginuous ore with iron content of 56% and 48% respectively. The lower grade ore was used in the largest and tallest of the varieties noted. Thus the stylistic variations in furnaces built may be explained with reference to a technological consideration of the ore used. The variations in tuyere and draught mechanism depicted one variety in which air was procured through effective blast introduced into the hearth from bellows (possibly bag bellows) through massive tuyeres with massive bores through air inlets that were inclined to the vertical as in the type I and II furnaces (Chapter Four). The air inlet is located opposite the hole through which the slag is tapped. The air hole is at the front and the slag hole at the back of the furnace. The other variety of air supply was naturally induced through multiple long thin walled tuyeres with access to the entire circumference of the furnace necessary for stoking the fire and replacing the tuyeres in the air holes radiating around the lower base of the furnace as is the case in Akpafu and Bassare (Pole 1985).

The data available currently thus suggests not only the existence of three different furnace varieties in the same area in Gambaga but also distinct technological traditions. The whole issue of the relationship between the productivity or technological accomplishments of the different furnace forms is a more delicately balanced question since it would require detail on the bloom size and its quality. The height and size of a shaft may not be the most distinctive feature of a furnace from the technical angle (Sutton 1985). The location of different furnace forms using different techniques and ores is one of the most impressive aspects of Gambaga iron smelting site. The full story must await further research but for now we could well imagine the Gambaga site as where experimentation took place, and where then - if enough research is applied and followed up with dates - we may discern the evolution of one style to the other. If, however, the answer is in the products demanded of the industry - that is the properties of the smelted metal, as well as the artifacts manufactured from it - there is an exicting but very difficult field of technological and economic history to be explored. For suggestions and control, such an investigation would require new experiments and a recourse to ethnography. And if it be objected that the latter cannot offer the wealth of primary information that it could a hundred years ago, we are nevertheless in a stronger position to probe it more perceptively for purposes of technology and history.

From the investigation, the concentration of the sites in a few localities near to or right on the banks of river sources has been made evident. Factors that determined the site location are the availability of ore, fuel and suitable clay materials. Water was vital in the manufacture of the furnace, tuyeres and in smelting process itself. It is, therefore, likely that the concentrated localization of the sites is optimal in relation to the maintenance of an easy access to water and continued supply of wood for charcoal fuel which grow in large amounts in the watersheds and near the banks of most watercourses on the Gambaga Escarpment.

The results from the research has provided evidence that the presence of tuyeres does not necessarily indicate the use of bellows. Tuyeres were found in the investigation but the study of the bore diameter and the length of the tuyeres was corroborated by ethnographic examples to suggest the use of forced draught furnaces as well as naturally induced furnaces. In Northern Ghana, pot bellows are the common types used for smelting according to the ethnographic and ethnohistorical accounts. But there is the need for researchers on iron technology to note that diversity in bellow types is a basic feature of the industry as was made evident by the data on the blacksmithing profession in Mamprugu (Chapter Five). For the Gambaga industry, the bag or skin bellows is suggested to have been used for the procurement of draught from bellows. This should explain the absence of bellow pots from the smelting sites investigated. The absence of direct evidence on the use of leather bellows, calabashes, gourds and other organic substances from the excavation should not be interpreted to mean they were not used. The survival of these materials is minimal because West African soils poorly preserve organic matter and it is possible for further research to yield more conclusive data on these aspects of the iron smelting tradition. This would provide archaeological evidence to compare with the ethnographic data.

The results of the tuyere analysis, adopted from recent call for the observation of tuyere form and function (Schmidt and Avery 1985), have indicated the full scale use of the technique of pre-heating at the Gambaga smelting sites. This is the second reported evidence of the use of the technique in Ghana. The other comes from the Dapaa site at Begho in the Brong Ahafo region. It has been dated to 1400-1700 A.D. (Goucher 1981:183). These, therefore, suggest that the use of the technique may have a wider distribution which should be revealed by future investigations.

The technique has been described as being designed to compensate for fuel shortages (Goucher 1981:109; Schmidt 1985). It could also have been to compensate for the lower iron content of most iron ores in tropical Africa while promoting the production of superior irons and steels. The development of this technique may therefore be due to a multiplicity of factors although shortage of fuel as Schmidt notes is doubtless an important factor. The selectivity of tree species for charcoal fuel by smelters and blacksmiths discussed above supports this view. It came out during the investigation that blacksmiths sometimes have to pay for such trees as Burkea africana and Prosopis africanus growing on other peoples land. These are then cut and used for making charcoal for smithing. The process of smelting itself depended heavily on labour, not only in obtaining and preparing the ore but also in the bellow's work especially where it is maintained throughout the smelt (Pole 1982). Against this, however, the preheating device probably economises on charcoal and a possible roasting of the ore by the Gambaga smelters may have assisted its more complete reduction and thus increased the quantity and quality of iron produced. In this case we may discern at the Gambaga sites methods designed to achieve maximum efficiency from the local natural and manpower resources.

The investigation has provided evidence to answer some questions that are raised by ethnographic experiments and demonstration iron smelts that need to be supported historically by archaeological projections. One important aspect that would be elaborated on here relates to the whole idea of successes and failures of smelting proceses. As many as three of the thirteen smelts reported by Pole (1974):8) ended in failure. At Zanlerigu, in the Upper East Region of Ghana, one smelt ended prematurely in blockage after few hours of smelting (Pole 1974a:38). From the Gisgara area near Butare, Rwanda, no iron was produced at the end of 7 days of preparation, construction and smelting (van Noten 1985:117). There is the tendency to associate failures of demonstration smelts to the idea that those surviving smelters recreating the process could not remember certain aspects. This is reasonable but where it is postulated too far it might conceal what may be a basic feature of African iron smelting technology - failures. Apart from the evidence of the premature blockage recorded from the interior excavation of F9 (Chapter Four), the surface survey had earlier on revealed seventeen cases of furnace structural remains in the form of slag lumps projecting above the land surface as noted in Chapter Three. The furnace wall surrounding these slag evidence have been eroded. Their tapering and smooth nature is evident of their attachment to the interior walls of the furnace bowl and shaft.

On the basis of the above evidence, the slag lump occupying the base of the Achimota furnace remains discussed in Chapter Two which Shaw (1969:48), rightly suggested had never been removed, might be another archaeological example of a smelt that ended in blockage. Since smelting evidence from Gambaga is archaeological the cause cannot be determined directly. As noted in Chapter Four, the cause may be technical (due to unsatisfactory level of iron ore and charcoal charge, trial with new iron ore, improper alignment of tuyeres, and excess heat loss) and/or supernatural. The latter factor needs not be left out since smelters and blacksmiths would not always attribute failures to physical factors. To them the activities, processes and techniques associated with smelting are not always functional or technical, they can be ritual. This serves to explain the complexity and seriousness attached to taboos and rituals associated with iron metallurgical technology. Ritual practices are a part of the African iron industry which does not make any of the components (smelting or blacksmithing) a matter-of-fact occupation. Traditional religion, herbal medicine and tribal ways of life are, therefore, firmly anchored in iron technology.

From the investigations, several suggestions have been made which are relevant in the reconstruction of Ghana's technological past and in future Iron Age studies. A few more need to be added. It is suggested that investigation of iron smelting sites should embrace a thorough visual observation of the industry in a wide geographical area. This would provide visually observed information on the variability in the data which would determine the nature of evidence to be expected from the excavation. In the actual recovery of data, complete excavation of entire slag mounds is proposed instead of the use of trenches cut across the heaps. This would enable one to document in detail the composition of the debris as well as the furnace structures buried within. A detailed study of both the interior and exterior of furnace remains needs to be conducted. For the benefit of supplying a firm basis for comparison and for making meaningful general statements about relationships between furnaces and smelting processes of different iron working communities, there is the need for archaeologists working on the industry in Ghana to emphasise as much as possible on the whole process and not concentrate on the morphology of the clay built furnaces (or "ovens", kilns") and on their visible external morphology. When chemical analysis of the ore, slag, charcoal, tuyere furnace wall material and other material features of the industry are combined with archaeological, ethnographic, and ethnohistorical data, it is thought that we shall be making a great contribution to our understanding of the functioning and underlying technology and the organizational institutions that supported the Ghanaian iron industry.

Interpretation of iron working data recovered through excavation of surviving sites can be complex and misunderstandings of the remains can easily affect the conclusions. It is in this light that the need to describe iron smelting techniques as still known by old smelters and/or blacksmiths is very paramount. Like the sites, the individuals with this knowledge will not be there forever, thus, the time should be now or never. The more ethnographic experiments and demonstration smelts we could have, the more we would be able to recognize different techniques and eventually to understand iron smelting furnaces as they come to us during archaeological excavations.

Gambaga is already one of the relatively favoured areas in Northern Ghana in terms of the amount of attention it has received over the years. It has been subjected to both intensive historical and anthropological study (Davis 1984; Brown 1975), and now archaeological inquiry as well. As always seems the case in scientific investigation, however, the more answers that are sought, the more questions that arise so that further work at Gambaga and in the surrounding area is required to establish a better picture of the variability of smelting devices and techniques that are available. There may be both major and minor variants of furnace styles yet to be revealed by further excavation. An even broader survey is required in the entire Escarpment area if more details of the wider geographical location and distribution of the industry is to be obtained.

The antiquity of the smelting evidence and circumstances surrounding its abandonment have raised important questions concerning the geological, settlement and vegetational history of the area and the origins and authors of the smelting evidence in Gambaga. Most of the these issues have been discussed in the body of the thesis but they still require further investigation and perhaps the presence of specialists like geologists, soil scientists, geographers, metallurgists, and chemists for adequate identification and study.

The problem of iron working (smelting and blacksmithing) in the Gambaga area is a large subject which cannot be exhausted at the present state of research. Over such an enormous area and also because of absence of a more complete inventory of all production sites in the Mamprugu region of Northeast Ghana, it is difficult to draw wider conclusions. The conclusions so far made are, therefore, more suggestive than definitive and they reflect the pioneering or exploratory nature of this research in this part of Ghana. Nevertheless, the materials obtained during the archaeological, ethnohistorical and ethnographic investigation show the importance of the problem and show that the people who settled on the Gambaga escarpment did not only acquire intimate knowledge about its agricultural potential but also its ability to supply all the natural requirements for the production of iron for development. It is, therefore, hoped that the data presented should fill perceived gaps in our understanding and knowledge of iron technology while depicting the great potential still existing for large scale (iron) industrialization based on the resource of the local environment. This should admonish us today and depict the need for a cultural and technological reawakening in Ghana.

BIBLIOGRAPHY

Agorsah, E.K.
1976 Some considerations on the archaeology and traditional history of the Begho area. M. A. Thesis, Department of Archaeology, Legon.

Agorsah, E.K.
1983 An Ethnoarchaeological study of settlement and Behaviour patterns of a West African Traditional Society: The Nchumuru of Banda - Wiae in Ghana. Ph.D. Thesis UCLA Los Angels, U.S.A.

Andah, B.
1983 Iron Age beginning in West Africa: reflections and suggestions. West African Journal of Archaeology 9:135-150.

Anquandah, J.R.
1967 Cultural Developments in Western Africa in the light of Pottery Studies. M.Litt. Thesis, Oxford.

Anquandah, J.R.
1982 Rediscovering Ghana's Past. Longman Great Britain.

Anquandah, J.R.
1985 Ethnoarchaeological Clues to Ghana's Great Past and a Greater Future: Monographs and Papers in African Archaeology. Legon.

Arkell, A.J.
1968 A history of the Sudan - from the earliest times to 1821. London.

Barker, P.
1986 Peoples, Languages and Religion in Northern Ghana. Worldwide Evangelization Crusade. England.

Barnes, H.B.
1926 Iron smelting among the Ba-Ushi. Journal of the Royal Authropological Institute 76:189-4.

Bates, D.A.
1962 Rural water supplies. Agriculture and land use in Ghana (led.) J.B. Wills, London 62-76.

Bellamy, C.V.
1904. A West African Smelting House. Journal of the Iron and Steel Institute, LXVI: 99-126.

Bellis, J.O.
1972 Archaeology and the Culture History of the Akan of Ghana, A Case Study. Ph.D. Thesis Department of Anthropology, Indiana University, U.S.A.

Boachie-Ansah, J.
1978 An archaeological contribution to the history of Wenchi. M.A. Thesis. Legon, Accra.

Boahen, A.
1966. Topics on West African history. London Longmans.

Bowdich, T.E.
1819. Mission from Cape Coast Castle to Ashante, London.

Brammer, H.
1962 Soil in Agriculture and Land Use in Ghana ed. by J.B. Wills, pp. 88-126, Oxford University Press, London.

Brempong, O.T.
1987 An Excavation at Awukugua and its significance to the Iron Age Archaeology of Kyerepong, Akwapim. M.Phil. Thesis. Department of Archaeology, University of Ghana, Legon, Accra.

Brown, S.D.
1975. Ritual aspects of Mamprusi Kingship. Cambridge.

Caillie, R.
1830 Travels through Central Africa to Timbuctoo. London.

Calvocoressi, D. and N. David.
1979. A new survey of radiocarbon and thermoluminescence dates for West Africa. Journal of African History. 20:1-29.

Cardinal, A.W.
1958. Natives of the Northern Territories of the Gold Coast. London

Chaplin, J.H.
1961. Notes on traditional smelting in Northern Rhodesia. South African Archaeological Bulletin, XVI:53-60.

Childs, T.S. and Schmidt, P.R.
1985. Experimental Iron Smelting: The Genesis of a Hypothesis with Implications for African Prehistory and History. In (Haaland and Shinnie eds.). African Iron Working, 121-141, Bergen.

Cline, W.
1937. Mining and Metallurgy in Negro Africa. Menasha.

Coghlan, H.H.
1956. Notes on prehistoric and early iron in the Old World. Oxford.

Crossland, L.B.
1973. A study of Begho Pottery in the light of Excavations conducted at Begho - B2 site. M.A. thesis Legon.

Daaku, K.Y.
1970. Denkyira - Unesco Research Project on Oral Traditions, Legon.

Daaku, K.Y.
1971 Oral Traditions of Adanse, Legon.

Darkoh, M.B.
1964. Economic life of Buem. Bulletin of the Ghana Geographical Association. 9:40-54.

David, N.J. Sterner, and Gavua K.
1988 Why Pots Are Decorated. Current Anthropology, Vol 29 No. 3 June.

David, N.R. Heimann, D. Killick and Wayman M.
1989 Between bloomery and blast furnace: Mafa iron-smelting technology in North Cameroon. The African Archaeological review, 7 pp. 183-208.

Davies, O.
1967. West Africa before the Europeans. London.

Davies, O.
1970 Ghana Field Notes. Part 2: Northern Ghana.

Davies, O.
1976 Ghana Field Notes: Part 4: Southern Ghana.

Davis, D.C.
1984. Continuity and Change in Mamprugu: A Study of Tradition as Ideology. Ph.D. Thesis Balme Library, University of Ghana, Legon.

de Barros, P.
1986 Bassar: A quantified, chronologically controlled, regional approach to a traditional iron production centre in West Africa. Africa. 56:149-173.

de Barros, P.
1988. Societal repercussions of the rise of large scale traditional iron production: a West African example. The African Archaeological Review 6:91-113.

Dickson, K.B. and Benneh, G.
1977. A New Geography of Ghana. Longman, London.

Diop, L.
1968. Traditonal iron working and the Iron Age in Africa. Bulletin de L'IFAN: 268-269.

Eckel, E.C.
1914. Iron Ores. New York: McGraw Hill.

Effah-Gyamfi, K.
1974. Oral Tradition and archaeology: a case study of the Bono State. M.A. Thesis, Legon.

Effa-Gyamfi, K.
1978. Bono Manso - an archaeological investigation into early Akan Urbanism. Ph.D. thesis, Legon.

Fage, J.D.
1964 Reflections on the Early History of the Mossi-Dagomba Group of states. In (Vansina, Mauny and Thomas eds.). The Historian in Tropical Africa. 177-191 OUP.

Fage, J.D.
1978. A History of Africa. New York: Afred A. Knopf.

Fagg, B.
1969. Recent work in West Africa: new light on the Nok culture. World Archaeology, 1:41-50.

Filipowiak, W.
1969. Iron working in the Old Kingdom of Mali. In (Haaland and Shinnie eds.) African Iron Working, 36-48. Bergen.

Forbes, R.H.
1933. The Black man's industries. Geographical Review, 23, 230-247.

Francis-Boeuf, C.
1937. L'industrie autochtone du fer en Afrique Occidentale Francaise. Bulletin du Comite d'Etudes Historiques et Scientifique de

Jeffreys, M.D.W.
1952. Bikom blacksmithing. Man 52: No.75.

Jobson, R.
1923. The Golden Trade. London.

Junner, N.R.
1935. Native iron-smelting furnaces in Lawra District. Gold Coast Geological Survey Annual Report 36-37.

Kense, F.J.
1981. Daboya: a Gonja Frontier. Ph.D. thesis, University of Calgary.

Kense, F.J.
1983. Traditional African Iron-working. African Occasional Papers, 1. Calgary.

Kense, F.J.
1985. The Initial Diffusion of Iron to Africa, In (Haaland and Shinnie eds.) African Iron Working, 11-26. Bergen.

Keteku, E.
1975. The Iron Age in Ghana. M.A. thesis University of Calgary.

Klusemann, K.
1924. Die Entwicklung der Eisengewinnung in Afrika Und Europa, Mitteilungen der Anthropologische Gesellschaft in Wien, LIV: 120-140.

Lane, D.A.
1962. The forest vegetation. In Agriculture and Land use in Ghana (ed.) J.B. Wills 160-169.

Leclant, J.
1956. Le fer dans L'Egypte ancienne, le Soudan et L'Afrique. Annales de l'Est, 16:83-91.

Levtzion, N.
1968. Muslims and Chiefs in West Africa. Claredon Press, Oxford.

Lhote, H.
1952. La connaissance du fer en Afrique Occidentale. Encyclopedie mensuelle d'Outre-Mer: 269-272.

Luschan, F. von.
1909. Eisentechnjk in Africa. Zeitschrift fur Ethnologie, XLI:22-

Manoukian, M.
1952. Tribes of the Northern Territories of the Gold Coast. LAI Ethnographic Survey. West Africa (5).

Maret, P. de.
1985. The Smith's Myth and the Origin of Leadership in Central Africa. In (Haaland and Shinnie eds.) African Iron Working, 87. Bergen.

Mauny, R.
1952. Essai sur l'histoire des metaux en Afrique occidentale. Bulletin de l'Institut Francais d'Afrique Noire 14:545-595.

McIntosh, R.
1974. Archaeology and mudwall decay in a West African Village. World Archaeology 9:181-199.

Nadel, S.
1942. Black Byzantium, Oxford.

Naden, Tony,
1988. The Gur languages. In (Kropp Dakubu ed.). The languages of Ghana. London.

Norton, F.H.,
1931. Refractories, New York.

Nunoo, R.B.
1957. Excavations at Asebu on the Gold Coast. Journal of West African Science Association. III:12-14.

Nunoo, R.B.
1970. Excavations at Beifikrom. West African Newsletter XII:73-74.

Okoro, J.A.
1984. A short history of Awukugua-Akwapim. B.A. Long Essay, Department of History, University of Ghana, Legon.

Oliver, R. and Fagan, B.
1975. Africa in the Iron Age. Cambridge.

Ozanne, P.C.
1962. Notes on the early historic archaeology of Accra. Transactions of the Historical Society of Ghana (6)51-70.

Ozanne, P.C.

Ozanne, P.C.
1971. Ghana: In the African Iron Age. London.

Pearce, S.
1960. The appearance of Iron and its Use in Proto-Historic Africa.

Penfold, D.A.
1970. Excavation of an iron smelting site at Cape Coast. Transactions of the Historical Society of Ghana 12:1-15.

Phillipson, D.W.
1977. The Latter Prehistory of Eastern and Southern Africa. London.

Phillipson, D.W.
1985. African Archaeology. Cambridge OUP.

Pole, L.M.
1974a. Iron-smelting in Northern Ghana, in National Museum of Ghana Occasional papers, 6-8: 1-40.

Pole, L.M.
1974b. Account of an iron smelting operation at Lawra, Upper Region, Ghana Journal of Science.

Pole, L.M.
1975. Iron working apparatus and techniques: Upper Region of Ghana. West African Journal of Archaeology 11:11-39.

Pole, L.M.
1982. Decline or survival? Iron production in West Africa from the seventeenth to twentieth centuries. Journal of African History 23:503-513.

Pole, L.M.
1985a. A Ruhr or Rural Industry? The scale of iron production in West Africa. Museum Ethnographers Group Newsletter, 17:41-59.

Pole, L.M.
1985b. Furnace Designs and the Smelting Operation: A Survey of Written Reports of Iron Smelting in West Africa. In (Haaland and Shinnie eds.) African Iron Working. 142-163. Bergen.

Posnansky, M. and R. McIntosh.
1976 New radiocarbon dates for Northern and Western AFrica. Journal of African history 17:161-195.

Rattray, R.S.
1916. The iron workers of Akpafu. Journal of Royal Anthropological Institute, XIX(NS) 431-435.

Rattray, R.S.
1932. The Tribes of the Ashanti Hinterland. OUP London.

Sassoon, H.
1963. Early sources of iron in Africa. South African Archaeological Bulletin. XVIII: 176-180.

Sassoon, H.
1964. Iron smelting in the Hill village of Sukur, Northeastern Nigeria .. Man, IXIV: 174-178.

Schmidt, P.
1974. An investigation of Early and Late Iron Age Cultures through oral tradition and archaeology: an interdisciplinary case study in Buhaya, Tanzania. Unpub. Ph.D. Thesis, Department of History, northwestern University.

Schmidt, P. and Avery, D.A.
1978. Complex iron smelting and prehistoric culture in Tanzania. Science, CCI: 1085-9.

Shaw, C.T.
1961. Excavation at Dawu. Legon and Edinburg.

Shaw, T.
1969. An iron-smelting furnace excavated in Ghana. Bulletin of the Historical Metallurgy Group, III:48-54.

Shinnie, P.L. and Ozanne P.C.
1962. Excavations at Yendi Dabari. Transactions of the Historical Society of Ghana, V1, 87-118.

Shinnie, P.L.
1971. The African Iron Age. Oxford.

Shinnie, P.L.
1985. Iron Working at Meroe. In (Haaland and Shinnie eds.). African Iron Working, 28-35, Bergen.

Sutton, J.E.G.
1981. 'New work at Dawu - Southern Ghana'. Nyame Akuma, 18.

Sutton, J.E.G.
1985. Temporal and Spatial Variability in African Iron Furnaces. In

(Haaland and Shinnie eds.). African Iron Working. 164-196, Bergen.

Tamakloe, F.
1931 Brief history of the Dagbamba People, Accra.

Tait, D.
1961. The Konkomba of Northern Ghana. Oxford.

Todd, J.A.
1976. Studies of Primitive Iron Technology. Cambridge.

Todd, J.A. and J.A. Charles.
1978. Ethiopian bloomery iron and the significances of inclusion analysis in iron studies. Journal of the Historical Metallurgy Society, 12, 2:63-87.

Todd, J.A.
1979. Studies of the African Iron Age. Journal of Metals, 31:39-45.

Todd, J.A.
1985. Iron Production by the Dimi of Ethiopia in (Haaland and Shinnie eds.) African Iron Working, 88-101, Bergen.

Tylecote, R.F.
1965. Iron smelting in pre-industrial communities. Journal Iron and Steel Institute 203-48.

Tylecote, R.F.
1968. Iron smelting experiments at Varde, Denmark, Bulletin of the Historical Metallurgy Group III : 64-65.

Tylecote, R.F.
1970. Iron working at Meroe, Sudan, Bulleting the Historical Meallurgy Group, IV: 67-72.

Tylecote, R.F.
1975. Iron smelting at Taruga, Nigeria. Journal of the Historical Metallurgy Society. 9:49-56.

Van der Merwe, N.J. and R. Scully.
1971. The Phalaborwa story: archaeological and ethnographic investigation of a South African Iron Age group. World Archaeology 3:182-200.

Van Noten, E.
1985. Ancient and Modern Iron smelting in Central Africa: Zaire Rwanda and Burindi. In (Haaland and Shinnie eds.) African Iron Working, 102-120, Bergen.

Vaughan, J.H.
1973. Nkyagu as Artists in Marghi Society. In W. d'Azevedo (ed.) The Traditional Artist in African Societies. Bloomington.

Wainwright, G.A.
1936. The coming of iron. Antiquity X:5-24.

Wainwright, G.A.
1942. The coming of iron to some African peoples. Man, 42:103-108.

Warnier, J.P. and Fowler, I.
1979. A 19th century Ruhr in Central Africa. Africa, 49:329-351.

Wertime, T.A. and J.D. Muhly (eds.)
1980. The coming of the Age of Iron. New Haven.

Wild, R.
1931. An unusual type of primitive iron smelting furnace at Abomposu, Ashanti. Gold Coast Review 2(5): 184-192.

Wynne, E.J. and R.F. Tylecote.
1958. An experimental investigation into primitive iron-smelting technique. Journal of the Iron and Steel Institute 190:339-347.

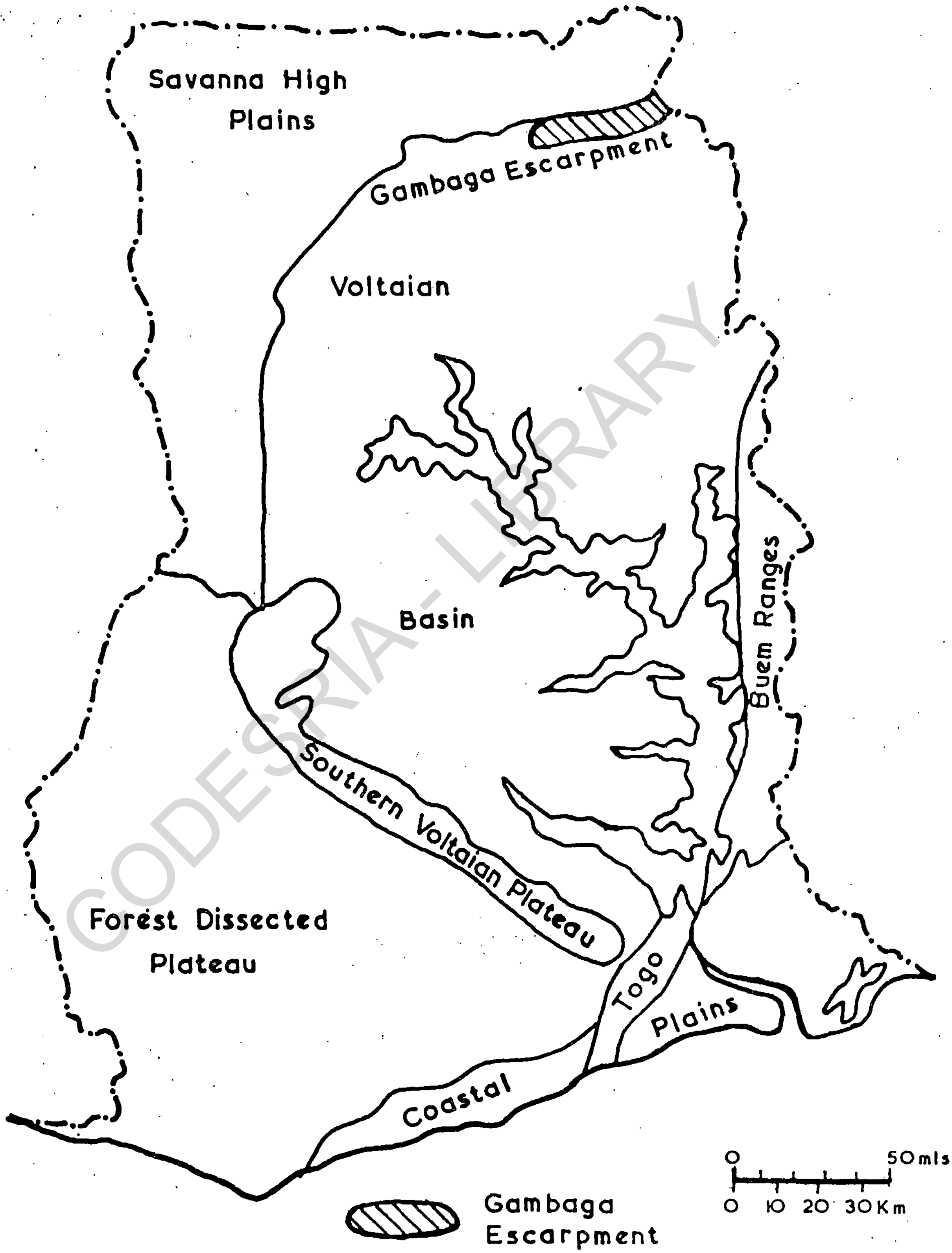
York, R.N.
1968. Volta Basin Research Project excavations at New Buipe: a preliminary report. Ghana Notes and Queries 10:33-35.

York, R.N.
1973. Excavations at New Buipe. West African Journal of Archaeology 3:1-189.

Zacharias, S. and H.G. Bachmann.
1983. Iron-smelting in West Africa: Ivory Coast. Journal of the Historical Metallurgy Society, 17:1-3.

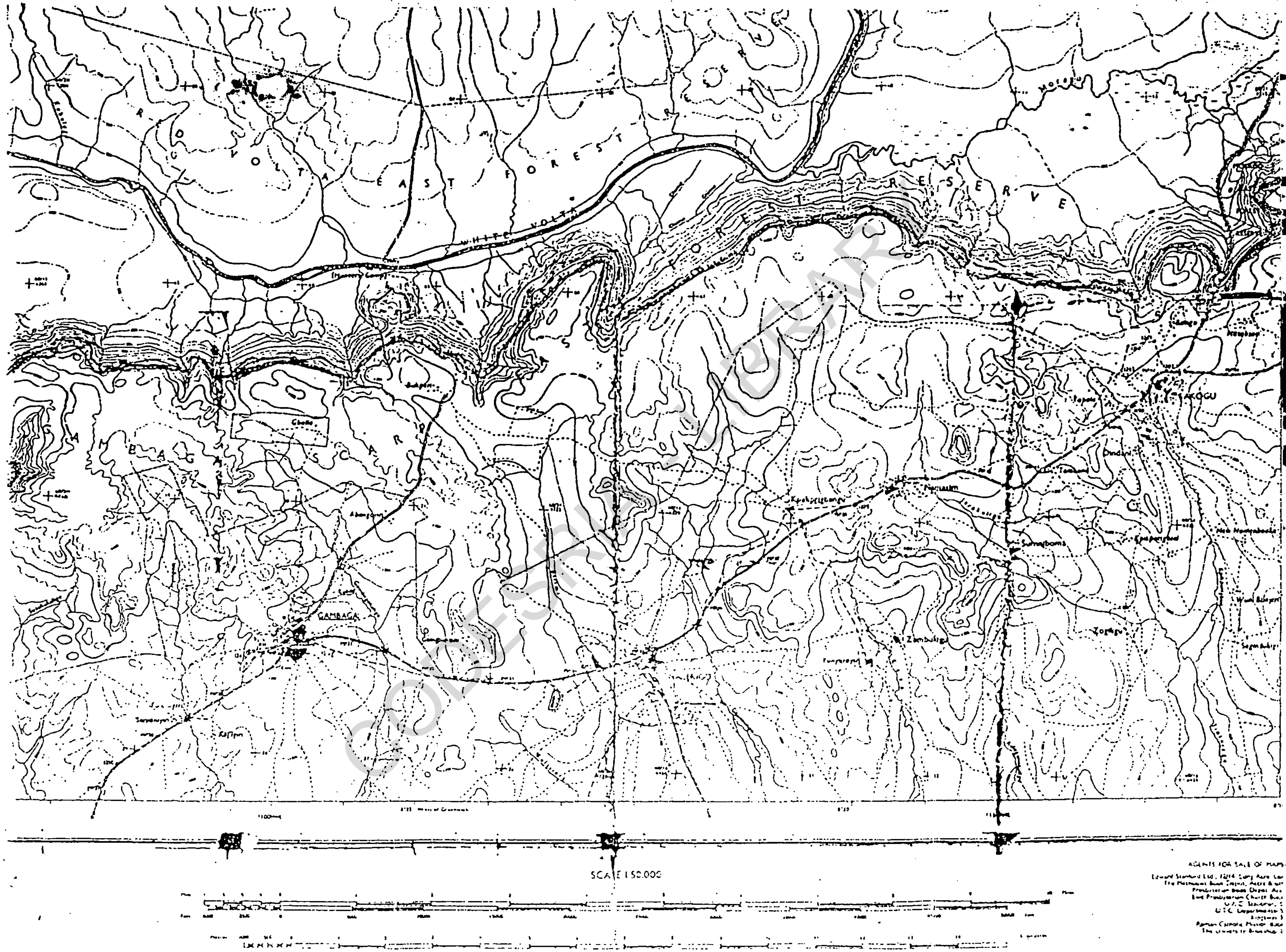
Zahan, D.
1967. The Mossi Kingdoms. In West Africa Kingdoms in the 19th century. O.U.P. Oxford (eds.) Forbes, D. and Kabery, P.M. 152-178.

PHYSIOGRAPHIC REGIONS OF GHANA

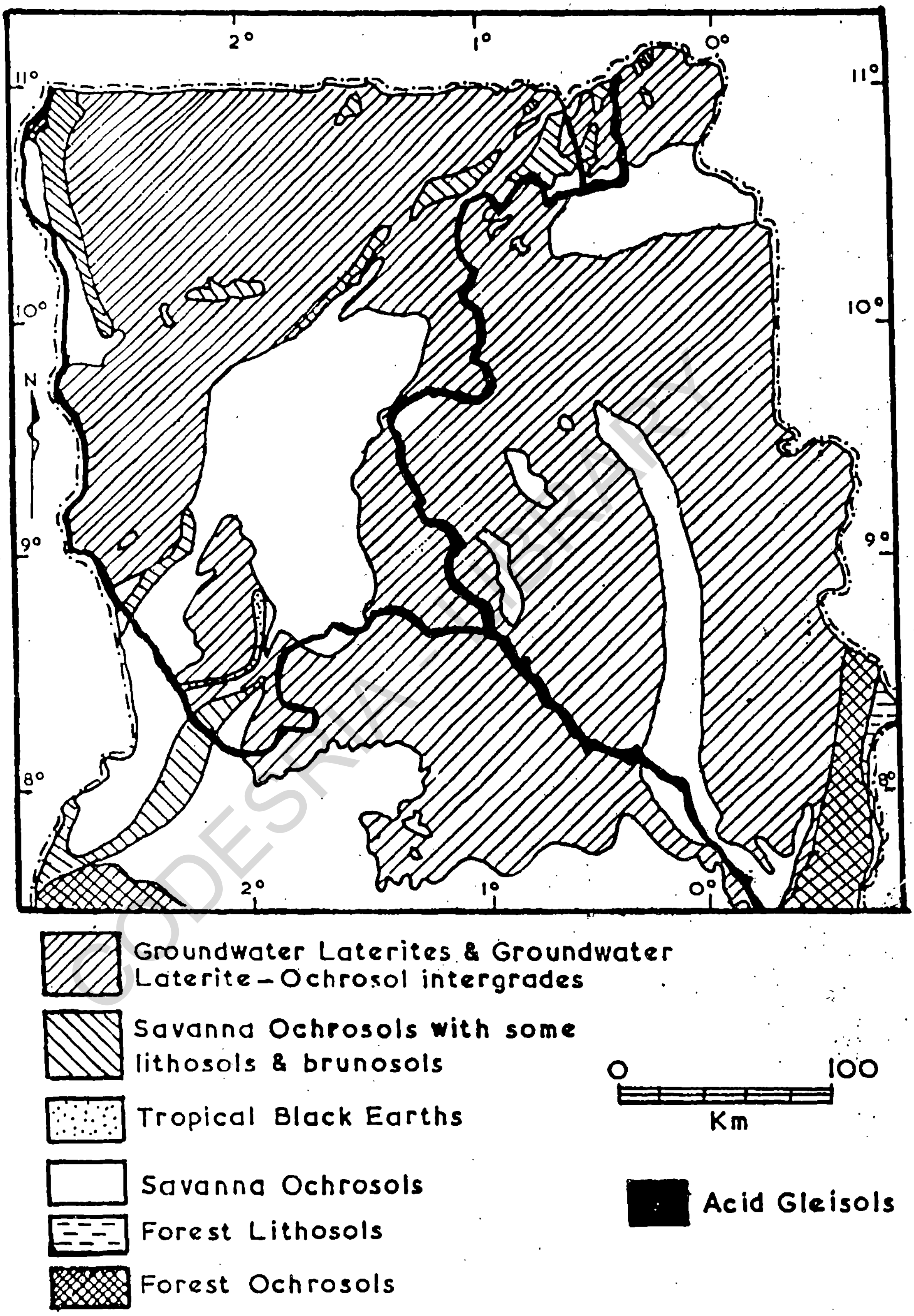


(After Dickson and Benneh, 1973 P. 17)

Map 1



Map 2. Topography of the Gambaga Escarpment

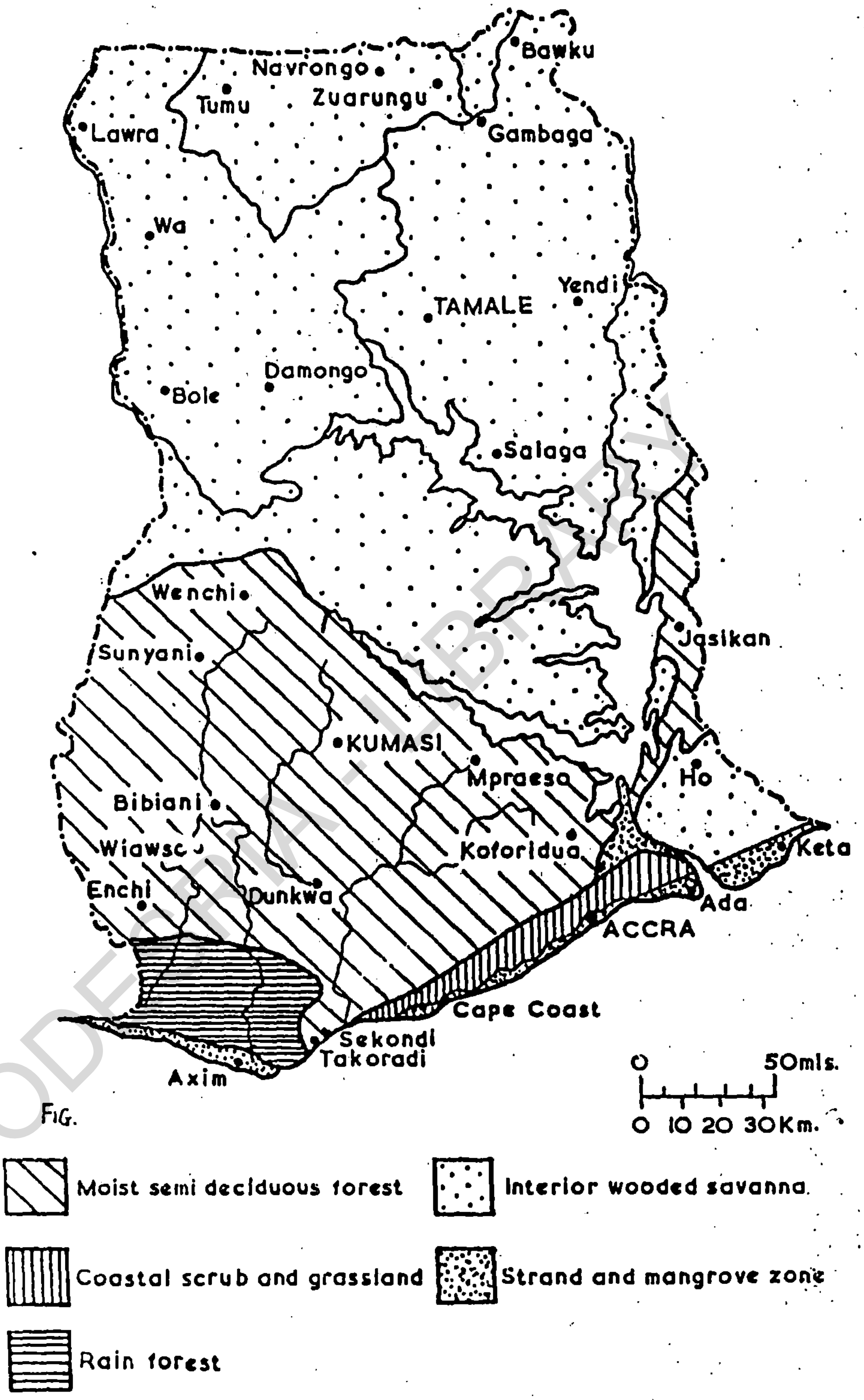


SOILS IN NORTHERN GHANA

(after Dickson and Benneh 1970; 43)

Map 3.

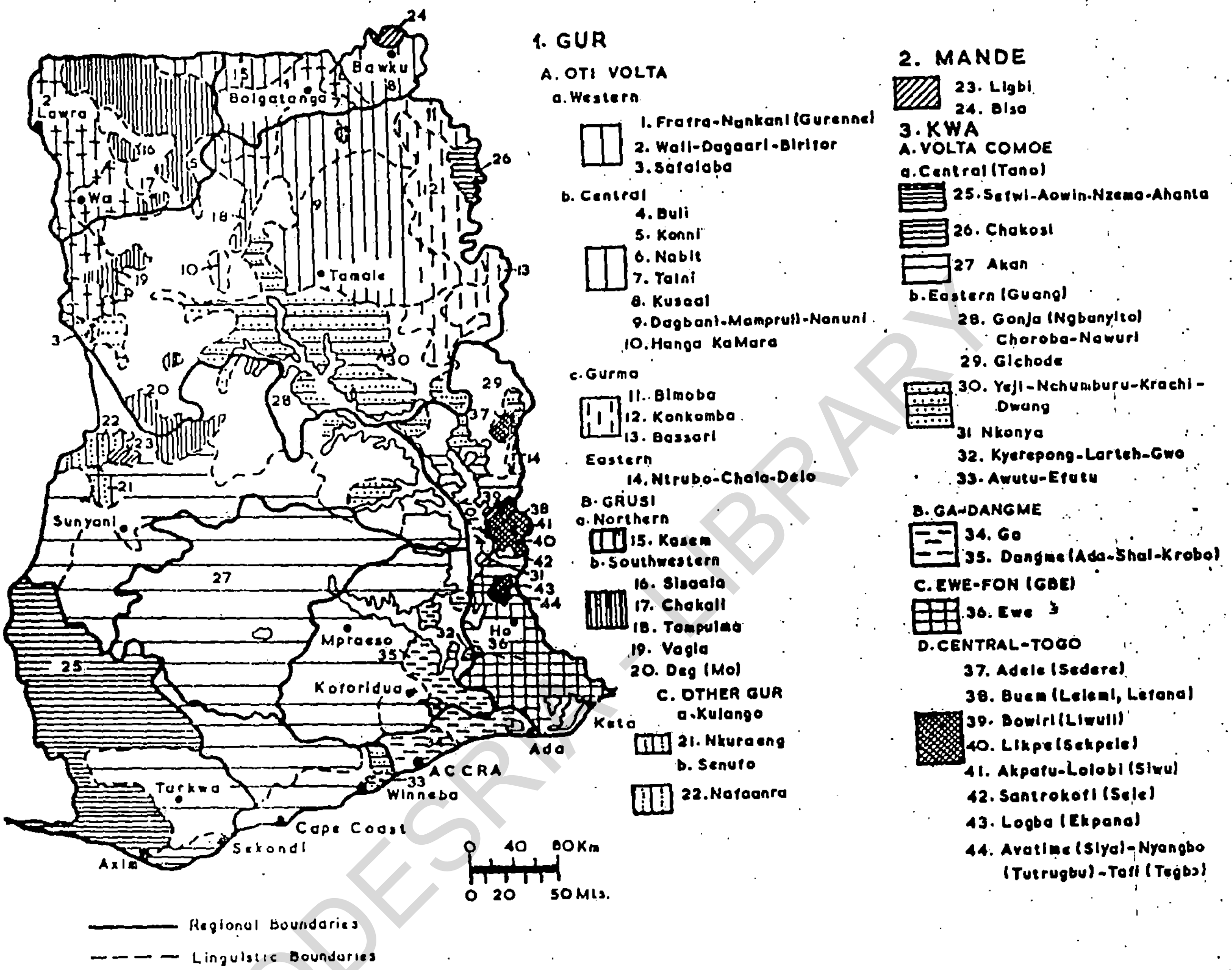
VEGETATION TYPES OF GHANA



(After Dickson and Benneh,1973, P.38)

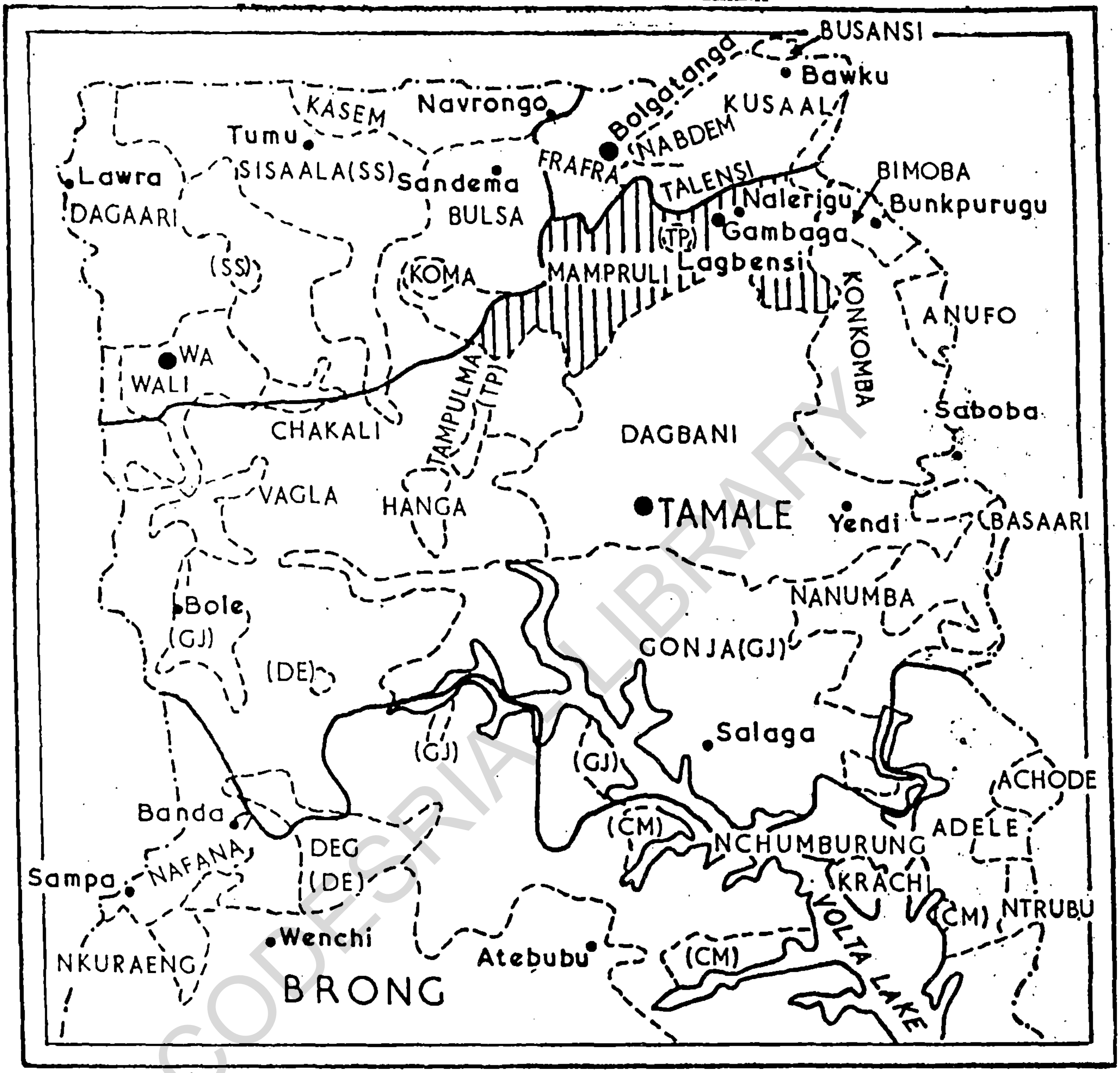
Map 4

LANGUAGE MAP OF GHANA

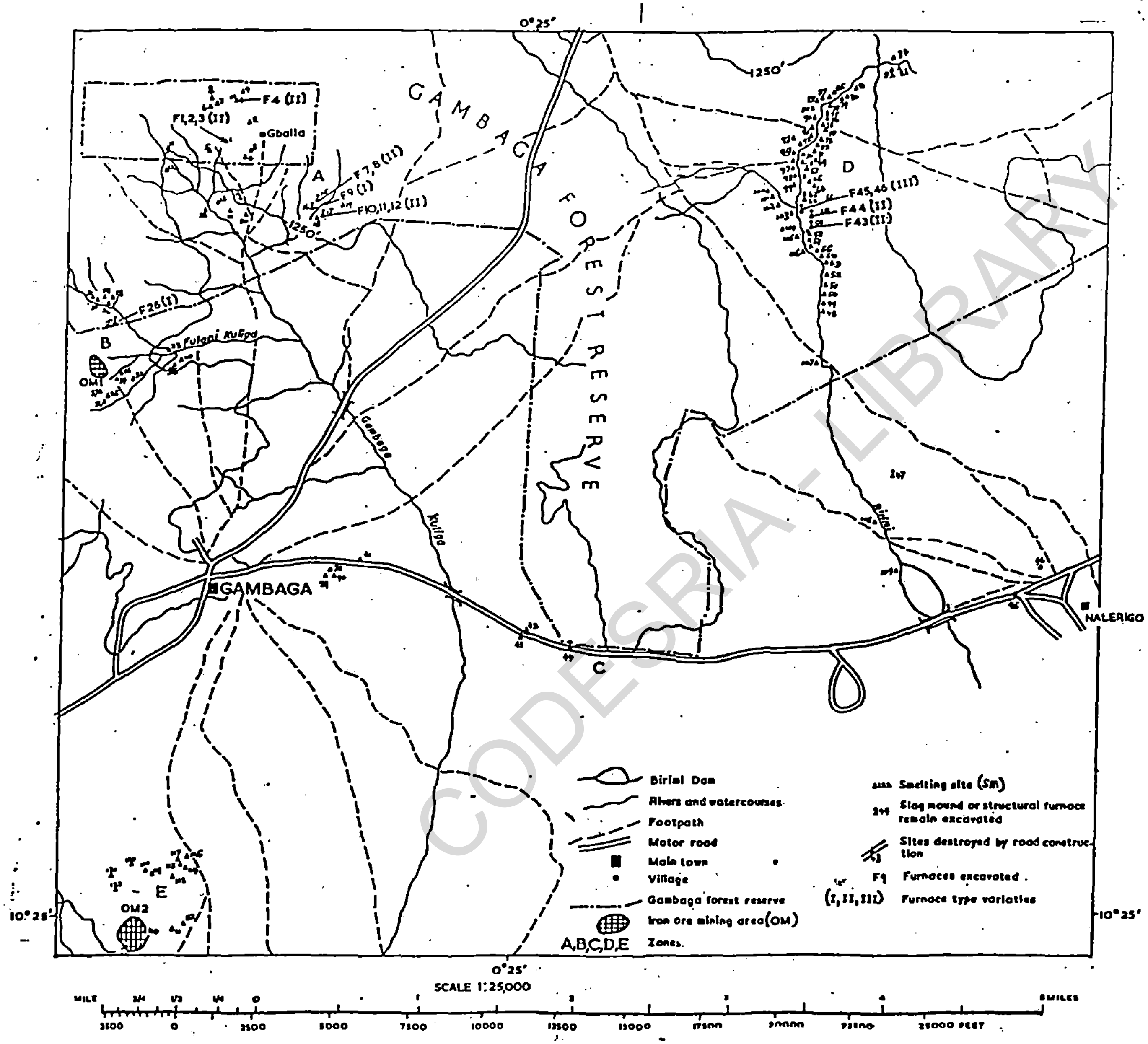


Map. 5

LINGUISTIC GROUPS IN NORTHERN GHANA

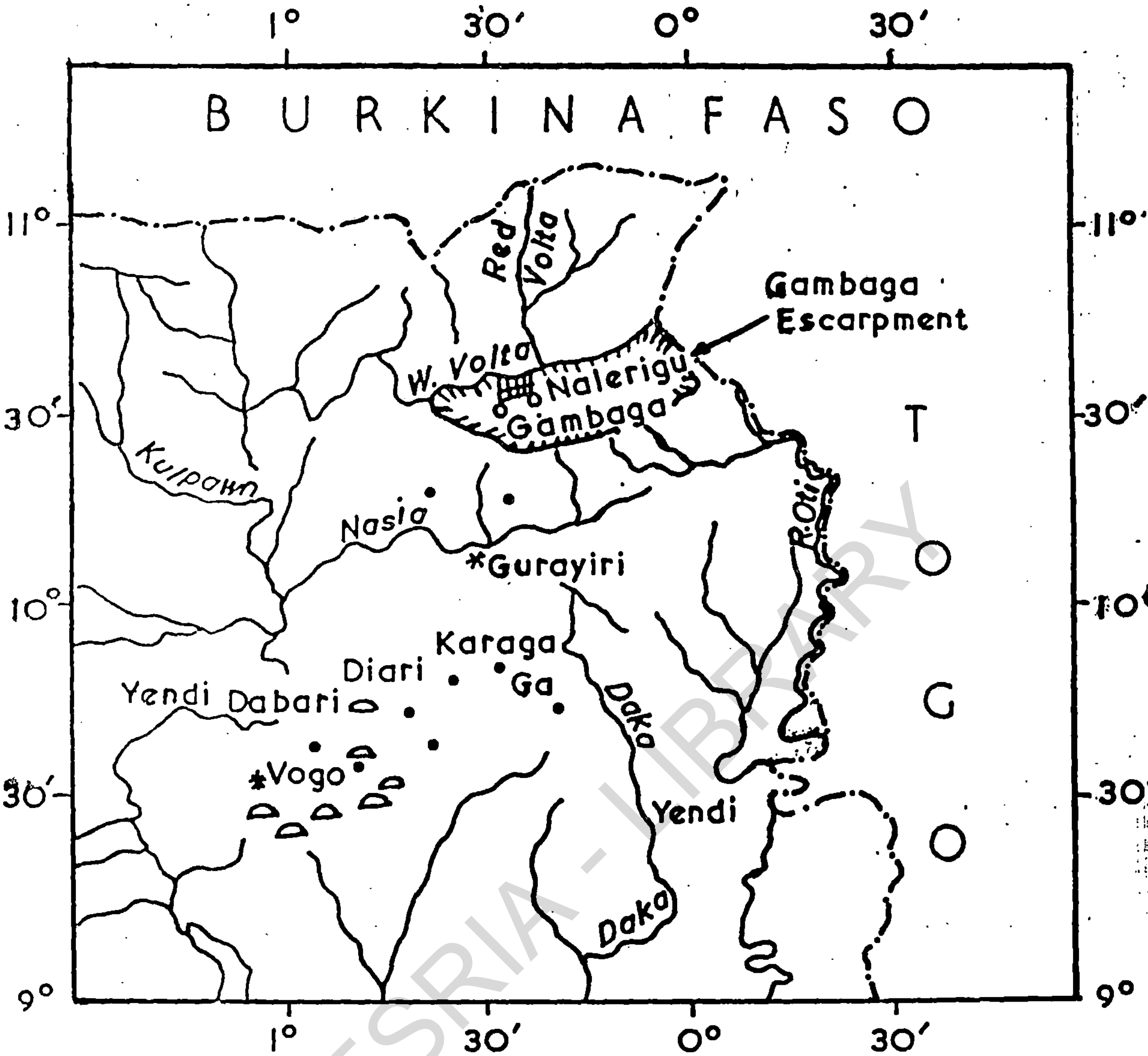


Map 6



Map. 7

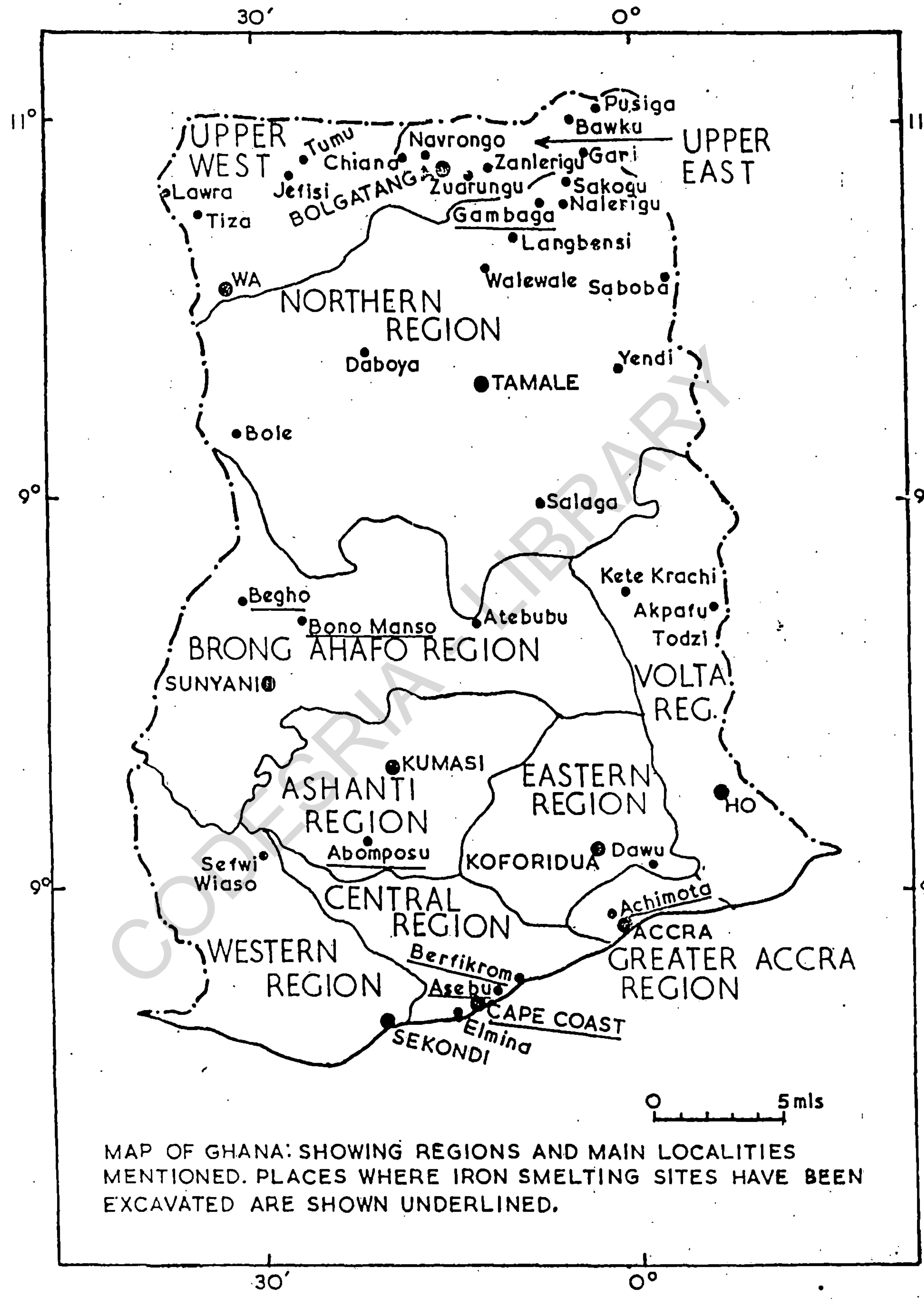
Area investigated showing the location and distribution of smelting sites and furnace varieties recovered from the excavation.



- "Adite" villages where tendanas were killed
- * Important "Adite" centres attacked and sacked by Nyagse
- Known mound complexes
- o Gambaga, ancient town in Mamprugu
- Known "Adite"(?) Smelting sites investigated in the Gambaga area.
- International boundary
- Rivers

NORTH EAST GHANA SHOWING AREA WHERE "ADITES" WERE KNOWN TO HAVE TRAVERSED AND SETTLED. (Adapted from Davis 1984)

Map. 8



MAP OF GHANA: SHOWING REGIONS AND MAIN LOCALITIES MENTIONED. PLACES WHERE IRON SMELTING SITES HAVE BEEN EXCAVATED ARE SHOWN UNDERLINED.

Map. 9

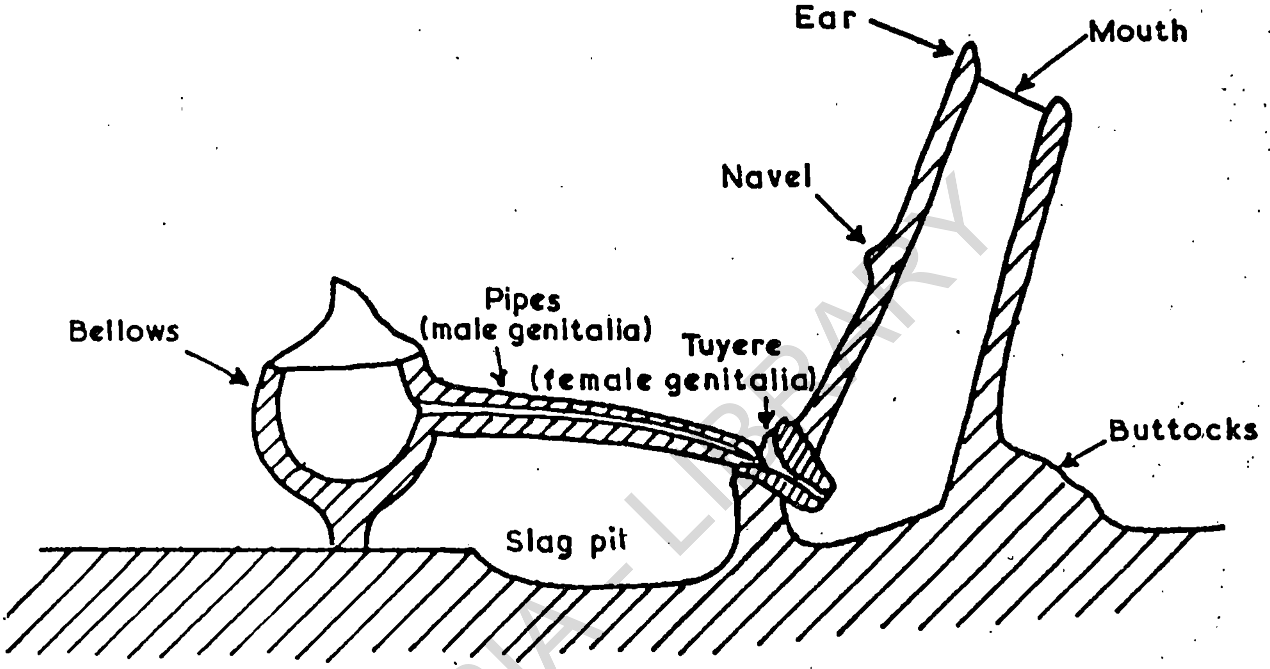


DIAGRAM OF ZALERIGU FURNACE SHOWING SYMBOLISM ATTACHED TO THE SMELTING APPARATUS (Drawn after Pole 1974:9)

Fig. 1

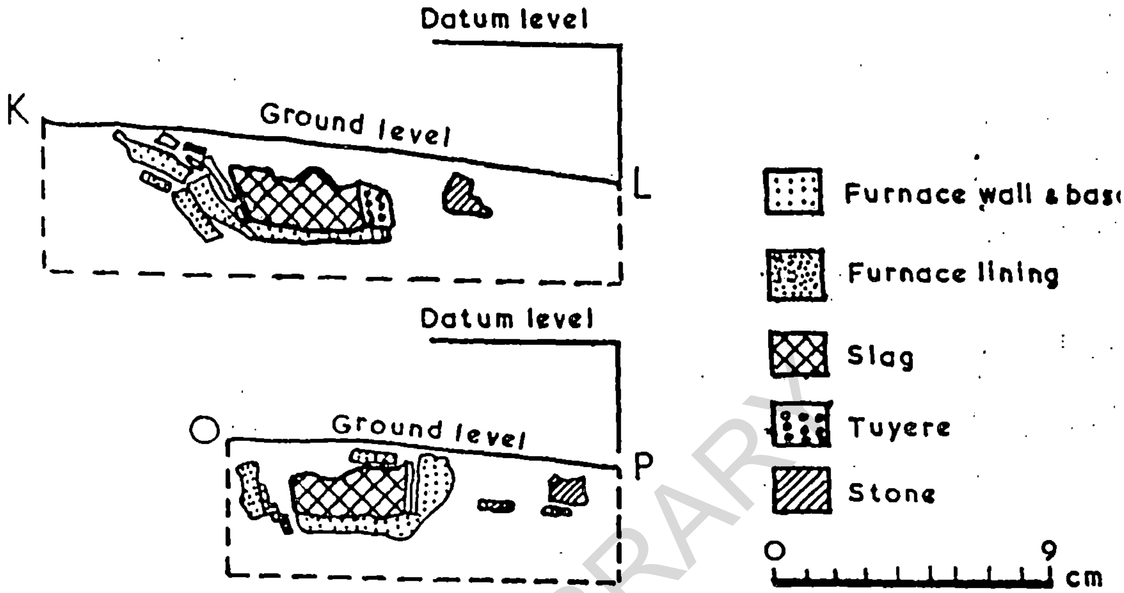


FIG. 2a

ACHIMOTA FURNACE, GHANA – SECTIONS THROUGH THE FURNACE ALONG THE LINES KL AND OP SHOWN IN FIG.1.

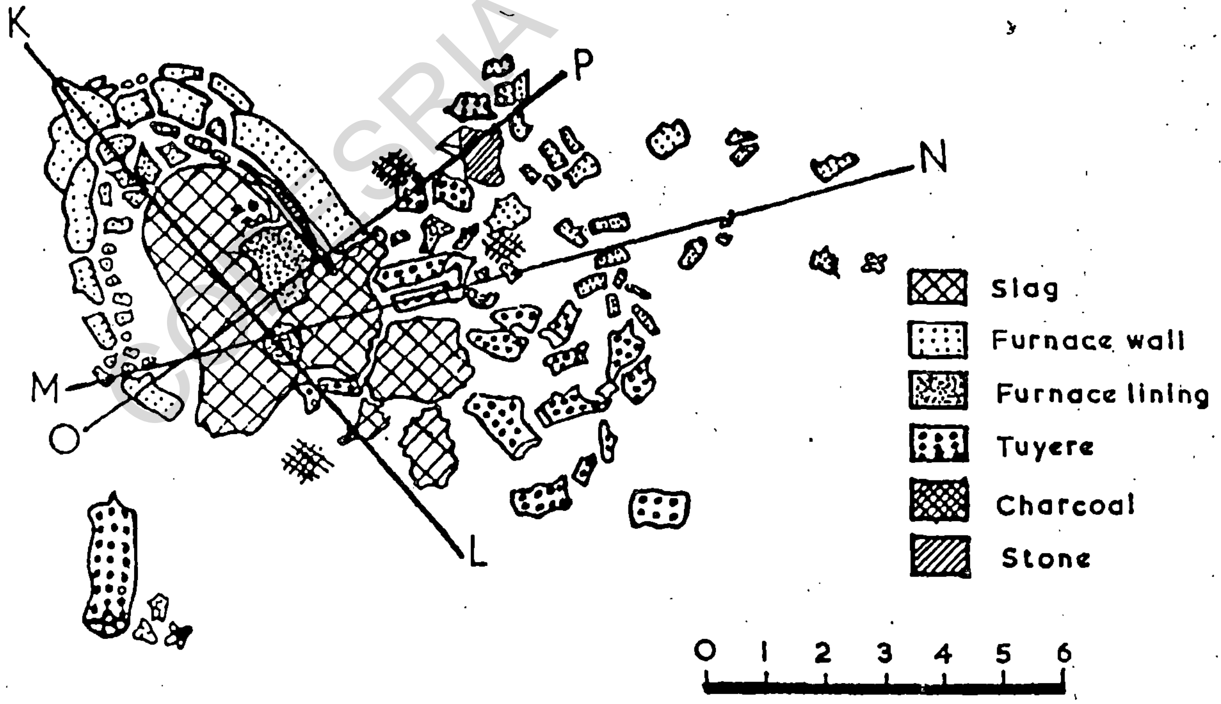


FIG. 2b

ACHIMOTA FURNACE – PLAN (Shaw 1969)

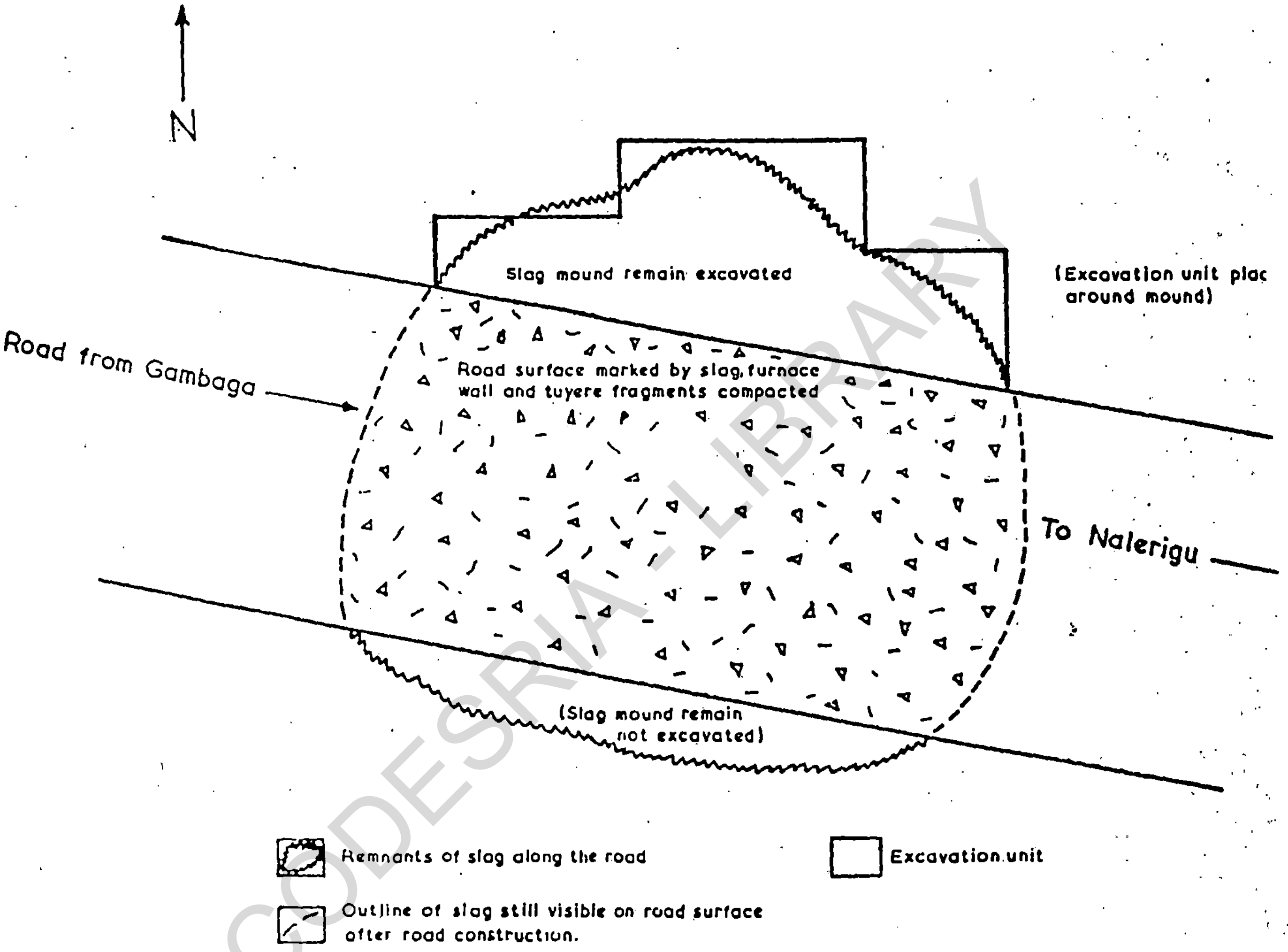


Fig. 3. SM.44 showing plan of slag mound destroyed by road construction

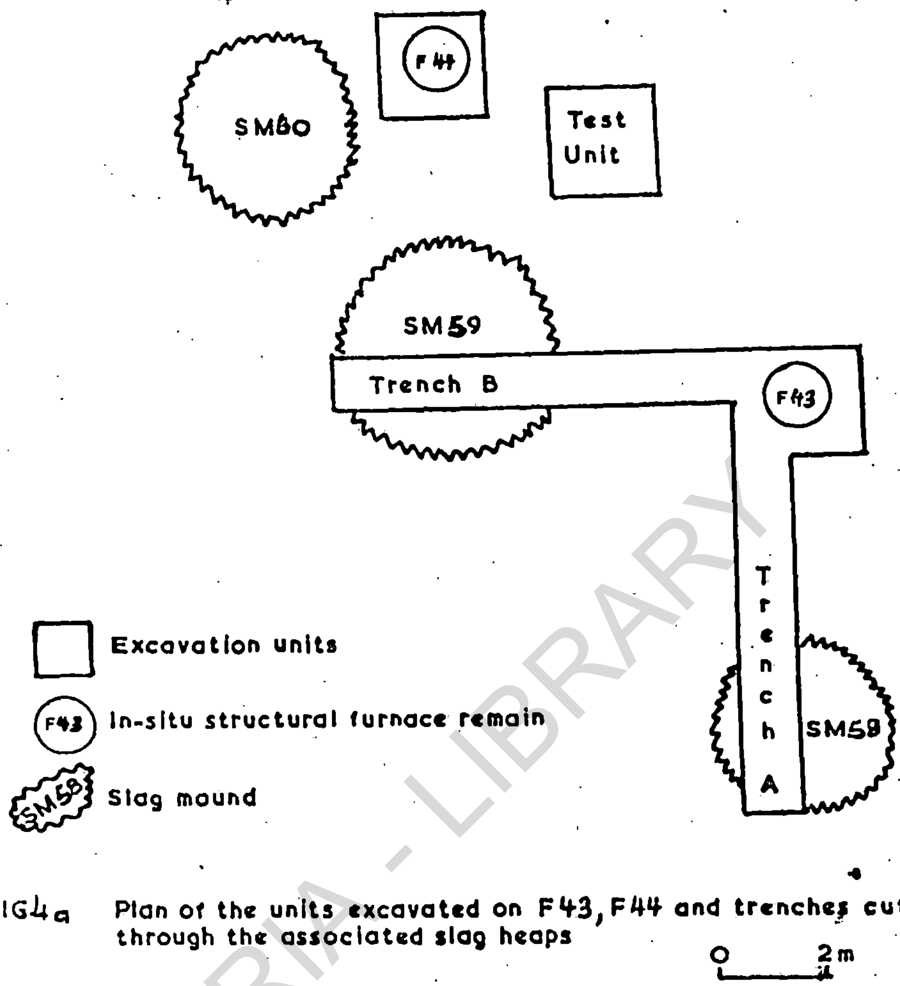


FIG4a Plan of the units excavated on F43, F44 and trenches cut through the associated slag heaps

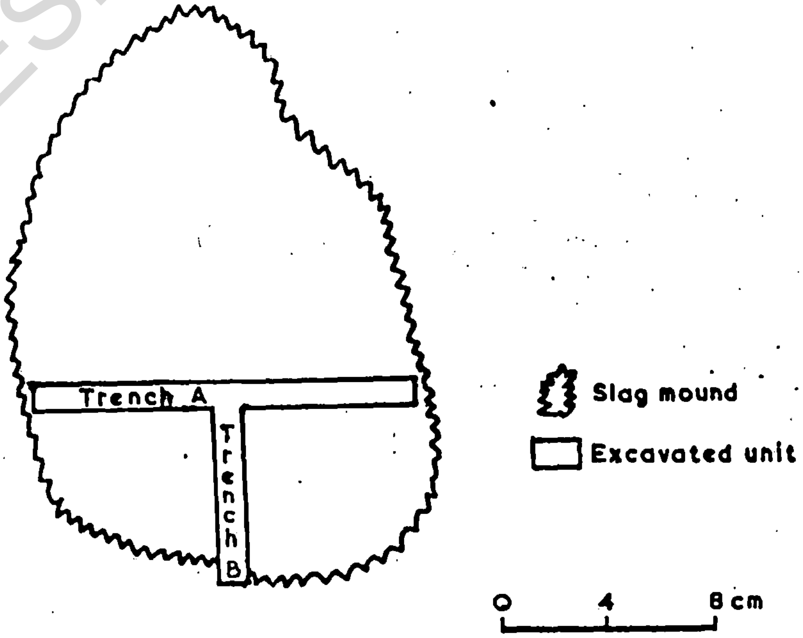


FIG. 4b Plan of SM 47 showing trenches excavated on the mound

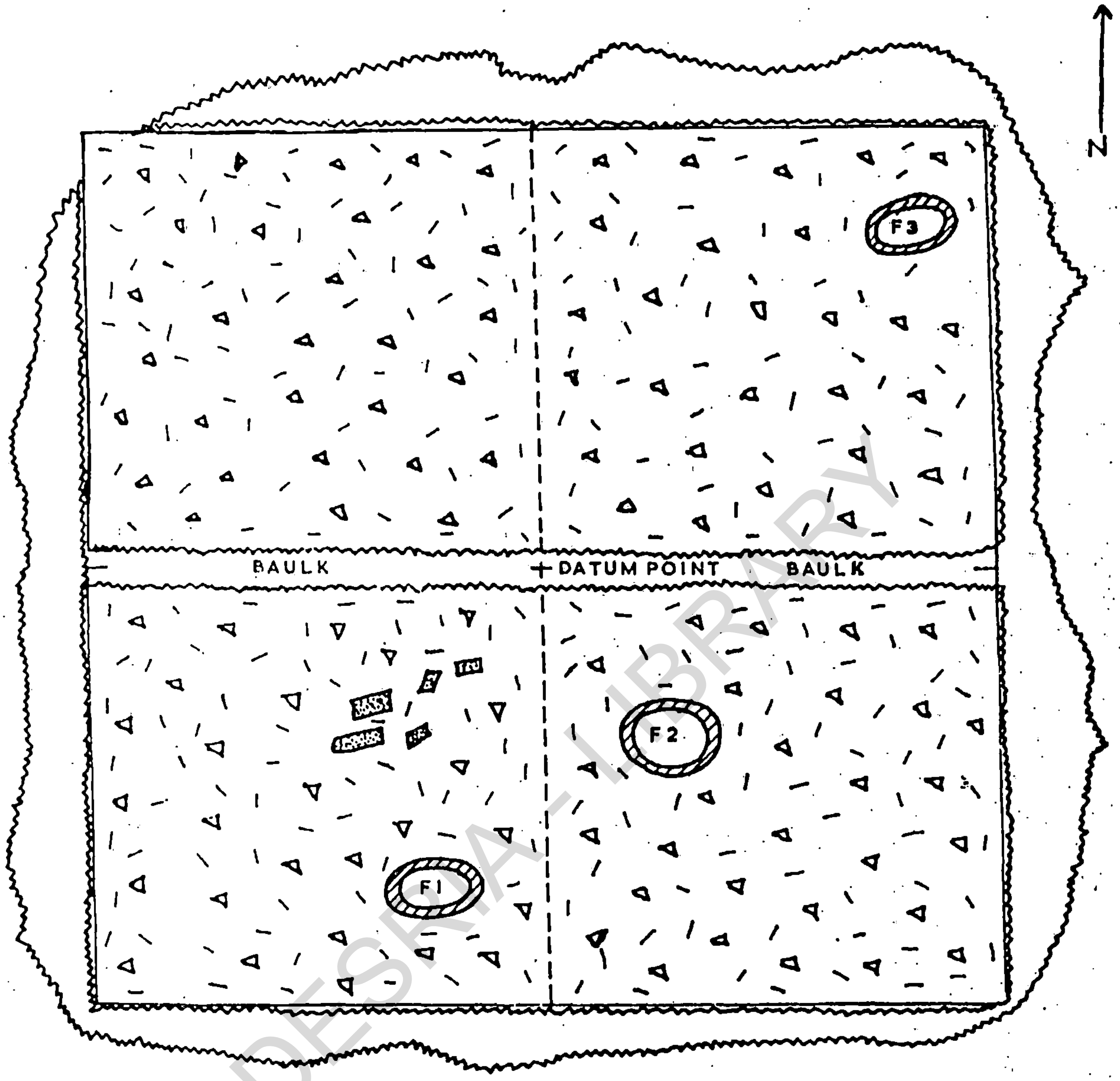
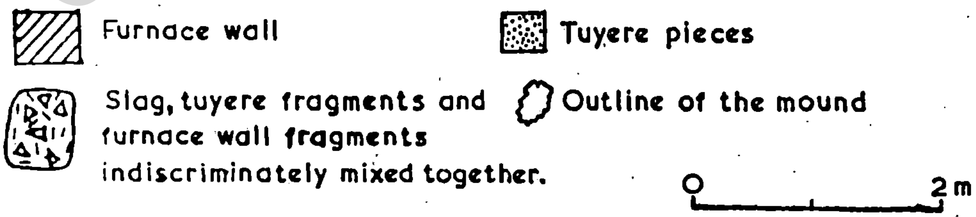


FiG. 5 SM.I A plan of the mound and the excavated units. Note the structural furnace remains exposed after the removal of c.20 cm of the surface layers of the mound.



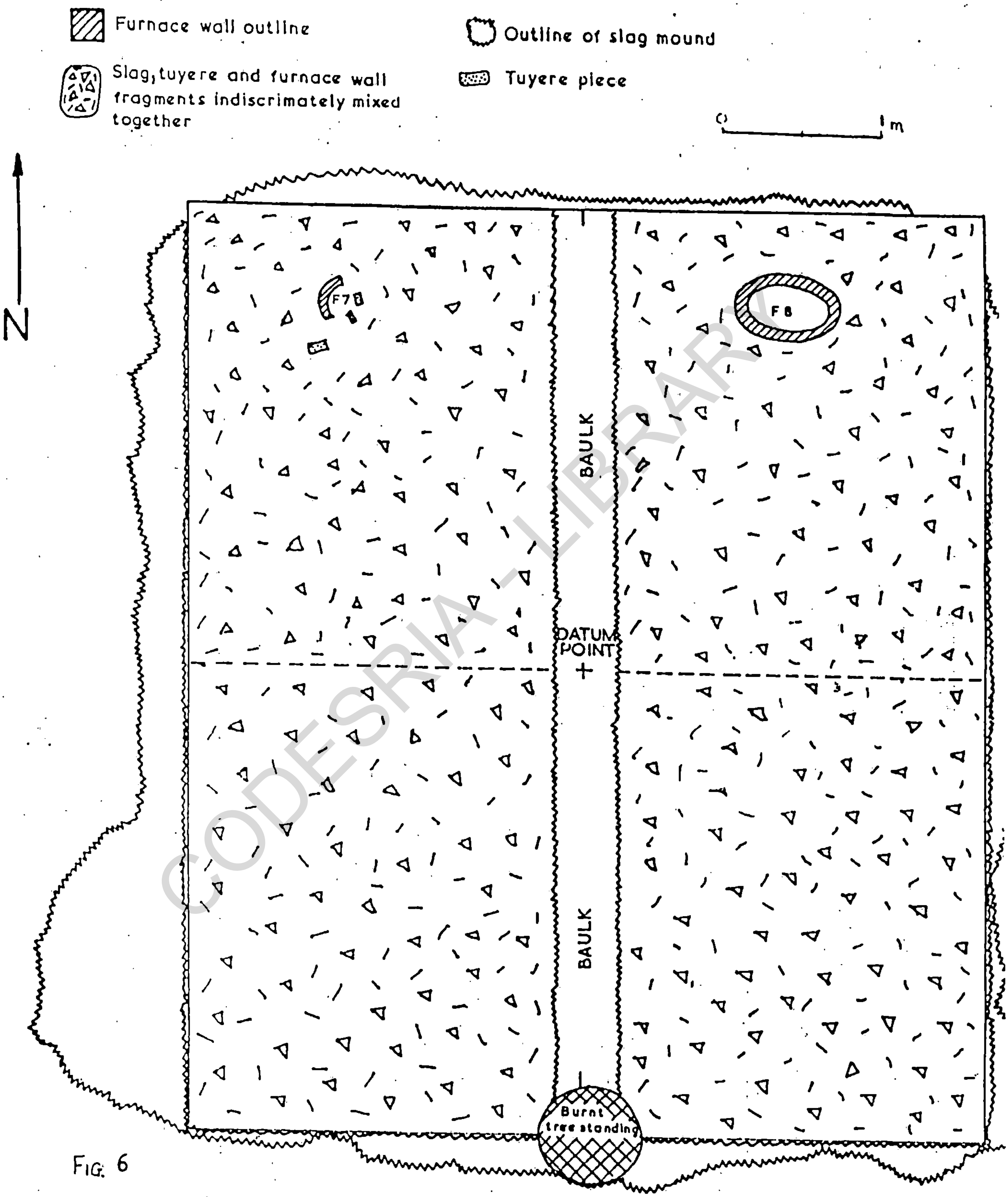


FIG. 6

SM 15 PLAN OF EXCAVATION UNITS AND OUTLINE OF FURNACES AND TUYERE EXPOSED AT A DEPTH OF 75 cm BELOW THE DATUM POINT.

SM. 27. SHOWING THE SMELTING SITE AND THE EXCAVATION UNITS

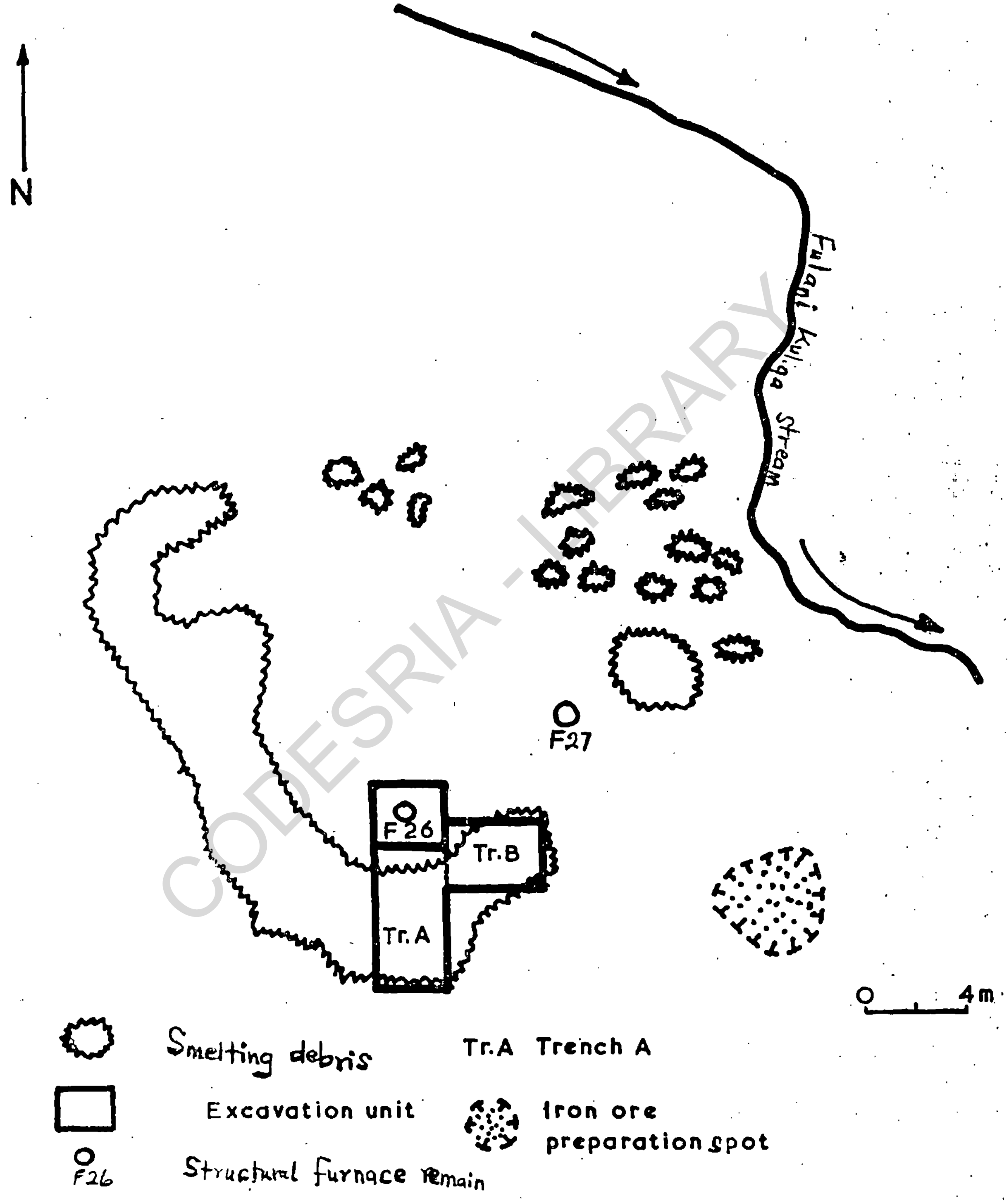
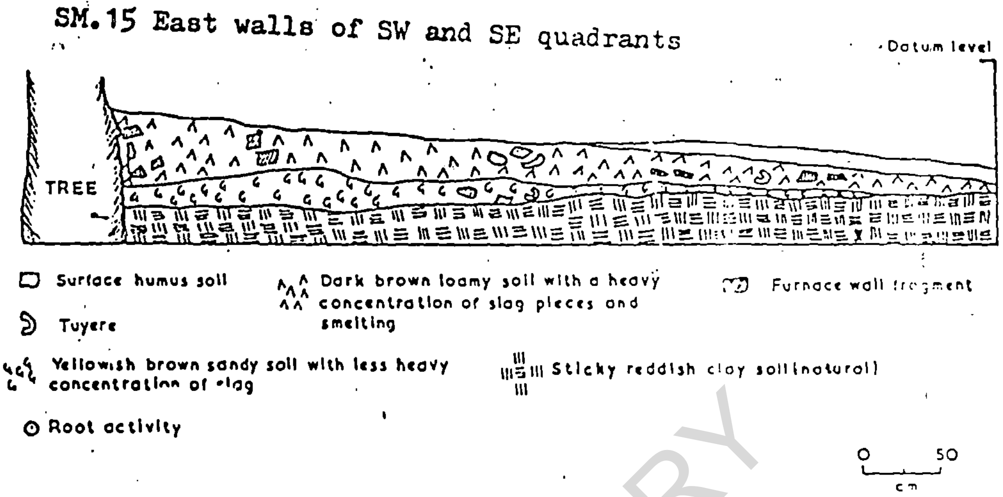
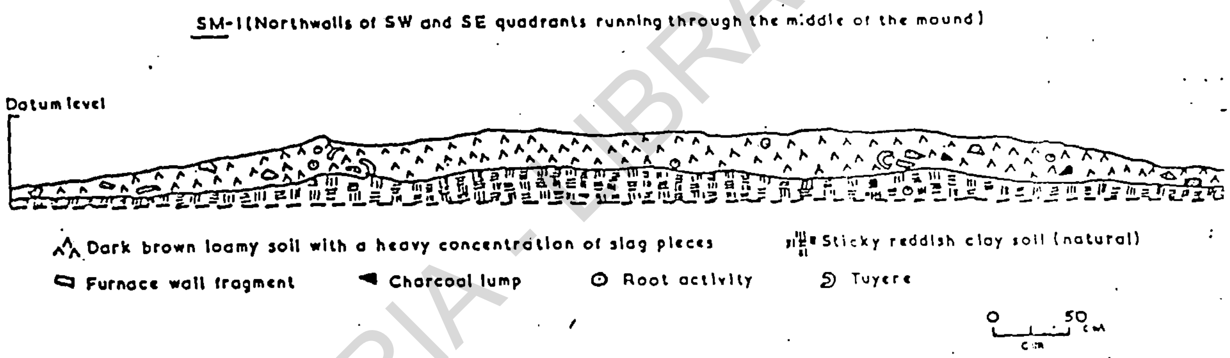


Fig 7

(a)



(b)



(c)

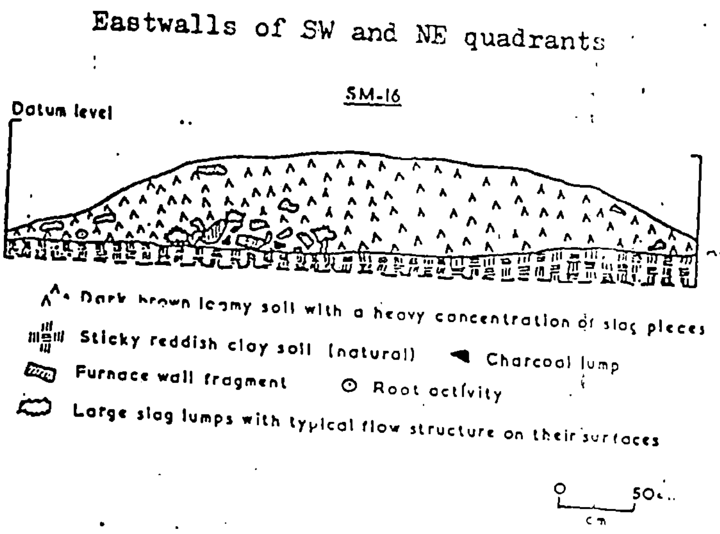
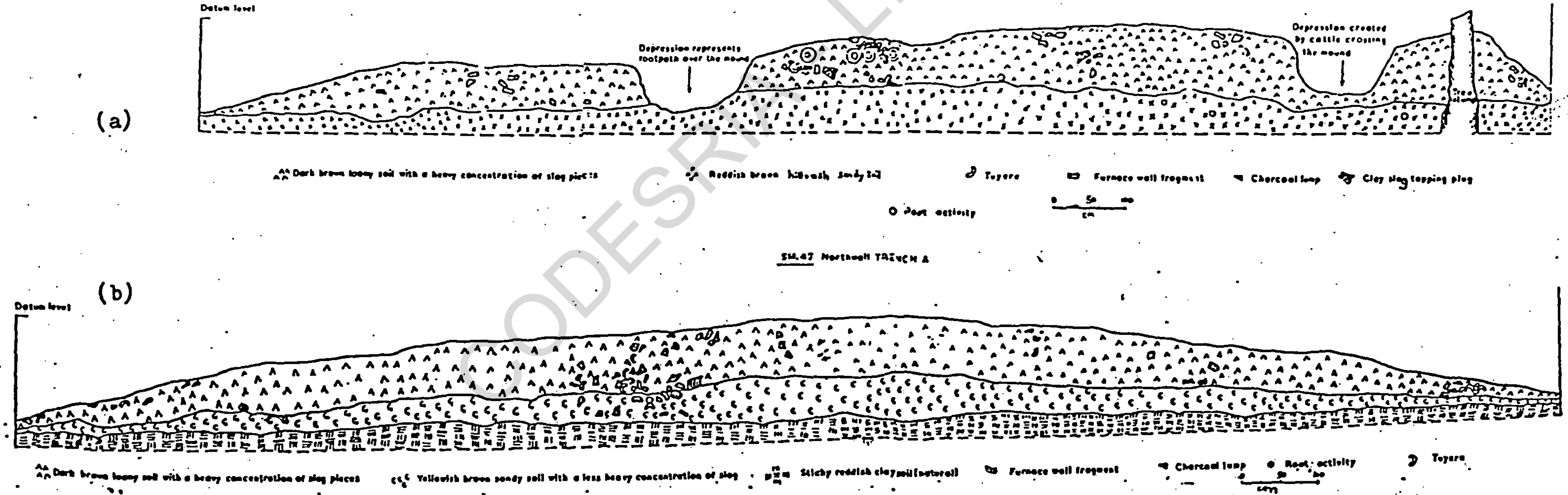


Fig. 8 STRATIGRAPHIC CROSS SECTIONS OF SLAG MOUNDS

SM. 44 - Cross section of mound stratigraphy along main road

(a)



(b)

Fig. 9. STRATIGRAPHIC CROSS SECTIONS OF SLAG MOUNDS

FURNACES WITH IN – SITU SLAG LUMP

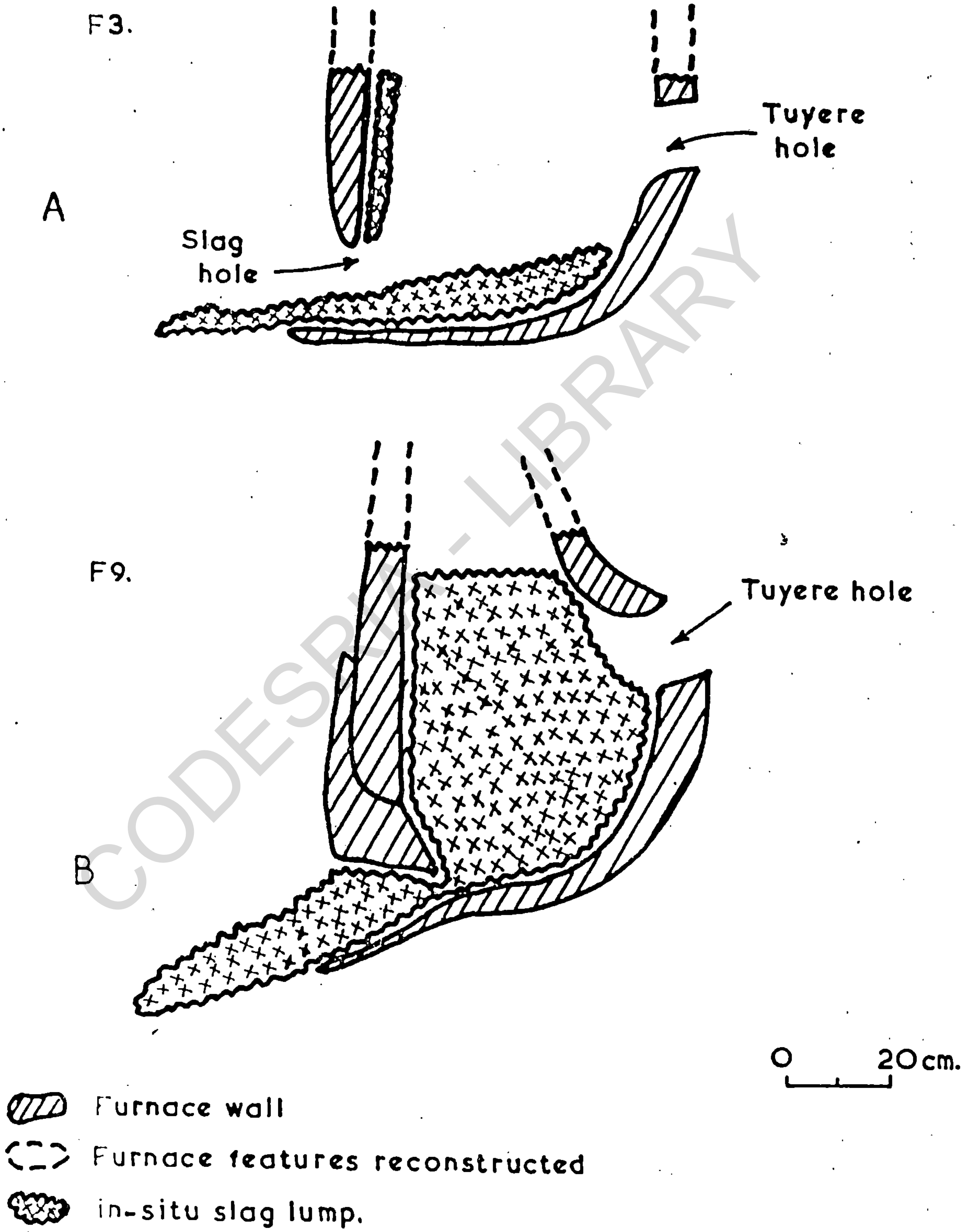
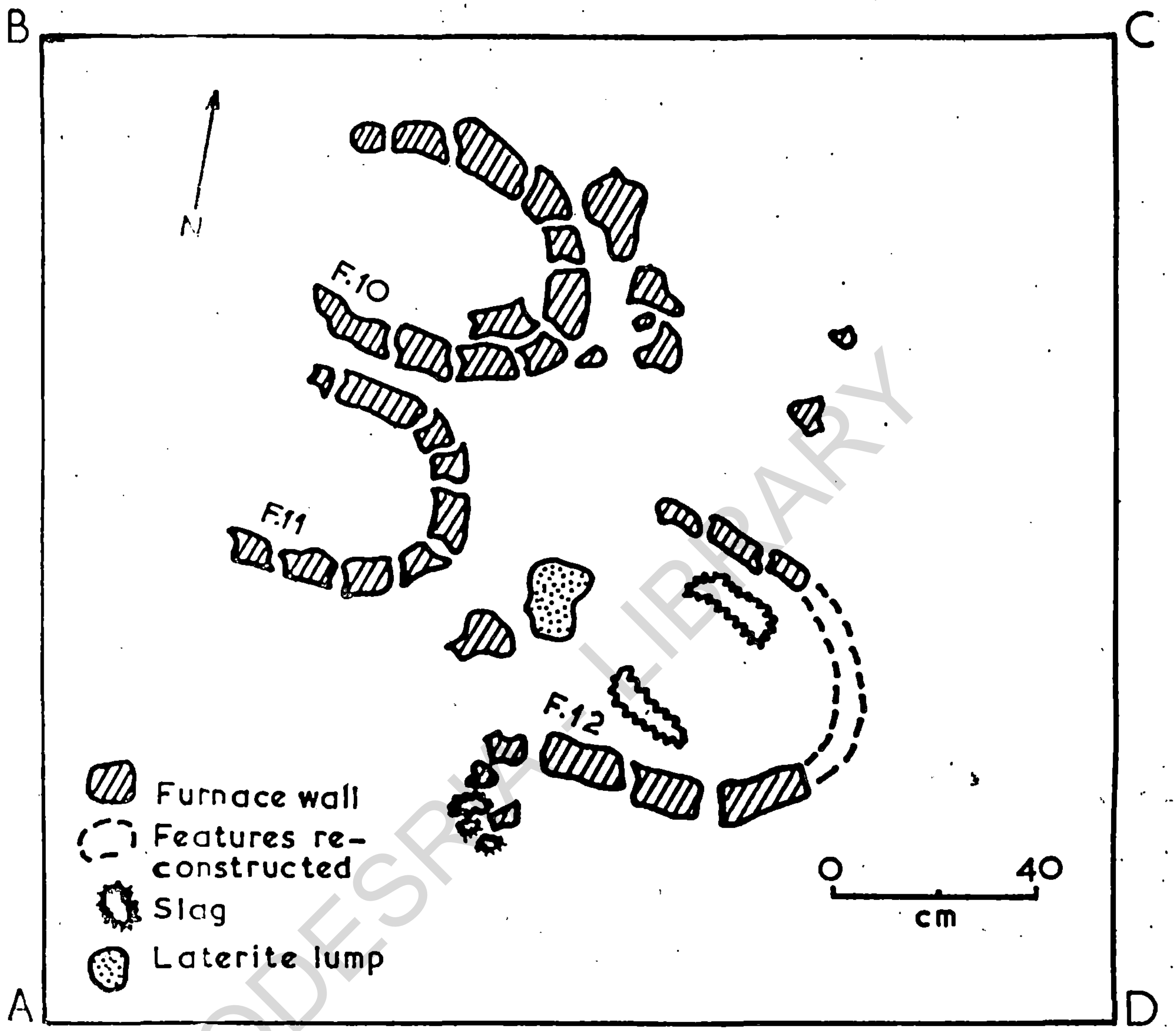


Fig. 10



PLAN OF FURNACES 10,11,12 AS THEY WERE DISCOVERED ON THE SURFACE. A B C D SHOWS THE OUTLINE OF THE EXCAVATION UNIT.

Fig. 11.

PLANS AND SECTIONS OF FURNACE BOWL BASES: No aperture found intact.

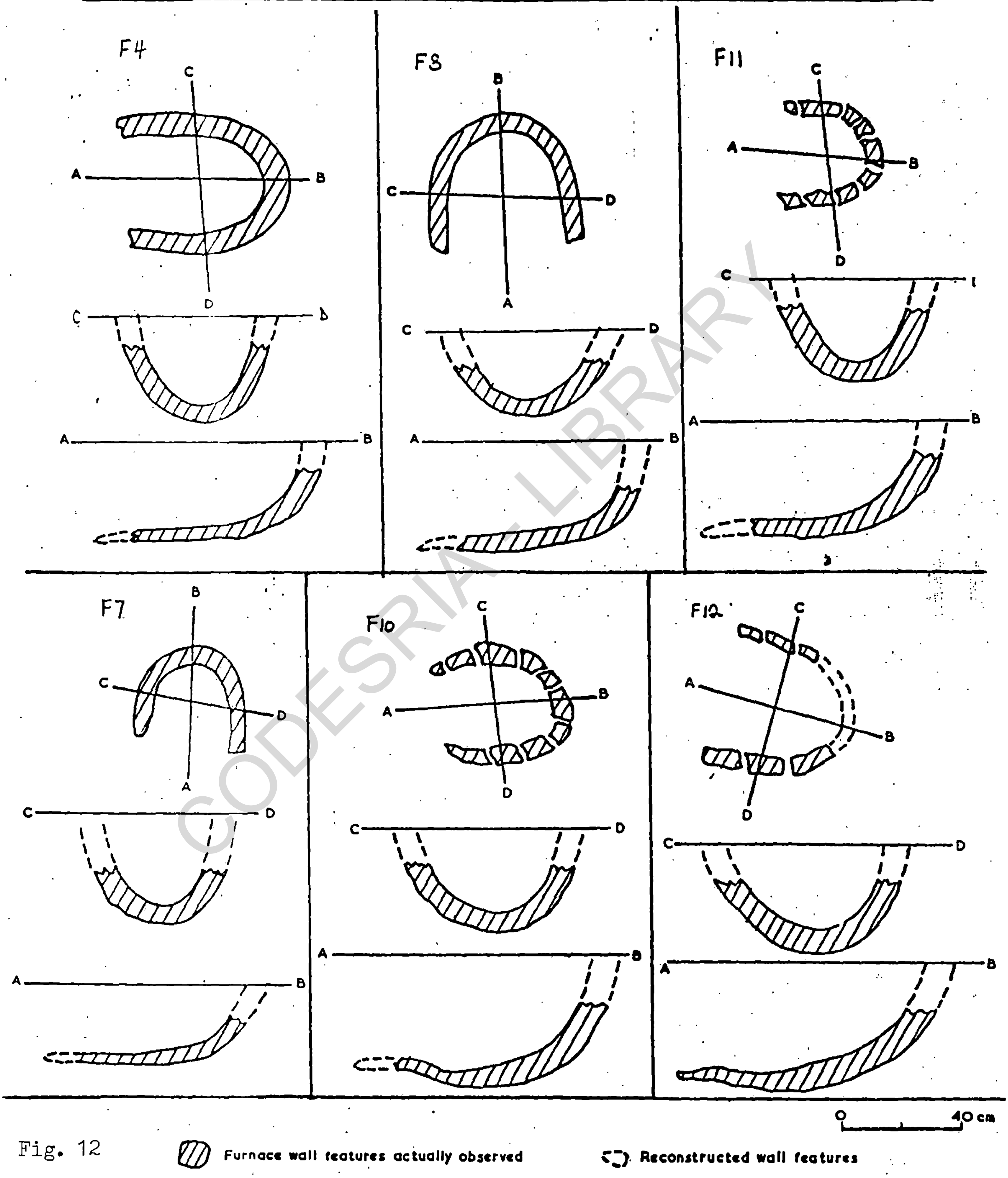


Fig. 12

NB: All the plans of the furnace outlines are aligned North

PLANS AND SECTIONS OF FURNACE BASES WITH ONLY THE SLAG HOLE INTACT

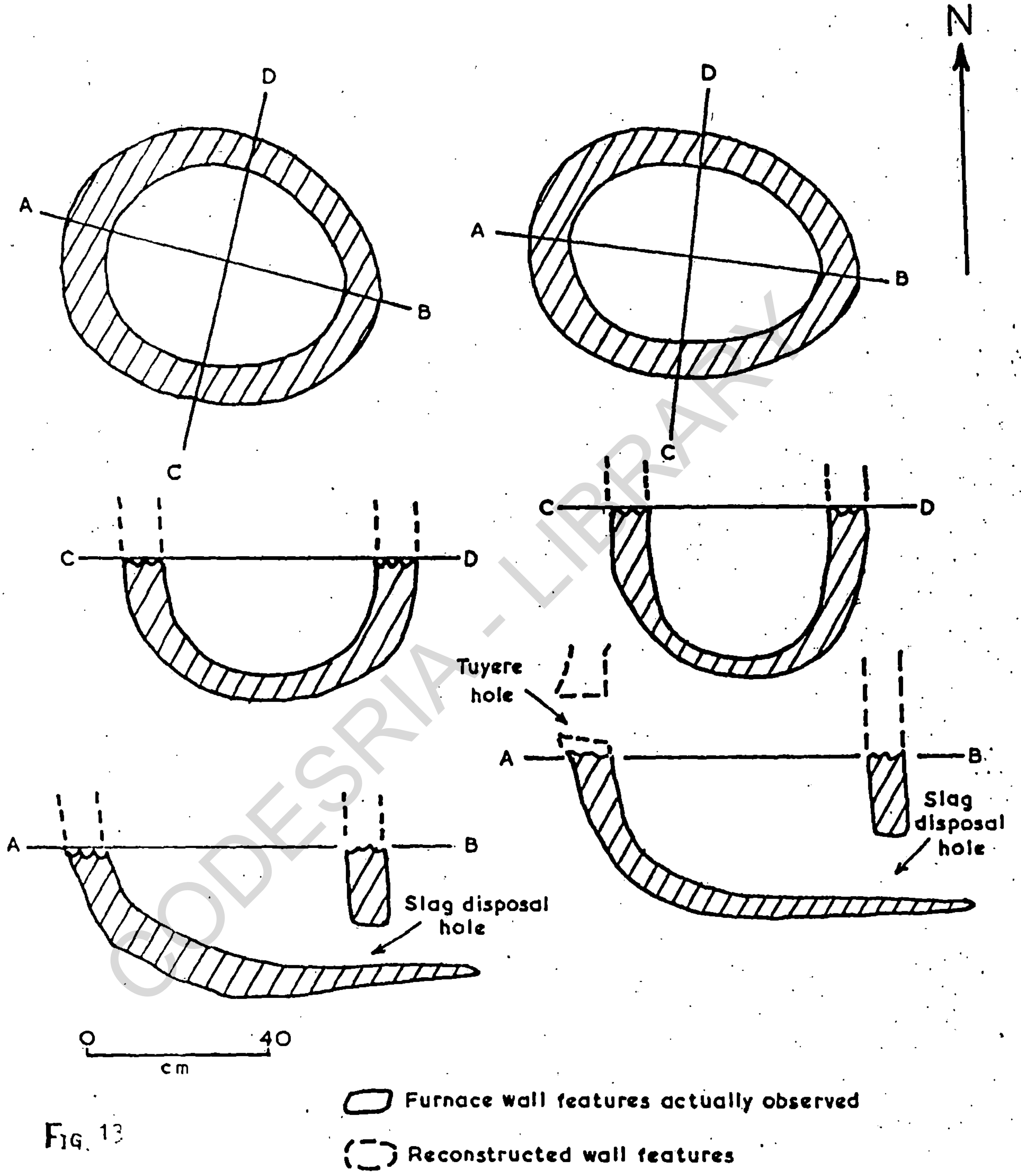
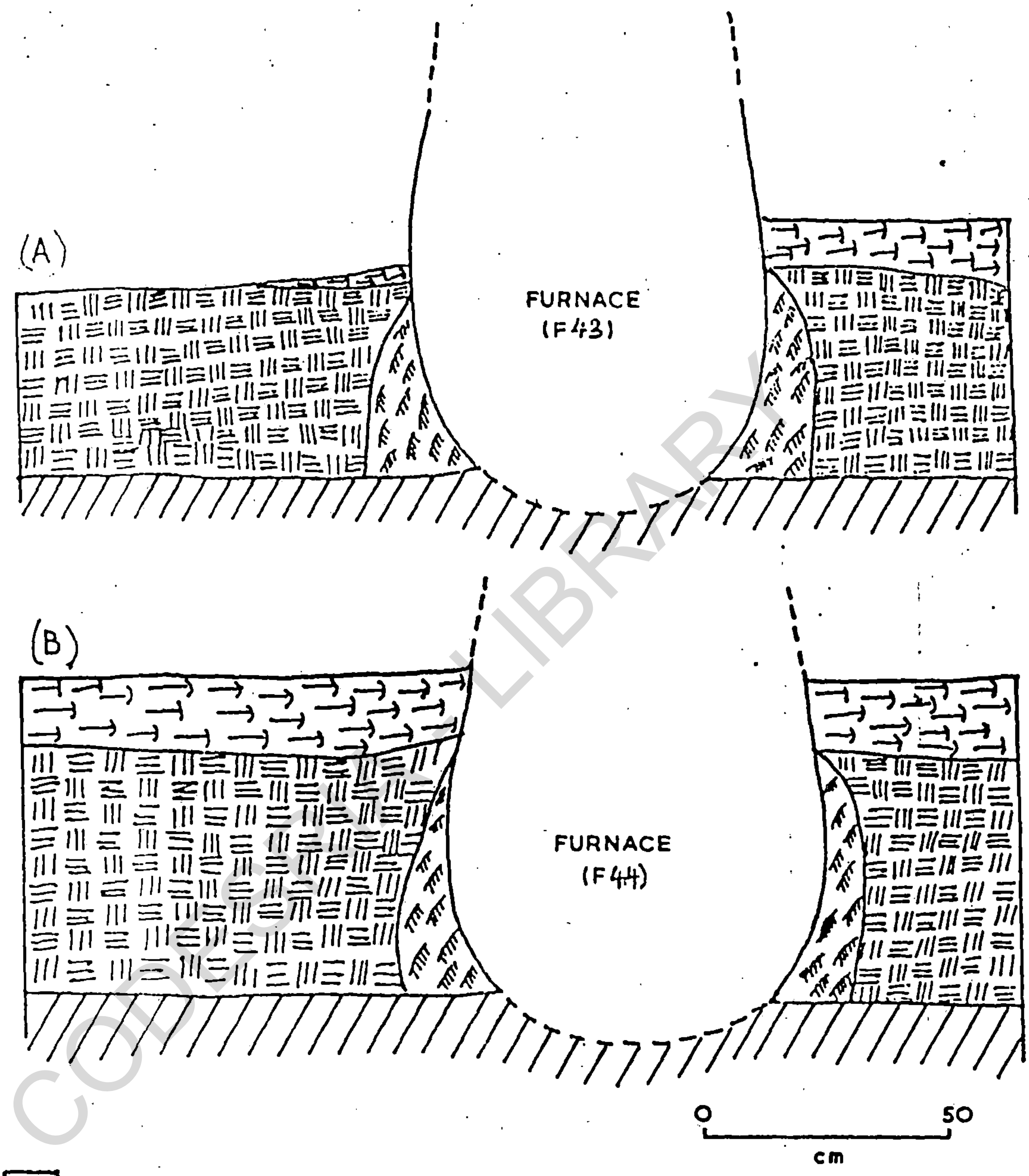


Fig. 13

STRATIGRAPHIC CROSS SECTION SHOWING FURNACE IN-SITU



Loose dark brown sandy/alluvial soil

Reddish clayey soil

Reddish brown-pinkish baked clay soil

Fig. 14

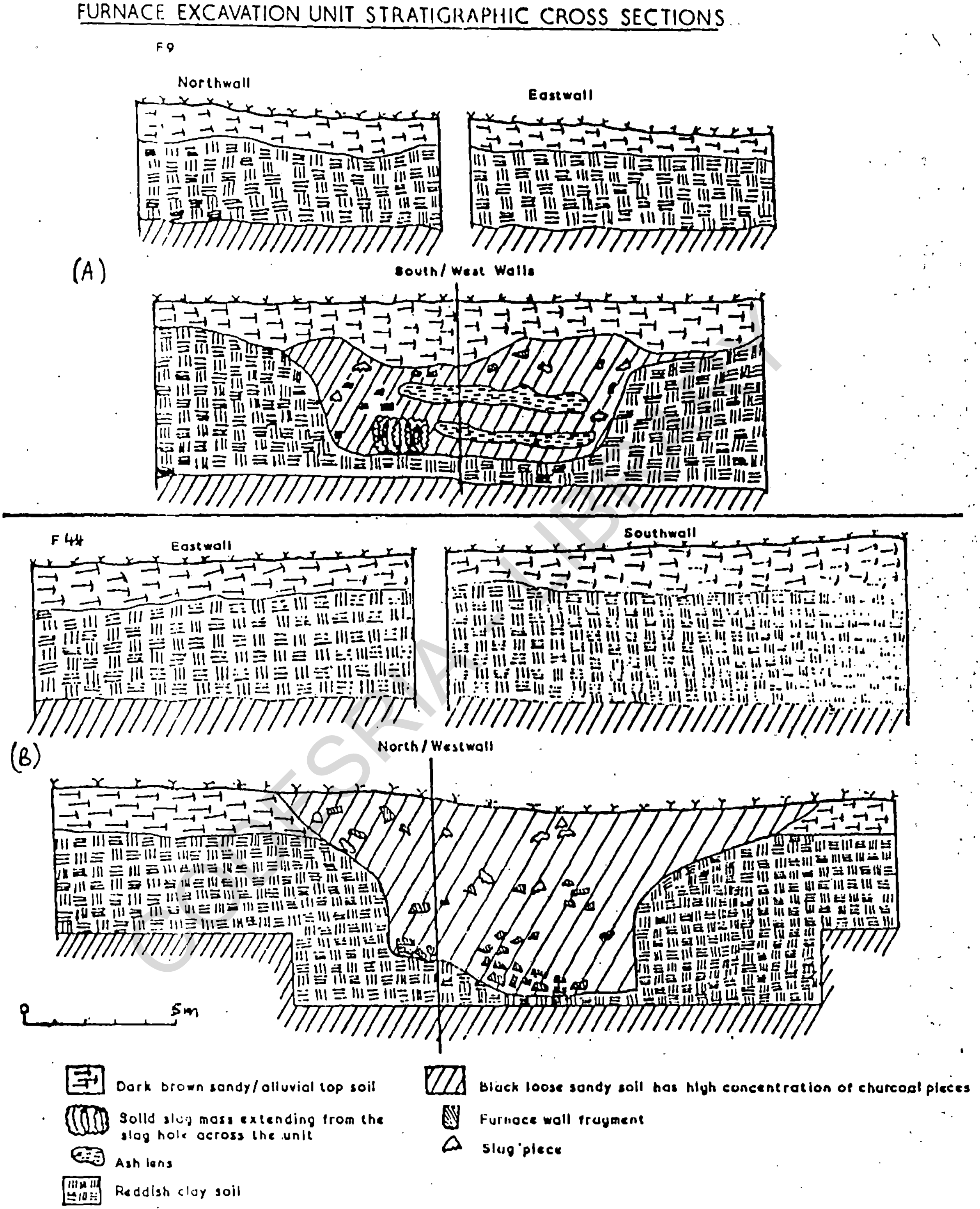

FURNACE EXCAVATION UNIT STRATIGRAPHIC CROSS SECTIONS
F9
Northwall
Eastwall
(A)
South/West Walls
F44
Eastwall
Southwall
(B)
North/Westwall
0
5m
Dark brown sandy/alluvial top soil
Solid slag mass extending from the slag hole across the unit
Ash lens
Reddish clay soil
Black loose sandy soil has high concentration of charcoal pieces
Furnace wall fragment
Slag piece

Fig. 15

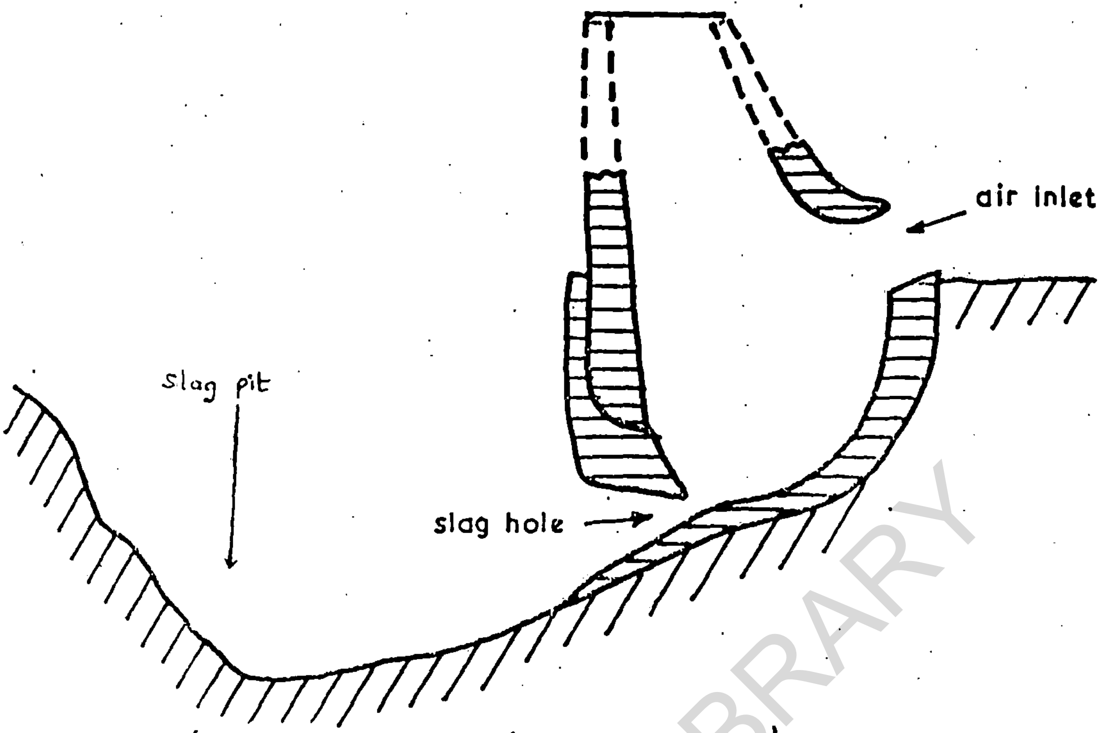


Fig.16a. TYPE VARIETY I 'SHAFT-IN-BOWL' BELLOW BLOWN FURNACE

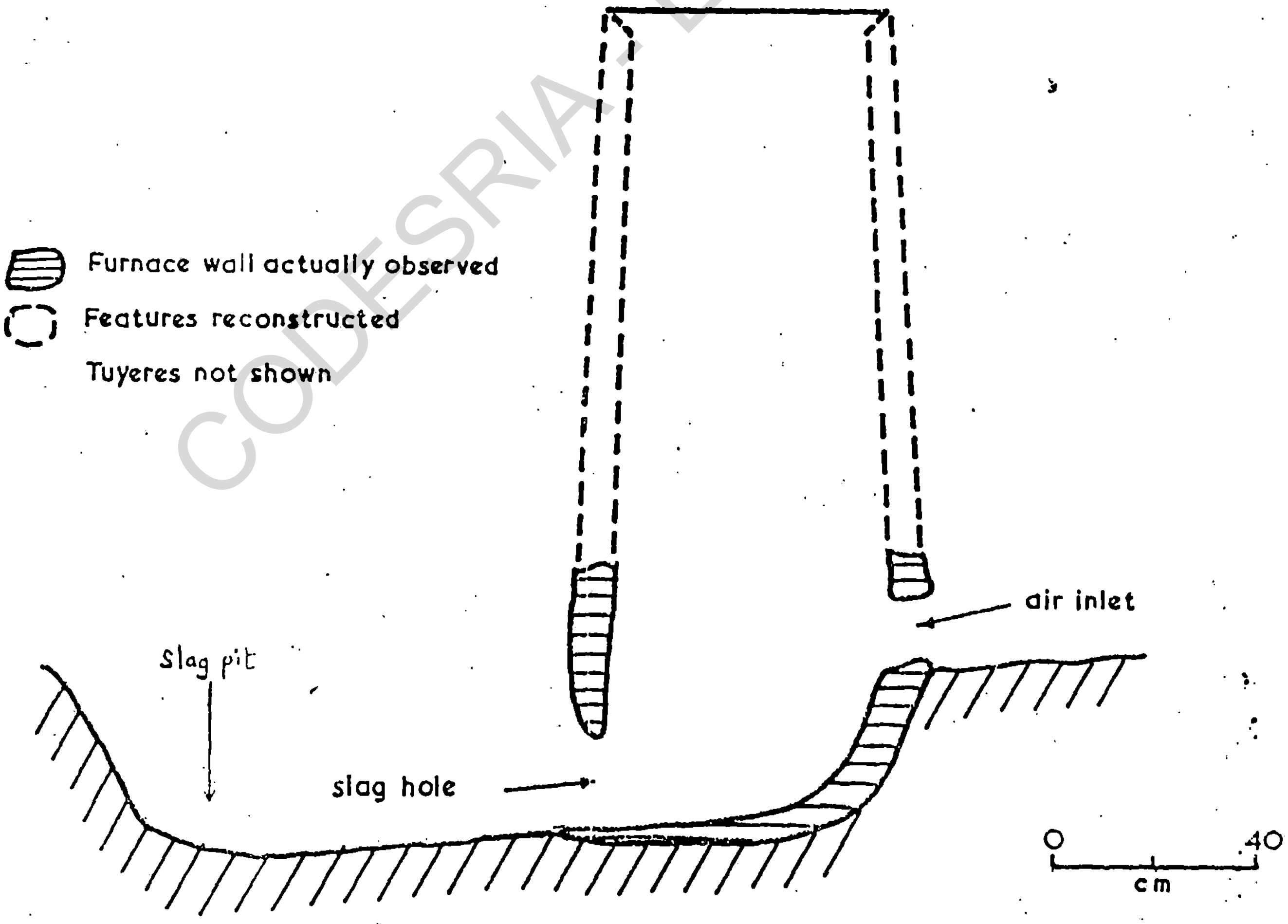
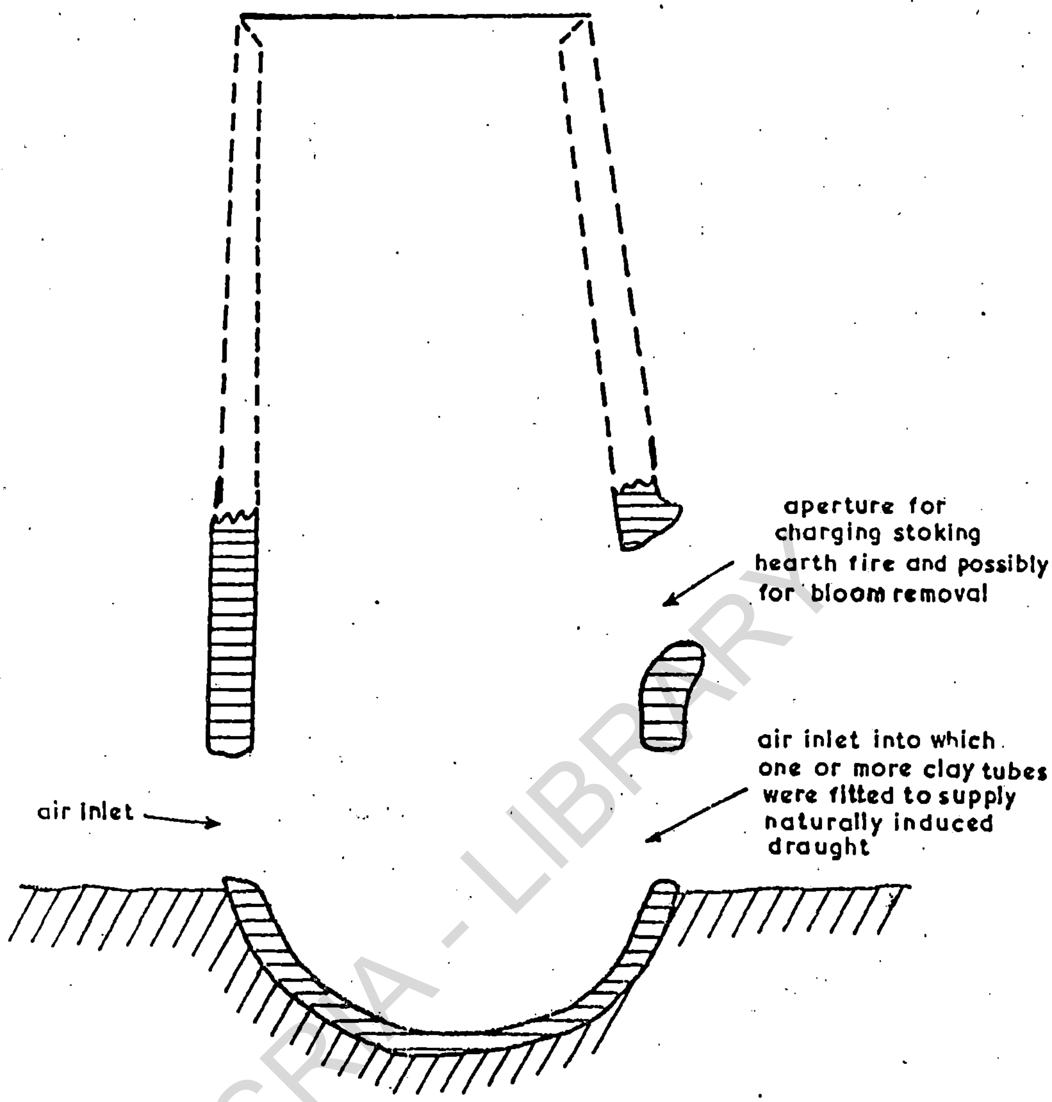
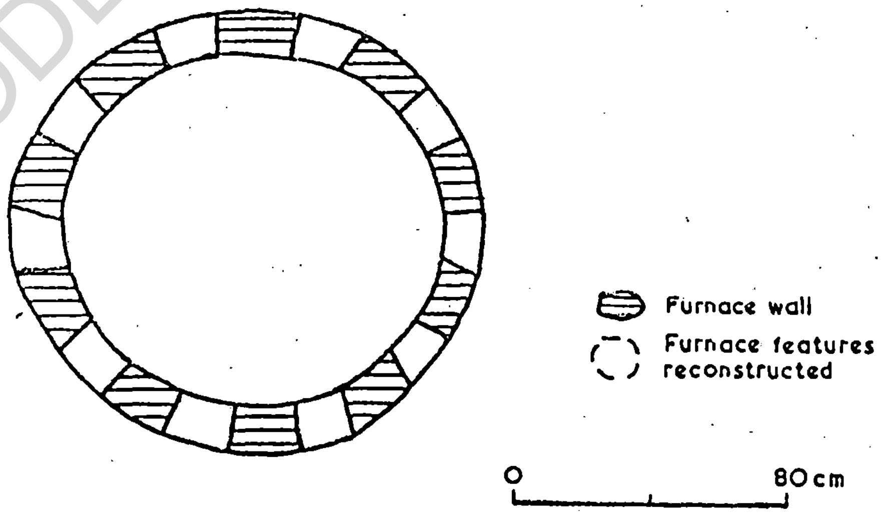


Fig.16b TYPE VARIETY II 'BOWL SHAFT' BELLOW BLOWN FURNACE



TYPE VARIETY III TALL NATURALLY INDUCED FURNACE



PLAN SHOWING AIR INLET RADIATING AROUND THE FURNACE.
LOWER BASE

Fig 17.

TUYERE VARIETIES BELONGING TO THE THREE FURNACE DESIGNS

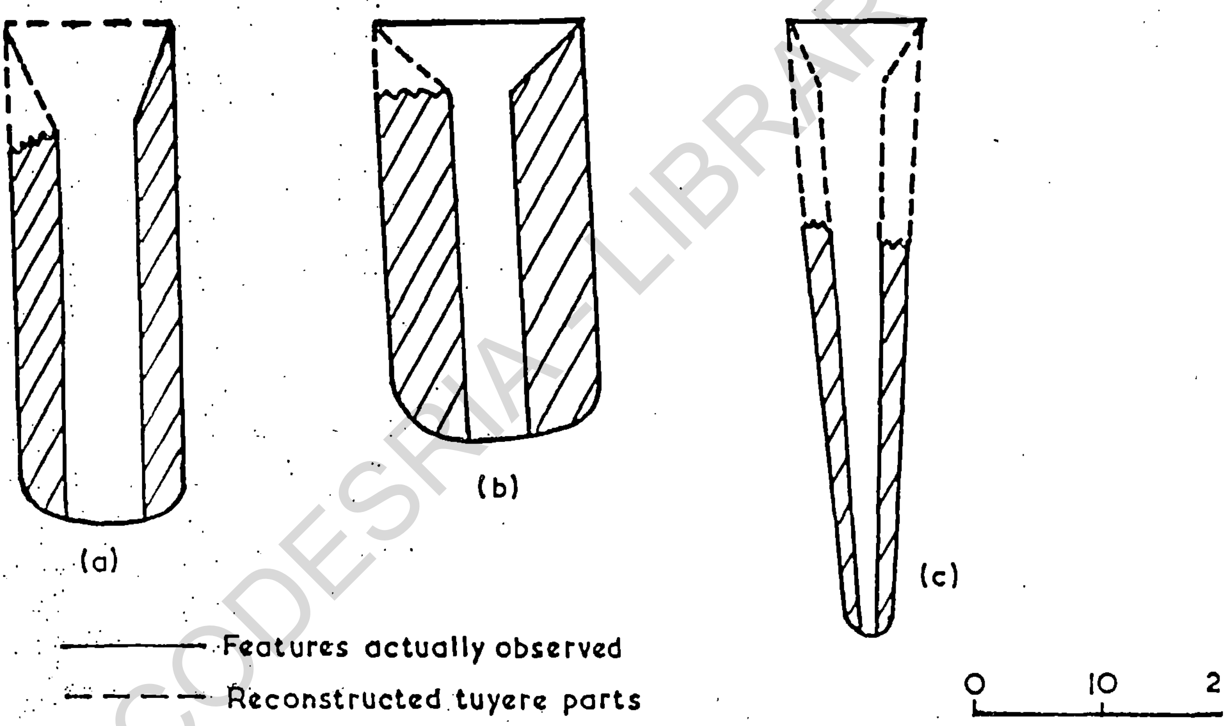
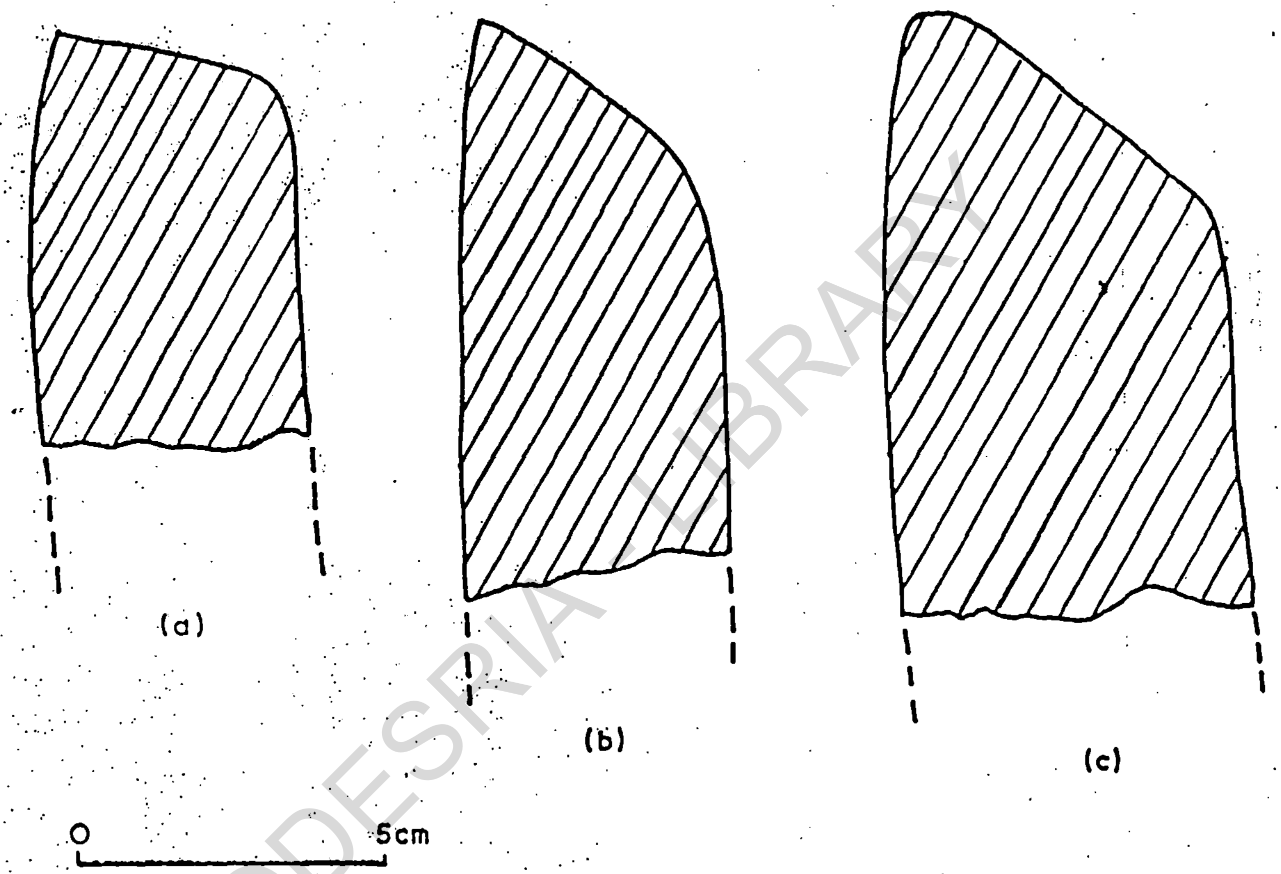


Fig. 18



RIM FORMS OF THE THREE FURNACE VARIETIES

Fig. 19

SMELTING FURNACES FROM UPPER REGION GHANA (After Pole 1975)

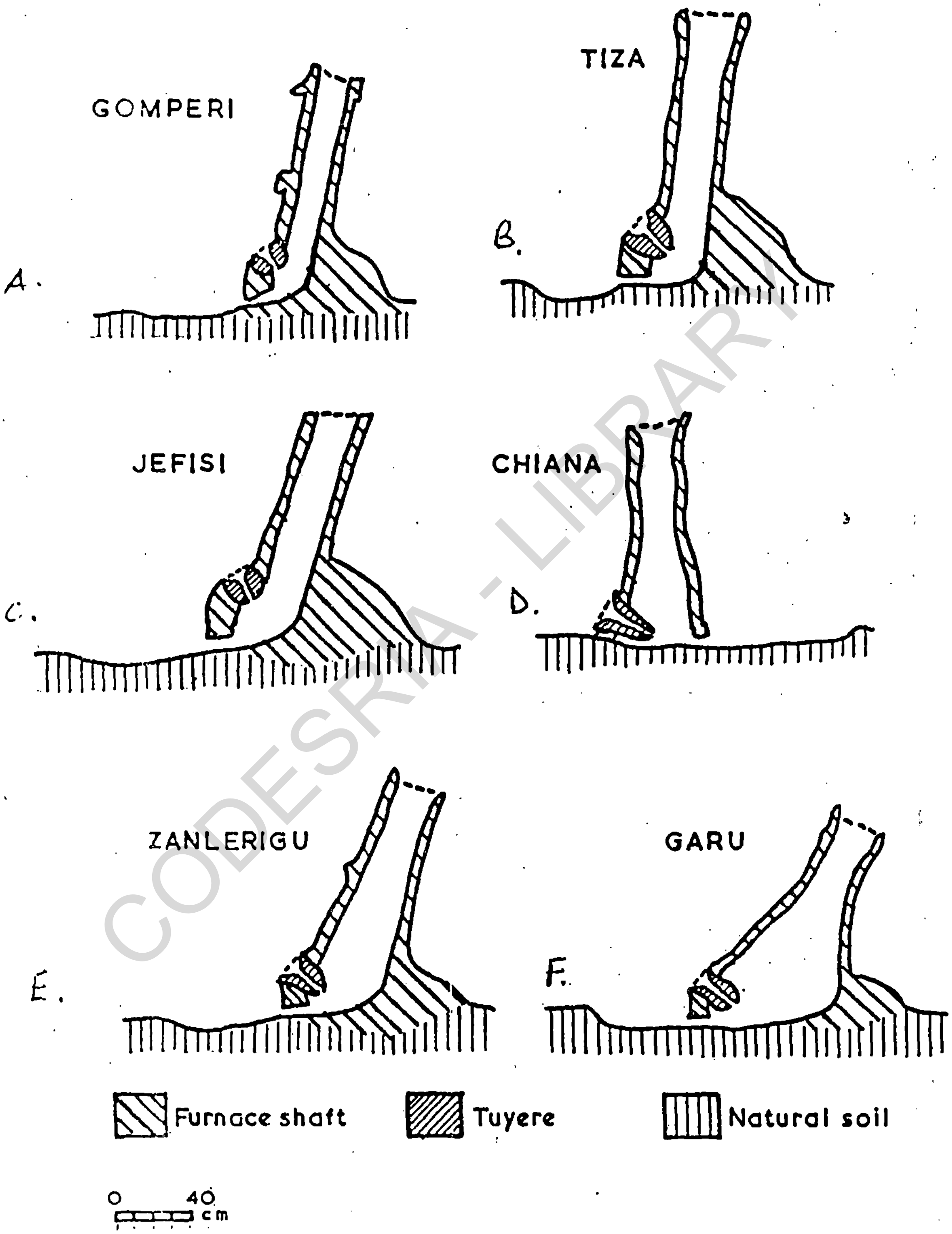


Fig. 20

DRAWINGS OF IRON SMELTING FURNACES IN W. AFRICA

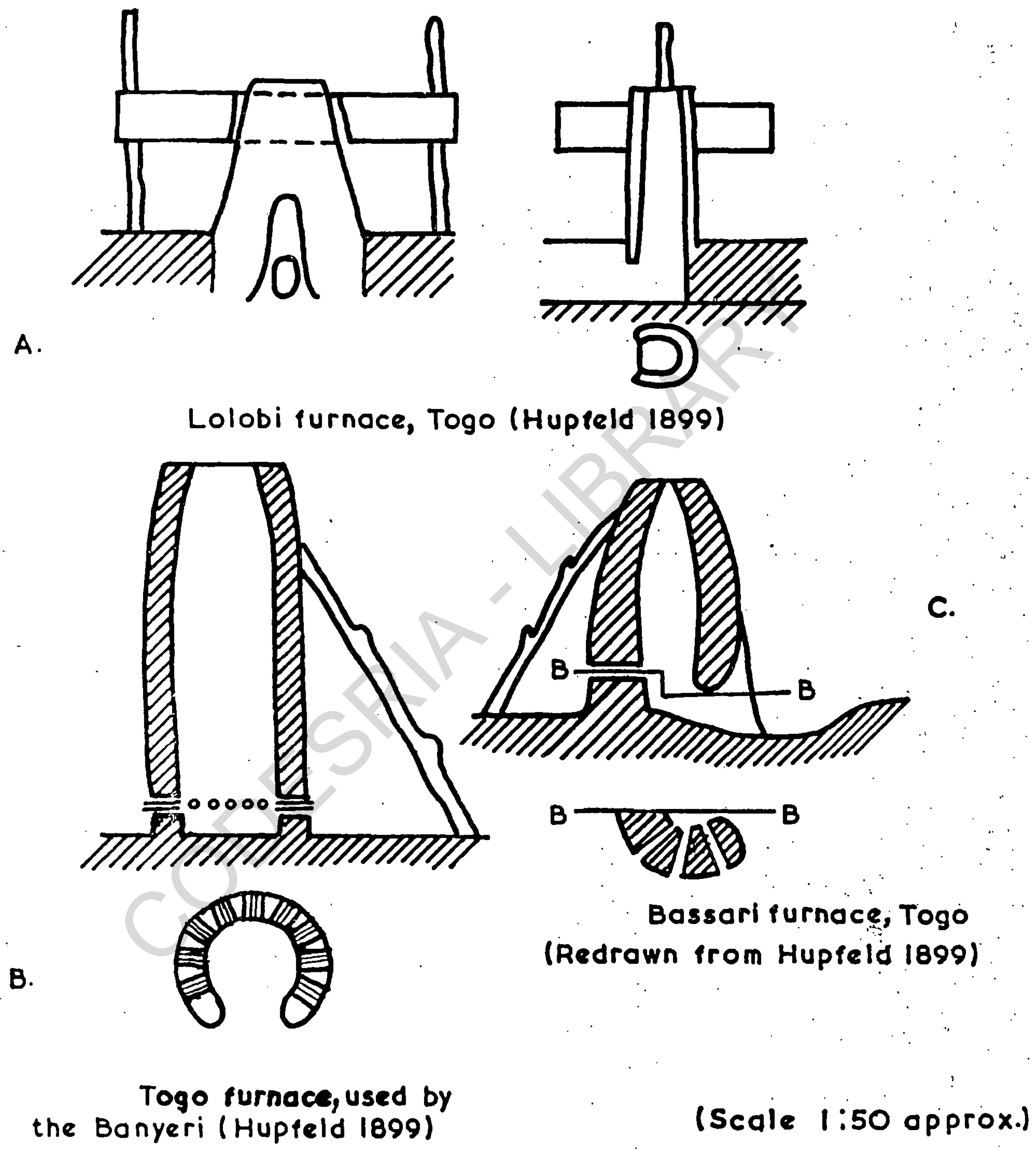
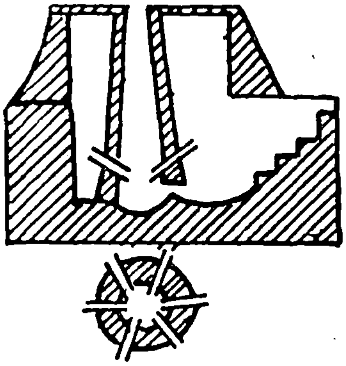


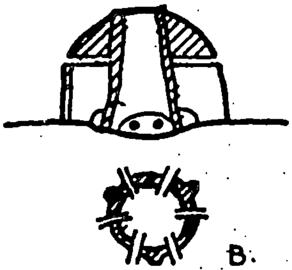
Fig. 21

DRAWINGS OF IRON SMELTING FURNACES IN WEST AFRICA



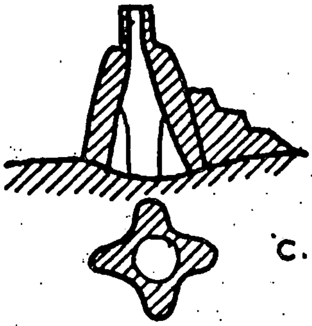
A.

Dedougou furnace, Burkina Faso (redrawn from Forbes 1933) 234)



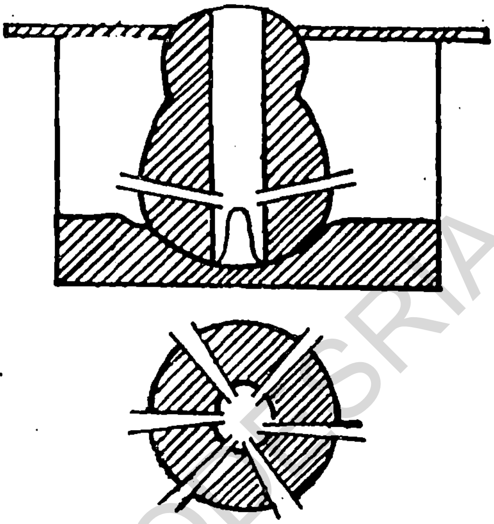
B.

Koni furnace Cote D' Ivoire (Pole 1985 redrawn after Gardi (1969) 34-5)



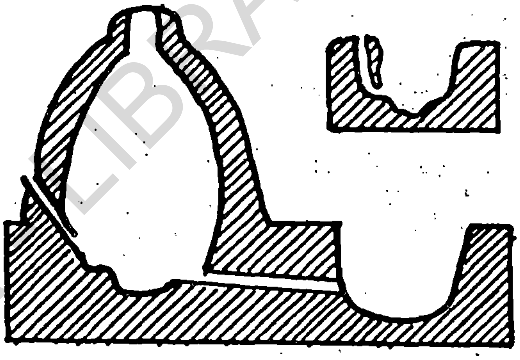
C.

Tourni Mali (Pole 1985, redrawn after Gardi (1969 and Meniaud pl xxxi)



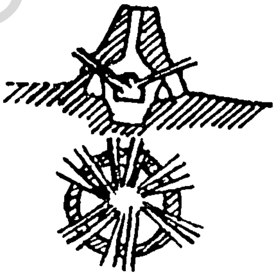
D.

Akpafu furnace, Ghana (redrawn from Rattary 1916) 245.



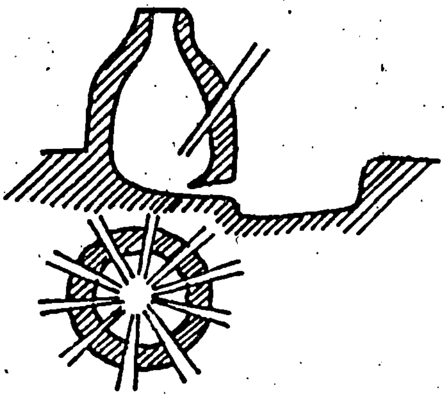
E.

Sierra Leone furnace, (Kense 1983:20) drawn from Dixey 1920)



F.

Dalaba furnace, described by Doelter 1965 as bell shaped (Pole 1925 redrawn from Appia 1965) 340.

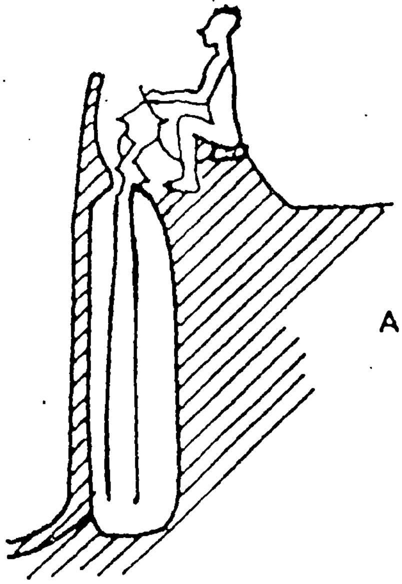


G.

Babels furnace, Guinea described by Campbell (1920) as bottle-like (Pole 1985 redrawn from Campbell 1920.

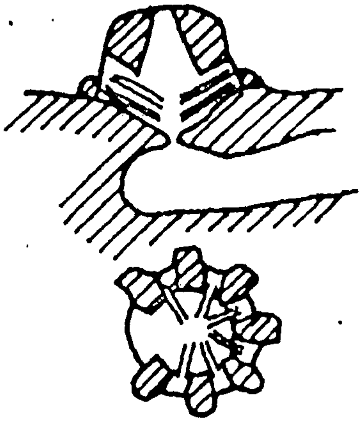
(Scale. 1 : 50 approx.)

Fig. 22



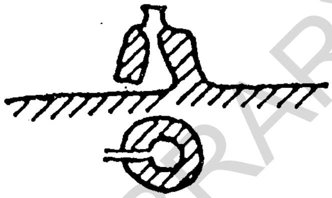
A.

Matakam furnace, Cameroun (Kense 1983:200, drawn from Hinderling 1955)



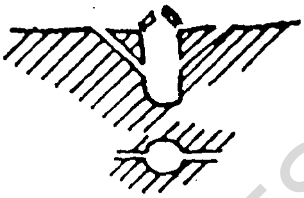
B.

Ola-Igbi furnace, Nigeria (Pole 1985:161, redrawn from Bellamy (904) 109)



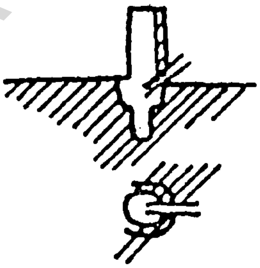
C.

Esu furnace, Cameroun (Pole 1985:161, redrawn from Jeffreys 1948) fig.1)



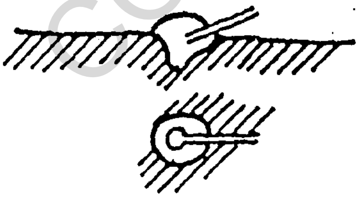
D.

Biron furnace, Nigeria (Pole 1985:162, redrawn from Tambo 1976)



E.

Afema furnace, Cameroun (Pole 1985:162, redrawn from Williams(1969) fig.7. and 1974 fig. 31c)



F.

Bikom furnace, Cameroun (Pole 1985:162, redrawn from Jeffreys(1952) fig.1)

Fig. 23: DRAWINGS OF IRON SMELTING FURNACES IN W. AFRICA
(Scale 1:50 approx.)

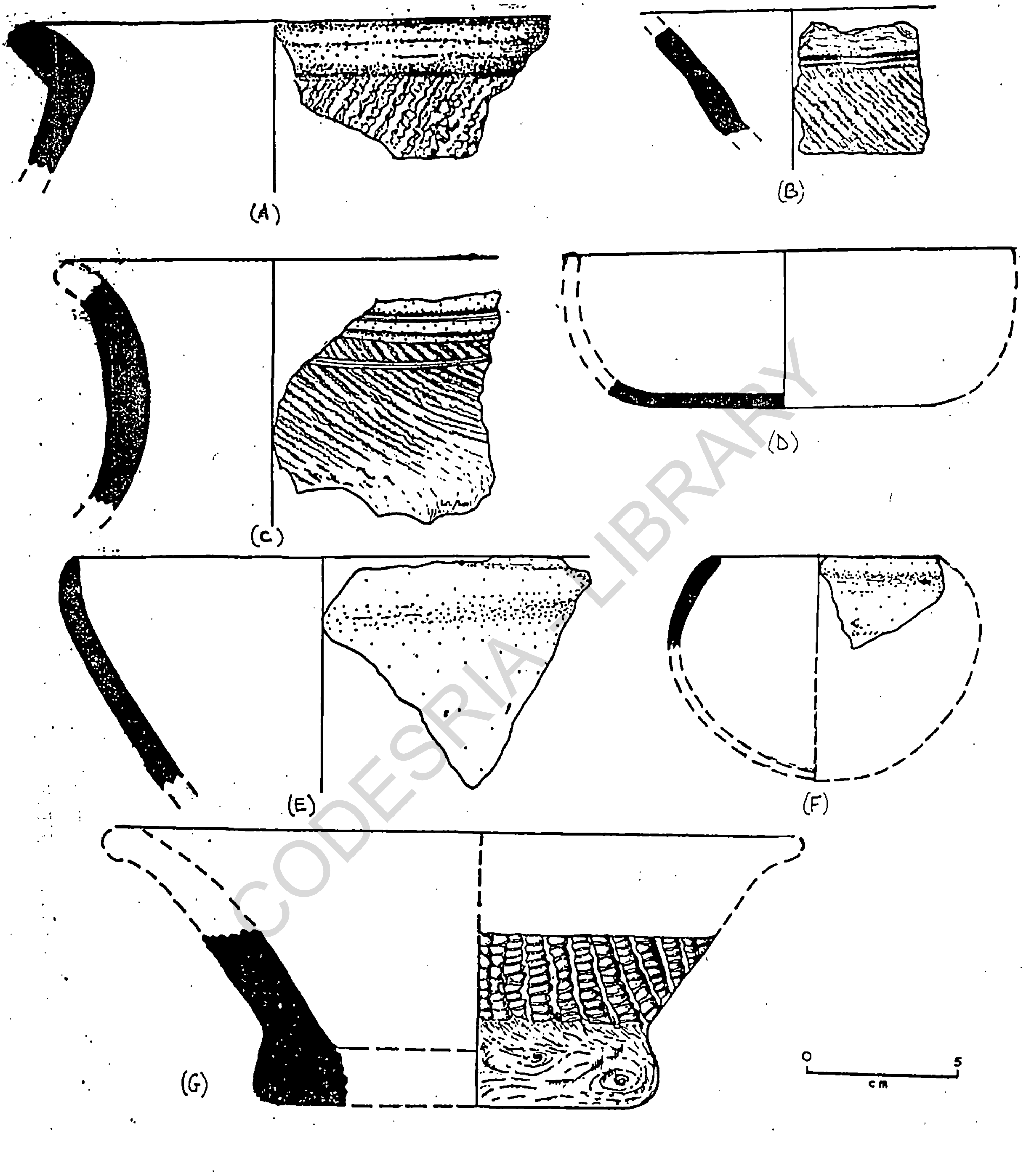


Fig.24 POTTERY FORMS AND DECORATION FROM THE SMELTING SITES

SMOKING PIPES FROM THE INVESTIGATION

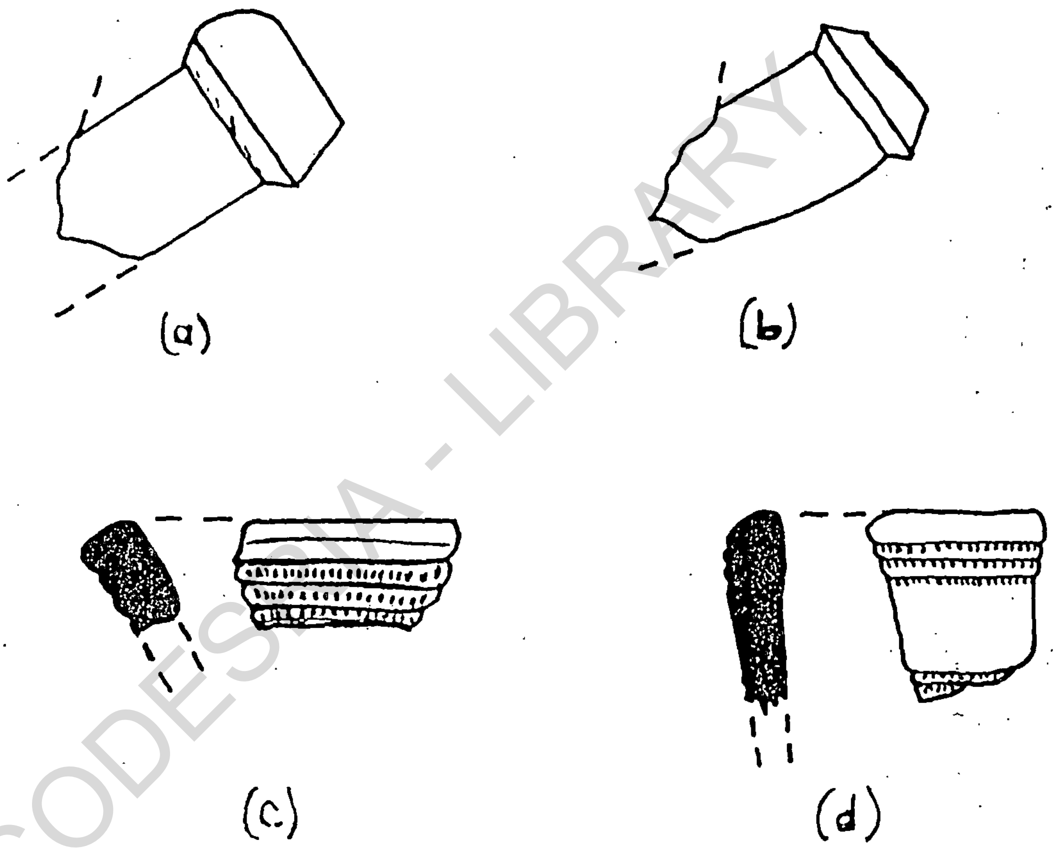


FIG 25

Table 3: <u>Composition of Gambaga smelting debris in percentage of total volume of slag</u>

1.	Slag and debirs of charcoal, ash pottery, organic material from vegetation growing on the heap, discarded ore pieces, miscellenia	86%
2.	Pieces of tuyeres	10%
3.	Furnace wall fragments	4%
		100%

Table 4: <u>Summary of details on Iron ore mining sites discovered</u>

Site No. pits	Location	No. of mine pits counted	Diametre Range of mine pits	Depth	Area covered by mine
OM.1	Zone B	32	3m - 10m	10cm - 40cm	16,200m²
OM.2	Zone E	60	3m - 8m	20cm - 100cm	45,000m²

* There are 10 mine pits that had diameters ranging between 8-12m. These pits were among the most shallow, measuring not more than 50cm deep.

Table 5: <u>Summary of the details of the excavated slag mounds</u>

Site No.	Zone	Dimensions: Height	Length	Width	Excavation units and area covered	Furnaces counted from: Surface Survey	Excavation
1**	A	55cm	9m	9m	8m x 8m [$64m^2$*]	–	3
15**	A	90cm	6m	5.5m	6m x 5m [$30m^2$]	–	2
16**	A	60cm	4m	2.5m	4m x 2.5m [$10m_2$]	1	–
27***	B	70cm	22m	4.7m	5.8m x 2m [$11.6m^2$]) 2.5m x 2m [$5m^2$])	2	–
44***	C	60cm	15m	4.5m	15m x 4.5m [$67.5m^2$]) 15m x 4.5m [$15m^2$])	–	–
47***	D	100cm	22m	16.5m	6.63m x 1m [$6.63m^2$]	–	–
58***	D	45cm	2.5m	2.1m	3m x 1m [$3m^2$]	1	–
59***	D	38cm	3m	2.6m	4m x 1m [$4m^2$]	–	–

* Total area excavated = $216.7m^2$

** Entire mound excavated

*** Trenches cut through the slag mound.

Table 6 Summarized Data of Furnaces Excavated

	F1	F2	F3	F4	F7	F8	F9	F10	F11	F12	F26	F43	F44	F45	F46
Furnace type variety	II	II	II	II	II	II	I	II	II	II	I	II	II	III	III
Height of structure above land surface before excavation	-	-	-	-	-	-	15*	3	5	4	5	34	1.5	15	22
Height of structure from inside floor after excavation	25	32	47	17	6	12	72	17	18	17	92	82	69	123	83
Height of structure from furnace bottom after excavation	30	36	50	22	11	18	77	24	25	25	108	87	75	135	95
Estimated full height from bottom	-	-	180	-	-	-	100	-	-	-	120	170	170	2.5-	3.5m
Minimum wall thickness measured from excavated wall fragments	6	6	5	8	6	6	4	8	6	6	7	4	5	8	7
Wall thickness on broken height	8	8	8	8	8	8	8	8	8	8	9	8	9	13	14
External diameter on broken height along longest axis	68	72	68	66	64	64	40	88	60	75	70	80	66	128	114
Maximum internatl diameter	52	56	52	50	49	48	24	58	52	60	52	64	48	104	90
Maximum external diameter	63	61	55	48	43	45	40	55	48	60	66	62	63	91	103
Minimum internal diameter	47	45	39	32	27	29	24	39	38	44	46	46	45	67	79
Evidence of type hole intact on furnace remain	-	-	/	-	-	-	/	-	-	-	/	/	/	/	/
Slag duct intact on remain	/	/	/	-	-	-	/	-	-	-	/	/	/	/	/
Number of tuyere holes counted on furnace	-	-	1	-	-	-	1	-	-	-	1	1	1	10	10
Height of air inlet	-	-	13	-	-	-	18	-	-	-	26	15	20	60	46
Width of air inlet	-	-	18	-	-	-	18	-	-	-	24	18	18	15-20	15-20
Height of air inlet from furnace base	-	-	33	-	-	-	48	-	-	-	50	53	55	28	28
Height of slag duct	10	14	18	-	-	-	60	-	-	-	55	32	35	60	60
Width of slag duct	35	35	35	-	-	-	32-35	-	-	-	30-40	32	35	40	40

* All measurements given in centimetres (except where indicated otherwise)

/ Evidence present.

Table 7: Chemical Analysis (Weight percentage) Ores, Slags

	ORE	ORE	ORE	SLAG	SLAG
	From OM.2 Site in zone 'B'	From SM.27 Site in zone 'B'	From F45 in zone 'D'	From SM.27 Site in zone 'B'	From F45 (SM.61) Site in zone 'D'
SiO_2 (Silica)	18.42	19.91	22.89	37.67	29.53
Al_2O_3 (Alumina)	14.69	17.99	19.27	14.18	16.46
Fe_2O_3 (Ferric Oxide)	57.09	54.84	48.37	40.15	41.33
CaO (Lime)	0.52	0.39	1.03	5.81	1.19
P_2P_3 (Phosporic Anhydride)	0.14	0.12	0.11	0.18	0.24
TiO_2 (Titanium Oxide)	0.58	0.63	0.60	0.56	0.66
MnO (Manganous Oxide)	Trace	Trace	0.15	0.25	0.30
MgO (Magnesia)	Trace	Trace	Trace	0.92	0.96
S (Sulphur)	Trace	Trace	Trace	Trace	Trace
Ho_2 105°-110°C	8.42	1.22	0.99	0.72	0.67
Loss on ignition (probably) organic matter) at 1000°C	8.47	6.49	1.99	-	-
Total*	91.44	93.88	92.51	99.72	91.34
Specific Gravity (S.G.)	3.0	3.0	3.5	3.0	3.0
Refractory Index (R.I.)	0.76	0.89	0.82	0.33	0.54
CaO/SiO_2	-	-	-	0.15	0.04

*Total excludes H_2O and Ignition loss.

Table 7 (Contd.)

Charcoal

	From SM.16 (F9) Site	From SM.44 Site
CaO (Lime)	1.68	2.64
K_2O (Alkali)	0.36	0.84
TiO_2 (Titanium Oxide)	0.20	0.37
P_2O_5 (Phosphoric anhydride)	0.13	0.15
Na_2O (Sodium Oxide)	0.08	0.13
SiO_2 (Silica)	0.010	0.025

Total Ash at 800°C - 1.42 wt %.

Table 8: List of some major iron items produced by the blackmsiths of Mamprugu for the various sectors of the society and periods of highest demand

	Sector	Principal Items	Peak Purchasing Season
1.	Agriculture	Hoes, axes, bullock ploughs, sickle, kinves	Mid-April-October
2.	Hunting	Traps, guns, spears, arrow-heads, knives, axes	October-mid-April
3.	Carving	Axes, short cutluasses, knives, sharp semi-circle metal scrapers	October-mid-April
4.	Construction	Door locks, hinges, keys, sickle	October-mid-April
5.	Meat Trade	Variety of double-edged knives, skewers	During festive occasions
6.	Intermediate improvi-sation and mechanic repair	Spare parts for tractors, motor cycles, bicycles, buses, cars, carts, and tools, like chisels, screw drivers and hammers	All year round
7.	Personal Items for adornment and ritual	Rings, bangles, bracelets, anklets all iron and iron shod walking sticks.	All year round

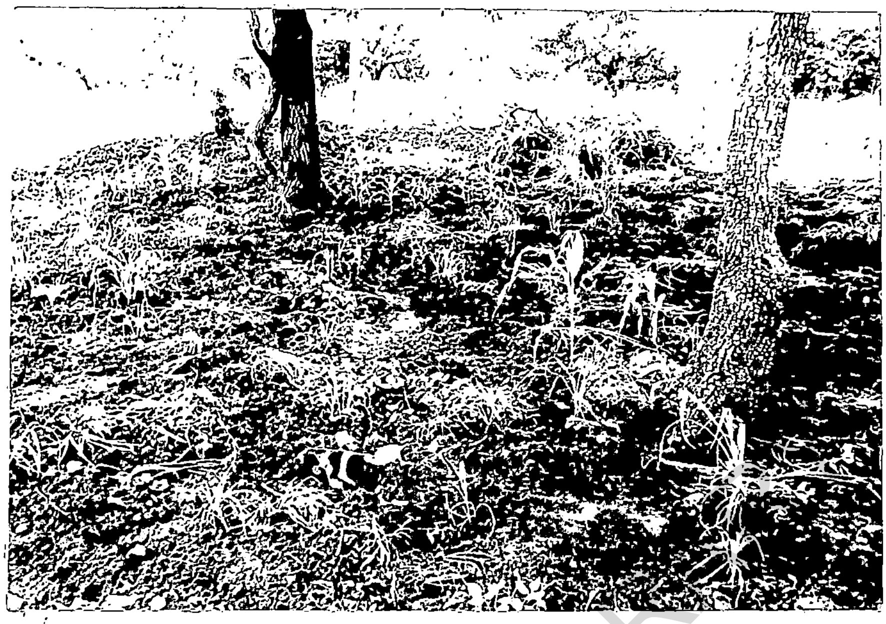


Plate 1: Surface of slag mound cultivated with millet and corn

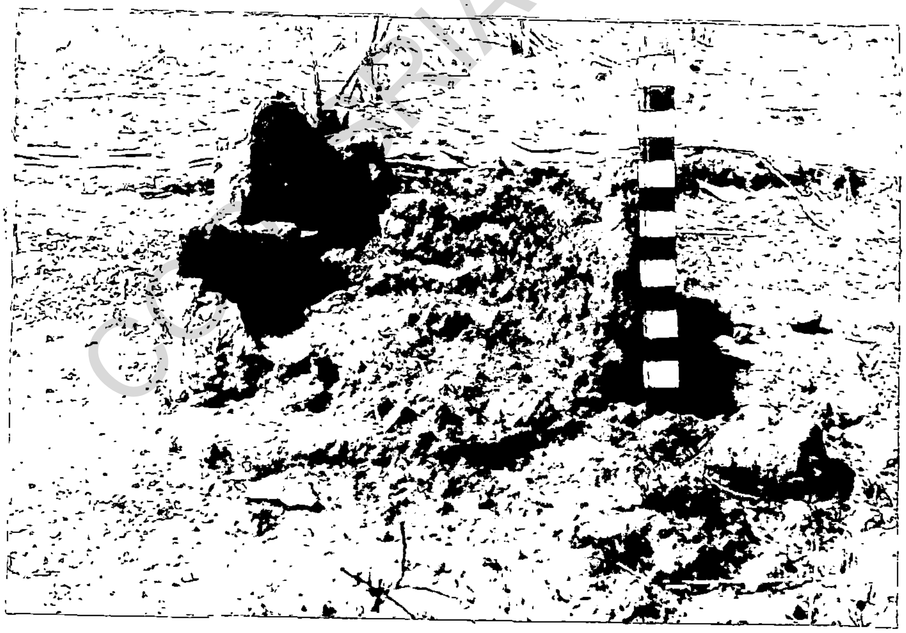


Plate 2: In-situ structural furnace remains: walls

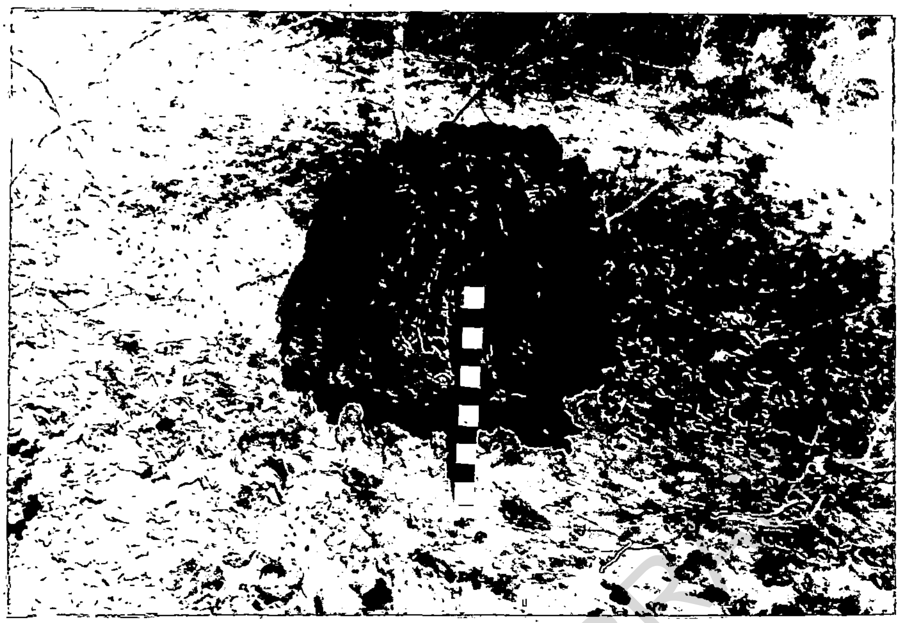


Plate 3: In-situ structural furnace remains: slag lump

Plate 4: SM. 15 showing the cleared surface of the mound and the unit to be excavated.

Plate 5: SM. 44 slag mound destroyed by road construction

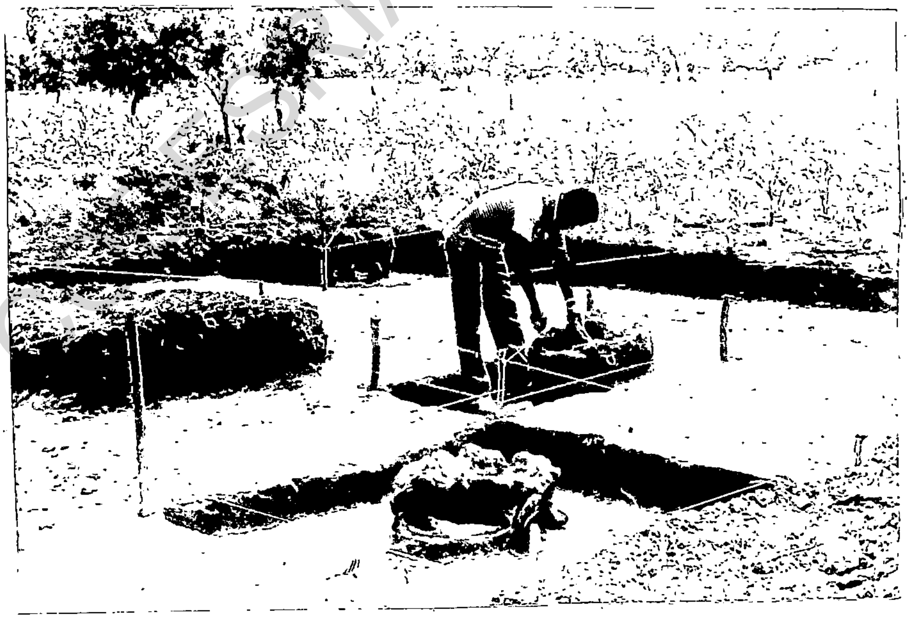


Plate 6: SM.1 Furnaces (F1, F2, F3,) recovered from the excavation of the slag mound.

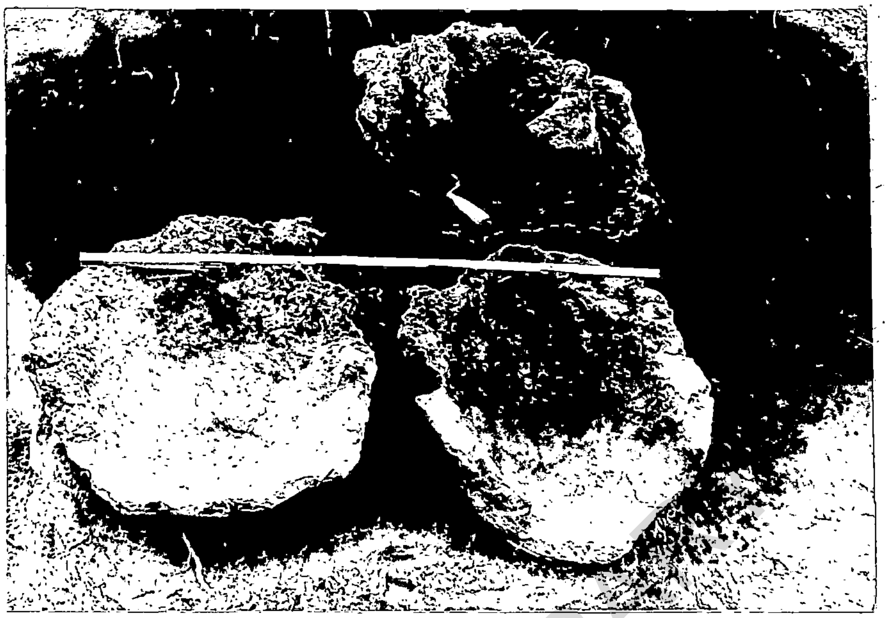


Plate 7: Furnaces (F10, F11, F12) showing remains as bowl bases without any apertures surviving.

Plate 8: F9: Type I Furnace variety.

Plate 9: F43: Type II furnace variety

Plate 10: F45: Type III furnace variety

Plate 11: F45: Furnace interior excavation

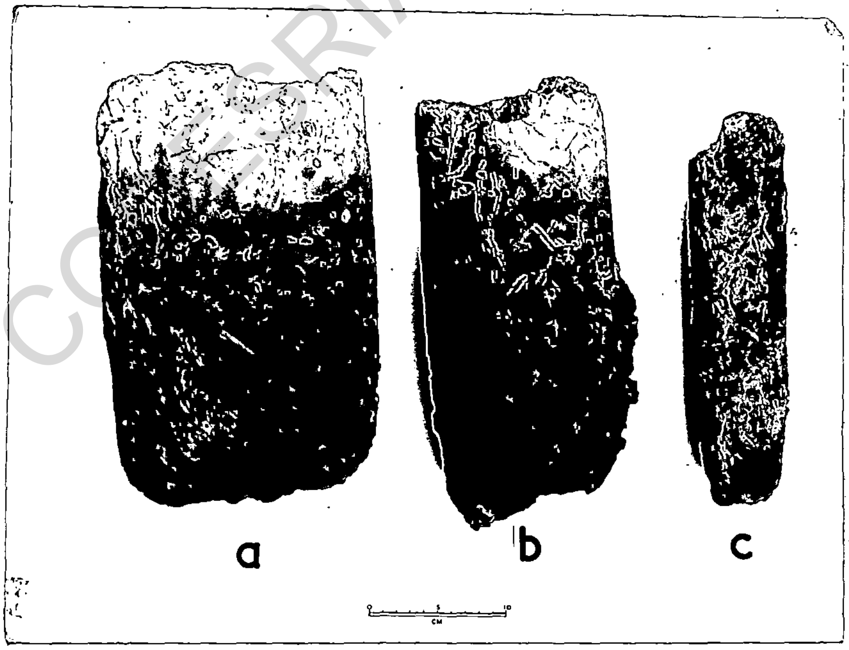


Plate 12: Tuyere varieties

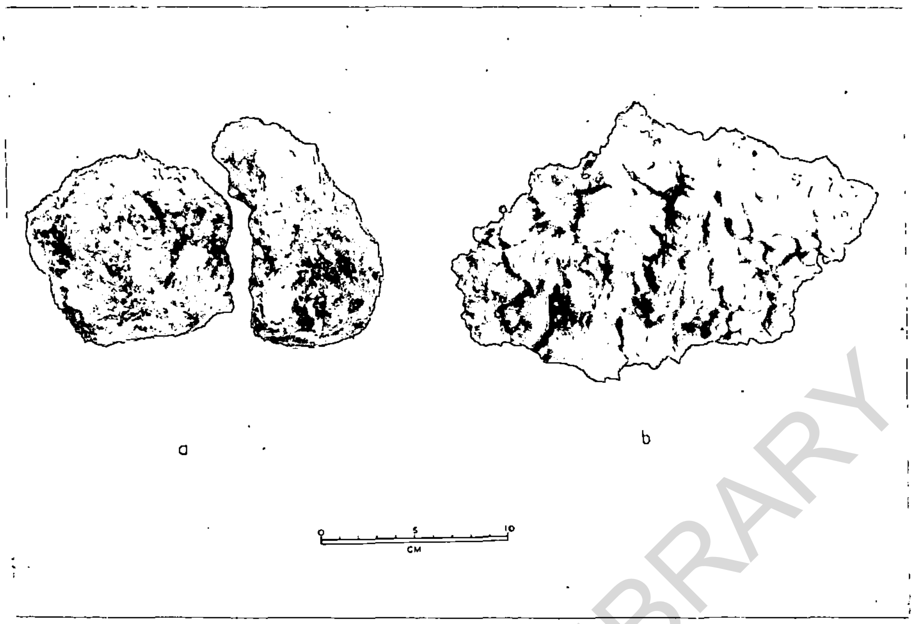


Plate 13: Slag samples

Plate 14: Iron bloom being kept by aged blacksmith.

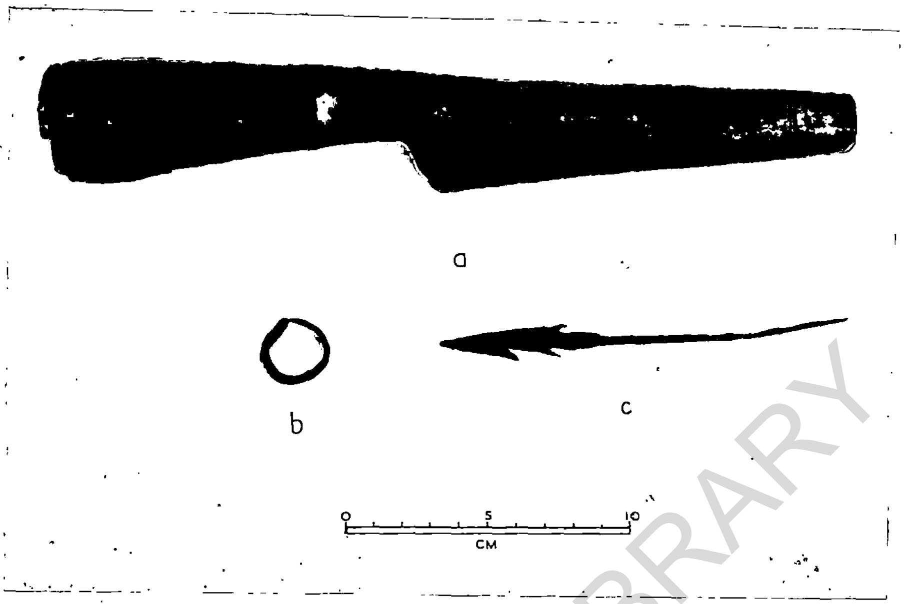


Plate 15: Iron objects obtained from the investigation

Plate 16: Interviewing aged blacksmiths in a smithing workshop (Type A).

Plate 17: Stone Anvils

Plate 18: Type 'B' blacksmith workshop

Plate 19: Type '1' blacksmithing devices and techniques

Plate 20: Type '2' blacksmithng devices and techniques

Plate 21: Type '3' blacksmithing devices and techniques

Plate 22: Blacksmith's son making a new tuyere in the workshop

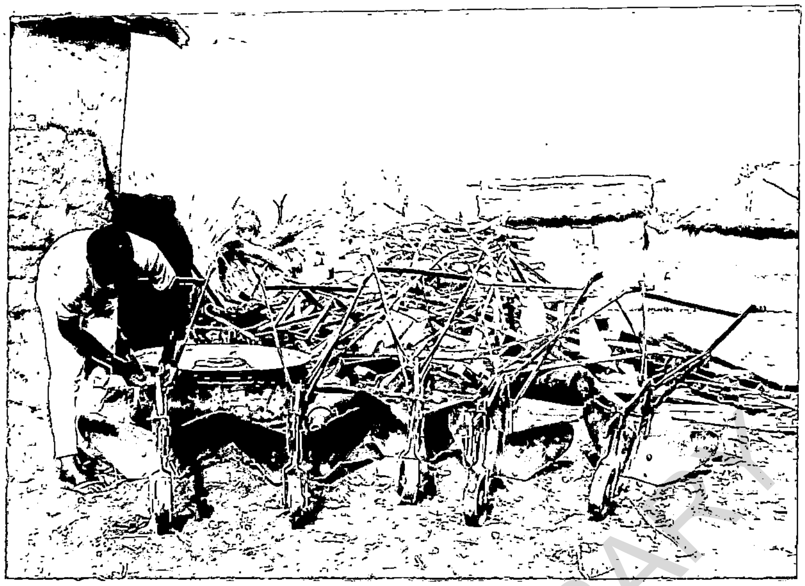


Plate 23: Bullock ploughs produced by local blacksmiths

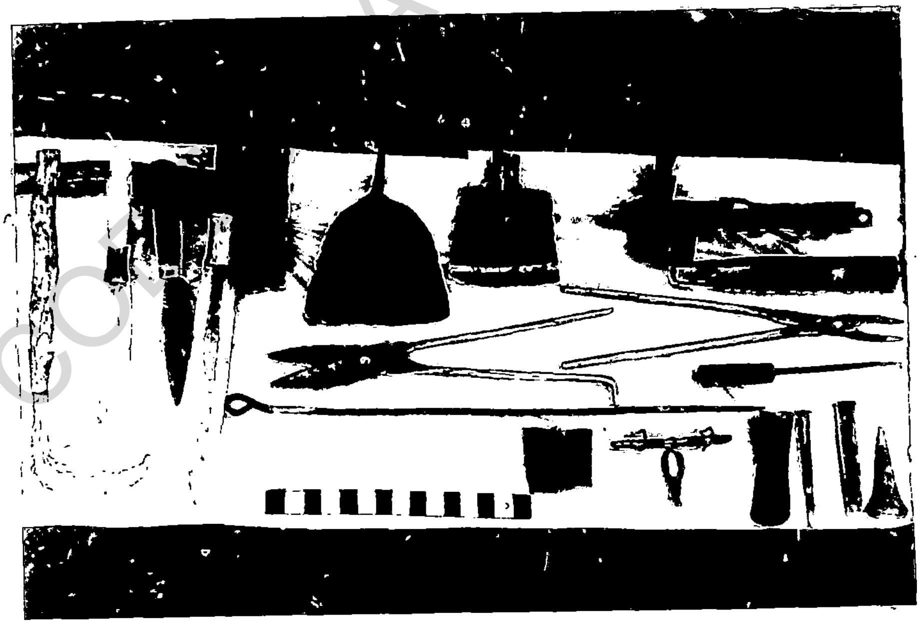


Plate 24: A variety of iron items produced by local blacksmiths

Plate 25: Different clay vessels in Nalerigu brought from Garu in the Upper East region of Ghana.

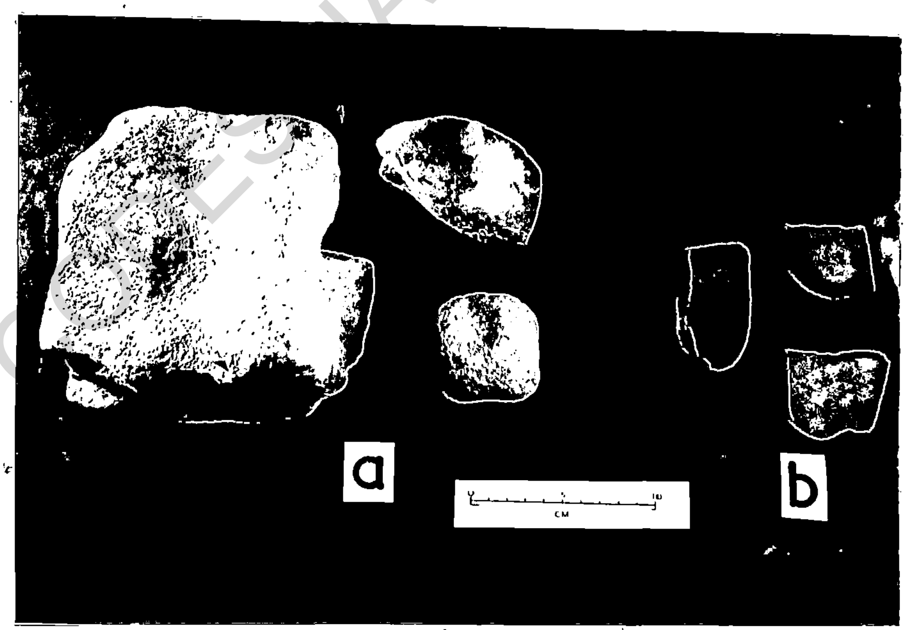


Plate 26: Lithics recovered from the investigation

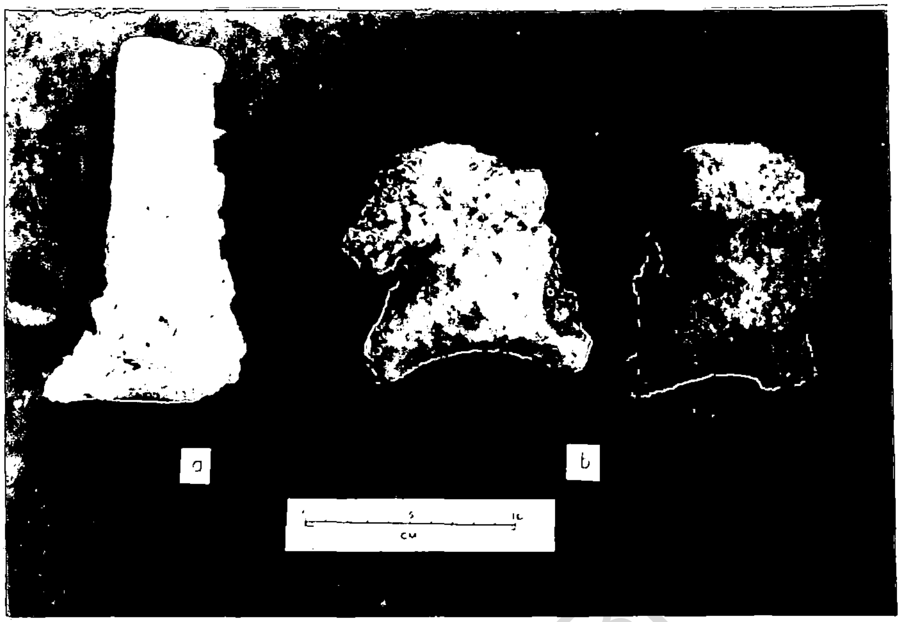


Plate 27: Shaped clay pieces (plugs?) recovered from the investigation.

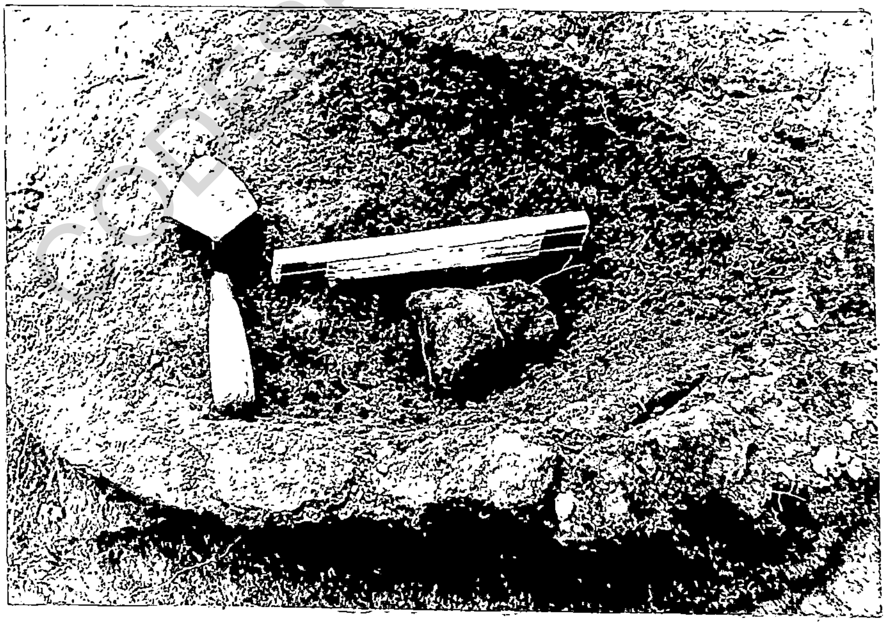


Plate 28: Plugs (?) found in the bowl-shaped base remain of furnace (F12).

APPENDIX I

BRIEF HISTORY OF GBALLA

Gballa is an abandoned village site located some five kilometres north east of Gambaga. Apart from Nalerigu and Gambaga, Gballa was the only settlement site that was plotted in the surveyed area. It lies totally within the Forest reserve to the south of the Gambaga escarpment (see Map 3) and had lots of iron smelting debris. Most of these have been disturbed by farming activities.

The oral traditions gave the proper name of the settelement as Gbara which is the Mampruli word for wire traps. But this has been corrupted to Gballa. The people of Gballa are Mamprusi whose ancestry is traced to one Mahami Dramani who according to records at the Mamprusi Traditonal Council in Nalerigu ruled from 1831 - 1839 (see Appendix II No.18). Dramani was the son of Na Salifu I (1754-1831). The traditions indicated that during the long reign of Na Salifu, he sent most of his sons to oversee the affairs of villages and communities under Mamprusi sphere of influence. Dramani was sent to Tanga in the Upper East region to rule over the predominantly Frafra settlement. He stayed in Tanga for several years after which he enskinned a Frafra elder as the head in the area and moved to settle at a place nearer to Nalerigu. This decision was taken because his father Na Salifu I was old and infirm and his death was imminent. Since every son of a paramount chief in Mamprugu had the equal chance to rule on the death of his father, there were competitions and struggles for the throne which made proximity to Nalerigu advantageous to Dramani. After several days of long and ardous walking, he settled with his family on the site of Gballa where he specialized in trapping animals for sale in the major markets using wire traps. The other economic activity of the people was farming.

With the death of Na Salifu I, Dramani succeeded to the paramouncy of Mamprugu after contesting and fighting with one brother who was stationed at Nakpanduri. He was given the skin name of Dramani Mahami (Kuligabaa). The settlement, the oral traditions maintained, was not abandoned with the departure of Dramani to Nalerigu. His many sons and their wives continued to stay in Gballa. But some Kusasis who had joined the settlement during the time of Dramani left for their home country in the Upper East region of Ghana. Their departure was attributed to the result of the constant state of fear of attack under which the people of Gballa lived after the death of Dramani in the 1840s. This factor also led to the migration of most of his sons and grandsons as well as their families to the bigger settlements like Gambaga, Za'ari and Nalerigu. Dissensions among the sons was also mentioned as another factor. This exodus led to a drastic reduction of the population of Gballa which at its peak was said to have had about twenty large compounds. The population estimate as at the time of the establishment of Gambaga Forest Reserve in 1948 has been given as 34. The informants noted that although the population was small there were several farms in the area owned by other former Gballa settlers now living in other towns and villages. This might explain why the colonial administrators found it expedient to allow the demarcation of the Gballa site from the area put under forest reserve as is shown in Map 3.

The settlement was finally abandoned in the early 1970's by the last surviving family of Sando "Gballa" Tampurie now aged over 90 years. He left

---

(1) Data obtained from File No.214 sub-File No.5, Forestry Department headquarters, Accra.

the site due to his failing health which necessitated that he should be near other members of the Gballa people for assistance and attention. Today, most farms on the site of Gballa belong to people who are descendants of Na Dramani Mahami. Thus, although the site has been abandoned, there is a continuity in the economic activity carried on in the area.

The people of Gballa did not work iron. Their ancestors found the slag mounds and furnace remains on their arrival. The informants were aware of what the slag represented but they had no idea about the authors. On the other hand, ploughing and cultivation on the mounds has been carried out for generations. For this reason, the farmers in this area were able to point to slag mounds that have been reduced to the same level as the surrounding land or mixed with the surface soil that it is hardly conspicuous on the surface. During the excavation of SM.1, these people visited the site and were amazed by the recovery of furnace structures preserved in the slag mound on which maize and guinea corn had been cultivated continuously for several decades. The significance of the history of settlement of Gballa in the determination of the chronology of the smelting activity in the Gambaga area has been discussed in Chapter Six.

APPENDIX II

KING LIST - NAYIRIS (PARAMOUNT CHIEFS) OF THE MAMPRUSI STATE

Order of Succession	Name	Other Names	Claim	Date
1	Na Gbewa	-	Son of Tohaijie	-
2	" Tosugu	-	" " Gbewa	-
3	" Banmaligu	Zirli	" " "	-
4	" Gbigema	Zobzia	" " Banmaligu	-
5	" Kumasure	Zomsaa	" " Gbigema	-
6	" Mahami	Moari	" " Zomsaa	-
7	" Tampuri	-	" " Gbigema	-
8	" Sigri	Kapanga	" " "	-
9	" Woantoali	-	" " Sigri	-
10	" Atabia	-	" " Woantoali	-
11	" Jaringa	Yamusah	" " Atabia	-
12	" Kurugu	-	" " Jaringa	-
13	" Apisi	Suleimana	" " Atabia	-
14	" Haruna	Bongu	" " Kurugu	-
15	" Issaka	Zia	" " Haruna	-
16	" Mahami	Dambongu	" " Apisi	1735-1754
17	" Salifu I	-	" " Mahami	1754-1831
18	" Dramani	Kuligabaa	" " "	1831-1839
19	" Dawura	Nyongu	" " Salifu	1839-1850
20	" Azabu	Pa'ari	" " "	1850-1864

(Appendix II (contd.)

Order of Succes-sion	Name	Other Names	Claim	Date
21.	" Yamus	Bariga	" " "	1864-1901
22	" Suleimani	Sigri	" " Azabu	1901-1905
23	Na Zinya	Zore	Son of Salifu	1905-1909
24	" Mahami I	Wubiga	" " Nyongu	1909-1916
25	" Mahami II	Wafu	" " Yamusa	1916-1937
26	" Badimsuguru	Zulim	" " Azabu	1937-1942
27	" Salifu II	Salima	" " Zinya	1943-4 months
28	" Abudulai I	Soro	" " Suleimana	1944-1947
29	" Abudulai II	Sheriga	" " Mahami II	1948-1966
30	" Adam I	Bongu	" " Badimsuguru	1966-1985
31	" Sulemana	Saa	" " Salifu II	1985-1986
32	" Mahamadu	Gamni	" " Abudulai I	1986- -

APPENDIX III

LIST OF INFORMANTS FROM MAMPRUGU*

Name	Age	Town or Village	Occupatiion or Status	Educa-tional Background
Awudu Adam	60	Gambaga	Blacksmithing	Nil
Zuberu	70	"	"	"
Issah Adam	45	"	"	"
Adam Maijeda	65	"	"	"
Mahama Baba	74	"	"	"
Salifu Adam	55	"	"	"
Bugri Achiri	40	Nalerigu	"	"
Megida Nantoma	46	"	"	"
Huudu Amadu	42	Langbensi	"	"
Issifu Alidu	70	"	"	"
Saamu Abayi	55	"	"	"
Alhassan Musah	65	Walewale	"	"
Abu Mahama	60	"	"	"
Issahaku Mumuni	69	"	"	"
Mama Samuni	69	"	"	"
Sulemana Awudu	60	"	"	"
Jebon Bawa	41	"	"	Primary
Kwame Sampson	30	"	"	"
Alhassan Baba	50	Nakpanduri	"	Nil
Awumbila Ziafro	65	"	"	"
Iddrisu Mahamadu	26	"	"	"

(Appendix III (contd.)

Name	Age	Town or Village	Occupatiion or Status	Educa-tional Background
Adam Musah	61	Sakogu	"	"
Ali Ibrahim	70	Bowku	"	"
Alhaji Yakubu	80	Nagbo	Muslim leader	"
E.K. Nantomah	49	Walewale	Public servant	G.C.E. O.L.
Bukari Grunshie	84	Gambaga	Retired Grade II Court Magistrate	Cert 'A' Teacher.
Alhaji Ali	63	"	Muslim leader	Nil
Mba Adam	58	"	Farming/Hunting	"
Mumuni Nasamu	70	Gambaga	Farming/Dyeing	"
Enusa Yahaya	44	"	Farming	"
Issah Mazadu	65	"	"	"
Gariba Amadu	50	"	Leather Tanning	"
Mahammed Bawumia	40	"	Farming/Hunting	"
Baba Tanko	70	"	Farming	Elementary
Alhaji Abdulai	75	"	Muslim leader	Nil
Hamzah Mohammed	48	"	Leather tanning	"
Issah Abubakari	42	"		
Yompap Nanone	45	"	"	"
David Hamidu	39	"	Teaching	G.C.E. O'L
Sando Tampurie	80	"	Herbalist	Nil

(Appendix III (contd.)

Name	Age	Town or Village	Occupatiion or Status	Educa-tional Background
Adam Mahama	68	"	Farming	"
Musah Bawumia	62	"	Acting priest-chief of Gambaga	"
Musah Yamba	31	"	Teaching	G.C.E. 'O'L
Abdulai Somo	72	"	Farming/Hunting	Nil
Sando Mahami	68	"	Farming/Hunting	"
Alhassan Iddrisu	60	"	"	"
Anaba Abdulai	52	"	Forestry Guard	"
E.A. Azumah	49	Nalerigu	Teaching	G.C.E. 'O'L
R.N. Salifu	36	"	"	"
E.Y.A. Gumah	51	"	Registrar Mamprusi Traditional Council	"
Sule Yakubu	38	"	Teaching/Drummer Nayiri Palace	"
Isahaku Asani	52	Nalerigu	Teaching	Cert.'A
Wunni Saamni	66	"	Weaving	"
Tampurie Isifu	68	"	Elder, Nayiri Palace	"
Mahami Tampurie	64	"	Retired Civil Servant	G.C.E. O'L
J.S. Nantomah	54	"	Secretary, Mamprusi Traditional Council	R.S.A. II

(Appendix III (contd.)

Name	Age	Town or Village	Occupatiion or Status	Educa-tional Background
Adama Chuu	80	"	Weaving	Nil
Akado Mahama	55	"	"	"
Hatte Tanga	57	"	Farming/Weaving	"
Adam Sambani	60	Nanori	Farming	"
Zara Damprugu	63	Kasape	"	"
Isahaku Domogu	60	"	"	"

Note: Interviews were conducted between July - August 1987 and particularly from February - December 1988.

APPENDIX IV

LIST OF BLACKSMITHS INTERVIEWED IN PLACES IN THE UPPER REGIONS OF GHANA

Name	Age	Town or Village	Occupatiion or Status	Educa-tional Background
Lari Kuduku	55	Garu	Blacksmithing/Farming	Nil
Jaafa Asana	68	"	"	"
Nasawu Wubri	90+	"	"	"
Ali Wubri	34	"	"	Elementary
Bajunde Awuo	85+	Chiana	Blacksmithing	Nil
Achurugu Kandima	48	"	Blacksmithing/Farming	"
Awande Awuo	40	"	"	"
Tiya Mahama	60	Lawra	"	"
Mbruma Juma	55	Jefisi	"	"
Mandoo Subre	60	"	"	"

* Interviews were conducted in November and December 1988.

(2) To determine the variety and nature of cultural materials that compose the slag mound.

(3) To obtain charcoal samples for dating.

(4) To determine whether any furnaces would be found buried in the slag mounds especially where the surfaces had been disturbed extensively. This goal was based on the assumption that furnaces whether preserved or destroyed existed where there were slag accumulation that can be determined to have resulted from iron smelting activity. The investigation was aimed at verifying the presence of furnaces in the slag heaps.

(5) Linked to this was the desire to determine the number of furnaces in the mounds and to relate the number to the sizes of the mounds.

Methodology

The surface of the mounds to be excavated were thoroughly examined for any evidence of surface materials like pottery, smoking pipes, bangles, rings and tools of iron or any other artifacts. The vegetation growing on the surface of the mounds and in the immediate surroundings were cleared with the aid of cutlasses or pulled out where they were likely to disturb the mound. This surface clearing was done in a careful manner to avoid any serious disturbance of any suspected features on the mound. All large slag pieces that were likely to obstruct the excavation process, furnace wall pieces and fragments of tuyeres were collected and gathered separately. In the case of furnace and tuyere fragments, the excavated remains were also examined closely for their forms and features like rims in addition to measuring their