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TECHNOLOGICAL, SOCIAL AND ECONOMIC ASPECTS OF GOLD PRODUCTION AND USE BY THE IRON AGE PEOPLE OF SOUTHERN AFRICA

Nirdev Desai

Submitted in fulfilment of the Degree of Master of Science in
Archaeology at the University of Cape Town

ABSTRACT

This dissertation addresses technological, social and economic aspects of gold production and use in the Late Iron Age of southern Africa. The topic is approached in two ways. The first is to define the fabrication technology employed in producing gold artefacts. The second is to use trace element fingerprinting to try to determine which geological deposits were exploited by gold miners of this period. Three assemblages exist that allow these questions to be addressed; Mapungubwe (10th - 13th century AD), Great Zimbabwe (12th - 15th century AD) and Thulamela (14th - 17th century AD). Previous descriptions of the fabrication technology of southern African gold exist, but this is the first, systematic study of all three assemblages. The fabrication technology reconstruction used three lines of analysis; visual inspection with the naked eye, microscopy of the surfaces, and microhardness testing and metallography of selected polished samples. Fifty eight specimens were studied from Mapungubwe, two hundred and sixty eight pieces from Great Zimbabwe and fifteen from Thulamela. Trade and socio-economic effects of southern Africa's Later Iron Age are discussed in the light of the now available trace element analysis and fabrication technology of the gold artefacts studied here.

No tools for working gold have been found, and inferences have been made by modelling them on tools for copper and iron working. The basic toolkit consisted of a blade, hammer, chisel, a punch and an anvil. There were four basic artefact types; wire, beads, foil and tacks. There was no significant stylistic change in artefact types and the number of artefact types in the three assemblages. Cold working and annealing were standard practices in fabrication. Ten finished artefacts types have been identified; wrapped, rolled and punched beads, foil, strips cut from foil, tacks, straight and coiled wire, rod sections and links. Other gold artefacts were recovered but were either offcuts or in the process of being made into one of the ten types described above. These are prills, discs and offcuts.

Trace element groups were based on grouping the samples by similarities in the signature profiles. Identification was on the basis of the presence and absence of metallic impurities. It was deduced that alluvial gold mining was practised alongside reef gold mining. Mixing of gold ores occurred. Alloying was not intentionally practised. Identification of the gold sources would require further analysis of unworked material from potential geological sources.

ACKNOWLEDGEMENTS

I would like to thank Dr Duncan Miller for his support and encouragement in producing this work. I thank the staff of the Archaeometry Research Unit, and in particular John Lanham who assisted me in matters that were often outside his job description. Lynn Cable and Dawn Fourie, thank you for helping the cogs run smoothly. I extend my gratitude to the Department of Archaeology and the University of Cape Town for providing research facilities and administrative support. I thank the University of Pretoria and the Groote Schuur Museum for the loan of various gold artefacts. Lindsay Hooper of the South African Museum, thank you for assisting me to access the other half of the Rhodes collection. I would like to thank Pauline Mitchell for assisting and showing me the ropes in the Materials Laboratory, and for reducing red tape. I thank Dr Marian Tredoux for her assistance in understanding geological and geochemical aspects of research described here. I particularly thank Mrs Cora Jardine for the meticulous illustration of the reconstruction of the fabrication technology. I am thankful to Anglo American Research Laboratories, particularly Mrs Dara Grigorova and Dr Wyatt Smith for the analysis by LA-ICP-MS of the archaeological gold. Financial support from the Foundation for Research Development (now NRF) and the Wenner-Gren Foundation is gratefully acknowledged. Finally thank you, family, and friends, for your unconditional love and support.

CONTENTS: Page

CHAPTER SIX

CHAPTER SEVEN

CHAPTER EIGHT

CHAPTER NINE

PUBLISHED PAPERS:

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LIST OF FIGURES

LIST OF TABLES

Page

CHAPTER ONE

INTRODUCTION

Definitive evidence for the earliest use of gold in southern Africa occurs in the form of gold mines in this region with dates that span the last 1000 years. Gold mining was stimulated by increased trade with the East Coast, that started in the late 1st millenium AD. This trade led to significant economic changes that contributed to the rise of a complex social structure. Trade with southern Africa was taken over by the Portuguese from about the 16th century AD, but never flourished to the same extent as Islamic trade in southern Africa did. Various lines of evidence have allowed us to describe this history. However, there are numerous technical questions pertaining to the production and use of gold in the Late Iron Age that have not been answered satisfactorally. Several of these will be addressed here. This is the first study of assemblages of gold from major Late Iron Age sites that employs both metallographic and trace element chemistry analyses to address questions of the origins of the metal, and the technology used in its production. This is integrated with the archaeological and historical evidence to address gold acquisition, fabrication and use in the southern African Late Iron Age.

This study begins by explaining the context of the gold technology scrutinised here. Three assemblages were utilised for this purpose, Mapungubwe, Great Zimbabwe and Thulamela (Fig. 1). A reconstruction of the fabrication technology has been made of gold artefacts from these sites. This was achieved by studying these artefacts metallographically. Anglo American Research Laboratories applied the recently developed technique Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) to a sample set of the three gold-bearing assemblages mentioned earlier. Theoretically this technique might identify which areas were mined, whether the gold used was alluvial or not, and whether the metal used was alloyed and mixed in any way. An archaeological assessment of the trace element and metallographic analyses has been carried out, integrating the scientific data with the human past. Issues addressed include the impact of gold production and trade on the use and production of other metals, the use of gold in the expression of status and wealth, and the development of social complexity in southern Africa.

CHAPTER TWO

BACKGROUND

The study of gold production and use from an archaeological perspective requires background knowledge from several related yet distinct disciplines, including history and geology. The archaeological occurrence of gold in southern Africa can only be appreciated in the context of the local and regional geological setting, historic and oral evidence, archaeological surveys and excavations. In the 1960s, Summers acknowledged that there is little to be learnt from taking a solely archaeological approach to the study of early gold production in southern Africa (Summers 1969). Here follows a summary of the historical literature. Some of the details presented here have been superceded by more recent research, much of it unpublished.

Gold first appears in the archaeological record of southern Africa during the Late Iron Age, after about AD 1000 (Huffman 1984; Phimister 1974, 1976; Summers 1969; Swan 1994). Worked gold of the Late Iron Age has been found in elite burial sites such as at Mapungubwe (Meyer 1998), Thulamela (Küsel 1992), and political centres such as Great Zimbabwe (Huffman 1996). Gold mines have been identified, such as the Geelong and Aboyne mines in Zimbabwe (Swan 1994). Production sites, containing slagged crucibles and other diagnostic implements of gold working have been found (Swan 1994). The Maund Ruin in Great Zimbabwe (Swan 1994), Garaubikirwe, a stone-walled ruin containing vitrified slag (Swan 1994), and Thulamela (Küsel 1992) are examples of these. The mines, working sites, and elite burials provide insights into only some of the important aspects of archaeological gold production and use in the southern African Late Iron Age (Fig. 2).

The earliest archaeological dates for mining are from the Aboyne and the Geelong Mines situated in the Gwanda Gold Belt of Zimbabwe, both giving dates of between AD 1065 and AD 1300 (Swan 1994; Summers 1969). These were associated with Leopard's Kopje pottery (Summers 1969). Summers suggested that since earlier Ziwa pottery was found at mining sites close to Harare, gold reef mining very possibly started before AD 1000. Huffman (1974) was in doubt as to whether mining could have occurred as early as AD 600, as Summers had suggested.

As to who started gold trading, working and utilisation, Summers (1969) proposed that it might have been the result of external influence rather than an independent development by indigenous southern Africans. This he based on the argument that only a few people knowledgeable on the subject of gold reef mining and use would be needed to build, develop and teach others about mining and gold utility. Some academics have implied that the discovery in some mines of trade goods from India means that Zimbabwean gold mining was developed by Indians (Summers 1969; Hromník 1991). Summers illustrated how similar the mines from India and southern Africa appear to be (Summers 1969: 118), but Miller (1995) pointed out that what similarities there are may be due to geological constraints.

Geological setting

Most of the gold deposits in southern Africa formed during the Archaean Period of the Pre-Cambrian Era 3500 to 2500 million years ago. (Summers 1969; Swan 1994; Cairncross & Dixon 1995). Most of the gold-bearing rocks form part of the Basement Complex (Cairncross & Dixon 1995). This consists typically of schists, highly metamorphosed rocks, surrounded by intrusive granite formations. Gold mineralisation appears to have been associated with the intrusion of the granites into the metamorphosed volcanic and sedimentary rocks, approximately 3500 to 2900 million years ago (Cairncross & Dixon 1995). The Archaean Zimbabwean gold belts were the source of most, if not all the gold mined during the Late Iron Age in Zimbabwe (Swan 1994). Gold deposited in quartz veins or reefs during mineralisation was the target of hard rock/reef mining, and weathered material formed eluvial and alluvial secondary deposits (Summers 1969).

Within South Africa there are three main belts of gold bearing rocks from the Archaean Period (Hammerbeck 1976). The earliest are the earlier greenstone belts that include the Barberton mountainous region, well known for its gold yields from historic and modern mining, and the Murchison hills. The Barberton greenstone belt is the oldest belt, formed up to 3500 million years ago. The Pietersburg greenstone belt appears to be somewhat younger (Hammerbeck 1976).

The other main gold bearing deposit within southern Africa is the more recent Witwatersrand Basin (Whiteside *et al.* 1976). The basin used to be an ancient sea and river system, in which sediments containing gold were deposited until about 2500 million years ago, when the system dried up and gold bearing sedimentary rocks were formed. Subsequent burial, compaction and metamorphosis resulted in the formation of gold bearing reefs.

Location of early mining

Early prospectors and mining engineers remarked on the relative lack of gold mines in South Africa (Fripp 1912; Trevor 1912 a & b). These engineers noted that the region formerly called the eastern Transvaal had abundant supplies of alluvial and reef gold, and the former northern Transvaal was renowned for its gold ore bodies. The scarcity of recorded archaeological gold mines in these regions is even more surprising when one considers that they were fully exploited in pre-colonial times for their copper and tin (Summers 1969). The archaeological gold mining sites at Zimbabwe, and to some extent Botswana and Mozambique, have been documented by Summers (1969) and Swan (1994). Summers (1969) noted that in the Basement Complex of Zimbabwe there were about a hundred distinct gold mining regions, versus sixty or fewer copper mines. It could have been that visible gold in quartz reefs may have formed the initial target of prospecting, as has been argued by several scholars, an idea formulated by Fripp (1912). If this was the case, then quartz reefs with no visible gold showing at the surface would not have been exploited (Mennell & Summers 1955; Mennell 1957).

Summers has suggested that the gold mines were clustered around dwellings characteristic of the Great Zimbabwean style (Summers 1967, 1969). He was the first to discuss the location of these early mines and their implications. He noted that one type of pottery, of the Gokomere Tradition was found in association with gold at earlier ruins.

However, the working sites contained some imported goods and therefore Summers suggested that the miners were traders as well as miners. His study was based in Zimbabwe, where the pre-colonial gold mines were the most abundant in southern Africa. Summers (1969) listed thirty-five distinct areas that contained gold deposits and described the mining style, archaeological significance of some of the mines in these belts, and any early prospecting documents about mining of each region or site. The most important region was the Tati gold belt where two hundred Late Iron Age workings were found, but these had not been intensely worked due to the shallow depths of the deposits. Regions rich in gold deposits found on the outskirts of Zimbabwe fell in the Makaha gold belt where eighteen gold mining sites were found. No mining sites in Mozambique were identified by Summers (1969). Summers (1969) suggested that the Botswana area was used mainly for copper mining, and that the Messina region of the Transvaal contained copper mines, but no gold mines.

The work of Swan (1994) used the spatial correlation of mines with occupation sites in Zimbabwe in order to establish the historic sequence of mining and settlement. Pottery styles were used to provide relative ages, because the characteristics of the radiocarbon curve at this time makes meaningful calibration of radiocarbon dates to calendar years difficult. If pottery of the same class was found in a mine and a nearby occupational site, it was inferred that the two were contemporaneous and that the mines probably supported the occupants of the settlement. Using this approach Swan (1994) concluded that there were six distinct periods in the rise and fall of gold mining in southern Africa, possibly starting as early as the rise of coastal trade in the 1st millenium AD.

Although evidence was found for trade with the East Coast during the first half of the 1st millenium AD, correlation between gold mines and Ziwa sites was tenuous (Swan 1994). At sites situated in the southern part of the Zimbabwean plateau, including Mabveni, the Nunyani Ruin, and the Gokomere Tunnel site, glass beads and sea shells were found indicating contact and trade with people at the coast. Firmer evidence exists for a link between gold mining and trade in the latter part of the 1st millenium AD. Several mining sites including the so-called R.A.N. mine and Golden Shower Claim have pottery dating to this period, and are associated with occupation sites in the Nyanga area. Swan believed that reef mining may have been practised by this time, contrary to opinions that placed the impetus for mining somewhat later during the rise of the Zimbabwe culture (Huffman 1974; Phimister 1974). Occupation sites of the 11th to 15th century AD were divided into two social classes - lower and upper status settlements (Swan 1994). Ingombe Ilede and Great Zimbabwe belong to this period. Dolly holes close to Montevideo, the R.O.M. Mine and the Kwe Kwe Mine were associated with the Great Zimbabwe tradition, and nearby sites contained Islamic trade beads. This suggests that mining started in this region before the 16th century AD. Other important mining sites from this region and period include Joy Claim, Family Claim and various other Woolandale sites (Swan 1994).

Since she could not make any direct correlation between any particular gold mine and the Zimbabwean Tradition, Swan was of the opinion that the occupants of the elite sites of this period were not directly involved in mining. Nevertheless, evidence for gold smelting and artefact manufacture, such as crucibles and other tools, have been found at many of these sites. Mudenge (1988) and Swan (1994) suggested that gold was acquired by the ruling elite by a variety of means, including taxes or even military force.

Gold mining sites from the 16th to 19th century AD include Tebekwe in the south of Zimbabwe, and Pangani, Patsy, and the Eldorado and Fernhill Farms in the south western part of Zimbabwe. Although Swan (1994) noted that from the start of Portuguese trade, from at least AD 1500, there was a steady decline in gold being mined and exported.

Mining techniques

Diverse prospecting and mining techniques were employed by the Late Iron Age gold miners of southern Africa. The presence of gold may have been detected using a variety of signals such as antheaps containing gold-bearing soil, to tracing alluvial gold deposits through to the placer deposits and finally to the source of these deposits, the reef (Summers 1969). Molomo (1992) suggested that other indicators of gold bearing rocks were used, such as the distribution patterns of tree-growth.

The tools and equipment found at sites along the banks of rivers are believed to be the material archaeological evidence for alluvial and eluvial mining (Summers 1969). The Shashi, Limpopo, Tuli and the Umzingwani Rivers of the Umnati-Umfuli System were mined for their alluvial gold deposits (Summers 1969). Sites on the banks of this system of rivers have been found in association with Leopard's Kopje pottery.

Summers (1969) distinguished two methods of mining: open stopes and shafts with underground stopes. Shafts with underground stopes had a limited distribution, mainly in the north east of Zimbabwe. At first this was taken to indicate a different group of miners (Mennell & Summers 1955). Later, it was recognised simply that the latter method was used for less steeply dipping reefs (Summers 1969).

The open stope was by far the most common method used in both Zimbabwe and the former Transvaal in South Africa. The surface outcrop, which is believed to have been very rich, was first removed, and then the steeply dipping reef was attacked from both sides. Since the reefs were up to 1,5 m wide, a large trench resulted. This is called side stoping, and was used where the reef was in relatively soft rock. Where the walls were of hard rock, underhand stoping was used - only the reef was taken out from under the miner. These stopes tended to be much narrower (Summers 1969).

Shaft mining consisted of sinking a shaft about 1 m in diameter, until the reef was reached, and then exploiting it in all directions for a few metres. Another shaft was then sunk nearby and the operation repeated. Sometimes the chambers were connected. An example of this type of mine was the Umkondo mine (Summers 1969; Swan 1994).

Another method used was a combination of the above - open stopes with occasional shafts. This method was used when the reef dipped at between 25° and 50°. An example was the Aboyne Mine, where the shafts may have been for ventilation. In the absence of explosives firesetting was used to loosen ore-bearing deposits. A quantity of charcoal found in the mines has provided evidence that the technique of firesetting was used to break up rock. This technique involved heating the rock face by lighting a fire next to it, and if necessary, quenching with water. To remove the smoke produced by firesetting at a working face, charcoal fires made at the bottom of shafts may have been used to create an updraught (Summers 1969).

Three main types of mining tools were used. These were hammers, iron gads, and stone or wooden wedges (Summers 1969). Stone hammers were made from fine grained materials such as dolerite and sometimes greenstone in order to crack or shatter the brittle quartz that hosts most of the gold naturally. Gads were tools made of a mild steel that were used to further crack and dislodge the rock partially cracked by firesetting. Stone or wooden wedges were used to further crack gold-bearing ores. Summers observed that a wooden wedge placed in a crack would cause further splitting when wet, since the wood expands when it absorbs the water. Very few of these have been found.

There is a general consensus in the literature that the tools utilised in copper, tin, gold and iron mining were the same (e.g. Fripp 1912; Mason 1962; Summers 1969). The most common digging tools found are hoes, shovels and scoops. Whereas a gad would be used to crack rocks, something more refined would be used to gather the rocks. Shovels are thought to have been used for this purpose. Support for this presumption comes from Zambia, where small scoops have been found in archaeological sites (Summers 1969).

A series of specialised mining tools have been found. The most common tools found were stone hammers, made of hard stone. They were used to pound the quartz ore, as well as to drive in iron gads, another fairly common find. With the latter use the originally round stone became cuboid (Mennell & Summers 1955). Stone wedges were occasionally used in place of iron gads. In the Geelong mine, an iron gad hafted into a wooden handle was found - this must have been used as a pick. Iron shovels have been found in some mines, presumably used to scoop up loose rock. Woven baskets were probably employed for carrying ore. A small wooden bucket was found in one mine (Summers 1969: 171). Manuel Barreto, a Portuguese observer of the 18th century noted that the ore was passed from hand to hand in wooden bowls, called *pandes* (Axelson 1973: 50; Mudenge 1988).

How the ores were hoisted to the surface is not known precisely. Summers (1969) described a wooden bucket with a carrying capacity of three litres, with three holes on the sides, suggesting that it was suspended for hoisting. However, oral evidence has suggested that dishes shaped like soup plates were used for hoisting (Summers 1969). They were made from palm leaves and the underside covered with leather. No evidence for mechanical hoisting has been found and the ores were probably removed by hand.

Summers (1969) has also reported on a document from the Far East describing mining during the Late Iron Age of southern Africa. The Chinese scholar, Chau Ju Ju-kua wrote that the only place where gold was mined at the time of writing (12th century AD) was Zanj-bar. However, Summers claimed that the most valuable information was that concerning import and export. The Portuguese documents are most relevant to mining, but they only start in the 16th century AD. The earliest one described mining activities in the Zambesi, and the most detailed one was written in 1667 on the same region. It stated that the alluvial gold was of a better quality than reef gold. The main regions for mining were recorded as Mokaranga, Manica and Butua (Summers 1969). Reef mining was performed in the following manner. A chief of a village would choose to open a mine (called *marondos*) and each family would dig a hole about straddling width wide. This hole would be dug about 70° to the vertical and notched steps would be cut to facilitate deeper mining (Summers 1969). The procedure was noted to be quite hazardous, and Summers (1969) claimed that once a mine started filling with surface water, the mines were abandoned even though they were probably only starting to reach the richest gold ore.

Water seepage posed a great dilemma to early Zimbabwean miners, as recorded by Manuel Barreto, a 17th century Portuguese scholar (Axelson 1973; Fripp 1912; Summers 1969). He claimed that there was no successful method employed by these miners to cure the flooding of mines, and this could have caused many mines to be abandoned.

Since shaft mining would generally not need light (it was noted earlier that the greatest depth was about 45 m), especially around noon, this could have been sufficient for many purposes of Late Iron Age mining. However, Summers (1969) noted that illumination when mining in inclined stopes would be problematic. Oral evidence has not yet provided a clue to a sustainable source of light, and archaeological evidence is limited to the blackened roofs of the inclined stope mines, which could also be explained as being the result of firesetting.

Hazards

While some safety techniques were utilised by the early miners of the Late Iron Age, there were major problems that limited gold production and safety. Deaths resulting from cave-ins have been recorded. At the Gaika Mine four skeletons were recovered from excavations (Summers 1969). At the Aboyne mine, a female skeleton was found, with age of about nineteen at death. Several other skeletons were found in and near the Aboyne mine, evidently the result of a series of collapses (Summers 1969: 22-28). From the skeletons recovered it has been noted that many of the miners were female, although it has also been suggested that mines were managed and worked by a community leader, and that all people in that community were miners (Keith 1924; Summers 1969; Huffman 1974). This view is supported by an account by Barreto, who described that the whole village - men, women, and children - turned out to dig the mine, under the guidance of the chief. This was usually at the end of the rainy season, but mines in Manicaland were worked all year round (Axelson 1973: 50).

Ventilation was a significant problem and it has been considered, somewhat paradoxically, that firesetting assisted in freshening and cooling air in circulation (Summers 1969). However, the common hardwoods of the Zimbabwean Plateau emit copious amounts of carbon monoxide when burnt. This may have caused miners to faint during extended exposure to the gas in a confined space. Summers thus felt that miners would have evacuated the stopes to wait for the gas to disperse before commencing work again. Fripp (1912) mentioned "baffles", and suggested that they would have kept the mine cooler, and helped to remove the noxious gases. The use of baffles for this purpose was later also noted by Molomo (1992). Ventilation, Summers (1969) asserted, was much more of a limiting factor to southern African miners of the Late Iron Age than water seepage was, since several mines have been found worked to the water table level and even below that. The Geelong Mine, and other mines were remined by modern prospectors and were found to produce still much more gold. In this instance Summers (1969) believed that this indicated that the faulty and incorrect design of mechanisms of ventilation at this mine could have caused it to be abandoned.

Mining outputs

Portuguese and Arabic documents have been used to provide vague estimates of the outputs produced by various mines in the Zimbabwean region (Summers 1969; Swan 1994). Little is known from Mediterranean sources. Al-Masudi, of the 10th century AD provided the earliest report of gold export from the East coast of southern Africa (Axelson 1973). Portuguese documents discussed gold trade only from the 16th century onwards (Summers 1969). This was also the period in which the Munhumutapa state flourished (Mudenge 1988). The reports in these early documents tended to be biased and pessimistic, suggesting that the total amount of gold traded by the indigenous Late Iron Age gold miners was more than what was recorded. This can be seen from extracts in a document sent to the Viceroy of Goa on the mining potential of the Sofala region (Summers 1969).

The earliest quote given for the total production of gold by Late Iron Age people was 21.5 million ounces (666.5 million grams) calculated by Hall (1909). Caton-Thompson (1931) felt that it was impossible to calculate such a total with variables such as the large region and vast time period being considered. Hall's calculation was based on his estimate of the average number of miners and the amount of deposit removed. Summers (1969) noted that Hall's estimate covered only the period in which the Zimbabwean mines were producing the greatest quantities of gold, and that the amount of gold gained from these deposits at this time differed from that of early miners employing different mining techniques.

Rickard (1930) took a few more factors into consideration. He suggested that over the period concerned gold weighing about 1.25 to 2 million ounces (38.75 to 62 million grams) per century was produced. He however, considered a limited region and worked over only a fraction of the total area occupied by miners during the Iron Age. Secondly, he collected quotes and figures from others and never personally visited the mines, except for one. His primary source was only one person whose work experience was limited to Lonely Mine, which produced only a small gold output, and was situated on land between two gold belts, the Insiza and the Queens gold belts. In fact, Summers (1969: 68) noted that the mine was "exceptionally small" and that the reef was still under the stope.

One can summarise all criticisms of these previous estimates. The average production of one mine differed to the next, from those in different belts and from present mines and shaft mining, and eluvial and alluvial deposits were not considered together and added to the total output.

Summers (1969) considered the amount of gold that would have been mined from alluvial and eluvial deposits when he attempted his own estimate, and cautioned that eluvial production cannot be estimated successfully. Adding in the alluvial and the shaft mine deposits removals, he suggested a total of between 15 and 25 million ounces (465 to 775 million grams) per century. Although the way in which Summers calculated his estimate is different to Hall (1909), the end result is not substantially different. Summers (1969) felt that it was technically inaccurate to calculate outputs from archaeological remains, when trade was a driving force of the development of the Zimbabwe culture.

In order to calculate how much gold was traded, Summers (1969) felt that one should subtract an estimated amount kept for local use in the form of burials, ornaments and jewellery, from the total output of gold. He concluded that this amount was between 15 and 25 million ounces (465 to 775 million grams) per century. Historical documents from the Arabs and the Portuguese noted the general absence of indigenous gold jewellery (Summers 1969). Instead of gold, iron, copper and ivory jewellery was worn primarily. The only items that needed to be considered here were those from burials. Summers tabulated the amount of gold from a total of 40 burials. Robberies and the raiding of burials complicated the estimation. Swan (1994) noted that 11 103 grams of gold was recovered in 1896 and declared as such, which was most likely only a portion of that which was stolen. Hall & Neal (1902) stated that more than 62 000 grams of gold was stolen between 1895 and 1900. Using various records, such as those made to the Northern Rhodesian Monuments Council by Chaplin (1962), Summers (1969) figured that the total amount of 10 000 ounces (310 000 grams) covered all the burials uncovered thus far. This does not include Thulamela where excavations only started in the 1990s (Küsel 1992). Furthermore, the burials in Summers' (1969) database were concentrated around the 15th century

AD, when gold production started to decrease and the Muhumutapa state was in decline (Mudenge 1988), and therefore the estimate cannot be accurate.

Phimister (1976) attempted to revise the estimates of gold mining outputs. Phimister's premise was that the Shona were primarily agriculturalists/pastoralists and therefore the mining outputs should not be the maximum amount that could be produced by a primarily mining community with the same technology and skill. He furthermore differed from Summers (1969) in that he believed that the gold ore was not as rich as Summers thought. Phimister's estimates were between 50% and 25% of Summers's figures, 775 tons per century to 39 tons per century for the most active period. The most recent estimate is that of Austen (1987: 276) of 1.5 tons per year for the period of Islamic trade, and 0.5 tons per year for the period when trading with the Portuguese occurred.

Gold working techniques

The premise here is that metal working includes ore processing, metal melting and metal smithing. Evidence for ore processing has been found at various gold working sites in Zimbabwe, such as Marcardon Claims, in the form of dolly holes (Garlake 1971; Summers 1969; Swan 1994) situated in materials such as dolerite and sometimes granite outcrops. They are usually hemi-spherically shaped and are associated with adjacent deep striations in the rock. These dolly holes were usually not portable; however the dolly hole bearing sections were sometimes chiselled out of the rock substrate.

Swan (1994) documented the presence of crucibles (used for melting various metals including gold) from Zimbabwe. Gold processing was not restricted to Zimbabwe. At a site called Chibuene in Mozambique, situated along the coast, crucibles were found (Swan 1994). However, without adhering gold droplets one cannot say for certain whether gold or copper was melted, since crucibles are a general metal working tool. Fripp (1912) described copper ingots from Messina, and believed that they contained some gold. However, most gold found in sites associated with the Late Iron Age of southern Africa is relatively pure, and not alloyed (Fouché 1937).

There are various interpretations as to the gold smithing process. Sites that contained precolonial gold artefacts whose fabrication has been inferred, include Mapungubwe and Great Zimbabwe. The gold from Great Zimbabwe thus far has been described and interpreted mostly by Oddy (1983, 1984). Foil from this site was worked by creasing folding and pleating (Oddy 1984: 71), and nail heads were produced as part of the manufacturing process, and not as a result of use. He noted that the pieces of gold foil from this site, had holes in them, which were probably caused by punching with tacks. The main type of bead was what he called "a small cast flattened sphere" (Oddy 1984:75), which he noted were exactly the same as those from Mapungubwe. The other item described was gold wire. He suggested that the wire was both beaten (hammered) and drawn, and sometimes further modification to this artefact was to wind it into a spiral. The other type of bead he described was an even further flattened spherical bead, which he claimed was done in order to create a tight fit between the beads when strung. A "sub-type" of bead was of the grooved type. The third type of bead was made by bending a small piece of gold wire around into a circle. Wire was made in two ways; one he called "true wire" (Oddy 1984: 75), which was made by hammering (round in cross-section) and the other was trapeziodal-shaped, made by cutting a section off the side of a gold sheet. Meyer (1994, 1998) reiterated Oddy's interpretations for the gold from Mapungubwe.

Trade centres and trade routes

Documents from the 13th century AD onwards discussing trade and imported goods do not address the earliest known trade and the goods being traded with Late Iron Age southern Africans (Summers 1969). Archaeologists have excavated numerous imported goods that can be traced back to the imported goods' place of manufacture (Caton-Thompson 1931; Summers 1969). These include ceramics, glass beads, coins and metal work distinct from that known to be indigenous to southern Africa. These were sought by southern Africans in exchange for slaves, metals such as copper, tin, iron and gold, as well as various organic materials such as ivory, bark, and animal skins (Swan 1994).

Various sites have indications of having been trade centres. One such site is Ingombe Ilede (Summers 1969). It is situated on the banks of the Lusitu River close to the lower Kariba gorge where there is a well used crossing. This site has produced numerous burials with imported goods, in particular glass beads and woven cloth preserved as impressions. This led Chaplin (1962) and Fagan (1972) to suggest that this site was a trading post. Another trading site is the town of Kilwa, where the earliest date for suggested trade is the 13th century AD. More recently Huffman (1982) and Pwiti (1991) suggested that the initialisation of trade and an evolution in the general culture occurred almost simultaneously, although which one prompted the other is still contested.

How people from different continents, and hemispheres traded is a hotly contested debate, and one of several issues in the archaeology of the gold trade during the Late Iron Age of southern Africa in which many refrain from expressing their opinion. Summers (1969) made the assumption that any seafaring would be totally dependent on the monsoon cycle. With this axiom he noted that Kilwa is the southernmost point of safe travel during the monsoon. It is approximately 1 300 km overland to the nearest gold field. Summers (1969) suggested that the distance combined with demands made on traders for their goods when passing through alien territory would have made life very difficult for these travelers. Thus an alternative waterway would be sought. This Summers thought would be possible by travelling down the Zambezi and then going overland from the mouth of the Zambezi to Kilwa.

Summers (1969) asserted that until the 12th century AD, beads were not very varied and that they were all of a Mediterranean style and origin. This therefore suggested that the trade was confined to a small group of people. From the 13th .century AD onwards, beads different from those found at Mapungubwe were used in Zimbabwe. Summers (1969) noted that this period was accompanied by an increase in the number of mines and areas that were mined, as well as more ports becoming well established on the East Coast. Furthermore, there was an increase in the number of beads and the appearance of Chinese porcelain found at contemporaneous sites. Summers (1969) believed that gold was not as prized by southern African miners of the Late Iron Age as it is today and therefore they were content in trading it for small quantities of beads and cloth (Summers 1969: 209). This would fail to explain the abundance of gold in post 15th century AD Zimbabwean elite burials, and why gold burial goods were limited to the elite in the Zimbabwe culture. Huffman (1974) and Mason (1974) believed that it was the trade in gold at the East Coast with other nations that lead to the development of reef mining, and supported the development of the Zimbabwe culture.

Gold mining, working and production acted as a commodity of meaningful international contact. Gold mining, working and production increased simultaneously with increasing international trade. Important external trading partners were the Portuguese and particularly the Arabs. Local gold producers traded to a lesser extent with the Dutch and ephemerally towards the end of the Late Iron Age with the English (Axelson 1973; Leisegang 1977; Summers 1969). This decrease in international trade also correlated with a decrease in gold mining activity, and movement away from the use of one large political centre such as Great Zimbabwe.

A chronology for indigenous gold trade can be established from imported traded goods that are dated (Huffman and Vogel 1991). These goods show that coastal trade started in the latter part of the first millenium AD, and activity increased after that. By the 10th century AD it was well established, and peaked in the 15th century AD. Gold only appears in the archaeological record from the mid 13th century AD. The Islamic records, which make more than a passing reference to gold from the land of Sofala also, date from this period. Until the beginning of the sixteenth century AD, Islamic trade flourished. The Portuguese waged war on the Islamic traders and mounted various exploratory and military expeditions into the interior in attempts to locate and command the sources of gold (Axelson 1973). This disruption, coupled with the slave trade, spread of disease, and internecine warfare in the interior, led to a drastic decline in local gold production, but still continued as a marginal activity (Swan 1994; Pikirayi 1993; Austen 1987). It seems likely that initially the slaves, iron, copper, ivory, wood, animal skins and resins mentioned in the early Islamic documentary records were the principal exports and that gold became important only after the 11th or 12th century AD. This was the period of Mapungubwe, which controlled trade along the Limpopo, after which the focus of trade moved north to Zimbabwe, and the Sabi, Save and Zambezi Rivers (Summers 1969).

A few radiocarbon dates for charcoal found in mines in Zimbabwe span the 12th to 20th centuries AD (Summers 1969: 134). There is ample evidence that gold mining continued despite major fluctuations in output throughout the turbulent period of Portuguese domination. Another invasion by the Nguni in the mid-19th century AD largely put an end to systematic small scale mining, scattered and demoralised the Mashona, and paved the way for European colonial expansion (Wallis 1946; Miller 1999). Dutch documents from the 18th century AD described the Venda Kingdom of "Inthowelle" whose occupants mined and traded gold. This kingdom included areas in South Africa, in modern Mpumalanga. Furthermore, the Dutch who traded from Delegoa Bay discovered that others, primarily the English, were trading from Delegoa Bay before them (Leisegang 1977). This supports the notion that mining south of the Limpopo may have been a later development than in Zimbabwe. Gold mining and trade may have become possible in these regions as a result of the rise of the kingdom of 'Inthowelle', whose name and location suggest that it may be synonomous with Thulamela (Küsel 1992; Miller, Desai & Lee-Thorp 2000; Verhoef & Küsel 1995).

Gold mining started before the advent of concerted international trade. There is no reason to suggest that gold mining did not receive its impetus from copper and iron mining, especially since gold mining succeeded this other metal mining in southern Africa, and was exercised no differently either. There is also no reason to suggest that gold mining did not develop independently from international influence. Gold was traded from at least the 13th century AD, evidenced by imported goods found from Mapungubwe, a gold producing and trading centre. Gold was also kept for local consumption. Gold was found in burials from Ingombe Ilede in Zambia (Chaplin 1962; Fagan 1969), Mapungubwe (Fagan 1964; Fouché 1937; Meyer 1994, 1998) and Thulamela (Miller, D. 1996; Miller, S. 1996; Steyn *et al.* 1998). These objects included beads, beaten gold attached to a backing with gold tacks, a gilded 'bowl', a gilded staff, a 'macehead', numerous wound wire bangles and the famous gold rhinocerous. These goods represent elite insignia, used by the rulers of the last major phase of occupation at Mapungubwe, from about AD 1220 to AD 1290 (Meyer 1998: 212-213).

Gold was traded internationally for glass beads, Chinese ceramics, and cloth (Axelson 1960, 1969, 1973; Huffman 1971, 1972a, 1988). Goods from Renders Ruin hoard, found by Hall in 1903 at Great Zimbabwe, consisted of a mix of local and imported objects. These have been interpreted as the trade goods of a Swahili trader (Garlake

1973), and included thousands of glass beads, cowrie shell, iron tools, gold wire and beads, and some domestic objects of coastal origin. Most of the imported beads have been interpreted to be Indian in origin (Garlake 1973). Work by Saitowitz (1998) indicated a possible Egyptian origin for some of the beads found at Mapungubwe. Imported Chinese celadon ware and the absence of 'blue and white' ware date to Period III/IV at Great Zimbabwe, shortly before the mid-15th century (Garlake 1973). Also at Great Zimbabwe an Islamic coin dated to AD 1320-1333 was found *in situ*. Various other goods show that Great Zimbabwe symbolised the peak of international trade during the Iron Age of southern Africa. The departure point of all these goods from Great Zimbabwe was on the Sofalan coast (Axelson 1960, 1969, 1973; Freeman-Grenville 1962).

Southern Africa produced a substantial amount of gold during the Late Iron Age and had a significant impact on the world economy of gold at the time (Axelson 1960, 1973; Phimister 1974; Summers 1969). This does not mean that southern Africa was a region that was mined by external international groups and cultures. On the contrary, gold mining occurred locally after the establishment of iron and copper mining and it is much more likely that gold mining activity grew out of the experience the local mining community gained from searching for and mining copper and iron ores. There was also no stylistic difference between artefacts that were produced in gold as well as copper. For most of the 2nd millennium AD copper mining was prevalent south of the Limpopo, and gold mines dominated the Zimbabwean Plateau and surrounds. Towards the middle of this millenium the indigenous practice of gold mining may have spread to South Africa.

Gold was an important commodity on the international economic market circles. Often it has been the most important commodity for establishing the wealth of a country. Although gold was sourced from southern Africa to trade with the rest of the Old World it does not necessarily follow that the Late Iron Age people of southern Africa viewed gold as a currency.

Gold was recovered by Late Iron Age southern Africans to be used locally as a means of paying for trade and paying tribute to the elite (Axelson 1973). The status of this elite was determined in various ways. The amount of gold that the elite were buried with was an indication of the importance of a person in this community, and an indication of their ritual and social status. Furthermore it is very probable that it was a general practice that the royalty was buried with all the gold that they possessed, since most of the gold recovered from the sites has been from burials. If gold was important as a currency then the deceased person's gold would belong to the one who would take over power, in a similar manner to the way land is passed from one royal to the successor. It is therefore unlikely that gold was seen as a currency in the same light as in Europe and the Meditterranean during the Late Iron Age.

CHAPTER THREE

THE SITES

Gold artefacts have been found at numerous sites in Zimbabwe, but only at a few in South Africa. Three sites, Great Zimbabwe, Mapungubwe and Thulamela, have been chosen in this study in order to analyse various aspects of the southern African Late Iron Age gold mining, trade and consumption.

Mapungubwe

The collection of sites on Greefswald, commonly called Mapungubwe, has been reviewed and discussed by several people (Eloff 1979; Fouché 1937; Fagan 1964; Gardner 1963; Huffman 1982, 1988; Meyer 1994, 1998; Sentker 1969; Voigt 1983). The Greefswald farm is situated in the Northern Province, a province of South Africa, at the confluence of the Sashi and Limpopo Rivers, on the southern bank of the Limpopo. The three main sites here are Mapungubwe Hill, Mapungubwe Southern Terrace and K2. The geographic location and site layout have been presented in detail by Gardner (1963) and Meyer (1994, 1998).

The main occupation of these sites was between AD 900 and about AD 1300 (Meyer 1994). Exploration of the Mapungubwe Hill by the group led by van Graan in 1933 revealed numerous artefacts, including gold beads, helically wound gold bangles and gold sheets used for covering animal statuettes. Most artefacts recovered from the Hill were poorly provenienced. In subsequent excavations on the north-western part of the Hill, the first burial (designated M1) was found in association with gold bangles and beads, and other items. The total mass of gold found here was reported to be 75 ounces (about 630 g) with the bangles, gold plate and beads averaging about 92% gold (Fouché 1937). The Southern Terrace excavation of 1933 yielded one gold sheet, two pieces of wrought gold, and slagged crucibles (Fouché 1937), which means that there might have been a processing site closely situated to, or at Mapungubwe.

Mapungubwe Hill, also called the "Summit" (Fouché 1937: 12) and the Southern Terrace was then further excavated in 1934, in six main trenches, JS1 to JS6. The excavations were described in Fouché (1937) and Meyer (1998). Between 1934 and

1935, a female burial was uncovered, which led to the excavation of twenty four burials in total during that season, all on the Hill. Two burials, skeletons No. 10 (M5) and No. 14 (M7) contained gold. The former was a male buried with a gold "sceptre", and a necklace comprising 100 small gold beads. The other was most probably a female buried with about 70 ounces (about 2170 g) of gold. The female burial was buried with numerous artefacts that included over 100 gold bangles, pieces of gold plating, and about 12 000 gold necklace beads.

The 1935 to 1940 season revealed more than 61 burials at K2. Gardner (1963) did not mention any gold being found in association with these burials. The further Mapungubwe Southern Terrace excavations in 1953 and 1954 were reported by Sentker (1969). During the 1953 excavations two pieces of gold were recovered, one a gold helix and the other a decorated gold sheet, with lengths of approximately 13 cm and 18.75 cm respectively, recovered from Square A3. The following year one gold artefact was recovered from Square B3: an ornamented sheet. From Square C2 one gold bead was recovered. Although several of the gold artefacts identified by Sentker (1969) and Eloff (1979) are housed temporarily in the UCT Materials Laboratory, many of these items were not catalogued originally, and some appear to have been lost. The Southern Terrace was excavated in squares starting with Square B2. The metallography of gold artefacts from this square and C3 were studied by Pienaar and Becker (Eloff 1979). These analyses, although very preliminary, suggested that a gold bead and helix studied were worked cold.

The period of occupation at the Southern Terrace and the Mapungubwe Hill has been divided into four phases (Eloff 1979; Meyer 1998). Phase One is the earliest and is currently considered to be a temporary Early Iron Age settlement, with pottery inferred to belong to between AD 300 and AD 500. Mapungubwe was uninhabited from AD 500 to AD 1000. From then on for two hundred years K2 was occupied, during a period known as the K2 phase or Phase Two. These people were both agriculturalist-pastoralists and metal workers. They manufactured woodwork, and iron and copper, and beads made of ostrich eggshell and shell and large glass beads. Ivory was traded for exotic glass beads at least some of which originated from Egypt (Meyer 1998; Saitowitz 1998). Once the huts that comprised the settlement Phase Two burnt down it was replaced by a Phase Three settlement that was a central point for local subsistence farming between AD 1220 and 1250. In addition to the items from Phase Two these people possesed gold artefacts, and a new style of pottery called "Mapungubwe Vessel Series", as opposed to the "K2 Vessel Series" (Meyer 1998: 263). This phase was subdivided into two. Phase IIIb is supposed to be the most characteristic of the Mapungubwe culture. Burials are mostly found on the Hill summit. Phase Four denoted the fall of the Mapungubwe settlement as less of the total area was occupied, but the material culture was mostly the same except for new material from San and external agricultural influences being adopted, and probably rapidly declined after AD 1290.

Some of the gold beads recovered from the Mapungubwe excavations were analysed by H.C. Beck (Fouché 1937). These beads were tested for gold density by the Archimedes Principle, and were studied microscopically for methods of manufacture. The test for purity by submersion in an aqueous solution was unsuccessful due to gas bubbles sticking to the beads during testing. Beck's initial tests revealed that the beads were either wrapped or cast. The gold foil sheets were made by hammering flat and were thereafter cut with a sharp edged object into sections. It was suggested that the holes for/from nails were punched in, and not drilled. Some beads seemed to have been drawn, and then bent around a piece of wire, or wire was flattened and thereafter punched through the centre when cold (Fouché 1937).

Mason (1962) suggested that gold trading started at Mapungubwe with a group of experienced Asian miners teaching indigenous people how to mine and use gold. This opinion was supported at the time by Huffman (1972b). Mason (1962) furthermore noted that at Mapungubwe artefacts that identify the Stone Age were still present, such as bone arrow points and link-shafts. This suggested a gradual transition from a Stone Age to an Iron Age culture, and lifestyle. More importantly ostrich eggshell beads, a popular feature during the Late Stone Age, have been found at this site. Such artefacts were stylistically similar to what Mason (1962) termed the "Later Smithfield" at Magabeng and Olieboompoort, dating to about 820 - 1020 BP, by radiocarbon analysis (Mason 1962: 342).

More recently Huffman (1982) has suggested that trade was occurring already from the 9th to 12th century AD at Mapungubwe, with exotic goods such as glass beads and cloth imported via trading stations in Mozambique. This would have affected the way in which traditional wealth, such as cattle, was viewed. The introduction of this international trade led to a change in the general organisation of cattle managing communities to gold producing and trading communities at Mapungubwe. There was a corresponding ceramic style change, as noted previously, and spatial layout was reorganised, among other changes. However, this was more of an evolutionary change in the cattle managing Bantu culture, rather than an exclusive replacement of this culture (Huffman 1982), as a result of the increased power gained by the group who adopted gold and ivory trade.

Great Zimbabwe

Great Zimbabwe is situated approximately 28 km south-east of the town Fort Victoria, and covers a region of about 60 acres (Fagan 1972). It was first reported by Carl Mauch (1874). Romantic myths about Great Zimbabwe only started changing with the findings of systematic studies by scholars such as Caton-Thompson (1931) and MacIver (1906), and later from the use of a combination of archaeological, and Portuguese and Arabic historical documents. The exact translation from the Shona language of the term "Zimbabwe" is not known, since different connotations have been attached to it over time. Various interpretations have ranged from "the king's court" to "the sacred graves of the chiefs" (Summers 1965). Another possible meaning of Zimbabwe is "houses of stone" (Garlake 1973). The region is dominated by a rocky granite outcrop. On top of this hill is the so-called "Acropolis" (Bent 1892; MacIver 1906). The hill is covered by large boulders, and can be divided into two parts for easier description, the eastern and the western end. Fagan (1972) stated that the western section was relatively unused when compared to the eastern section, and was therefore considered to have been used for ritual purposes. To the south of the hill is a set of ruins, the largest being the "Great Enclosure" or "Temple", consisting of an existing series of walls and a tall tower, among other structures. The hill and surrounding valley sites comprise the site of Great Zimbabwe (Huffman 1996). Great Zimbabwe is situated on the outskirts of a large gold mining region, although archaeologically there were no mines close to the site (Fagan 1972).

The most intense excavations at Great Zimbabwe was performed by Robinson (1958). These excavations revealed five distinct periods of occupation and abandonment.

Period I was identified by the presence of Gokomere Pottery and was followed by a hiatus of unknown length of time. Huffman (1974) noted that this hiatus was followed by a period where socio-economic activities of the occupants of the central plateau increased. This was accompanied by an increase in the number of Shona communities from about AD 1000.

Period II was characterised by Robinson's Class 2 Pottery. It is not known when this period started. It ended at about AD 1075. No stone walls were built during this period. The occupants lived in daga huts. A few imported goods in the form of glass beads were found in the middens. The pottery style was a variation on the Leopard's Kopje design, but was not readily identifiable (Fagan 1972).

Period III lasted from about AD 1075. There is no break in the transition from Periods II to III. It seems as if the Period II huts were demolished and new ones erected, with thicker floors and foundations (Fagan 1972). The southern wall of the Hill was built during this Phase. The South Wall, and other buildings on the Acropolis built at this time were described by Fagan as "P" walling (Fagan 1972). This type of building structure Fagan suggested was built by people who specialised in building on rocky foundations. The pottery texture was finer and the decoration comprised a characteristic row of incised triangles on some pottery artefacts. Glass beads had also changed stylistically in the transition from Period II to III. Period III was also accompanied by the first houses in the valley, 13th to 14th century AD. Summers (1965) stated that this period lasted from AD 1080 to AD 1450, dated by radiocarbon analysis. It has been suggested that this period was the time when Great Zimbabwe became a centre for the elite, and when a complex state hierarchy developed (Garlake 1973).

Period IV was accompanied by the greatest activity in the valley compared to the other periods, which suggested that this period saw the greatest trading taking place. The Great Enclosure was continuously modified. Imported goods, such as glass beads and ceramics increased in quantity. Gold, copper and other metal jewellery and implements were commonly found. The Fourth Period was accompanied by the greatest building activity. Robinson (1966) identified at least eight stages of development at the Great Enclosure during the Fourth Period. The builders of this Period gave special attention to both quarrying and construction. The Great Wall, the Platform and the Conical Tower were built during the second half of this period during the Rozwi occupation. The pottery style of this period generally comprised spherically shaped pots, characteristic of the Rozwi. Pottery from this period dated from between approximately AD 1440 to AD 1833, at which time historical records show that Nguni people led by Zwangendaba ended the dynasty at Great Zimbabwe (Fagan 1972). An even later date was given by C. Mauch (1874) and Summers (1965) who suggested that the destruction only occurred in about AD 1860, about twelve years before Mauch first encountered Great Zimbabwe.

The lack of agreement over the causes of social complexity associated with Great Zimbabwe is mirrored by the lack of agreement on the causes of its eventual decline.

Most of the artefacts recovered from excavations of the early 20th century are lost. The remaining artefacts have been catalogued by Caton Thompson (1931). These include items that were housed at Sheffield University (gold pellets, beads and a coiled gold wire). The other artefacts traced and catalogued included a gold foil fragment and twisted gold wire from the Acropolis area No.4, a gold wire bangle from the Plateau and a small gold bead from the Conical Tower (Caton-Thompson 1931). At present the so-called Rhodes collection is divided into two, one housed at the Groote Schuur Residence and the other at the South African Museum in Cape Town.

Huffman (1974) suggested that since trade led to increased resources, and that surplus goods were produced, this cycle led to the establishment of Great Zimbabwe as a trade centre starting with Period One. Since there is no direct evidence of gold production near Great Zimbabwe, it is possible that other surplus goods were available for trading that could have lead to a stratified hierarchy. It is also true that from Period Two onwards stone buildings were not utilised daily by all in the community, and that rare porcelain has only been found in association with these stone buildings. However, several feel that gold production and trade alone may not have been sufficient to lead to a stratified society (Swan 1994; Pwiti 1991).

The vast amount of architectural work and intrinsic stone artefacts at Great Zimbabwe suggests that it was an important centre of ritual and religion (Garlake 1973). Garlake suggested that religion was the main proponent of the development of stratification and hierarchy, and that religion and ritual were practised intensely at Great Zimbabwe.

Huffman (1974) believed that by the turn of the 15th to 16th century AD Great Zimbabwe was abandoned due to environmental over-exploitation. Furthermore, Huffman calculated that the resources of mines in the near vicinity of Great Zimbabwe were quickly depleted. He claimed that a typical mine in that region would easily have been depleted in one season, and that therefore by the beginning of the 16th century AD the decline of Great Zimbabwe was complete.

Garlake (1973) suggested that the decline of Great Zimbabwe occurred in the mid 15th century, possibly due to a shortage of salt. The community of Mutota dispersed from this site and during this time five stone buildings were erected in the hill slopes of the Mazoe Valley. Trade was then performed by the community of Mwene Mutapa, until the early 16th century AD when trade records of Portuguese and Mediterranean sources stopped.

One should, however, be cautious about suggesting that after about 500 years of intense wealth, power and the ability to purchase food with tools and expensive jewellery, that one year's drought, or shortage in salt could destroy a powerful civilisation.

One point that seems to be agreed on is that Great Zimbabwe was the state capital between AD 1250 and 1450 (Garlake 1973; Huffman 1972a, 1996; Huffman & Vogel 1991; Thorp 1995).

Since the 1970s new work has been done on Great Zimbabwe. Huffman & Vogel (1991) have radiocarbon dated horizons excavated previously. The earliest Period I was dated to about AD 320. They also found that gold from the Great Enclosure was the earliest at this site, associated with levels dated to about AD 1260.

Thulamela

Thulamela is said to mean "place of giving birth / place with no vegetation" (Allen 1996: 24). It is situated 17 km south of the confluence of the Levubu and the Limpopo Rivers. This site was discovered during the archaeological investigations carried out in the Pafuri Region and specifically at the site of Makahane in the early 1960s (Küsel 1992). Recently interest in this site has grown as it has produced among the most valuable information concerning gold studies in the Late Iron Age of southern Africa (Allen 1996). Küsel's (1992) preliminary paper observed that this site represented the earliest known gold processing site in South Africa.

The site can be divided into two main periods of occupation, occurring between the 14th and the 17th century AD (Miller, S. 1996). A nearby site, Makahane, reported by Eloff and de Vaal (1965), was probably occupied between the 17th and the early 19th century AD by descendants of those living at Thulamela. The earlier period at Thulamela had low numbers of glass beads, but substantial quantities of indigenous artefacts such as ostrich eggshell beads and domesticated animal bones. The onset of the main occupation has been dated to about the late 14th century AD because it was associated with late phase Mapungubwe pottery. No stone walls were present at this time. The second phase could be subdivided in two; the first was very characteristic of the Great Zimbabwean pottery tradition associated with the distinctive stone wall design. It was accompanied by a decrease in the number of faunal bones, and an increase in the numbers of glass beads, and therefore imported goods. Although gold was found at these levels it occurred in very limited quantities, suggesting that it had a monetary value to pay other communities. This earlier part of the second period dated to between the 15th and the 16th century AD. The latter part of the second period dated from the late 16th to the 17th century AD. The ceramic style of this period was distinctive, and similar to the Khami Ruins ceramic style. This period was also accompanied by an increase in the number of gold artefacts, and prills or gold "droplets" (Miller, S. 1996: 3). A notable increase in the wealth present at this site from the 16th century AD onwards compared to that at the sites north of Thulamela suggested that this community enjoyed a certain degree of regional independence (Verhoef & Küsel 1995).

The presence of the elite stone buildings at Thulamela in conjunction with the presence of trade goods suggested that the Pafuri region was influenced by the Zimbabwean civilisations further north, possibly due to the discovery of gold in this region. The only two other sites where gold artefacts have been found as far south as Thulamela are Mapungubwe and Machemma, but neither were utilising gold as recently as Thulamela (Küsel 1992). The question of who founded the settlement of Thulamela, or whether it was designed as a trading post has been addressed (Miller, S. 1996; Allen 1996) but has yet to be resolved.

The excavations supervised by Küsel (1992) revealed numerous gold artefacts. Küsel (1992) claimed that these were the first to have been properly provenienced, since the artefacts from Mapungubwe and Great Zimbabwe were not. Evidence for this site has refuted the notion that once Mapungubwe and Great Zimbabwe were deserted, gold ceased to be of importance to indigenous southern Africans (Küsel 1992). Artefacts recovered from Thulamela included slagged crucibles containing gold, indicating actual gold working at the site in the late 16th century AD (Küsel 1992).

Excavations led by S. Miller (1996) of the floors of an area with huts revealed two burials. Both were lavishly buried with gold artefacts including gold wire bangles and gold beads (Miller, D. 1996a; Steyn *et al.* 1998). The first burial excavated was that of a female aged approximately 40-45 years at death. It was buried under the floor of an elite person's dwelling and was buried in a crouched position with both hands under one cheek. The female is commonly referred to as "Losha", as this is the term used to describe the deferential burial position. It displays much respect in the Shona and Venda culture. The gold artefacts in this grave were two bracelets, and one comprising 3 spirally gold strips (Fig. 15). The other was a string of gold beads. The male (commonly referred to as "King Ingwe"), was found wearing gold beads and necklaces. The burial included fragments of an iron helix with gold sections (Allen 1996).

CHAPTER FOUR

MATERIALS AND METHODS

Optical Metallography

This study involved the physical and chemical analysis of a selection of gold artefacts from the two major assemblages of Mapungubwe and Thulamela. A number of specimens from the Rhodes collection housed at Groote Schuur (supposedly from Great Zimbabwe) were included, as well as a single artefact from the site of Bosutswe in Botswana. All the Mapungubwe, Thulamela and Bosutswe material had been catalogued, described, measured, drawn and weighed previously. The Rhodes collection material had simply been listed before the specimens were despatched to Anglo American Research Laboratories (AARL) for trace element analysis. Material forming part of the Rhodes collection housed at the South African Museum was studied visually and described. The material studied is listed in Tables 1 to 4.

Fifty eight specimens from Mapungubwe, fifteen from Thulamela, and the single piece from Bosutswe were selected for metallographic study. These specimens were mounted in acrylic resin, using a venturi vacuum pump to remove any bubbles, and then ground and polished on rotary laps. Two initial grinding stages were used, starting with 600 grit and then 1 200 grit emery paper. This was followed by diamond grinding with one micron diamond paste. The final polish was with $^{1}/_{4}$ micron diamond paste. Contamination was problematic and a less than perfect polish was unavoidable with this soft material. The finally polished specimens were etched with aqua regia (a mixture comprising 40% HNO_3 and 60% HCl) for approximately 30 seconds, and polished and etched again as necessary to achieve an acceptable result. They were then studied metallographically using a Reichert-Jung Polyvar-Pol dual metallographic/petrographic microscope. Microstructural interpretations were made with reference to established archaeometallographic analyses of gold and copper (Maddin *et àl.* 1980; Scott 1991). Copper and gold both have face centred-cubic structures (Scott 1991: 1), and behave mechanically similarly in the nearly pure alloys encountered in this study.

Light Microscopy

The fundamental purpose of the microscope, the magnification of an object, is futile without the element of focus. Thus the definition of microscopy is aptly put by Slayter & Slayter (1992: 1) "the purpose of microscopy is to reveal detail not perceived by the unaided eye," that is, to provide useful magnification. Focus can be defined as the point where the resolution of an object is achieved, that is, when two closely placed objects can be distinguished most clearly, or when the most detail can be seen. This is achieved through various lenses for adjustments to the image.

All microscope systems typically consist of the microscope, the illumination systems (the source and condenser lenses) and the viewing and/or photographing components. The microscopes used in this research were a stereo light microscope and a metallographic/ petrographic microscope. Both microscopes were used for analysing polished and etched samples. These instruments will be described separately.

The stereo light microscope is an Olympus model #B061 incident light microscope, consisting of two sets of lenses, the objective and the ocular lenses. The objective forms the initial image and the final image is provided by the ocular or the eyepiece lens. A fibre-optic light source was used for work on this microscope. The microscope has a magnification range of between 0.8x and 20x. The image directed to the camera film occurs by redirecting the source of the object image from the right eyepiece through a projection lens to the camera. Photographs on this microscope were taken with an Olympus OM101 Power Focus automatic SLR camera. All pictures taken were in black and white, with a film speed of 400 ASA.

The dual petrographic/metallographic microscope is of the Reichert-Jung Polyvar series, with both incident-light and transmitted light capability. It has a flat field of view. Magnification extends from 20x to 1000x. This microscope was used in the incident light mode only, in which light is projected through the objective lens and reflected back through the objective and ocular system. Images for photographs are directed to the camera film from an image off the objective lens. Pictures were taken using slide film, with an film speed of 100 ASA.

Trace element analysis: Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS)

Archaeology has become heavily dependent on chemical analytical techniques. Mass spectrometry is arguably the most utilised of these methods, with Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) being the most popular at present. Even though early research was at a disadvantage due to its complexity, the technique showed considerable potential (Gihwala *et al.* 1986), as consideration of this technique progressed.

The recently developed and increasingly popular ICP-MS analytical technique has given scientists a new means of measuring both isotopic and elemental signatures very quickly and economically and with great sensitivity (Young *et al.* 1997). The growing popularity of ICP-MS amongst archaeologists is due to various factors. It is relatively easy to perform analyses rapidly compared to many other ICP dependent analytical techniques. Furthermore, only small sample amounts are required, and it is relatively non-destructive so the scope for analytical applications is broadened.

The technique is applicable to a wide range of materials both organic (such as hair), and inorganic (such as gold) with laser ablation sampling. There is no need for sample preparation, thereby reducing the element of experimental error. If corroded, the surface of metal artefacts can be penetrated by laser drilling and a deeper section of the metal can be sampled. The technique as used in this work aims at deriving semi-quantitative data, that is, only the presence or absence of a selected number of elements or isotopes are required to produce a trace element fingerprint. There is a large sample chamber, and therefore whole artefacts can be tested.

Laser mass spectrometry filters by mass, with a resolution of one atomic mass unit, and counts the number of ions or molecular ions ablated at each mass from the sample. ICP-MS does this by focussing the ions of one element at a time in a quadrupole using RF and DC voltages to count these ions. Two methods of ICP-MS analytical techniques are available; either by sample introduction as a solution or by laser ablation. In the latter, a laser beam vapourises a small volume of sample which is aspirated into a plasma flame by an argon stream. In this plasma flame the gas is ionised, and the charged ions are accelerated into a mass spectrometer counter where the entire periodic table is scanned very rapidly. Since the count rate is related to the elemental concentrations, the relationship usually needs to be calibrated due to changing analytical conditions. In the case of the fingerprinting analysis, only the presence and absence of ionised species is established, and thus calibration is unnecessary.

The technique used for the gold analysis in this project was Laser Ablation ICP-MS (LA-ICP-MS). The whole artefact was put into a chamber where a laser vapourised an almost invisible part of the gold (thereby minimising destruction). The upswept gas was transported to the plasma torch where the gas was atomised and ionised into positively charged ions. In the technique used here the presence or absence of each of the 234 naturally occurring isotopes potentially would be recorded and this resulted in a unique signature that could in theory be matched to the closest matching geological deposit.

The application of ICP-MS in sourcing gold samples is aimed at identifying a trace element signature of the gold sample and correlating it with the most suitable geological source (Goldstuck 1996). It is assumed that the sources from the same geological region have distinctive similarities in their fingerprints (Grigorova *et al.* 1998, 1999).

Two obvious possible disadvantages have been identified. The first is that the sample size is limited to the size of the door of the laser ablation chamber, which is not a problem with the small gold samples. The other more serious, somewhat paradoxical limitation is that the technique used here is semi-quantitative, which means that samples such as these studied here could probably not be identified to distinct geological sources. However, since the project aimed to associate samples only with distinct geological regions of southern Africa, as well as taking advantage of financial and time saving, this method of analysis was most suitable.

The AARL team initially performed time resolved analyses on the artefacts, essentially boring a hole with the laser to ensure that material analysed was not contaminated gold found on the surface of the artefact. In general the surfaces were uncontaminated and where there was contamination, it was surficial. In the subsequent analyses this surface layer was removed by a preliminary surface ablation. The artefacts were tested several times across their surface areas, and each area was sampled six times to ensure representative sampling.

CHAPTER FIVE

DESCRIPTION OF ARTEFACTS

Mapungubwe

Most of the gold from the Greefswald sites was poorly provenienced, but by far the majority originated from the burials on the Hill (Fouché 1937). Two sample sets have been analysed. The first, M1231 A-Q, is from the University of Pretoria collections. The second set, UCT A-L, is permanently housed at the University of Cape Town. These samples were tested for silver content by energy dispersive X-ray (EDS) fluoresence by Duncan Miller at UCT, and trace element concentration (ICP-MS) by Suzanne Young at Harvard University. The ICP-MS analysis conducted at Harvard University determined the concentrations of a selected suite of elements. These preliminary results revealed five distinctly recognisable patterns based on the total concentrations of the platinum group metals. Since these samples had relatively high concentrations of silver (confirmed by EDS analysis at UCT), it was suggested that the gold analysed was probably mined from reefs (S. Young, pers. comm.), where leaching of silver is less likely than in alluvial and eluvial deposits.

Due to the lack of detailed provenience all the Mapungubwe gold samples provided by the University of Pretoria for analysis were classified as a single group and all the mounted artefacts were labelled M 1231. There were seven beads, one gold globule, four pieces of gold helices, two tacks, one piece of wire, one foil sheet and one strip wire. Two additional beads from the University of Pretoria collections were labelled M 870 and M 1118 respectively. The UCT Mapungubwe objects were labelled UCT A through to UCT L. This group consisted of four tacks, one helix, one sheet, and beads divided into four subgroups (on the basis of their size and mode of manufacture) containing six beads, three beads, fifteen beads, and seven beads respectively. Twenty eight gold artefacts were analysed metallographically and are described below. Microhardness testing was performed on seven of the beads using a digital microhardness tester, with a load of 10 g and a 10 second dwell time (Table 5).

M1231 A

Description: This is a round gold bead with a visible join. The sides have not been flattened. The bead has a diameter of 3.5 mm, a height of 2.2 mm and a mass of 0.191 g.

Structure: This is a wrapped bead. The grain structure is fairly homogeneous. There is a visible open join. It has a Vickers microhardness of HV 48 (10g, 10 s, n = 3, range 45 - 51).

Constituents: There are a few cracks on the inner margin. A visible join is present. The bulk of the metal consists of angular recrystallised equi-axed grains with bent annealing twins caused by hot or cold working.

Grain Size: ASTM 6-7. (ASTM: American Society for Testing and Materials (1981)).

Deformation: The grain structure shows substantial grain deformation, with the grains on the inner margin tightly squeezed together, and those on the outer margins being elongated. Towards the join from either side, all the grains are elongated; with intense cold-working visible at the join itself. The inner margin contains a few cracks and protuberences that have been flattened probably from stringing wear preceded by crystallisation. Some lamination occurs on the external margins, possibly from natural wear.

Fabrication: A strip was cut from a hammered sheet and then annealed before being wrapped around. The ends were worked cold. The outer margin was cold worked, most probably through use wear.

M1231 B

Description: This sample is a round gold bead with a visible join. The sides have not been flattened. The bead has a diameter of 3.2 mm, a height of 1.5 mm and a mass of 0.099 g.

Structure: The material structure is fairly homogeneous. Lamination and elongated voids occur all along the inner margins, and five irregular voids are present on the outer margin. A join is clearly visible from one margin to the other. It has a Vickers microhardness of HV 67 (10g, 10 s, n = 2, range 66 - 67).

Constituents: The bulk of the grains are recrystallised, angular and equi-axed, with straight annealing twins.

Grain Size: ASTM 5.

Inclusions : There are no inclusions in the metal.

Deformation: The grains around the join are deformed, lengthened and curved. The outer margin has a small amount of local deformation and smearing. The inner margin contains some lamination and deformation, probably due to smearing, as well as a few strain lines.

Fabrication: A strip was cut from a hammered sheet and then annealed before being wrapped around cold, preserving the rough inner surface. The join was then hammered closed by cold working. The outer margin was cold worked or burnished, most probably through use wear.

M1231 C

Description: The artefact is a round gold bead with no visible join, but has a four-fold punch mark on one side. It has a diameter of 2.1 mm and a thickness of 1 mm. Its mass is 0.041g. It has a Vickers microhardness of HV 56 (10g, 10 s, n = 3, range 55 - 56).

Structure: The material is fairly homogeneous. There are two small voids on the inner margin. There is no visible join.

Constituents: The grains are recrystallised, angular and equi-axed, however, a few strain lines are present. Lots of bent annealing twins occur.

Grain size: ASTM 4.

Inclusions: There are no inclusions in the metal.

Deformation: On the outer margin, many slip bands and elongated grains occur. The bulk of the material contains a few slip bands. On the inner margin two voids occur opposite each other, and slight smearing is present.

Fabrication: A cast droplet was perforated with a four-sided punch, followed by annealing. Mild cold working in the form of slip bands and bent annealing twins on the outer and inner margins was probably caused by use wear.

M1231 D

Description: The specimen is a round gold bead with no visible join. The sides are flattened. It has a diameter of 1.9 mm, and a thickness of 1 mm. Its mass is 0.037 g.

Structure: The bead has large serpentine voids. The original material was homogeneous. There is no visible join. Four stress fractures running through the cross-section of the sample correspond to the punch marks.

Constituents: The grains are recrystallised, angular and equi-axed. Numerous slip bands occur in the body of the object, as well as some twinning.
Grain Size: ASTM 5-6.
Inclusions: There are no significant inclusions in the metal.
Deformation: On the inner margin, one section is heavily deformed due to cold working, possibly burnishing, which has resulted in smeared areas. Voids are associated with crumpling of the layers of metals. The outer margin contains strain lines due to cold work. Elongation and deformation of the outer margin grains has occurred. In the bulk of the material there are four stress fractures that correspond to four punch marks in this area.
Fabrication: A cast droplet was perforated cold and then annealed, causing twinning. Thereafter it was cold worked (locally) on the inside, and substantially on the outside, most probably from use. This resulted in smearing and the slip bands occurring on the outer margin.

M1231 E
Description: This is a round gold bead with no visible join. There are a number of voids on the inside and the sides have been smoothened. The bead has a diameter of 2.1 mm, a height of 1.3 mm and a mass of 0.045 g.
Structure: The material structure is homogeneous. There is no visible join.
Constituents: The bulk of the grains are angular, equi-axed and recrystallised. Some of those on the edges are elongated. There are voids on inner margin, while on the outer margin strain lines occur. Bent annealing twins are present.
Grain Size: ASTM 6-7.
Inclusions: There are no inclusions in the metal.
Deformation: Intense cold working can be seen on the inner surface associated with crumpling and delamination at the voids. The grains are flattened circumferentially. The twin bands are bent by cold working also responsible for slip bands, strain lines and elongated grains in the outer third of the artefact. The bulk of the material consists of smallish grains with bent annealing twins. On the inner margin, four voids and elongated grains corresponding to punch marks occur. Smearing possibly resulted from stringing wear.
Fabrication: A cast droplet was punched cold and then annealed. Thereafter the bead was thinned, or flattened, seen from elongated grains, and then cold worked as seen on

the inner and outer margins. The outer margin became smoothed and smeared, most probably through use wear.

M1231 F

Description: This is a round gold bead with no visible join. It is grooved, with five grooves on the outer circumference. The bead has a diameter of 3.4 mm, a height of 2 mm and a mass of 0.201 g. It had a Vickers microhardness of HV 58 (10g, 10 s, n = 2, range 47 - 69).

Structure: The grains are fairly homogenous in the bulk, except at the voids that occur on the inner margin and at the grooved marks on the outer margin.

Constituents: The bulk of the grains show annealing; that is, recrystallised grains and straight twins. Heavy cold working occurred at the outer and inner regions and potentially at the base of the indentations, as seen by the presence of numerous slip bands.

Grain size: ASTM 5.

Deformation: Severe deformation, crumpling and flattening of the grains occur in the base of the grooves of the outer margin. Bent twinning is present in the grains immediately surrounding the grooves. In the bulk of the material slip lines occur throughout due to cold work. On the inner margin severe grain deformation and flattening occurs, as well as lamination due to smearing. The originally round hole was deformed into its pentagonal shape by the indentation of the five external grooves.

Fabrication: A cast droplet was perforated cold and then annealed. Five ornamental grooves were impressed cold into the outer margin causing cold work and deformation and distortion of the inner bore.

M1231 G

Description: This is a round gold bead nodule with five grooves on the external diameter. It does not have a visible join. The bead has a diameter of 2.2 mm, a height of 1.1 mm and a mass of 0.043 g.

Structure: The structure of the bead is homogeneous with large irregular voids. Two voids occur on the inner margin closest to two of the grooves and the third one is situated in the bulk.

Constituents: The grains of the bulk of the metal are recrystallised and angular. Numerous slip bands occur.

Grain Size: The grain size is extremely varied, with the grain size in the bulk, or centre being larger. Fine grains are associated with deformation around the voids, and on both the inner and outer margins.

Larger Grains: ASTM 5

Smaller Grains: ASTM 10

The reason for the varied grain size is possibly due to the larger grains having been less deformed by cold working before final annealing.

Inclusions: There are no visible inclusions.

Deformation: Slip bands occur mostly in the larger elongated grains. These bands are bent and residual. Original deformation appears to be associated with the voids. The original slip bands in these grains are now bent from subsequent cold working. There is heavy deformation of the grains at the base of the ornamental indentations. On the outer margin there are five grooves with associated strain lines and elongated flattened grains. Lamination of the inner margin possibly resulted from plastic smearing in use.

Fabrication: A cast droplet was perforated with a punch. Thereafter five grooves were impressed cold into the outer margin. The inner margin was smoothed by smearing, possibly in use.

M1231 I

Description: This is a helical strip or coil fragment made of a flat strip, with the edges cut into bevels. The internal appearance is rough. Its length is 13.5 mm, 1.5 mm wide and 0.3 mm thick. Its mass is 0.221 g.

Structure: The artefact is fairly homogeneous, with no large voids present.

Constituents: The grains are recrystallised, angular and equi-axed , while annealing twins are present there are no slip bands. The inner margins are rough and the outer margins smooth.

Grain Size: Although the grain size is consistent in size it is fairly small. ASTM 6-7.

Inclusions: There are no inclusions.

Deformation: The original equi-axed grains have been deformed. The grains were then recrystallised due to annealing.

Fabrication: A strip was cut from a hammered sheet on a rough anvil. The strip was chisel cut from the "inside" forming a trapezoidal cross-section tapering towards the rough inner surface. It was then wrapped into a helix, possibly around a fibre core (not preserved). Finally the outer surface was burnished and flattened.

M1231 J

Description: The artefact is a helical fragment strip with the edges bevelled. There is a rough appearance inside. Its length is approximately 10 mm, 1.5 mm wide and 0.3 mm thick. Its mass is 0.175 g.

Structure: The grain structure is fairly homogeneous. No voids are present. However, the edges have been ground away.

Constituents: The grains are recrystallised, angular equi-axed and contain straight annealing twins and no slip bands.

Grain size: ASTM 5-6. The grain size is constant throughout the sample.

Inclusions: There are no inclusions in the metal.

Deformation: The original material was annealed forming an equi-axed structure. No subsequent deformation can be seen on the artefact.

Fabrication: A strip was cut from a hammered sheet on a rough anvil resulting in one rough side (the underside). The strip was cut from the inside forming a trapezoidal cross-section tapering towards the rough inner surface. The strip was wrapped into a helix (possibly around a fibre core) and the outer surface was finally burnished and flattened.

M1231 K

Description: The artefact is a helical strip fragment, with the inside rough and the edges bevelled. Its length is 12.5 mm, 2 mm wide and 0.3 mm thick. Its mass is 0.090 g.

Structure: The grain structure is fairly homogeneous, with no voids present.

Constituents: The grains are recrystallised, angular and equi-axed. No slip bands or voids occur. Annealing twins are present.

Grain Size: The grain size is more or less consistent throughout the sample, and quite large. ASTM 3.

Inclusions: There are no inclusions.

Deformation: No extensive deformation occurs anywhere throughout the sample, and it was thoroughly annealed after cold working, as evidenced by the large grain size.

However, there is slight deformation of the equi-axed grains of the margins. Both sides are rough.

Fabrication: The original deformation of the equi-axed grains was removed by recrystallisation through annealing, which was followed by some cold working. A strip was cut from hammered sheet and then annealed. The strip was coiled to form a helix, with the cut bevels on the inside.

M1231 L

Description: This piece is a flattened fragment of gold. The edges are bevelled and the inner margin is rough. It is 11.5 mm long, 1.6 mm wide and 0.3 mm thick. Its mass is 0.089 g.

Structure: The structure is very homogeneous. There is a rough texture on the inner as well as the outer margin.

Constituents: The grains are recrystallised, angular and equi-axed and contain annealing twins. The annealing twins are generally straight.

Grain size: The grains are very large. ASTM 4.

Inclusions: There are no inclusions.

Deformation: There are no visible signs of working on the outer margin. There are no visible joins. The bulk of the material contains annealing twins with no slip bands. The inner margin has rough numerous pits and protuberances from hammering on a rough anvil. However, there is no evidence of crumpling at the margins.

Fabrication: The original material was hot or cold worked and then annealed causing straight twins and a large grain size in the bulk of the metal. The sheet was cut from one side with a sharp edged object. One side was smeared or burnished. It is probably a flattened fragment of helical strip.

M1231 M

Description: This artefact is a fragment of a flat sheet. It is 6 mm at its longest dimension and 0.2 mm thick. Its mass is 0.037 g.

Structure: The grain structure is fairly homogeneous. Two kinks, representing a fold, are present in the sheet.

Constituents: The grains are recrystallised, angular and equi-axed. Lots of bent twinning occurs in the bulk of the material.

Grain Size: ASTM 6.

Inclusions: There are no significant inclusions in the metal.

Deformation: Strain lines are present in numerous grains due to cold work. The twins are bent and there are several slip bands and voids. Both the outer and inner margins are pitted. Two areas of intergranular corrosion occur, possibly related to a locally high silver content.

Fabrication: A piece of gold was hammered flat on a rough anvil with at least one annealing stage, and made rough on both sides by burnishing.

M1231 N

Definition: The artefact is a wrought tack or nail. The head has a diameter of 1.5 mm and the nail has a length of 4.8 mm. Its mass is 0.062 g.

Structure: The grain structure is fairly inhomogeneous especially around the void, which is present through the length of the sample. Two longitudinal cracks occur down the length of the tack.

Constituents: The grains are heavily deformed, especially at the margins. There are a few bent annealing twins, and strain lines are common.

Grain Size: Inner /Centre grains: ASTM 5-6; Outer grains: ASTM 6-8.

Inclusions: There are no inclusions in the metal.

Deformation: Two longitudinal voids run through the length of the sample. Deformed grains occur especially at the edges and at the tip of the sample. The head shows severe cold working, since it was flattened. Both sides are smoothened. In the bulk of the material two voids occur, possibly being evidence of lamination, from the tip to the centre of the nail. The grains are generally highly deformed.

Fabrication: A piece of wire was hammered into a tapered four-sided wedge, which incorporated longitudinally running voids. It was cut off with a chisel. The head was formed in use, resulting in cold work damage. Penetration through some substrate deformed and flattened the grains on the outer margins, causing strain lines.

M1231 O

Description: The artefact is a wrought tack. The head has a diameter of 1.4 mm and the nail has a length of 4.8 mm. Its mass is 0.045 g.

Structure: The structure is quite inhomogeneous, with several voids occurring in the sample. Two longitudinally running voids occur with one large void being present in between the smaller ones at the tip.

Constituents: All the grains are small, and strain lines appear on several grains. Bent twinning is present.

Grain Size: ASTM 8-9. This is consistent throughout the sample.

Inclusions: There are no inclusions in the metal.

Deformation: In the head of the tack the grains are flattened and the edge smoothened. Both sides are smeared. The centre of the tack is slightly less cold worked than at the margin.

Fabrication: The end of a piece of wire was hammered cold into a four-sided wedge, which incorporated longitudinally running voids. It was cut with a chisel. The head was formed in use, resulting in flaring and cold work damage. Penetration through a substrate smeared the grains on the outer margins, causing strain lines through cold work.

M1231 P

Description: The object is a helix made from squarish wire that has been flattened on the outside. It is approximately 15 mm long, 2 mm in helix diameter, and 0.5 mm in wire diameter. Its mass is 0.155 g.

Structure: The material is fairly homogeneous.

Constituents: Recrystallised, angular and equi-axed grains occur with annealing twins. There are no slip bands.

Grain Size: ASTM 4-5.

Inclusions: There are no inclusions in the metal.

Deformation: There is no deformation except for the bevelling or flattening of the sample outer margins. The margins are smeared.

Fabrication: A wire was most probably hammered and thereafter coiled cold. The outer margins were flattened by abrasion possibly in use, producing a D-shaped cross-section. Finally, the object was annealed, possibly accidentally.

M1231 Q

Description: This is a helical fragment similar to M1231 P. It is approximately 9.2 mm long. Its mass is 0.042 g.

Structure: The material is fairly homogeneous, with a few voids. Pitting occurs on the outer surface.

Constituents: The grains are recrystallised, angular and equi-axed and contain annealing twins. No slip bands are present.

Grain Size: The grains are all large. ASTM 4-5

Inclusions: There are no inclusions in the metal.

Deformation: No deformation is visible except for some bevelling or flattening of the outer margins due to smearing.

Fabrication: A wire was hammered and thereafter coiled probably cold. The outer margins were flattened by abrasion, producing a D-shaped cross-section. Finally the object was annealed, possibly accidentally.

The classification UCT K describes a collection of 15 beads. The combined mass of these beads is 0.842 g. Four have been studied metallographically.

UCT Ka

Description: This is a small bead (cut for trace element analysis), with a central void through the cross-section of the artefact.

Structure: The grain structure is inhomogeneous. Several voids are present. Two stress fractures run through the bulk to the inner margin. Few voids are present, as well as strain lines.

Constituents: Several slip bands are present. The outer margin has a rough texture while the inner is smooth. Heavy cold working with strain lines and grain crumpling is visible, especially on the inner and outer margins.

Grain Size: ASTM 5-6

Inclusions: There are no inclusions in the metal.

Deformation: This bead is very inhomogeneous and deformed. The outer margin consists of smeared layers. Two stress fractures run through bulk to inner margin. In the bulk of the material there is one only large void with a few strain lines present, while there are several in the outer margin. On the inner margin there is generally a smoothened edge but several strain lines occur as well as one void running from the outer to inner margin.

Fabrication: A strip was cut from a poorly consolidated, hammered sheet and then annealed. The strip was bent around cold in order to form a bead with a join. The outer margin is smeared, most likely due to use wear.

UCT Kb

Description: The artefact is a round small bead (cut for trace element analysis). One void occurs through the entire width of the sample.

Structure: The material is homogeneous. Several voids are present throughout the sample, on both the inner and outer margins. There is a possible join.

Constituents: There are a few twin lines present. Several slip bands occur on the outer margin, and a few bent twins are present in the bulk of material. There are some residual angular annealing grains.

Grain Size: The grain size is variable.

Inner margin:	ASTM 9-10
Outer margin:	ASTM 8-9
Centre:	ASTM 6

Inclusions: There are no inclusions.

Deformation: The outer margin consists of smeared, flattened, elongated grains and one void. The bulk of the material contains bent twins and strain lines. There are several continuous voids along the circumference of the inner margin. The grains on the outer and inner margins have been elongated. The grains at the edges are flattened, either from deliberate cold working or extensive wear. Around the possible join crumpling of the grains occur, along with strain lines.

Fabrication: A cast droplet was punched cold and then annealed. Thereafter the bead was thinned, or flattened, seen from elongated grains, and then cold worked as seen on the inner and outer margins. The outer margin became smoothed and smeared, most probably through use wear.

UCT Kc

Description: This is the remains of half of a bead that has been sampled for trace element analysis. A void runs through a quarter of the centre of the circumference of the artefact.

Structure: The material structure is inhomogeneous, and the sample contains several voids. One large one extends though the circumference of the bead, at the centre of the diameter.

Constituents: The annealing twins have all been bent.

Grain Size: The averages range between ASTM 10 and ASTM 7-8. The outer half's grains are smaller than the inner. Smearing occurs on inner margin.

Inclusions: There are no inclusions in the metal.

Deformation: Voids are present throughout the sample. The outer margin contains slip bands and elongated flattened grains, as well as two voids due possibly to smearing. The bulk of the material contains slip bands, bent twins and elongated grains. There is one large void in the bulk. The inner margin is smeared and contains one void. Here the grains are mostly flattened.

Fabrication: A strip was cut from a hammered sheet. The strip was bent around cold to form the bead and then annealed. Subsequent smearing resulting from use wear causing bent twins and voids to develop on the inner and outer margins.

UCT Kd

Description: This is the remains of a small round gold bead (sampled for trace element analysis). The outer and inner margins appear smooth.

Structure: The material structure is homogeneous and there is a possible join.

Constituents: There are a few bent twins on the outer and inner margins, as well as strain lines in the bulk of the material. There is no evidence of lamination.

Grain Size: Centre: ASTM 6

Very outer margin: ASTM 10

The grain size is generally larger that what the previous three small beads were.

Inclusions: There are no inclusions in the metal.

Deformation: Voids are present throughout the sample, two being cross sections right through the bead. Only one void has the adjacent grains running in the same direction as the direction of the void. The outer margin contains flattened and elongated grains; the edge is smeared. In the bulk of the material the grains are larger and contain bent twins; three voids are present. The inner margin contains smearing resulting from stringing wear with one void running towards the bulk of material.

Fabrication: A wire was wrapped around to form a bead with a join. Thereafter the bead was thinned, or flattened, seen from elongated grains, and then cold worked as seen on the inner and outer margins. The outer margin became smoothed and smeared, most probably through use wear.

UCT D

Description: This tack was sampled in the middle for chemical analysis, leaving the point and head. It was originally 7.1 mm long and its mass was 0.135 g.

Structure: The material is relatively homogeneous. It is more smeared on one side than on the other. The point is heavily damaged.

Constituents: The grains are elongated along the length of the sample. Although there are some bent twins, they are rare.

Grain Size: ASTM 4-5

Inclusions: There are no inclusions in the metal.

Deformation: At the head end one void occurs at one corner. The end is not as heavily worked as UCT C, which is similar. In the bulk of the material elongated grains run along the length of sample. Strain lines are present due to cold working in the final phase of manufacture, or in use.

Fabrication: The end of a piece of wire was hammered into a tapered four-sided wedge, which incorporated longitudinally running voids. It was cut with a chisel. It is possibly an unused tack.

UCT C

Description: This is the remainder of a nail. It consists of two sections. The head is still present. It was originally 7.1 mm long and its mass was 0.135 g.

Structure: Although the material is relatively homogeneous it is less so than UCT D. It is smeared on one edge and smooth on the other.

Constituents: The grains are elongated along the length of the sample. Strain lines are present as well as a few bent twins. There are elongated, flattened grains in the bulk of material. A few residual slip bands remain. In general it is heavily deformed and cold worked.

Grain Size: Centre ASTM 7-8
Outer margin ASTM 5

Inclusions: There are no inclusions in the metal.

Deformation: The head is flattened and contains voids on its outer edge. It has flattened and elongated grains. One side of the tack is smooth while the other is smeared. In general there is heavy cold working throughout the tack.

Fabrication: A piece of wire was hammered cold resulting in a tapered four-sided wedge, which incorporated longitudinally running voids. It was cut with a chisel. The head was formed in use, resulting in cold work damage. Hammering through a substrate smeared the grains on the outer margins, causing strain lines.

UCT F

Description: The artefact is a gold sheet that has been bent. The apex has been ground away, resulting in two exposed areas. It has six punch holes which flare towards the inside. The sheet is rough on the inside and scored or burnished on the outside. Its mass is 0.368 g.

Structure: The material is fairly homogeneous. No voids are present.

Constituents: The grains are equi-axed, angular and contain bent twins.

Grain Size: ASTM 4-6. Although the grain size is relatively small, it is constant.

Inclusions: There are no inclusions in the metal.

Deformation: There are no voids. The grain size is consistent, but both sides are smeared and pitted, the sheet is heavily annealed. The outer margins are rough.

Fabrication: A nodule of gold was hammered out on rough anvil producing a sheet. This was annealed, followed by post-annealing deformation.

UCT I is a collection comprising six gold beads some with no visible join, and with four-fold punch marks. A few are folded beads. The average diameter is between 3.5 and 4 mm, with a height of 1.8 to 1.9 mm. The combined mass is 1.718 g.

UCT I1

Description: The artefact is a large round gold bead that had been sampled for trace element analysis.

Structure: The structure is fairly homogeneous. There is one void on the outer margin which possibly resulted from use. It had a Vickers microhardness of HV 72 (10g, 10 s, n = 4, range 64 - 80).

Constituents: The annealed grains contain very few visible straight twins. Mostly bent twins and strain lines occur in the bulk of the material. The inner margin. is heavily cold worked but some residual angular grains remain together with numerous slip bands.

Grain size: The inner margin: ASTM 9-10
The outer margin: ASTM 8-7
The centre: ASTM 5

The grain size is smaller, deformed and elongated on the outer margin and the grains are elongated only on the inner margin.

Inclusions: There are no inclusions.

Deformation: The outer margin's grains are crumpled, flattened and elongated. The bulk of the material contains strain lines and bent twins in most of the grains. The inner margin consists of crumpled grains; most of the strain lines occur here while two voids are present on the edge.

Fabrication: A cast droplet was punched cold and then annealed. Thereafter the bead was thinned, or flattened, seen from elongated grains, and then cold worked as seen on the inner and outer margins. The outer margin became smoothed and smeared, most probably through use wear

UCT I2

Description: The artefact is a round gold bead (sampled for trace element analysis).

Structure: The structure is homogenous at the centre of the bead but there are several voids on the outer margin.

Constituents: There are bent annealing twins and strain lines in the grains of the bulk of the material.

Grain size: ASTM 5

Inclusions: There are no inclusions.

Deformation: The outer margin is evenly worn which could have been due to cold working or use by the wearer. There are no visible joins, except for the voids. On the outer margin smearing occurs on part of the outermost layer, incorporating long voids which were probably a result of lamination. The inner margin has elongated flattened grains.

Fabrication: A gold prill was flattened and punched through. Smearing on the inner and outer margins occurred from use wear.

UCT J was a collection of two gold beads that have been made from rough wire with bevelled edges. The average diameter is 4.5 mm and the average height is 1.7 mm. The combined mass is 0.378 g.

UCT J1

Description: The artefact is a small round gold bead (cut for trace element analysis).

Structure: The material is relatively homogeneous. It had a Vickers microhardness of HV 70 (10g, 10 s, n = 3, range 69 - 74).

Constituents: There is evidence of bent twinning and strain lines across several parts of the sample. Residual equi-axed, angular grains with numerous slip bands occur.

Grain Size: ASTM 5-6

Inclusions : There are no inclusions in the metal.

Deformation: The outer margin's grains are crumpled, flattened and elongated. The bulk of the material contains strain lines and bent twins. The inner margin has crumpled grains where most of strain lines occur, two voids occur on the edge of this margin. In general there is evidence of cold working on both outer and inner margins.

Fabrication: A wire was wrapped around. Thereafter the bead was thinned, or flattened, seen from elongated grains, and then cold worked as seen on the inner and outer margins. The outer margin became smoothed and smeared, most probably through use wear.

UCT J2

Description: The artefact is a small round gold bead that has been cut for trace element analysis.

Structure: The material is relatively homogeneous.

Constituents: The grains are angular and equi-axed. Some straight annealing twins remain.

Grain Size: ASTM 6

Inclusions: There are no inclusions in the metal.

Deformation: Smearing occurs on the outer margin, and lamination is visible on the inner. Several voids run through the centre of the circumference of the sample. Two run parallel to the outer edge about 1/4 way deep and about 1/10 of the circumference of the bead. One large void runs along the length of the inner region.

Smearing on the outer margin caused voids and crumpled grains here. The bulk of the material contains annealed bent twins. The inner margin contains lamination and cracks with several voids. Large voids occur near the join, while cold work is visible around the join.

Fabrication: The bead was possibly a lamination of two sheets bent around cold. The bead was then worked hot or cold to its final shape, that left the voids on the inner margin, and the artefact was annealed. This did not get rid of all the bent twins. Finally the outer surface was roughly burnished whereas the inner surface became smeared through stringing wear.

Great Zimbabwe

The gold from Great Zimbabwe housed at the South African Museum was donated by Cecil John Rhodes in 1874. These pieces were described and analysed here. They were unprovenienced, and several artefacts were fragmented. There were in total 16 pieces of foil, 146 tacks, 64 beads, 21 pieces of assorted wire, 7 links, 5 nuggets and 9 spherical cast droplets.

All the artefacts were examined and representative artefacts were chosen for more detailed macroscopic description. The purpose of this analysis was to address similarities and differences between the artefacts from Great Zimbabwe and the artefacts from Mapungubwe and Thulamela. Preference was therefore given to the artefacts apparently different from those found at the other sites and to those pieces for which the methods of fabrication could be defined.

The museum catalogued the artefacts in groups (by catalogue number) that comprised predominantly one type of artefact. The artefacts were glued onto a flat opaque surface for exhibit purposes; thus they could only be viewed from one side.

SAM 7904: Three pieces of gold foil.
Structure: Only the underside of the first piece is visible. It has nineteen punch marks, which are more or less square. One straight edge (length 20 mm) can be seen, suggesting that this side was not damaged after being cut with a blade. The rest of the side lengths are 8 mm, 15 mm and 18 mm. The top side of the second piece is visible. The longest length from the apex to the base of the piece is 19 mm. One punch mark and burnishing marks are present on the second piece. It is irregular and is creased and pleated. The top side of the third piece is visible and contained three punch marks. Three sides were measurable, and were 13 mm, 14 mm and 18 mm long respectively. Burnishing marks in the form of fine grooves are present. There are two straight cut edges. The piece had been polished post-excavation.
Fabrication: Sheet was beaten from a nodule of gold on a rough flat surface. The foil was then placed on an object to be covered, and attached using gold tacks. Finally the exposed surface was scratch burnished in order to create a shine.

SAM 7905: Section of gold wire.
Structure: The wire has been twisted at one end. The length of the artefact is 27 mm with the twisted section comprising 12 mm. The twisted section is slightly out of line with the rest of the wire. Smearing marks occur on the untwisted section.
Fabrication: Wire was made by hammering and flattening a fragment of material. Finally one end was tightly wound by twisting.

SAM 7906: This catalogue number is a set consisting of seventeen gold beads, and offcuts and fragments of various artefacts.
Structure: Ten of the beads are punched and four are wrapped. The rest are unidentifiable by type. The fragments are mainly offcuts. Within these fragments and offcuts there are pieces that can be categorised as bevelled rod sections, cast blobs, used and unused tacks, and pieces of tightly wound wire similar to SAM 7905.
Fabrication: The punched beads were formed by perforating a cast droplet with a four-sided punch. A few pieces are better preserved than others, or less worn.

SAM 7907: This group consists of thirteen pieces of gold foil.
Structure: All the pieces are fragments. Four pieces are burnished; these pieces are glued down face up, i.e. the side that was burnished is exposed. There are no punch marks. All the pieces are less than 1 cm^2 in surface area.
Fabrication: A nodule of gold was beaten on a flat surface. Thereafter the sheet was cut (seen by the straight sharp edges) into smaller sections, possibly to make it more easily malleable. Afterwards the foil would be applied to some sort of substrate, and attached using tacks. Finally the exposed surface was burnished leaving fine grooves, resulting in a shine.

SAM 7908: This group consists of fourteen gold rod sections.
Structure: Two were cut from rolled wire and twelve were cut from beaten wire that was flattened afterwards. The pieces cut from rolled wire are also the two smallest sections.
Fabrication: A nodule of gold was beaten or rolled and stretched into wire. This resulted in the wire being flattened, often creating a facetted cross-section.

SAM 7909: Forty two gold tacks comprise this group.

Structure: Some nails have no heads. Most have four flat sides. The largest nails are 7 mm long and are unused. The shortest are 3 mm long and used.

Fabrication: A wire of approximately 3 to 5 mm thick was sharpened at one end by striking with a hammer and rotating 90° to the previous blow to create four flat sides. The sharp end was then cut off with a blade or chisel in a similar fashion to that used to cut bevelled rod sections. Once the tack was used and hammered into some object such as wood, the tack was deformed and a head would result at the struck end. The used nails are generally shorter, are bent and have heads.

SAM 7910: Various pieces of wire.

Structure: Both beaten and cut (seen by long even blade-like induced longitudinal slices along the wire) wire is present. There are two types of coiled wire; one like the end of SAM 7903 and the other was made from a flattened strip. Equal quantities of rolled/beaten and cut wire is present.

Fabrication: A nodule of gold was beaten, rolled and stretched into wire. This resulted in the wire being flattened, often creating a facetted cross-section. Through time the initially round wire becomes D-shaped in cross-section through use.

SAM 7911: Gold nuggets comprise this group.

Structure: These are presently called gold droplets or prills (The catalogue is outdated and is pending revision in 1999). However, all are not prills. There are nine cast gold droplets and five are failures or offcuts, with sizes between 0.5 and 1.5 cm^2.

Fabrication:Prills can be made by pouring molten gold into water, or fusing small fragments (possibly cut from wire) in a crucible packed with powdered charcoal.

SAM 7912: This group consists of forty nine gold beads, and seven links.

Structure: The beads were on average very small, compared to beads in the other assemblages analysed in this thesis, that is, between 0.4 and 0.7 mm in diameter. They consist of both punched and wrapped beads.

Fabrication: Of the forty nine beads, thirty are punched, and nine are wrapped. The rest are links, made by cutting segments from rolled wire, which was then bent around cold.

SAM 11567: This group consists of twenty nine gold tacks and one gold link.

Structure: The smallest tacks were between 2 and 3 mm long, and the largest were 6 mm long. Again the shortest are generally used (and warped) and the longest are generally unused (and straight and regular).

Fabrication: A wire of approximately 3 to 5 mm thick was sharpened at one end by striking with a hammer, rotating 90° to the previous blow to create four flat sides. The sharp end was then cut off with a blade in a similar fashion to that used to cut bevelled rod sections. Once the tack was used and hammered into some object such as wood, the tack would deform and a head would result at the struck end. Used nails are generally shorter, are bent and have heads.

Thulamela

Most of the gold from Thulamela was collected in 1996 from the two elite burials excavated by the team led by Sidney Miller (Steyn *et al.* 1998) and from the midden excavations (Küsel 1992; Verhoef & Küsel 1996). All the gold artefacts were catalogued, photographed, drawn and described at the University of Cape Town by staff of the Archaeology Materials Laboratory. The gold from these middens and burials that was available for analysis consists of six pieces of wire sections (of which two are bent), seven circular beads (two of which only half is available for study), one gold coil section, one piece of gold foil, one offcut section and one cast piece.

TM 10: Gold wire.

Structure: This round gold wire is 190 mm in length and has a diameter of 0.4 mm. It is slightly tarnished. The wire is flattened at one end. The surface of the rest of the wire is generally round and smooth. The remaining fragment shows kinks and twists along its length, due to use and other damage. Cut marks from the initial sectioning of the wire are visible on one side.

Fabrication: A piece of gold such as a nodule was beaten flat while being rolled to produce a round wire. One end was flattened due to the wire being grasped during working.

TM 26: Gold wire section

Structure: Its mass is 0.334 g. It is a squarish wire bangle consisting of six loops joined by a gold strand that was twisted closed at one corner. The surface is similar to TM 10 in that the wire is round and smooth.

Fabrication: A gold nodule was flattened and beaten flat while being turned to form a round wire. This was bent round to form a squarish wire bangle with six loops.

TM 32: Gold wire section

Structure: It is 17.5 mm long, 0.5 mm thick, and is twisted and bevelled, and slightly tarnished. The wire could be part of a bound coil wire that has unwound, as indicated by the regular creases in the metal. It generally has a smooth surface.

Fabrication: Gold wire was bent into a coil around a core, possibly another piece of wire, after which it was annealed. Subsequently, the coil had been unwound.

TM 38 A: An unwound piece of wire, from a coil.

Structure: It is 12 mm long. The wire itself is smooth and has a regular diameter of 3.5 mm. It is curved, and the ends are more bent than the rest of the wire. There is slight pitting and tarnishing.

Fabrication: A length of wire was bent around a core and then folded around the core as tightly as possible in order to ensure a coil once the core had been withdrawn.

TM 38 B: One gold wire section.

Structure: It is 4 mm long. The wire is smooth with one end flattened, similar to TM 10.

Fabrication: The wire was beaten from a piece of cast material while being turned. The end was held with a pliers-like implement causing one end of the artefact to taper.

TM 24: One gold wire nodule section.

Structure: It is 1.5 mm thick, 2.5 mm in height and 3.5 mm wide. Its mass is 0.059 g. The wire is part of a longer piece that was tightly wound at one end to form a nodule. One twist extends from the main body of the nodule.

Fabrication: Gold wire was bent into a coil around another piece of wire, which was withdrawn. It was then annealed. Over time however, the coil had unwound at certain sections. The remainder of the coil has been squashed somewhat to form a nodule.

TM 35A: One piece of bent gold wire.

Structure: The wire has a smooth regular surface on the straight sections. The bent sections are flattened.

Fabrication: A piece of gold such as a nodule was beaten flat while being rolled to produce a round wire.

TM 33: One piece of gold foil or sheet.

Structure: It is 6 mm on one side and 3.5 mm on the other side. The foil has been used and has torn where there once was a tack hole. It is crumpled and flattened. One side is shiny from being scratch burnished, and the other is rough, from being placed face down on a rough anvil during production.

Fabrication: A nodule of gold was beaten on a flat surface. Foil was then placed on an object to be covered, and attached, presumably using gold tacks. Finally, the exposed surface was burnished resulting in a shine.

TM 176 A & B: Two halves of a cylindrical bead.

Structure: One piece has a mass of 0.131 g and the other 0.032 g. The bead has been cut in half for trace element analysis. Both sections are pitted on the edges and at the surface. The bead was probably punched as is revealed by the right angled wedge shaped indents in the two bead halves.

Fabrication: A spherical nodule was flattened and the cast droplet in the form of a spherical punch was perforated with a four-sided square punch.

TM 28 A: One cylindrical bead.

Structure: Its mass is 0.247 g, and it is approximately 3.5 mm in diameter. It is cylindrical, with damage marks on the surface. Although there is a void at the edge of one side of the bead, the void it is not very deep.

Fabrication: A cast droplet was punched, evidenced by the right-angle wedge-shaped indents. Use and wearing of the bead would have caused the internal margin to become rounded.

TM 28 B: One cylindrical bead.

Structure: Its mass is 0.05 g, and it is between 2.75 and 3 mm in diameter. The bead has a flattened top and bottom surface. There is a continuous void in the form of a groove running along the outer margin. The internal margin is not totally circular. There are minor damage marks on the surface, and the edges are pitted.

Fabrication: A spherical nodule was flattened, and thereafter punched. The damage on the side was a product of extensive wear during use.

TM 28 C: One cylindrical bead.

Structure: Its mass is 0.105 g and is 2.5 mm in diameter. The bead is circular and rounded, in contrast to TM 28 B. Two indentations occur on the internal margin on opposite sides of each other. Wear marks are present on the outer edges.

Fabrication: A cast droplet was punched, evidenced by the right-angle wedge-shaped indents on the top and bottom surfaces of the bead.

TM 28 D: One cylindrical bead.

Structure: Its mass is 0.032 g, and is 2.25 mm in diameter. The bead has irregular end surfaces, and viewed from the side it is considerably thinner on one side, ie. wedge-shaped. The edges are worn and pitted.

Fabrication: A gold strip was bent around to form a thickened join.

TM 28 E: One cylindrical bead.

Structure: Its mass is 0.03 g, and is between 2.25 and 2 mm in diameter. The bead is more regular in shape than TM 28 D, and the top and bottom surface is flat. This cylindrical round bead has one surface slightly off parallel with the other surface, and some pitting marks are present on the edges.

Fabrication: A gold strip (thicker than that used for TM 28 D) was bent around to form a tight join, now invisible to the naked eye, but visible under magnification.

CHAPTER SIX

SUMMARY OF THE FABRICATION TECHNOLOGY

The gold artefacts from all the assemblages of the Late Iron Age of southern Africa can be divided into seven main categories. These are foil, tacks, prills, beads, rod sections, wire and discs. They are described here in this order, together with any sub-categories that may exist. A graphic description of the artefacts fabrication technique can be found in the Figures 6 to 14.

Foil:

Gold foil, or sheet, was well represented in the Rhodes collection housed at the South African Museum (16 pieces). Original size could be estimated if the foil contained punch marks, since these marks would have been on the edges of the foil pieces. Using this technique it was noted that they were usually no larger than 20 mm by 30 mm. The punch marks themselves were square, showing that the tacks were square in cross section. To fabricate the sheet, a nodule of gold was beaten on a flat surface with a hammer. This flat surface was probably a sandstone anvil, as evidenced by all the sheets being pitted and rough on the one side. It was then cut to the required size either by using a chisel (Fig. 6) or a blade. Foil was then placed on the object to be covered, and attached with gold tacks. Finally, the exposed surface was scratch burnished, resulting in a shine (Figs. 29 & 30). As overlapped areas of foil were not scratch burnished one can deduce that the foil was burnished after it was attached to the object to be covered.

Tacks:

The tacks were four-sided, tapering wedge-shaped pieces of gold that were between 3 mm and 10 mm long (Figs. 26 & 27). They were used to hold the gold foil in place on the item to be plated. The substrate would have to have been soft, probably wood. The tacks were made by hammering the end of a piece of wire into a four-sided point, and then cutting off the short tapered section, presumably with a chisel. The flattening of the heads took place by hammering the tacks into the substrate (Fig. 28), as evidenced by metallographic studies. The heads were not fabricated intentionally. Unused tacks had no splayed heads (Fig. 26). A comparison of used and unused tacks can be seen in Figure 27.

Prills:

Prills, or cast droplets, were globule-shaped pieces of gold found in diameters from 0,5 mm to 12 mm (Fig. 17). They were used to make various artefacts such as punched beads or flattened into flat strips, or foil. These spherical droplets were probably formed by pouring molten gold into water, or melting filings or short pieces of wire in a crucible packed with charcoal. In Fouché's (1937) book on Mapungubwe, R. Pearson suggested that prills could have been formed by spilling the molten gold onto a flat surface. This gold would theoretically then roll and form globules as it cooled. This method would have been rather complicated with the tools and techniques employed, and is therefore unlikely.

Beads:

Previous studies of the gold beads have either been very superficial, or consisted in making interpretations based on very small sample sizes. Weber (Fouché 1937) studied eight beads and together with Pearson (Fouché 1937) suggested that the beads were punched. Pearson (Fouché 1937) and Meyer (1998) suggested that these beads were cast with holes in place. Stanley (Fouché 1937) stated that the beads were of punched and wrapped varieties and that both cold and hot working and casting occurred in the fabrication process. These scholars studied only the beads from Mapungubwe, and only a select few from a fragmented assemblage.

Most of the gold beads analysed and described in the current study could be categorised into two groups distinguished by the means of manufacture; punched or wrapped. Within these two categories themselves there were variations as well.

Punched beads were sub-spherical items with single holes (Figs. 18 to 22). They were indeed punched, and not cast, since there were four evenly spaced indentations on the edge of the internal diameters on both the flattened surfaces of most of these beads. The bead hole was most often made with a square punch that left a four-sided squarish hole, sometimes with cracks extending from the sharp corners (Fig. 22). Beads were punched from both sides. Stringing wear subsequently rounded the aperture. One exception to the square hole was found where a circular round bead had a round indentation punched from one side only (Fig. 20). A possible explanation for the preference for a square punch is that it remained sharper for longer and was easier to sharpen with four hammer blows at the tapered edge. Bead sizes ranged between approximately 3 mm and 5 mm in external diameter, with an internal diameter ranging from 1 mm to 3 mm.

Some beads had five decorative indentations equi-distantly impressed on their outer circumferences (Figs. 19 & 23). These grooves had been indented after punching the central hole, and while the bead was cold. This produced visible cold work deformation beneath the indentations (Fig. 23).

The punch used for making holes in the punched beads was probably made with an iron tip, as it was the hardest metal mined in the southern African Iron Age and could easily pierce through a solid piece of gold, such as a prill (Fig. 11). Intensely cold worked copper is also a possibility but is less likely, since iron was available and the point would last longer.

Another type of bead was wrapped gold beads. They were round, often with flattened end surfaces, and to the naked eye looked superficially similar to punched beads, but the wrapped beads were often more crude and less symmetrical (Figs. 18, 19 & 24). A strip was cut from a gold sheet or wire, and then bent around a wire core until a coil was formed. Often the wrapped beads were barrel shaped and not flattened as much as the punched beads. Some beads were made with thicker strips of wire, possibly formed around a thick metal rod. The coiled gold was cut along the length of the rod with a chisel and incompletely closed beads were produced that could be squeezed closed.

Another type of gold bead was found at Mapungubwe, called rolled beads. Gold foil was used to make a strip that tapered gently at least to one end. This was folded around a core several times until the strip was completely wound into a tube. (Meyer 1998: 248).

Links:

The links were like wrapped beads bent around a core made of flattened (Fig. 16) or rounded (Fig. 32) wire, without the join being closed. They were very similar to the wrapped beads and probably made in the same way. In some cases they were simply wrapped beads that had been pulled open during use. Alternatively they could have been an intermediate stage for making wrapped beads, or used as ornamented clips, such as the ones found on the corroded iron necklace of the male burial at Thulamela (Miller, Desai, Grogorova & Smith 2001).

A representative set of beads and one prill was sampled for microhardness testing (Table 5). The purpose of this exercise was to show whether or not a relationship existed between a bead being punched, wrapped, annealed and/or cold worked, and the microhardness of the metal. There was a positive relationship between the final working stage and the microhardness of the metal, with annealed pieces being the softest and cold worked pieces being the hardest, as expected for virtually pure gold (Scott 1991). From the metallographic analysis it was clear that annealing was not practised systematically.

Rod sections:

These were generally square-shaped in cross-section, made by cutting the rod into various lengths with chisel cuts, at an angle between 60° and the perpendicular. The South African Museum catalogue describes these pieces as weights, but there did not seem to be a standard size or range of masses for these pieces. The most plausible interpretation is that these rod sections were flattened to make foil and perhaps hammered to form wire.

Wire:

Late Iron Age southern African gold wire, according to Swan (1994: 67) was made by drawing gold through successively smaller diameter holes in a draw plate. Fouchè (1937) and his colleagues suggested that the wire from Mapungubwe was drawn, as opposed to being beaten into shape. Oddy (1983, 1984) noted both drawn and beaten wire, with a D-shaped cross section as a result of being beaten on a flat anvil-like surface. In this study of the three assemblages only beaten wire was identified, as there was no evidence of consistent longitudinal clumping and striations along the length of the wire, but rather a facetted, scaly appearance (Figs. 16 & 25). Coiled wire pieces were made by beating a length of wire to the desired thickness by turning, flattening and stretching the wire. Then another wire was used as a template to bend the gold wire around, to form a coil.

Coiled wire (helices):

Helices (Meyer 1998: 247) were made from wire that had been coiled around a core, and hence the term helix is often interchanged with a coil, or coiled wire. The wire itself could have been hammered round wire, the same as would have been used to produce the links and the wrapped beads. Alternatively strips of wire cut from gold foil were used (Figure 9 & 31). A blade was most probably used to slice the desired length. A strip would then have been bent around a core, and the core removed after completion. Short helices would have been used as beads. The longer ones were made into bangles or necklaces (Figs. 33 & 34).

Discs:

Discs (Meyer 1998: 251, 252) were flattened prills in the form of discs made by hammering a large prill flat. Their use is unknown, but they were probably precoursers to making sheet.

CHAPTER SEVEN

RESULTS OF THE TRACE ELEMENT ANALYSIS OF GOLD FROM MAPUNGUBWE, GREAT ZIMBABWE AND THULAMELA

One hundred and sixty six gold samples were analysed by Anglo American Research Laboratories (AARL) by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). This comprised 1 piece from Bosutswe, 57 from Mapungubwe, 18 from Thulamela and 90 from Great Zimbabwe. The presence and absence of various selected elements, isotopes and element groups out of 130 isotopes were used by the AARL team to distinguish and group differing trace element signatures. These were scandium, titanium, vanadium, chromium, manganese, cobalt, nickel, copper, zinc, gallium, germanium, arsenic, selenium, rubidium, strontium, yttrium, zirconium, niobium, molybdenum, ruthenium, rhodium, palladium, cadmium, indium, tin, antimony, tellurium, cesium, barium, lanthanum, cerium, praesodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, mercury, thallium, bismuth, thorium and uranium. (Smith 1997a, b, c) The groupings were characterised principally by the presence or absence of strontium, mercury, rare earth elements (ree's), platinum group metals (pgm's) and barium (Smith 1997a). Even though it was not depicted on all trace element signature plots, all the artefacts had an appreciable silver content (D. Grigorova pers. comm.). The presence of silver was confirmed by studies done on the Mapungubwe samples at UCT, where between 2% and 12% silver was present (D. Miller pers. comm.).

The purpose of this investigation was to attempt to answer the following questions (Smith 1997a).

1. What was the environmental source of gold, reef mined or alluvial?
2. Was alloying practised?
3. Were different gold compositions used for the different applications of gold?
4. Can the gold recovered from different sites be traced by the identification of characteristic compositions?
5. What metallurgical technologies were employed and how were they used?

AARL divided the archaeological gold artefacts into four distinct groups on the basis of their characteristic trace element fingerprints (Fig. 3). The standard set consisted of three groups from Mapungubwe and the single piece of gold from Bosutswe, with a unique signature.

AARL found a marked similarity existed between all the samples from Mapungubwe, but the results of the trace element analysis revealed three distinct signatures in the sample set. These were designated M1 (containing Sr, Hg, rare earth elements, pgm's and Ba), M2 (ree's and pgm's) and M3 (Hg, pgm's), by the AARL team (Fig. 3). All the gold from Thulamela had a characteristic signature very similar to that of the M1 group from Mapungubwe. Thus the possibility exists that Mapungubwe and Thulamela had access to the same gold source (Grigorova *et al.* 1998; Miller, Desai, Grigorova & Smith 2001; Smith 1997a, b, c). Of the 90 samples from the Great Zimbabwe collection, 88 were divided into two categories, again based on the presence of characteristic element groups. These were called M1 and M2, identified with groups M1 and M2 of Mapungubwe respectively (Smith 1997b). M1 was characterised by the presence of rare earth elements, platinum group metals, various base metals, and copper, silver, strontium, tin, mercury and lead. M2 was not characterised by groups of trace elements but by the presence and absence of individual ones. They were copper, tin, mercury, lead, and the base metals iron and nickel. Two samples, called Small Lump and Big Lump, had signatures that contained more elements, compared to the other specimens analysed from Great Zimbabwe. The Small Lump's signature was similar to that of M3 from Mapungubwe, while the Big Lump matched M1 of the Thulamela signature. The Small Lump contained no lead (Smith 1997b). The piece from Bosutswe was a gold wire section. The trace element profile of this piece was unique when compared to the other sites. It had virtually no detectable trace elements compared to all the other artefacts that were analysed by the AARL team (see Fig. 4).

Lead isotope ratios were established by AARL for all the artefacts, as well as two natural gold samples from the Barberton Gold Belt and ETCM (Eastern Transvaal Consolidated Mines) with which to compare the archaeological artefacts (Smith 1997a). The two natural samples had normal lead isotope ratios and so did the artefact from Bosutswe. Mapungubwe and Thulamela had inverted mean lead isotopes ratios, compared to naturally occurring lead. This confirmed the distinction of the Bosutswe sample and suggested that Barberton was not the source area for the Mapungubwe and Thulamela gold.

These analyses were commissioned by D. Miller (UCT). AARL proposed an interpretation of these results, as described above. I have retabulated the results for this project (Table 6), reconsidered them, and have come up with an interpretation of my own.

Assessment of the analysis

Re-examination of the results in this study revealed that there were some inconsistencies in the application of the criteria used by AARL to distinguish the groups the AARL team constructed. The primary criteria used were the presence or absence of strontium, mercury, rare earth elements, pgm's, bismuth and barium. Geological co-occurrence of certain groups of elements is typical. For example, lead and bismuth very often occur together in metals (M. Tredoux pers. comm.). In the AARL analysis of the Mapungubwe, Bosutswe and Thulamela artefacts barium was correctly not classified as a rare earth element, although barium and rare earth elements often co-occur geochemically in gold. In the Great Zimbabwe analysis barium was classified as a rare earth element by AARL (Smith 1997b). When barium was present it was assumed that other rare earth element's were also present in the sample, but that these occurred below detection limits. In addition, the decision to assign artefacts to a certain group was achieved by assessing the results visually, with sometimes misleading results. Some of the Great Zimbabwe samples were incorrectly assigned (Smith 1997b). AARL assigned most of the Great Zimbabwe artefacts to M2 when they should have been M3, according to the classification criteria defined earlier by AARL on the basis of the Mapungubwe assemblage. Nevertheless, of the Great Zimbabwe M3 artefacts, some were classified correctly as M2 (namely 44, 47, 48, 66, 67, 63, 69, 72, 74, 75, 77, 78, 81, 82, 83, 84, 86, 88) because they did not contain any mercury.

It is possible to make finer distinctions. For instance, the Thulamela assemblage could be divided into M1, and another group similar to M1 but without rare earth elements.

This group could be called T1a. Mapungubwe itself was classified originally as having three categories. However, each of the groups distinguished could be divided even further if one used barium and rare earth element's as not being co-occurring element groups. Thus M1 could be divided into M1 and M1a, the latter not containing any barium. M1a would then be distinct from T1a. The Great Zimbabwe groups M1, M2 and M3 could be sub-divided much further, with more groups than the other assemblages contain if one correctly assumes that barium and rare earth elements should be used as distinct discriminators. Given that a full spectrum of natural source signatures with which to compare these hypothetical groupings does not exist, any further subdivision at this stage would not be meaningful.

The AARL trace element signature data was re-assessed in this study to test the robusticity of AARL's groupings. The data was rearranged to create a more user-friendly database in order to ascertain whether the interpretations of the Anglo American research team were sound, taking into account the presence and absence of a combination of metallic elements, rare earth elements, pgm's as well as using the likelihood of geologically co-occurring elements. A table was constructed in which the presence and absence of individual trace elements for each artefact were plotted (Table 6).

The occurrence of each trace element in a group was summed to show the abundance and indicate whether the trace element groups were distinct. Looking at the Mapugubwe assemblage (Table 6) one can see that the three groups do not look similar at all, suggesting that the distinctions were valid. The results displayed a definite pattern that paralleled the groupings derived by the AARL research team.

The presence and absence of rare earth elements is not a reliable distinguishing criterion. Where they are present, it will be at low levels of concentration. Furthermore, they can very easily be introduced accidentally. They could have been introduced during the gold processing stage, particularly during melting in a ceramic crucible during fabrication, or during the analytical process itself through surface contamination by handling. Contamination during the analytical process is less likely due to the sampling strategy of the ablation process. A good indication that introduction is unlikely during analysis was the sample from Bosutswe, where only five elements were present in the sample, (with silver being one that occurs in all the samples) and no rare earth elements. A more reliable way of grouping these gold samples would be by establishing the presence or absence of common metallic elements only, that is, iron, nickel, copper, zinc, lead and mercury. The Great Zimbabwe assemblage was evaluated using these elements as criteria. Using these criteria there seemed to be limited variation within each of the corrected AARL groups of Great Zimbabwe. There were a few samples which do not fit into either the AARL defined groups or anywhere close to a group defined on the basis of the metallic impurities, such as the artefact from Bosutswe, and Little Lump from Great Zimbabwe.

The results suggested that these groupings of the Great Zimbabwe collection approximately correlated with the data from AARL's (corrected) groupings M1, M2 and M3. M1 had a subcategory based on the presence of all the metallic elements except for iron and nickel, as well as not containing barium or significant rare earth elements. M3 itself then could be divided into a core group and a sub-category, where the sub-category is a combination of the other two groups M1 and M2. This can be seen in Table 6, that compares the metallic trace elements in the Great Zimbabwe assemblage. Figure 5 is a graphic depiction supporting this rationale.

CHAPTER EIGHT

DISCUSSION

Assessment and comparison of the metallography of gold artefacts with that of other metal artefacts from the Late Iron Age of southern Africa.

Metallography was performed only on gold samples from Mapungubwe. There was no surficial microscopic and visual distinction between the Mapungubwe gold and the other two assemblages analysed here. However, since the Thulamela and Great Zimbabwe collection did not contain rolled beads and flattened discs, these items were not analysed metallographically. There were very few of these pieces found at Mapungubwe. Furthermore the flattened discs were probably an intermediate stage to becoming a completed piece, such as foil. The rolled beads were nothing else but rolled foil.

The study of all the artefacts revealed the following common traits. There was very little if any corrosion in any of the gold artefacts. Silver was the main impurity but formed a small proportionate percentage that ranged between 2% and 12%. Silver naturally dissolves in the gold so no silver inclusions resulted. The metal's grain structure generally was homogeneous, and there were no inclusions in the metal. All the artefacts were both annealed and cold worked at some stage of manufacturing. There was no evidence of welding or soldering.

Punched beads had no visible joins and generally had scars that resulted from punching. A four-folded punching scar remained on one of the flattened surfaces of most of these beads. Both the outer and inner margins had evidence of mild cold working, which was probably as a result of damage from use. The grain sizes varied from relatively large (ASTM 4) indicating very little damage to the material structure from cold working, and that generally very little working occurred, to several punched beads that had grain sizes of ASTM 7. A variation of the circular punched bead had five indentations on the outer circumference. One punched bead, M1231 G, had a very fine grain size of ASTM 10, indicating significant cold work before a final annealling process.

Wrapped beads' most obvious difference to punched beads was the presence of a join, usually visible with the naked eye. The most deformed grains occurred around the join. There was an equal number of wrapped beads with recrystallised grains compared to those with deformed grains throughout the material. This indicated that a final anneal was not standard practice. The smallest grains were often ASTM 10 and the largest average approximated ASTM 5. Similar cold work deformation occured on the outer margins as on the punched beads, due to use wear.

Helical strip fragments were once part of larger coils, made of wire. M1231 P and M1231 Q were the only two pieces studied in this category. The cross section circumference was flattened on one side, and some cold work deformation was present on the outer margins. Both pieces had recrystallised grains, suggesting that annealing was the final phase of manufacture. Grain size was relatively consistent, ranging from ASTM 4-5.

Strip fragments were strips of sheet or foil fragments. Two pieces were analysed. The grains were recrystallised, equi-axed and angular. At least one of the sides of the sheet fragments was rough from cold work deformation. The grain sizes varied considerably. One had an average size of ASTM 4 and the other ASTM 8.

Two full tacks and one previously sampled tack were studied metallographically. The grains of all except one of the tacks were heavily deformed. These tacks when whole were flared at one end. The grain sizes of these tacks were generally quite small, ranging from ASTM 6 to 8. The tack with the largest grains, UCT D, had a grain size of ASTM 5. It was also not as burnished along its length as the other tacks were. Neither end of this tack was present for sampling. However, it would probably not have had a head, as those tacks that were not used had less evidence of cold working in the form of deformed grains and a splayed head.

The surfaces of artefacts from Great Zimbabwe and Thulamela were studied microscopically. Since the artefact types present in these assemblages were indistinguishable to those from Mapungubwe the artefacts from the two later sites were expected to have yielded similar metallographic results. The only noticable difference between the assemblages was the presence of rolled beads and flattened discs at Mapungubwe.

Very few large assemblages of metal artefacts from southern Africa's Iron Age exist, very possibly due to the acidic nature of the soils of the area. Another possibility for the scarcity of large metal assemblages could be due to the scarcity and value of the metal which was recycled (Miller 1996b). However, two well studied assemblages, Divuyu and Nqoma contain substantial numbers of jewellery items made of copper and iron with which the other published Late Iron Age assemblages could be compared. These include Broederstroom, in the Magaliesberg (Mason 1974) and the Greefswald sites K2 and Mapungubwe (Fouché 1937).

There are primarily two reasons why certain artefacts would have been made in one metal rather than another. One was the extent of malleability and the other the purpose of that artefact, or a combination of these two reasons. The application of gold was ultimately for adornment, not for producing tools. Thus for a direct comparison, one may exclude a substantial amount of the iron artefacts from these assemblages since there are few iron jewellery artefacts. One should look at the other metals that were also used to produce jewellery, namely copper and bronze. The jewellery from Divuyu and Nqoma consisted of wrapped beads, chains, earrings, pendants, finger-rings, flexible bangles made from helically wound ribbon, and rigid bangles made from either round wire or broad flat strips (Miller 1996b).

As with gold, copper working seem to have been geared towards jewellery production (Miller 1996b). The similarities between the two metals fabrication technology is substantial. Both have a similar melting point. Copper and gold were hot-worked to shape them at temperatures in excess of 730°C. Both copper and gold artefacts revealed no evidence for soldering. However, whereas most of the copper artefacts were generally left in the annealed state, the gold artefact grains were often deformed by subsequent cold work. This could be due to use wear, since gold is a softer metal and more prone to surface deformation in comparison to copper.

Table 7 is an inventory of the metal jewellery artefacts found at selected sites occupied during southern Africa's Iron Age. Bronze and brass is first seen in the archaeological record in the later part of occupation at Mapungubwe, simultaneously with the appearance of gold. A bronze bar was found, as well as bronze helices (Miller in press; Sutton 1981). Thulamela and Bosutswe also contained bronze pieces. Was there a difference between the fabrication technology of gold and that of the iron and copper alloy artefacts of the Late Iron Age? Gold working was preceded by copper and iron working in southern Africa. There were therefore preconceived tools and techniques for working metal Strong ethnographic evidence exists for the ritual importance of metalworking in Africa (Avery *et al.* 1988; Brown 1995; Herbert 1993; Miller & van der Merwe 1994). A significant change in fabrication technology would imply that the beginning of gold production in southern Africa would then also have caused a change in the status of metalworking in the rituals of Late Iron Age people. Furthermore the incentive to begin gold mining and working must have been enough for it to be added to the established copper and iron mining and working already present for 1000 years prior to local gold mining.

There is virtually no difference in the fabrication technology of the gold, iron and copper artefacts of the same type. The gold artefacts studied in this project have similar structures as the copper and iron artefacts from the intensively studied Tsodilo jewellery assemblages analysed by Miller (1996b). The only differences between the metal working processes of gold compared to the other metals in southern Africa is in the few artefact types that were only made in gold, such as tacks, punched and rolled beads, which exploited the intrinsic malleability of this metal. Similarly, there were artefacts made in copper and iron that were not made in gold, such as hooks, and rings. Due to the metallurgical properties of copper and iron artefacts such as punched beads were not possible. These could be, and were made in gold. There is thus a direct correlation between the malleability of these metals and whether specific artefact types were or were not produced in gold.

Discussion of the trace element analysis results

I now return to the questions initially asked prior to the trace element analyses. The first question asked was whether the gold was sourced from alluvial or hard rock mining. This has already been addressed by scholars such as Phimister (1974) who was of the opinion that alluvial gold mining preceded gold reef mining. Various forms of evidence exist that can be used to attempt to answer the question; ethnographic accounts, inferences made from the fabrication technology, and trace element analyses of the southern African archaeological gold. The interpretation of the chemical analysis can be addressed in three ways: by the presence or absence of certain trace elements, the proportion of silver present in a sample, and the presence or absence of pgm inclusions. To establish whether gold mining started as alluvial or reef mining, one needs to look at Mapungubwe, which contains the earliest evidence of archaeological gold in southern Africa (Meyer 1994, 1998). One needs to try to establish where the gold from Mapungubwe was sourced.

Nineteenth century prospectors' accounts and early archaeological expeditions from the beginning of the 20th century indicated that there were numerous precolonial gold reef mines on the Zimbabwean Plateau (Fripp 1912; Mason 1962; Summers 1969; Swan 1994; Trevor 1912 a & b 1930). However, alluvial mining was also quite common in the same area (Axelson 1960, 1973; Summers 1969). This observation was supported by the ethnographic account of Barreto, a Portuguese traveller in southern Africa (Axelson 1973: 50). Furthermore, since scholars have been identifying gold mines there has been an ongoing debate as to whether the identified archaeological mines in South Africa and Zimbabwe were exclusively, or partially, copper or gold mines. To identify the type of mining from an ethnographic and archaeological perspective is therefore unlikely if one cannot even confidently identify whether specific reef mines were for gold or not. What could be deduced is that both reef mining and alluvial mining was practised. When attempting to use trace element analysis to distinguish between them one needs to account for two factors. There should be different variations between geological regions, and different signatures for different deposits within a region. Furthermore, alluvial gold can be leached, losing concentrations of certain elements, and therefore would have different signatures to the original reef source.

What are the identifiable features that could distinguish reef gold from placer gold? Gold always occurs naturally as an alloy, with other metallic elements (Craddock 1995; Patterson 1971), typically silver, mercury and pgms. The alluvial environment is an oxidising one, and some elements, such as silver which is more reactive than gold, leach preferentially from the gold grains in such an environment (Craddock

1995). The extent of this loss is dependent on the length of time that the ore has spent in this environment. Mercury, like silver, is more reactive compared to gold and it also leaches from gold ores in an aquatic environment, but less so than silver (Craddock 1995). Mercury is also volatile in the gaseous state and evaporates easily during the melting process (van Straaten 1999). Silver and mercury are almost always present in gold ores, since these are geochemically co-occurring elements (Craddock 1995; M. Tredoux pers. comm.). Material from different sources with differing signatures should still have distinct signatures after leaching. Tin has been suggested as being more diagnostic (Craddock 1995) for identifying whether a gold ore was alluvial or not, but in the gold artefacts studied here no meaningful pattern based on the presence and absence of tin could be identified.

EDS analysis was performed by Duncan Miller on the Mapungubwe samples to define the silver content of these artefacts. It was determined that they contained silver at the percentage level, spanning a range of concentration of between 2% and 12%. This falls well within the range of the concentration of silver in gold mined from southern African geological deposits (Erasmus *et al.* 1987). Mercury was present in 44 of the 57 samples analysed from Mapungubwe (Smith 1997a). Therefore alluvial mining could not have been practised solely, and most of the gold at Mapungubwe was possibly acquired by reef mining.

Using the deductions made on leaching processes in water the single helix from Bosutswe could be an example of alluvially sourced gold since there were only six detectable impurity elements in it. It should be noted that it did not contain any mercury (see Figure 4), further substantiating this hypothesis. This sample's signature is unique and is definitely not representative of any other archaeological sample. However, no potential archaeological source has been analysed yet. It is therefore not possible to say unequivocally that any of the other samples were made either from Zimbabwean Plateau reef gold, or that the samples were definitely alluvial, having been leached of silver or/and mercury, in comparison to the geological source.

The Thulamela assemblage gold artefacts all contained appreciable amounts of silver and mercury, and were probably from hard rock sources. Of the 90 Great Zimbabwe artefacts analysed 18 did not contain any mercury (Great Zimbabwe samples 44, 47, 48, 63, 66, 67, 69, 72, 74, 75, 77, 78, 81, 82, 83, 84, 86 and 88), and it is possible that these specific artefacts were produced from alluvial gold.

In addition, it has been suggested that alluvial gold could be identified by the presence of pgm and osmium-dominant inclusions (Craddock 1995: 111-112). These dense metals can cold weld naturally with the gold in the alluvial environment. Furthermore, the dense pgm and osmium-dominant metal grains can be left behind with the gold after the panning process. With melting these grains will be incorporated with the gold and become inclusions. The metallographic study revealed no osmium-iridium inclusions in any of the gold samples from Mapungubwe. The absence of platinum group metal and osmium-dominant inclusions suggests that the Mapungubwe samples were not produced from alluvial gold from platinum rich areas such as the northern Transvaal.

Nevertheless, from ethnographic, historical, archaeological, and chemical evidence there is nothing to suggest that only alluvial mining occurred. One can also at least safely say that reef gold mining occurred often and was used to produce locally consumed goods. The strongest available evidence is the deduction made from the trace element results performed by AARL. The EDS analysis of silver performed on the Mapungubwe samples at the University of Cape Town confirms that significant leaching did not occur in most of these samples. All the samples analysed by AARL contained silver (Grigorova pers. comm.), and the Mapungubwe samples contained between 2% and 12 % silver, which falls comfortably within the range of silver in gold from southern African hard rock deposits (Erasmus *et al.* 1987). As explained earlier, mercury was present in most of the samples. Reef mining was therefore probably a standard practice from the beginning of southern Africa archaeological gold mining, even from the period of the Mapungubwe occupation.

In summary, if the Mapungubwe gold were alluvial, one might expect low silver values, and the presence of osmium-iridium inclusions. The silver content spans the full natural range and the expected inclusions are absent. This indicates that most of the Mapungubwe material is probably from hard rock mining rather than alluvial deposits. This can only be settled conclusively once a representative suite of known alluvial samples is available for analysis.

Alloying has been used across the world either as a means of enhancing the aesthetics of an article or to make a metal more durable. Did indigenous goldsmiths systematically practise alloying during the Late Iron Age of southern Africa? The Mapungubwe samples did contain silver at the percentage level, but these fell within the natural range for Witwatersrand deposits. Mercury was however not always present in all the archaeological samples, and never to the extent that silver was. Craddock (1995) noted that mercury can occur naturally in electrum by as much as 50% of the amount of silver present. Thus the mercury contents of the archaeological samples were normal. Furthermore there is the possibility that these metallic elements were introduced during the fabrication stage, as had been noted with mercury from ethnographic accounts for gold working in present day southern Africa (van Straaten 1999). Mercury is also volatile (van Straaten 1999) and may have evaporated during the melting process. The possibility that significant impurities were added were ruled out by noting that the sample from Bosutswe was fabricated no differently from the other archaeological gold artefacts, and yet there were only six elements detectable in the Bosutswe sample; five trace impurities and gold. No patterning could be identified in assessing the concentrations of the silver content in all the Mapungubwe samples. Since the silver concentrations for the gold from Mapungubwe conformed to natural amounts from Witwatersrand deposits (assumed to be typical of southern Africa in general), and no other element was present at the percentage level, the practice of systematic alloying seems unlikely.

Was mixing a standard practice? Put differently, were ores with different trace element profiles mixed? Were gold artefacts produced from this mixture? Why would it be practised? If ores with different signatures were mixed there would be no easy way of relating the unique signatures of the natural ores to only one trace element signature. It is thought that gold was mined by smaller groups of people, and transported to Great Zimbabwe in the form of taxes from all over the Zimbabwean Plateau (Summers 1969; Swan 1994). These taxes or tributes may have been used to produce gold artefacts. It is thus very possible that gold ores were mixed. Furthermore, during the fabrication phase off-cuts and waste pieces of gold would have been recycled, and one off-cut could very well have been mixed with off-cuts from other deposits with different signatures. The trace element analysis as a sourcing tool seems problematic. HHHowever, AARL have stated that it is possible to separate the signatures from a mixture composed of two distinct geological deposits, once a suitable comparative basis has been constructed (Smith 1997a). In the archaeological context this will depend on far more extensive sampling of natural material.

It is very likely that mixing occurred, especially at Great Zimbabwe, where gold was brought from various regions as trade goods and tribute. This gold accumulated from various regions would be mixed arbitrarily and the trace element signatures would become indiscriminant. If this was the case then definite groupings would become blurred. This corresponds to the trace element distibutions or groupings seen in the archaeological record at the three sites. Mapungubwe saw the beginning of trading with gold, and it is accepted that this activity was the greatest at Great Zimbabwe (Mudenge 1988). Thulamela was a satellite of Great Zimbabwe, where not as much trading took place. This corresponds well with the gold from Mapungubwe having definite groups (five), Great Zimbabwe only having two groups, one of which is a collection of diverse signatures, and Thulamela one, according to the method of classification by AARL. Great Zimbabwe would have a very limited number of resolved groups since the artefacts would have been made from gold mixed from several deposits. Based on this evidence it is unlikely that mixing was a standard practice at Mapungubwe and Thulamela other than for the sake of occasional recycling. At Great Zimbabwe mixing was practised as a matter of course due to the gold being brought in from more numerous sources than at the other two sites.

One of the initial questions posed by AARL was whether the results would reveal anything additional concerning the metallurgical technology used (Smith 1997a). The range of silver content, and the diversity of trace elements indicate that refining was not practised. Mercury was not used to recover gold as the mercury values are low.

The initial, and arguably the most important reason that LA-ICP-MS was performed on the archaeological gold was to determine where the Late Iron Age gold producers of southern Africa sourced their gold. Initially the LA-ICP-MS technique was developed to return stolen modern gold bullion to the rightful mine owners (Grigorova *et al.* 1998). The trace element signatures of the stolen gold are compared to a modern comparative data set of geological signatures, and the legitimate owner of the gold can be traced. Theoretically it should be possible to identify what geological deposits were used by Late Iron Age gold utilising communities by applying the technique to Late Iron Age gold artefacts. Since a database of potential archaeological sources still needs to be developed, alternative evidence needs to be considered to answer this question. It was earlier concluded that mixing was not always a standard practice. It was shown that if it was, the signatures of the gold artefacts, and therefore the signature groups, would have been relatively indistinguishable. Since there was more variation in the Great Zimbabwe sample signatures one can deduce that gold was sourced from a much larger area. Secondly, there are many samples (particularly from Great Zimbabwe) that do not contain any mercury whereas the Witwatersrand Basin deposits all contain mercury at the percentage level (Erasmus *et al.* 1987). The samples comprising the subgroup M2 from Great Zimbabwe were not sourced from the Witwatersrand region. The natural comparative samples available from the Barberton mines have normal lead isotope ratios compared to naturally occurring lead. Many of the samples from Mapungubwe and Thulamela have inverted lead isotope ratios compared to the natural lead average (Grigorova *et al.* 1998). The Mapungubwe and Thulamela gold was probably not sourced from Barberton. Once a comparative sample set of naturally occurring gold ores is established the tentative answers to the questions addressed here may be confirmed. Although it has not been possible to analyse natural samples yet, it is suggested here that the gold was not sourced from the Barberton region, and not mined south of the Limpopo, and that Mapungubwe gold and Great Zimbabwe gold came from distinct sources north of the Limpopo.

In summary then, gold ores were not mined only from alluvial sources, but also from reef mines mainly north of the Limpopo, most probably on and around the Zimbabwean Plateau. Mixing of gold ores was possible but from the trace element signatures seems an unlikely standard practice, except at Great Zimbabwe. Deliberate alloying with other metals did not occur. It seems as if the most effective means of interpreting and grouping trace element results for gold would be to define groups on the basis of the relative abundances of the metallic impurities present in samples. In order to determine which geological deposits were mined, a modern comparative basis needs to be established consisting of all possible sources that might have been used by Late Iron Age gold mining.

Discussion of the metallography

What, if any, similarities existed between the production and types of gold and copper artefacts? Gold mining and the production of gold artefacts were preceded by copper and iron mining and artefact fabrication. As explained earlier the only artefacts that were produced in gold and not produced similarly with the other materials were the punched beads. As an example copper beads from Nqoma (Miller 1996b) have the same microstructure as the wrapped gold beads from the southern African archaeological sites. Furthermore there was no change in the styles of artefacts being produced over time.

As can be seen from Table 7, there were several artefact types that were produced solely in gold; there were types that were not produced in a range of different metals and there were also types that were not produced in gold at all. The introduction of gold jewellery is seen in the second part of the occupation at Mapungubwe, where most of the artefacts were previously produced in another metal. These were wrapped beads, helices and links. It is noteworthy that Mapungubwe gold and glass beads seem to have replaced the earlier more plentiful iron and copper beads (Miller in press).

Before further analysing and interpreting the presence and absence of these metal artefact types it needs to be remembered that the sample sets were small, and the archaeological record is undoubtedly a fragment of the range that was actually produced and used at southern African Iron Age sites.

It can be seen that wrapped beads remained important with the introduction of gold. Helices also remained important. These artefacts were produced in all the metals employed in southern Africa's Iron Age. Very few new artefact types are introduced. Bead variations were introduced in the form of rolled sheet and punched droplets. Rolled beads were only produced at Mapungubwe, and not produced again. Punched beads were produced in equal quantities as the wrapped beads were. Sheet and tacks were the only other types of artefacts that were totally new concepts as a result of the availability of gold. Later sheet and tacks were produced in copper and bronze, at Thulamela (Miller in press).

Pendants were never produced in gold, only in iron. Similarly rings were never produced in gold, but in iron and copper, even until the end of the Iron Age. The same holds true for bangles and loops. Chains were never even in the same assemblage as gold artefacts. Chains, made in both copper and iron, were only found at Divuyu and Ngoma. Once gold became available, links made in copper and iron were not produced again, until the occupation of Thulamela, when no gold links but instead links of iron were found.

A period of approximately 1000 years passed during which gold was worked by Iron Age people. During that time only sheet and tacks were totally new innovations. If Late Iron Age southern African gold workers had significant international contact, why would there be no notable change in styles and types of jewellery produced over this time? Somehow it was more important to keep producing the same artefact types rather than having to change styles to meet international demands. Gold was employed for jewellery manufacture intended primarily for local consumption. These gold artefacts were also not just a trade commodity but a local symbol of power and social status (Huffman 1996). Ethnographic accounts across Africa have shown that metal working had significant ritual importance even though these processes might be uneconomical (Brown 1995; Miller 1995). This probably was also the case for gold working and production in the Late Iron Age of southern Africa.

CHAPTER NINE

CONCLUSIONS

Gold mining, working and production had a significant impact on the social and economic lives of the people of the Late Iron Age of southern Africa. Evidence concerning the use of gold has been found at several places, in particular Mapungubwe, Great Zimbabwe and Thulamela. Gold was found mostly in elite burials, although much gold was stolen during the early colonial era, especially from Great Zimbabwe. Undoubtedly much precious evidence has been lost as a result of looting. Fortunately gold is stable and therefore survived better than the other metal artefacts from the Iron Age. These two factors have allowed Late Iron Age gold artefacts to be studied metallographically and microscopically and their trace element signatures to be established by LA-ICP-MS.

In this dissertation it has been determined that a standard means of fabrication was used to produce each of the four main different types of artefacts: beads, wire, foil, tacks. The tools used to produce these artefacts have not been found anywhere in sites in association with evidence for gold mining and working. However, it has been deduced that nothing more than a pair of bellows, a melting crucible, a working surface, hammers, straight iron wire, a punch, and sharp cutting implements like a knife blade were needed to produce any of the above artefacts. It has been shown that the basic fabrication technology of the gold artefact types produced was the same for all three assemblages.

There was no significant change in the fabrication process of the artefacts produced though time. Crushing of ore and melting in ceramic crucibles was utilised to separate metal from glassy slag. Once the molten gold was separated it was cold worked. Intentional annealing after cold working was not a standard practice. Where annealing was the final stage of fabrication, it was probably accidental, easily occurring if an artefact was dropped into a hearth. The artefacts found were produced in the following manner. Molten gold was poured into water. During the rapid cooling process, spherical prills would form that could have been used for making various gold artefacts. Wire was produced by hammering and drawing the one side of a lengthened piece of gold while rotating it, causing it to stretch and form round straight wire. A tack was produced by hammering the end of one side of a wire until a four sided tapering edge resulted. This tapered end was cut off and the result was a tack. Using straight round wire and folding it around another straight wire resulted in a coil. This coiled wire was cut along its length and open links were produced. Links were an intermediate stage to becoming a wrapped bead. Wrapped beads were produced by cutting coiled wire along its length until open links were produced. These were then closed by light hammering or by hand. Alternatively, a flattened prill was punched on both sides, resulting in a squarish hole, producing a punched bead. Through stringing wear (from being part of a necklace) this squarish hole became larger and rounded. Rolled beads were produced from a piece of foil and cut into a long triangle. The ends were rounded and this leaf was folded around a wound core to produce a rolled bead. Discs were produced by flattening a prill to form a disc. A disc was most probably an intermediate stage to becoming a piece of foil. A flattened disc was smoothened and flattened out to produce a sheet of foil. This was cut to the required size with a chisel. The holes in the foil resulted from it being attached to a substrate such as wood with 4-sided tacks. Another type of coiled wire was produced by cutting a piece of foil into strips with a chisel. A strip would be wound around a straight core, resulting in a coiled wire.

Trace element analysis by LA-ICP-MS is a powerful tool for the identification of the geological source of a metal and for comparing trace element profiles of the same metal. This has been applied to archaeological gold at Anglo American Research Laboratories. From the time of Mapungubwe onwards gold ores were not mined only from alluvial sources, but also reef mines mainly north of the Limpopo, most probably on and around the Zimbabwean Plateau. Mixing of gold ores was possible but from the trace element signatures seems a practice limited to Great Zimbabwe. Deliberate alloying of gold with other metals did not occur.

The best way of grouping trace element signatures was on the basis of the presence and absence of metallic impurities. Since the analysis was aimed at providing a comparison on a regional basis, the semi-quantitative technique employed here was most suitable because it was relatively non-destructive, reliable and accurate. In order to determine which regions were mined, a modern comparative basis needs to be established consisting of representative potential sources that might have been used by

Late Iron Age gold mining.

The analysis of the gold by LA-ICP-MS forms part of a larger ongoing project in which the comparitive data base of gold bearing geological deposits in southern Africa will be expanded and inferences made on the origins on the gold ore of artefacts in the southern African Late Iron Age. Ideally a larger data base spanning international geological deposits from North Africa, Europe and Asia needs to be established that will test research done until now and give rise to new insights into international precolonial trade in African gold.

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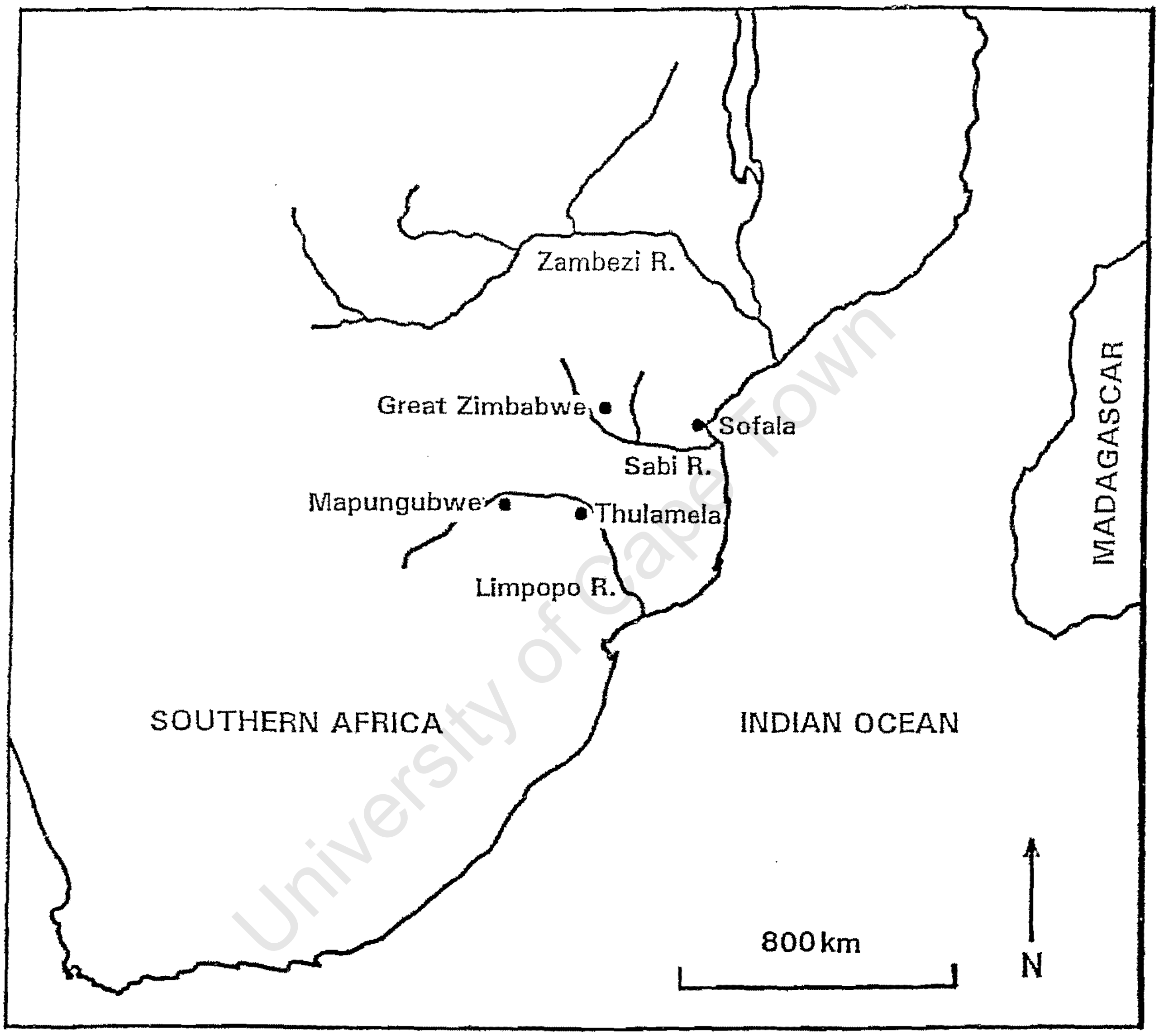


Figure 1: A map of important archaeological sites in southern Africa, with important waterways regarding trade shown. (from Miller, Desai & Lee-Thorp 2000)

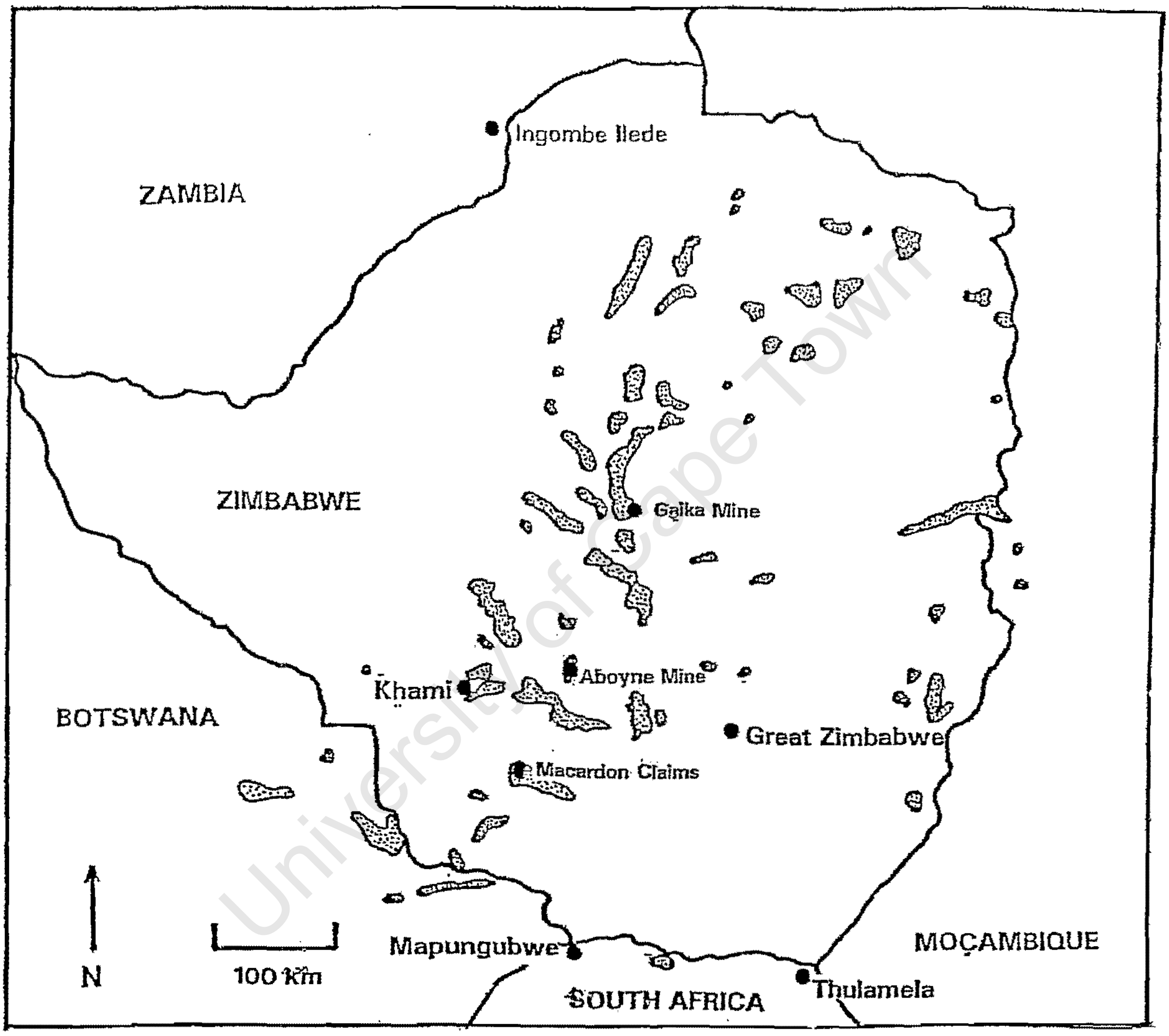


Figure 2: A map of the gold mining regions identified by Summers, and their proximity to gold working and gold utilising sites in southern Africa. (after Summers 1969)

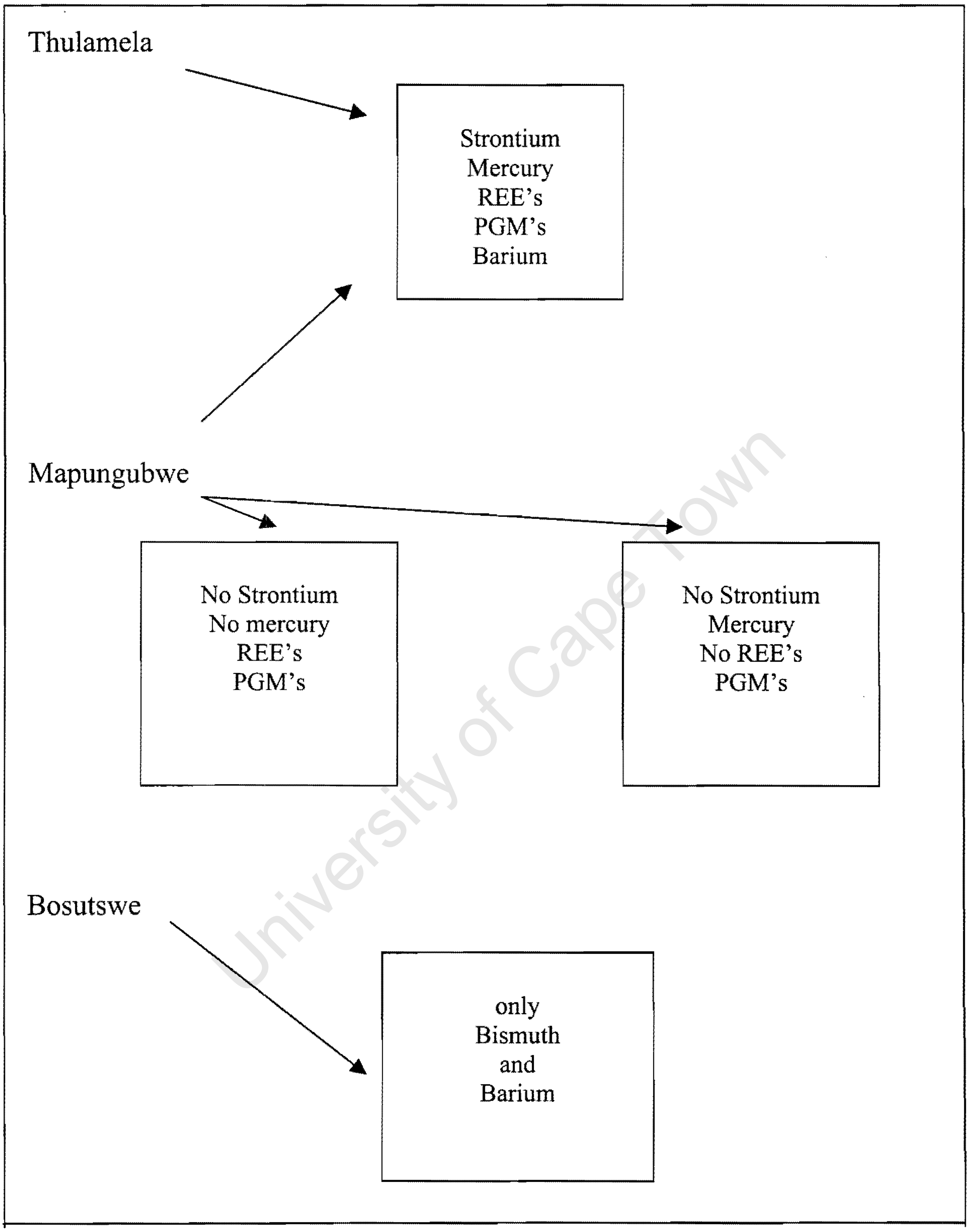


Figure 3: A flow chart summarising the reasoning of the groupings allocated to assemblages analysed by Anglo American Research Laboratories. (after Smith 1997a)

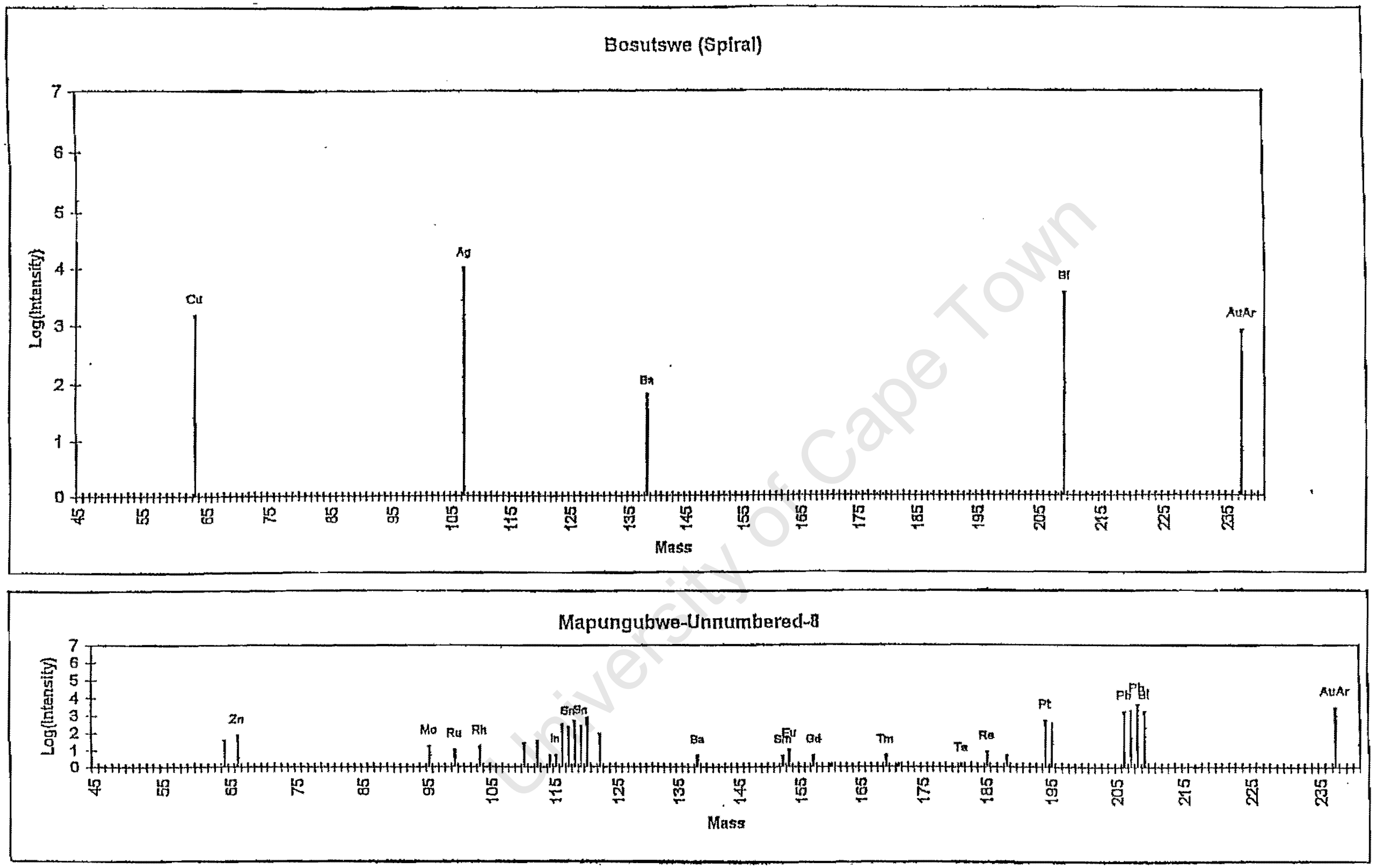


Figure 4: Trace element profiles derived by Anglo American Research Laboratories (after Smith 1997a,b). The trace element profile of the Mapungubwe artefact is a typical one, with a presence of numerous elements. The profile of the piece from Bosutswe is totally unique, having only five impurities.

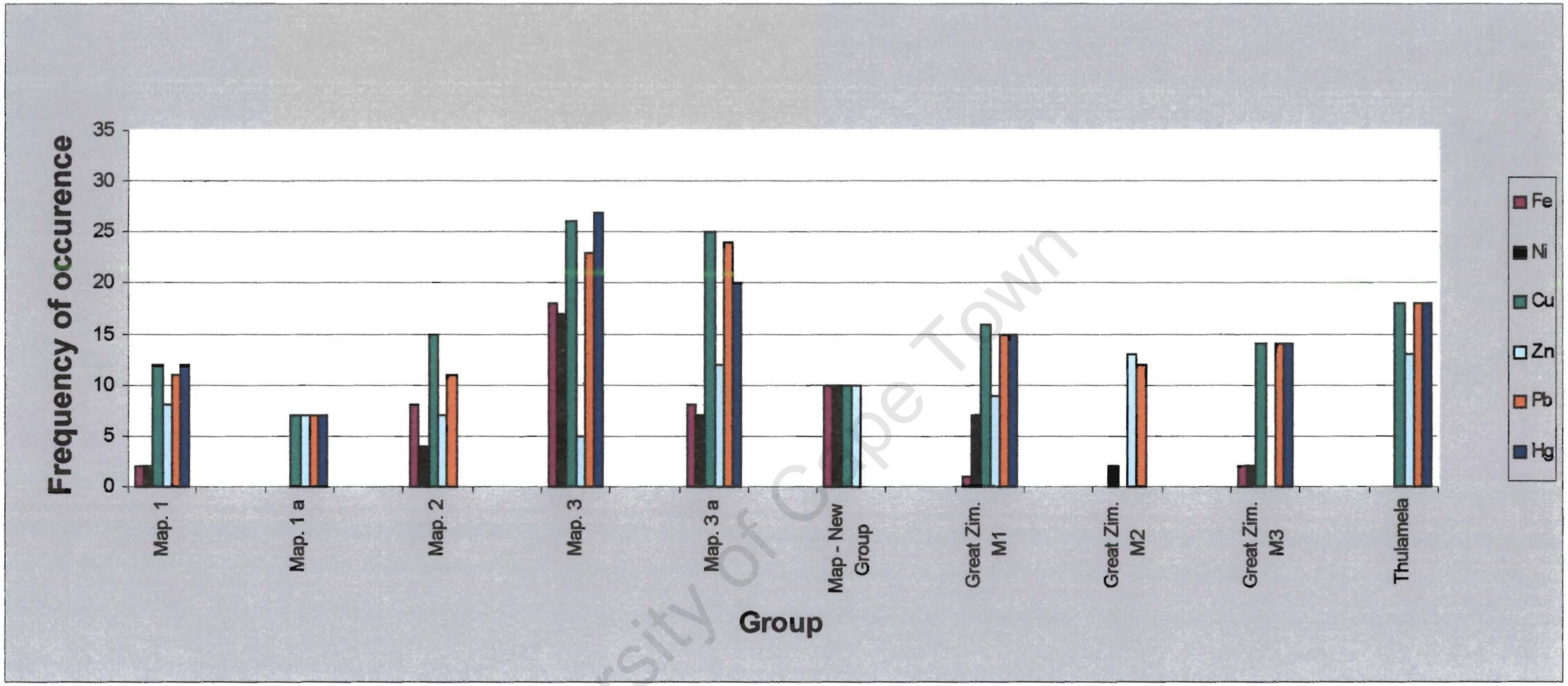


Figure 5: AARL trace element signature groups compared by the presence and absence of the metallic impurities of analysed gold artefacts

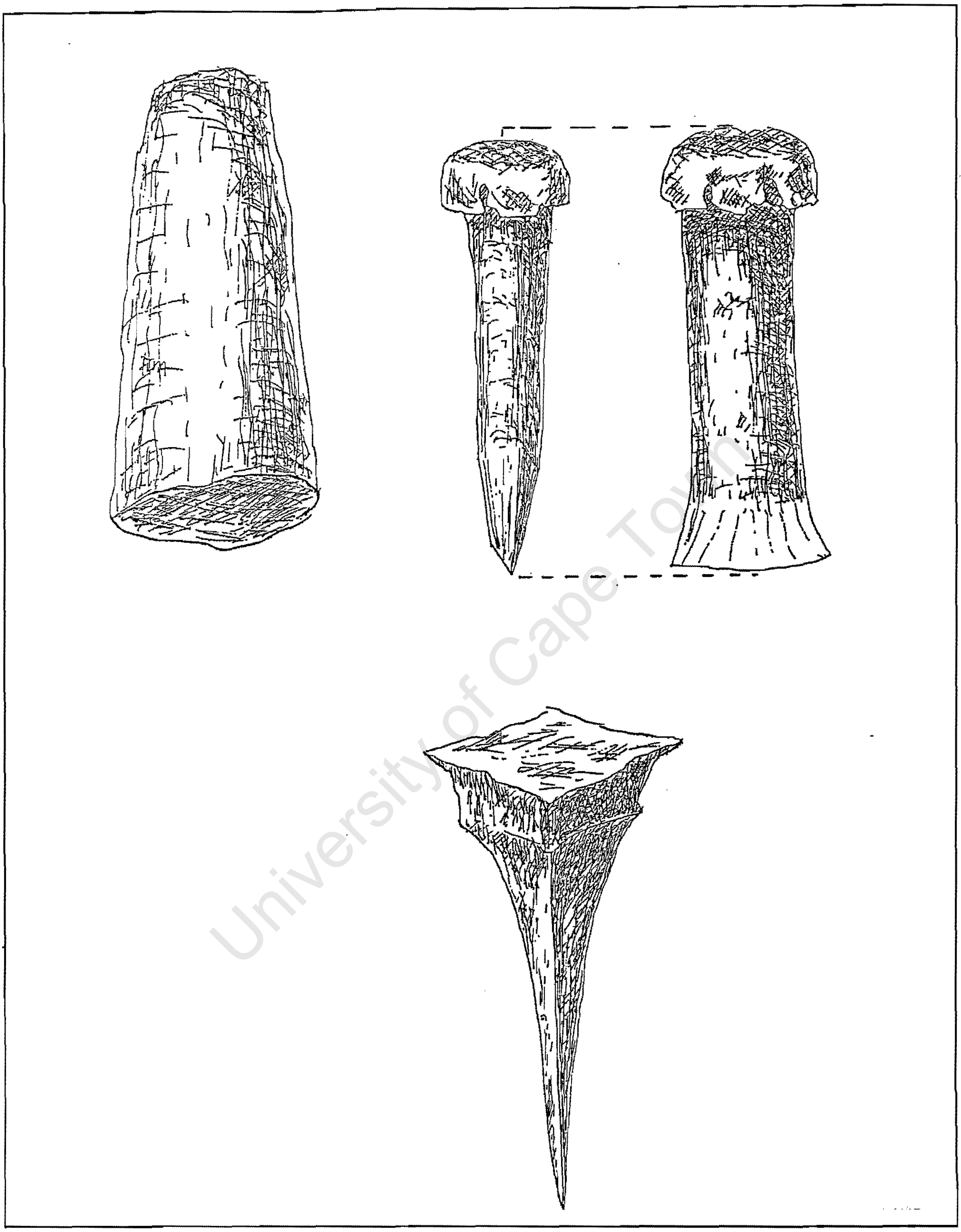


Figure 6: Tools: A goldsmith's toolkit primarily consisted of a hammer, a chisel and a punch. The punch and the chisel were made from iron. The hammer was made of iron, or a hard stone such as granite. (Scale: Chisel is approximately 4 cm long.) (Drawing by C. Jardine)

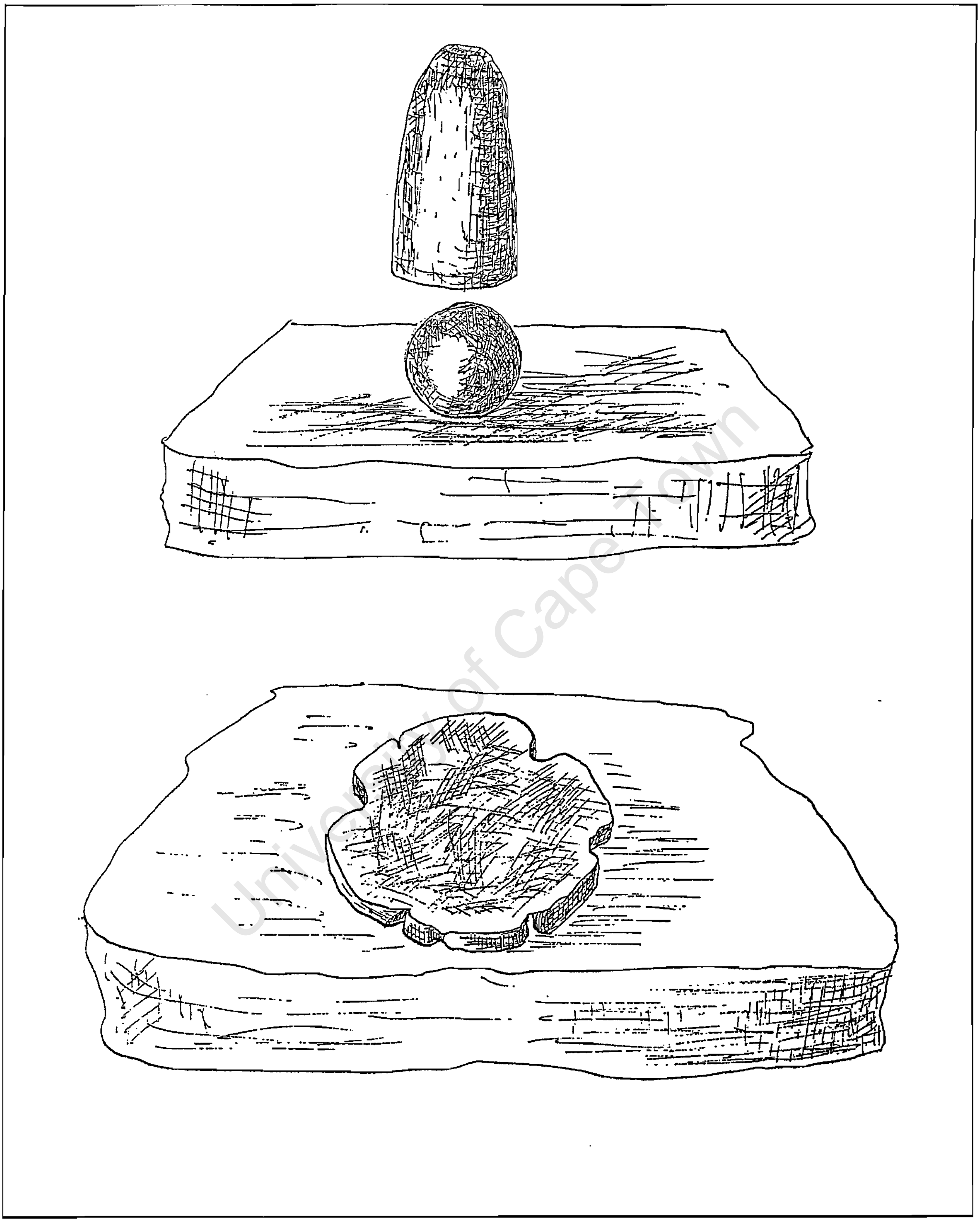


Figure 7: Discs: A prill is hammered flat to form a disc. A disc was most probably an intermediate stage of becoming a piece of foil. (Scale: Prills are approximately 3 to 7mm in diameter) (Drawing by C. Jardine)

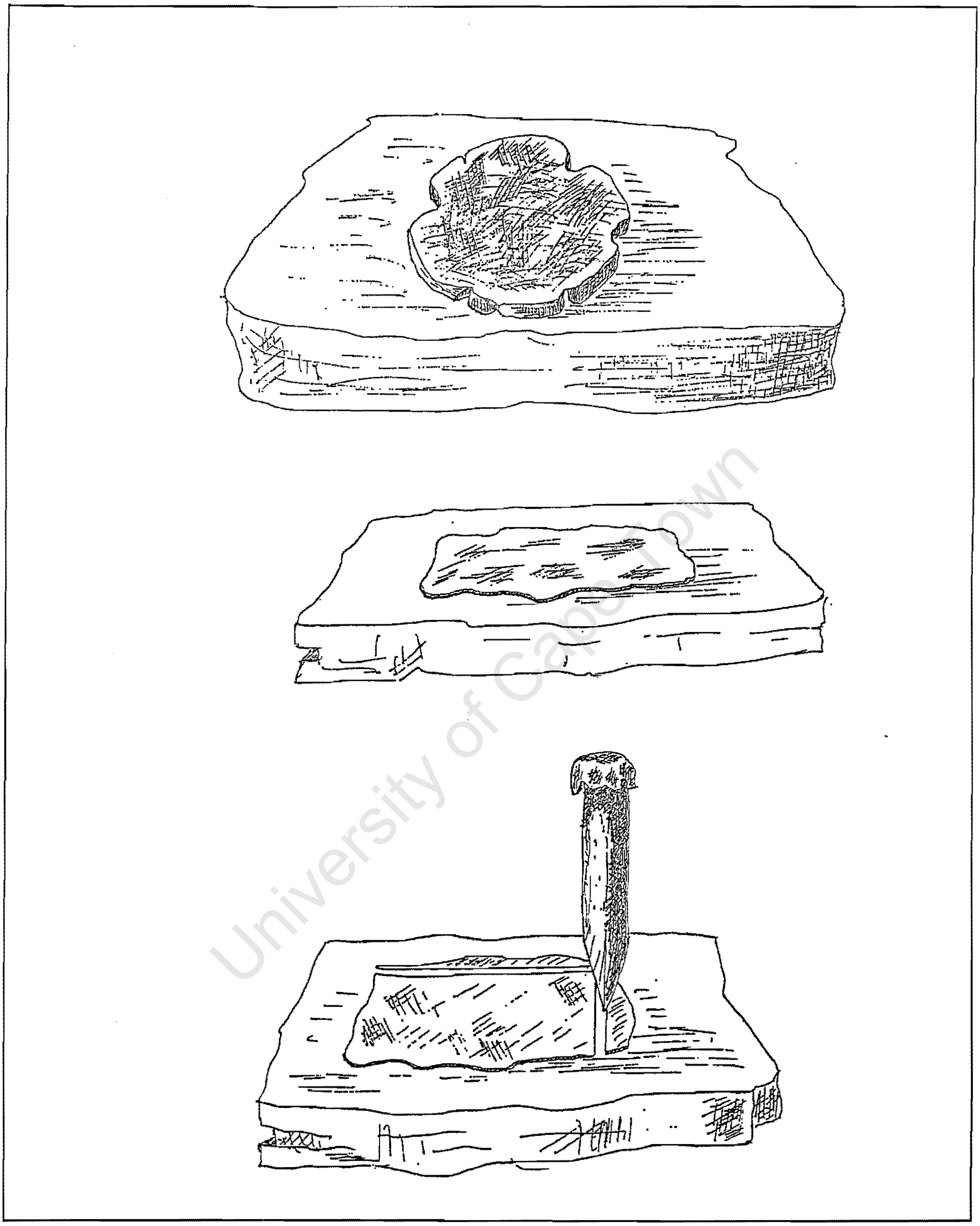


Figure 8: Foil: A flattened disc is hammered smooth and flattened out to produce a sheet of foil. This is cut to the require size with a chisel. The holes in the foil result from being attached to a substrate such as wood, with four-sided tacks. (Scale: Foil is approximately 2 cm in length) (Drawing by C. Jardine)

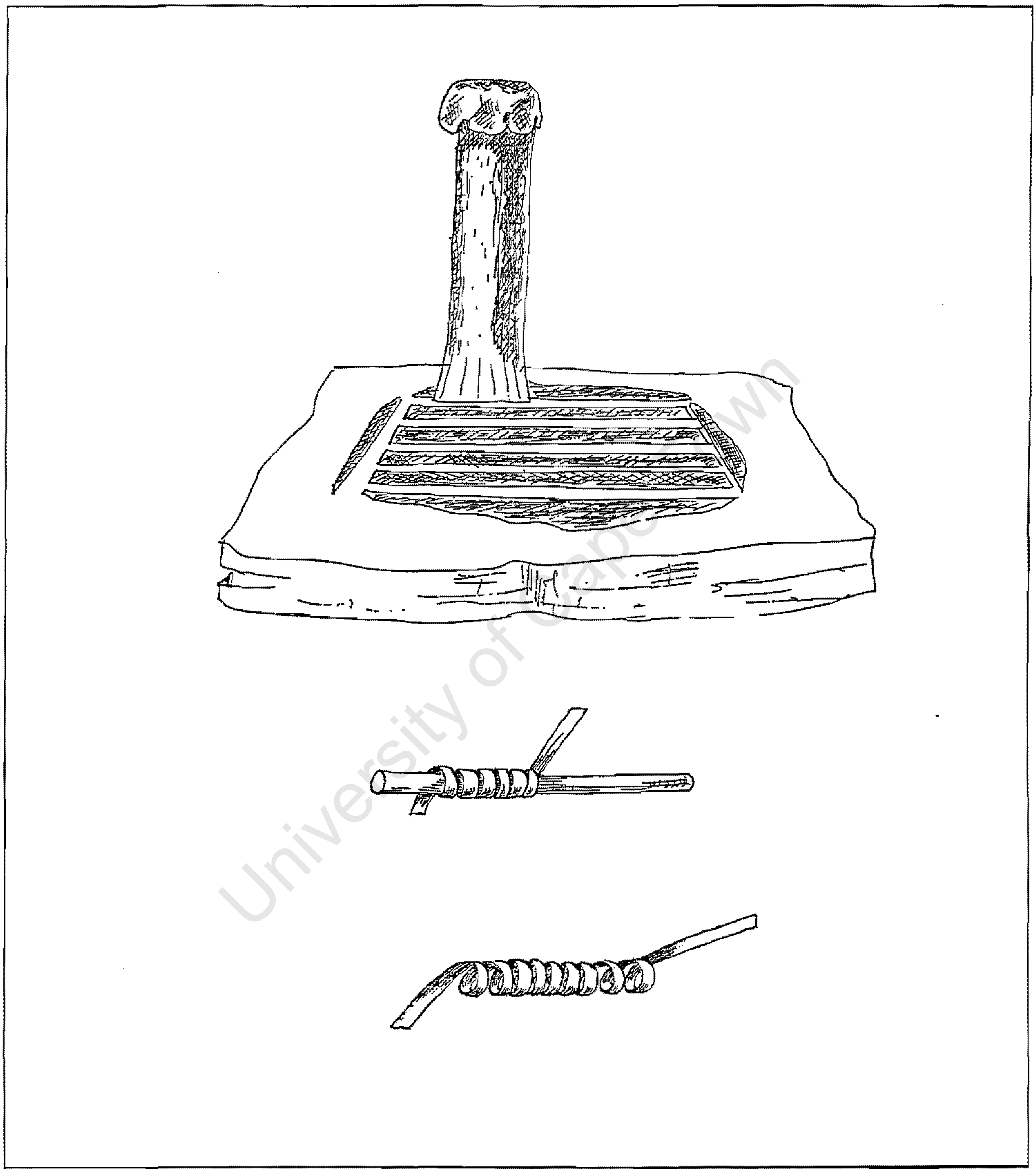


Figure 9: Coiled wire strips: These were made by cutting a piece of foil into strips with a chisel. A strip would be wound around a straight core. (Scale: Coil has an external diameter of approximately 10 mm.) (Drawing by C. Jardine)

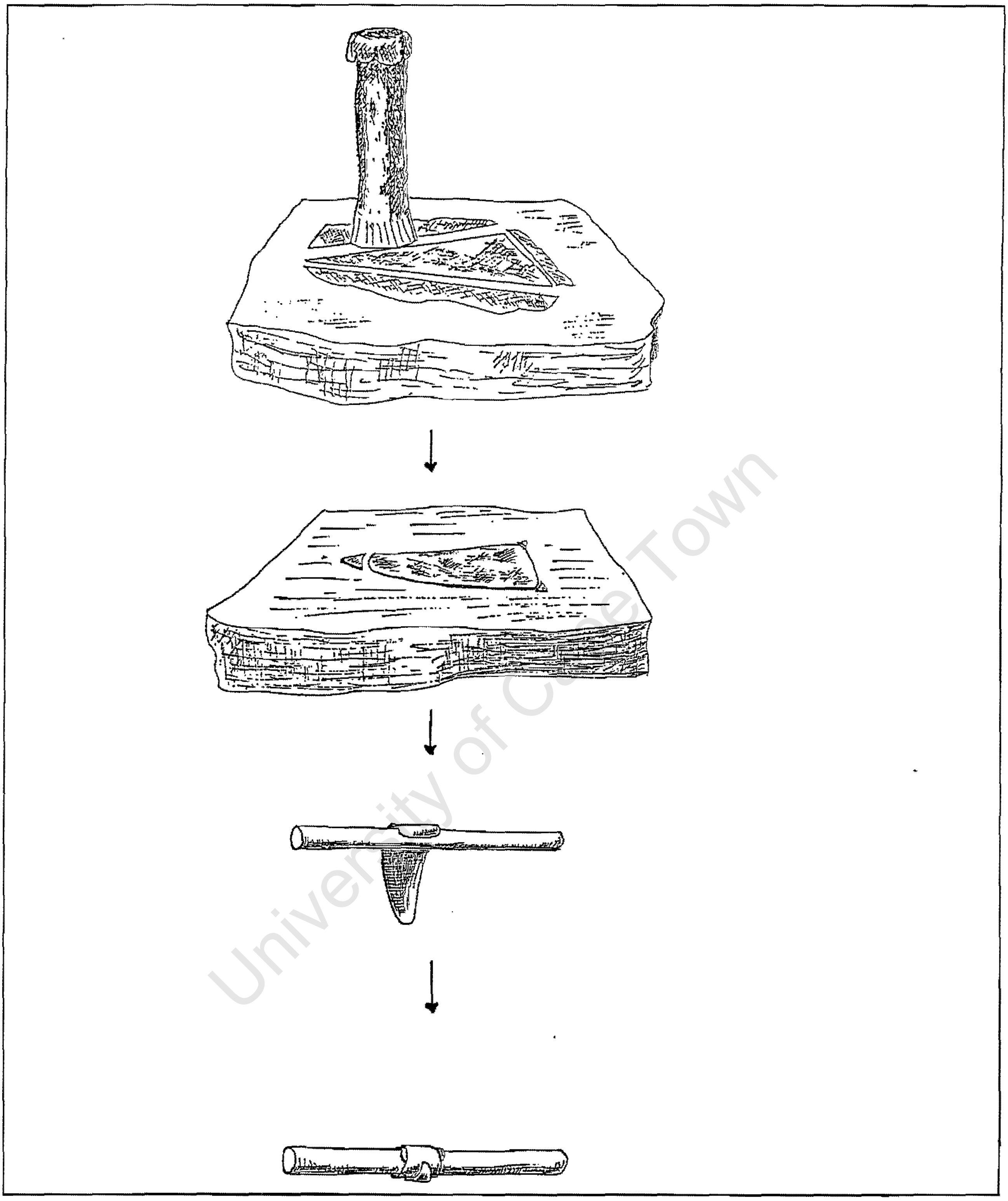


Figure 10: Rolled Beads: A piece of foil is produced and cut into a long triangular shape. The ends are rounded. This leaf is then folded around a rod to produce a rolled bead. (Scale: Bead has an external diameter of approximately 10 mm.) (Drawing by C. Jardine)

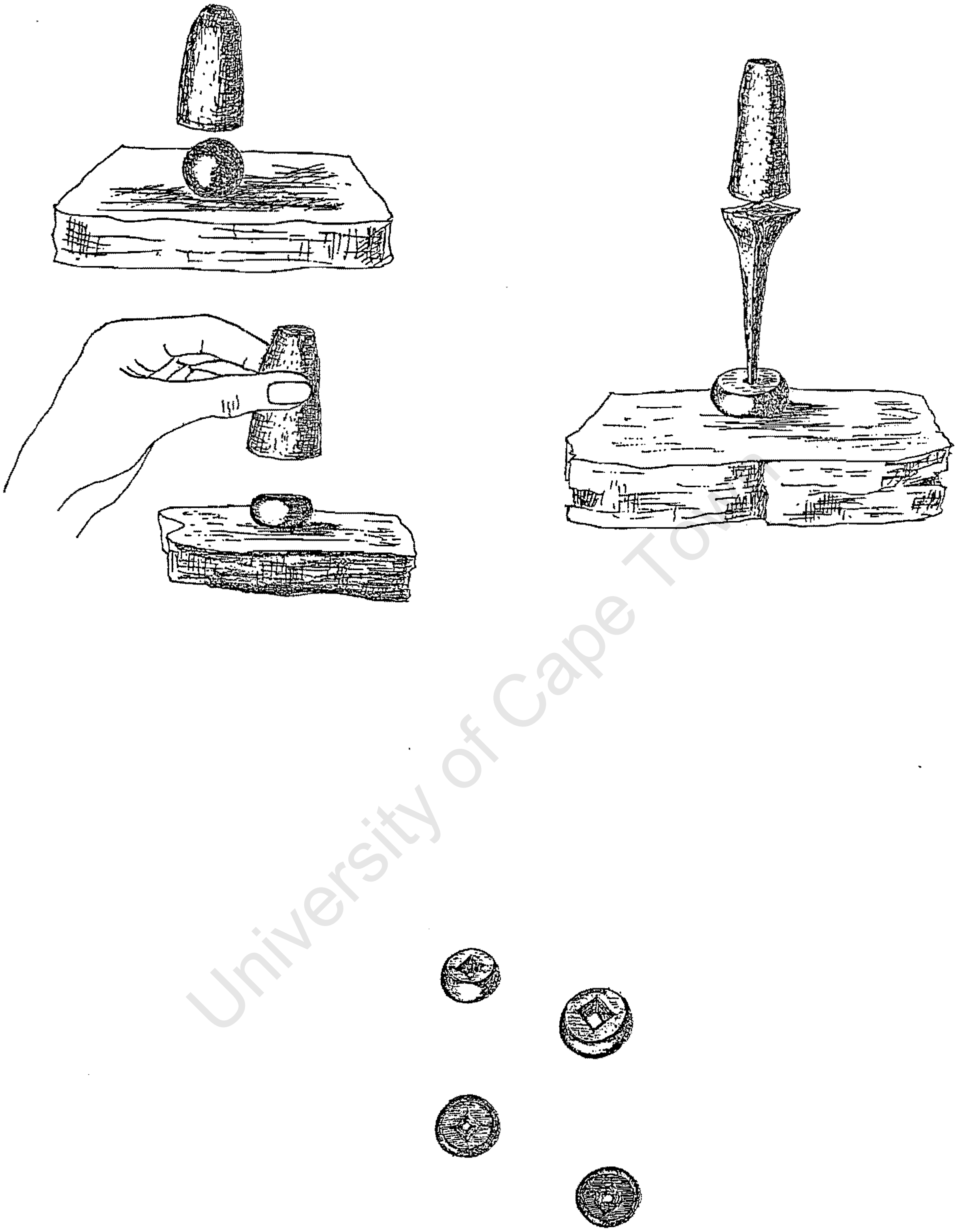


Figure 11: Punched Beads: A flattened prill is punched on both sides, resulting in a squarish hole. Through stringing wear (from being part of a necklace for instance) this squarish hole becomes larger and rounded (Drawing by C. Jardine)

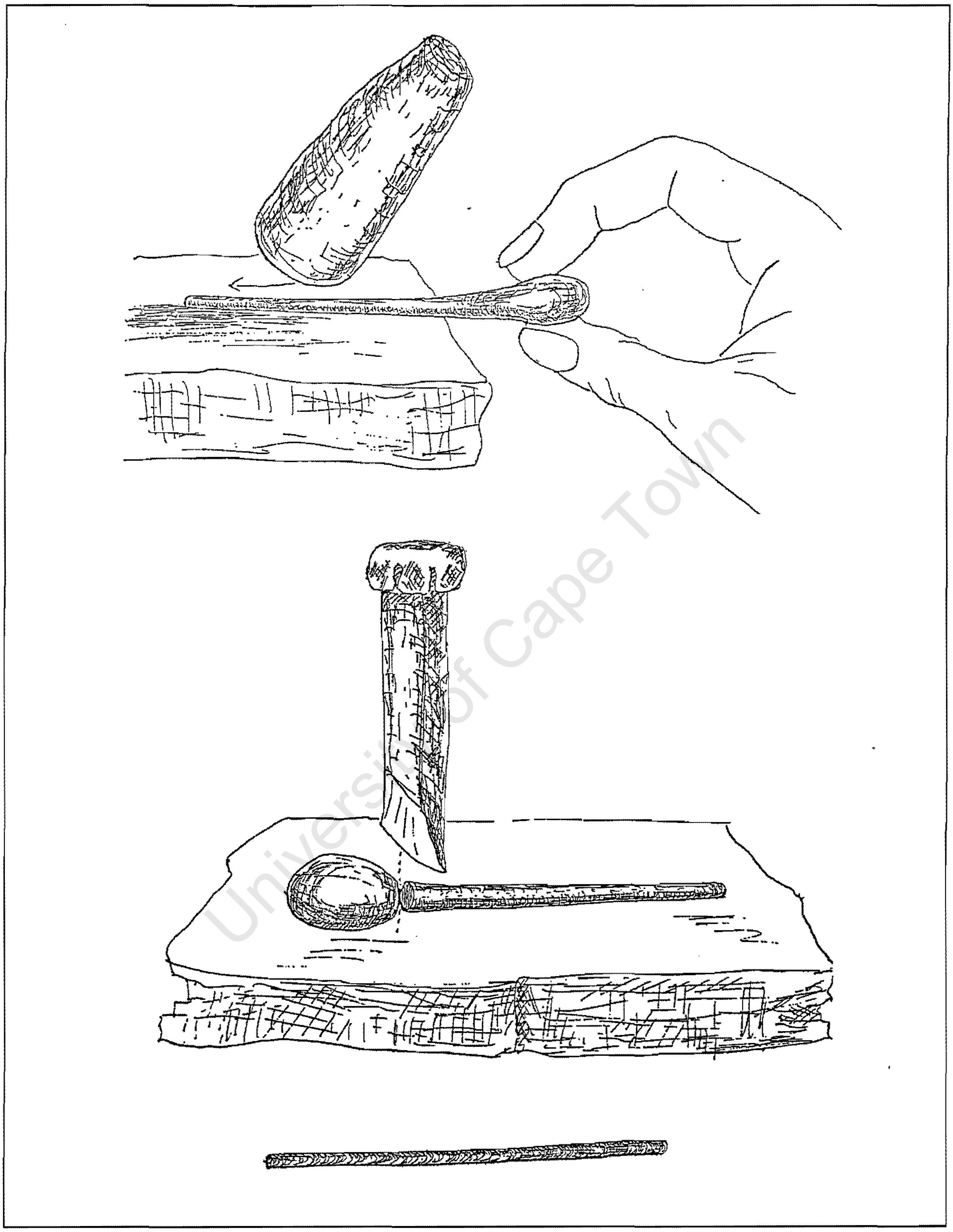


Figure 12: Wire: Wire was produced by hammering and stretching one side of a lengthened piece of gold while rotating it. This stretches and forms round straight wire. (Scale: see human hand.) (Drawing by C. Jardine)

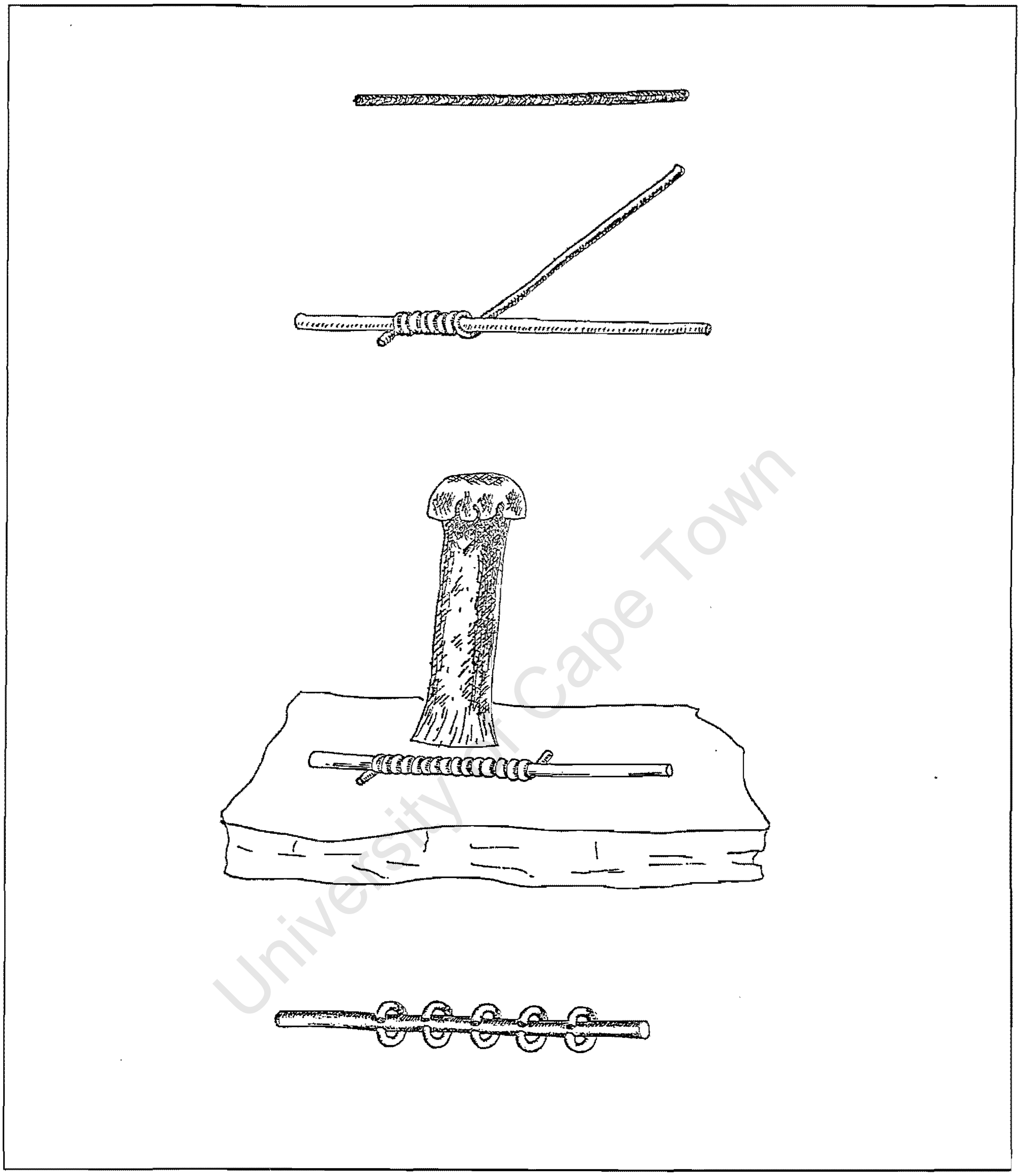


Figure 13: Coils: Using straight round wire and folding it around another straight wire acting as a core resulted in a coiled wire. It would have been used as a bracelet, for example.

Links: Coiled wire is cut along its length until open links are produced. Links are also an intermediate stage to becoming a wrapped bead.

Wrapped Beads: Coiled wire is cut along its length until open links are produced. These are then closed by hand. (Scale: Links are approximately 0.5 to 1.5 mm in diameter.) (Drawing by C. Jardine)

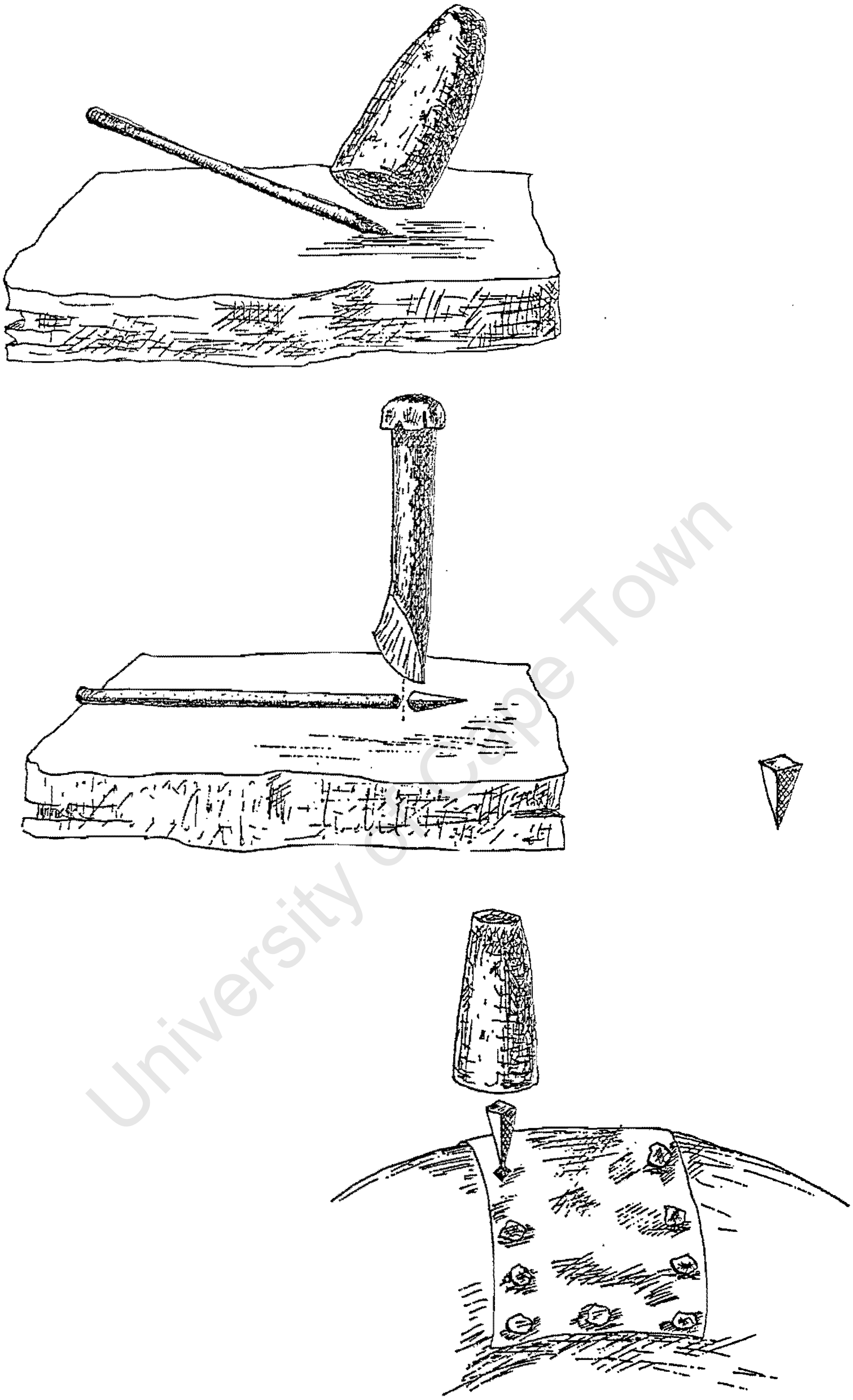


Figure 14: Tacks: A tack was produced by hammering the end of one side of a wire into a four-sided tapering point. This tapered end was cut off and the result was a tack. Only in use does it develop a splayed head (Scale: Tacks are between 0.7 and 1.4 mm in length.) (Drawing by C. Jardine)

Figure 15: This is one of the two royal burials at Thulamela. Commonly referred to as Queen Losha, she was found in primary context adorned with this wound gold bangle. (Photograph by S. Miller)

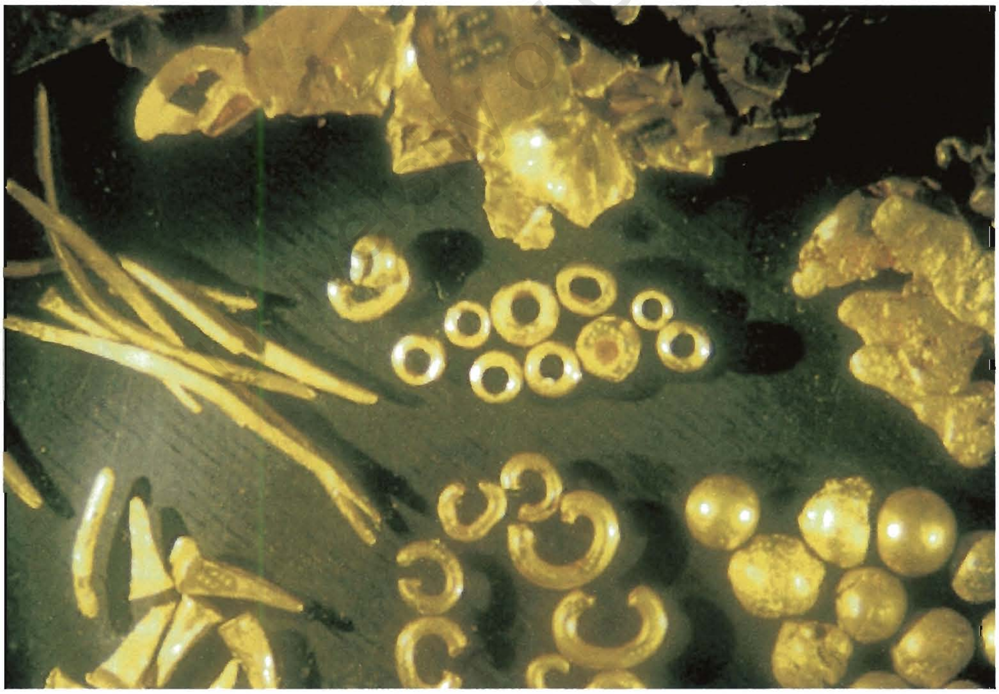


Figure 16: This is a representative collection of all the types of gold artefacts that have been recovered from assemblages of the Late Iron Age. Starting from the bottom left corner and working clockwise, these types consist of tacks, wire, foil, gold waste, prills, links. In the centre are assorted beads. (Magnification: 3x)

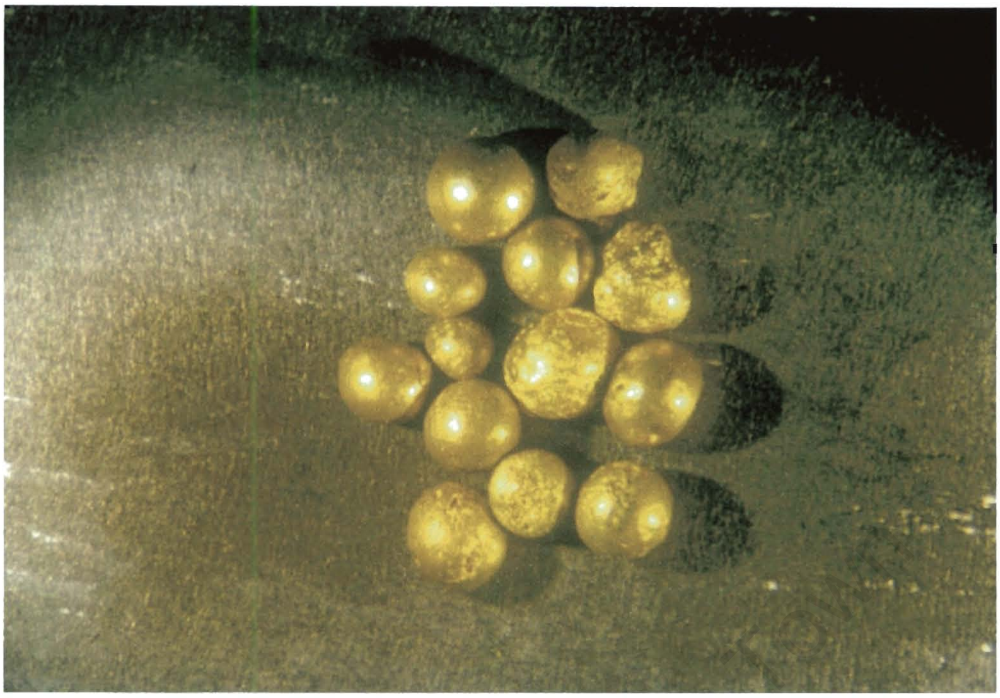


Figure 17: These prills are examples of the primary material for producing most if not all the artefacts described and viewed in the previous figure. These were most probably produced by pouring molten gold into water, or melting filings or short pieces of wire in a crucible packed with charcoal. (Magnification: 4x)

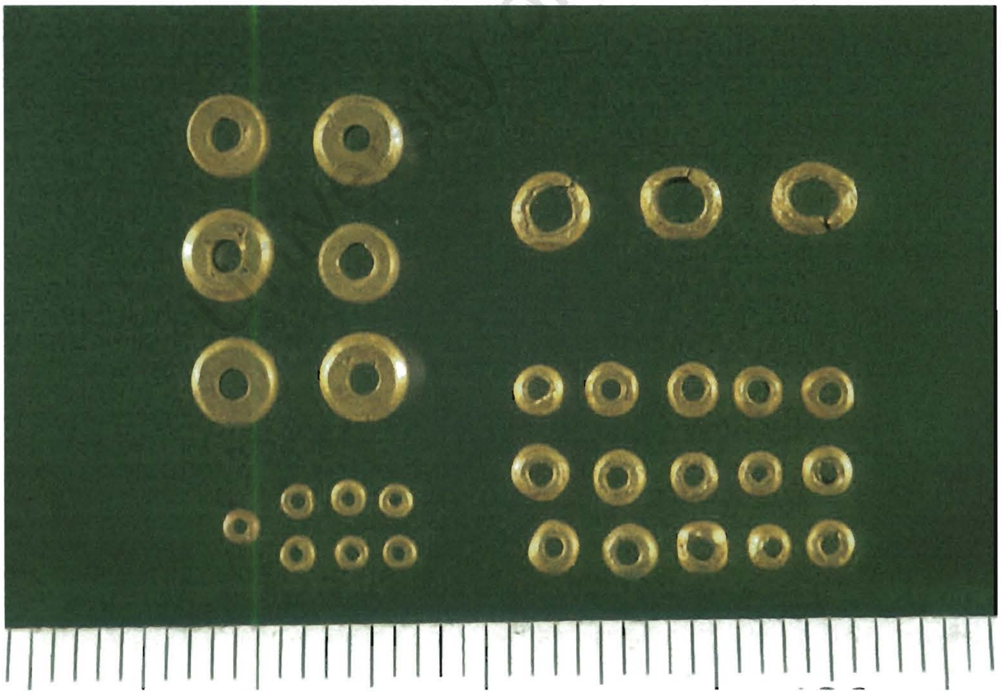


Figure 18: Beads are the most common type of gold artefact found in Iron Age assemblages. Two types are depicted here. One is a wrapped bead, where a short strip of wire was wound and closed. There are three examples in the above figure, in the top right quandrant. The other type pictured here is a punched bead, where a hole was punched through a prill. (Scale in mm.) (Photograph by D. Miller.)

Figure 19: The other types of beads are rolled beads, of which two were found at Mapungubwe (Meyer 1998: 251, 252), produced by rolling a three sided piece of foil closed. The other type was a variation of the punched beads where five indentations were impressed onto the outer margin. There are two examples above, one in the top right, and the other in the bottom row, second from left. (Scale in mm.) (Photograph by D. Miller.)

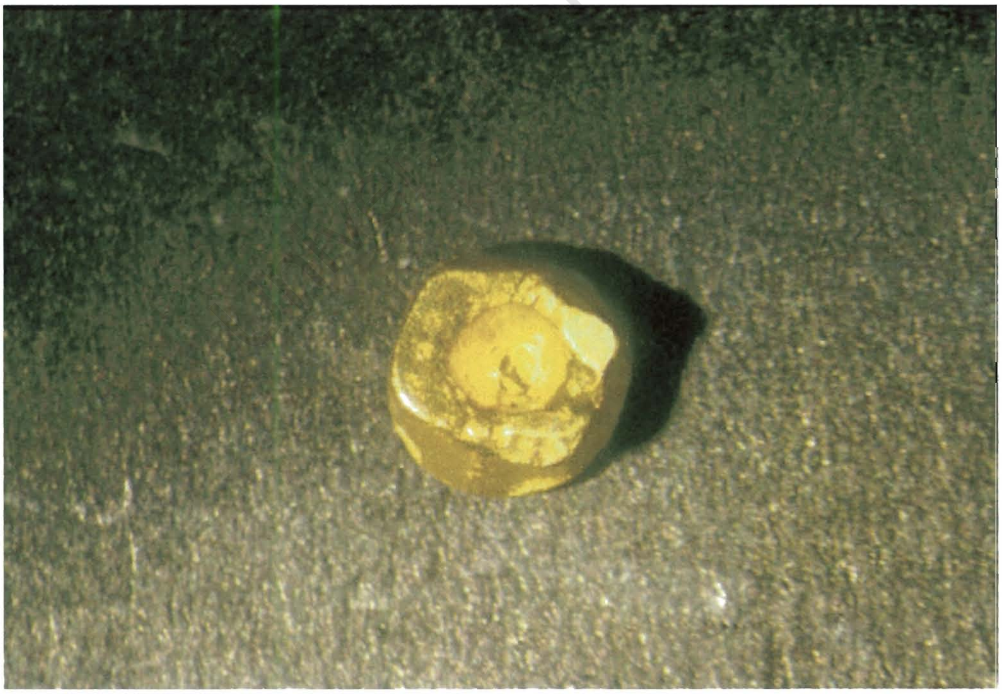


Figure 20: This is an example of a partially punched bead. Punched beads were pierced from both sides until a hole passed through the bead. The indentation seen here is tapered, and together with the four-folded punch marks usually seen on punched beads gives a clue to what punches looked like, depicted in Figure 6. It suggests that punches were four-sided tapering pieces made of a metal stronger than gold, most probably iron. (Magnification 11x)

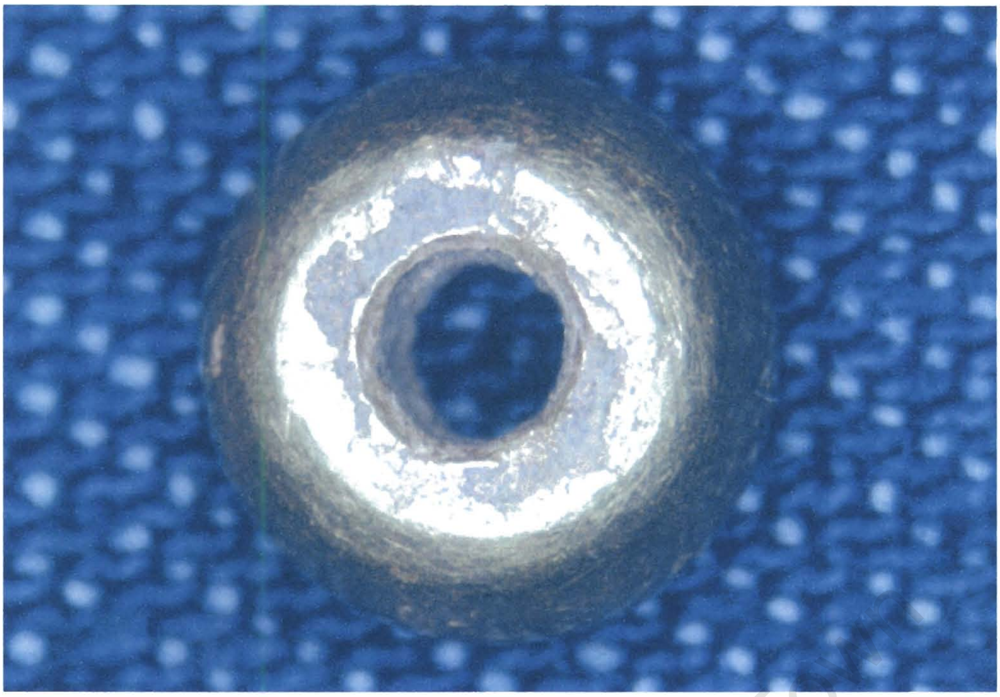


Figure 21: Even though this bead may have little visible fabrication damage, one can see the flattened sides, and the damage caused by punching in the form of the surficial wear just to the outer margins of the hole. (Magnification 15x) (Photograph by D. Miller.)

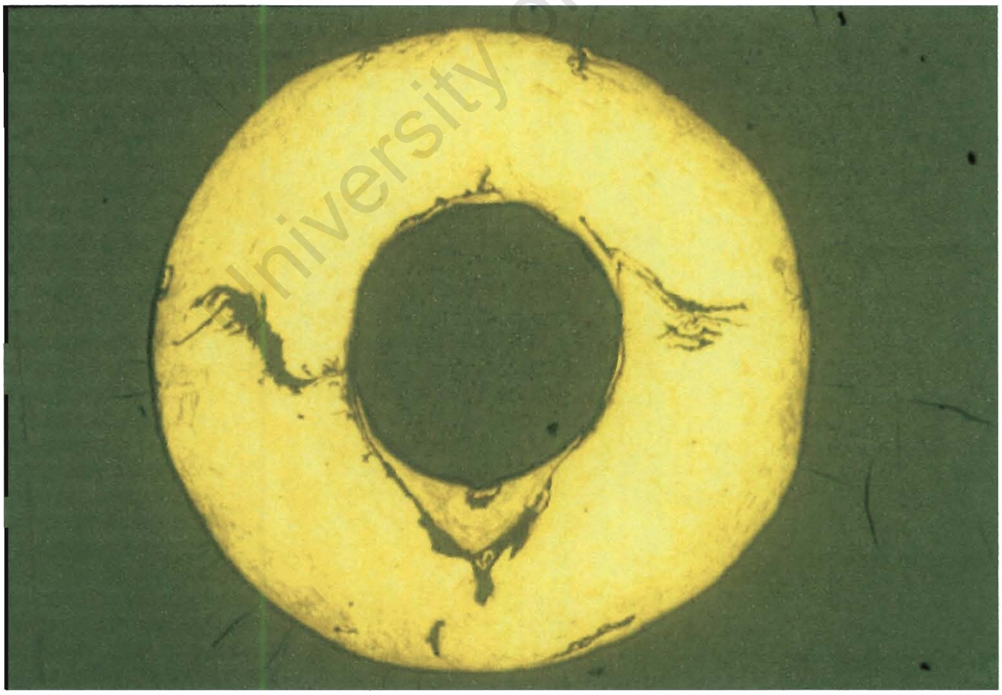


Figure 22: A metallographic section of a punched bead is seen here. The damage caused by punching is clear, evidenced by the four voids spaced equidistant from one another on the inner margin. (Magnification 42x)

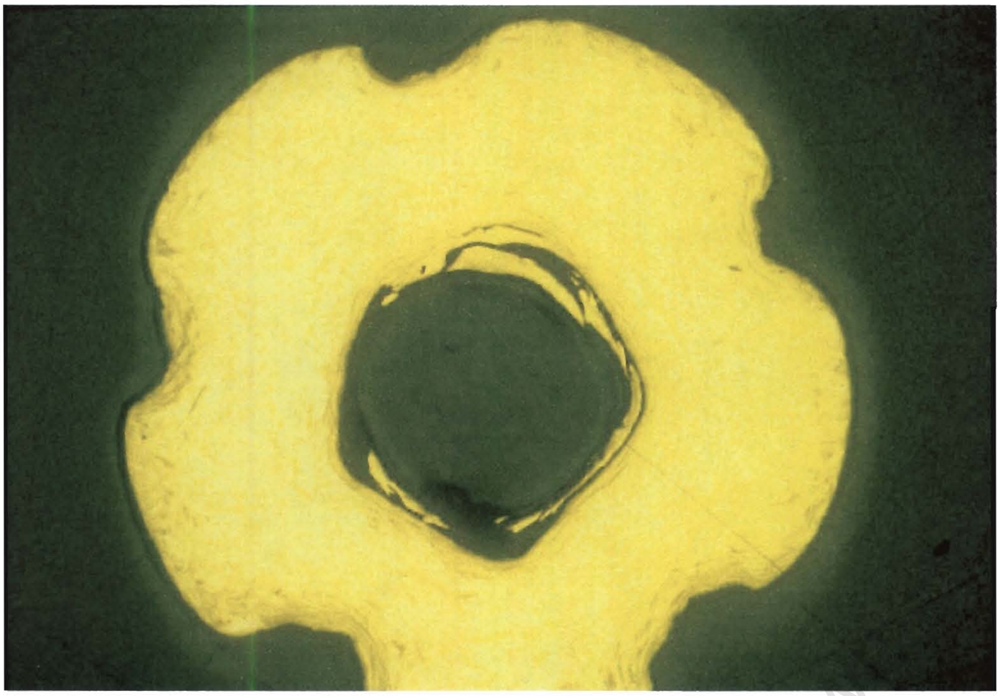


Figure 23: This is a punched bead with five indentations impressed on the outer margin. Crumpling of the grains at these indentations can be seen, as well as at the voids as a result of punching. This grain structure clearly shows crumpled grains on the outer margin. The majority of the rest of the grains contain slip bands as a result of cold working. Considering that this bead was punched, the inner margins grains do not show as much damage as would be expected, most probably due to stringing wear. (Magnification 27x)

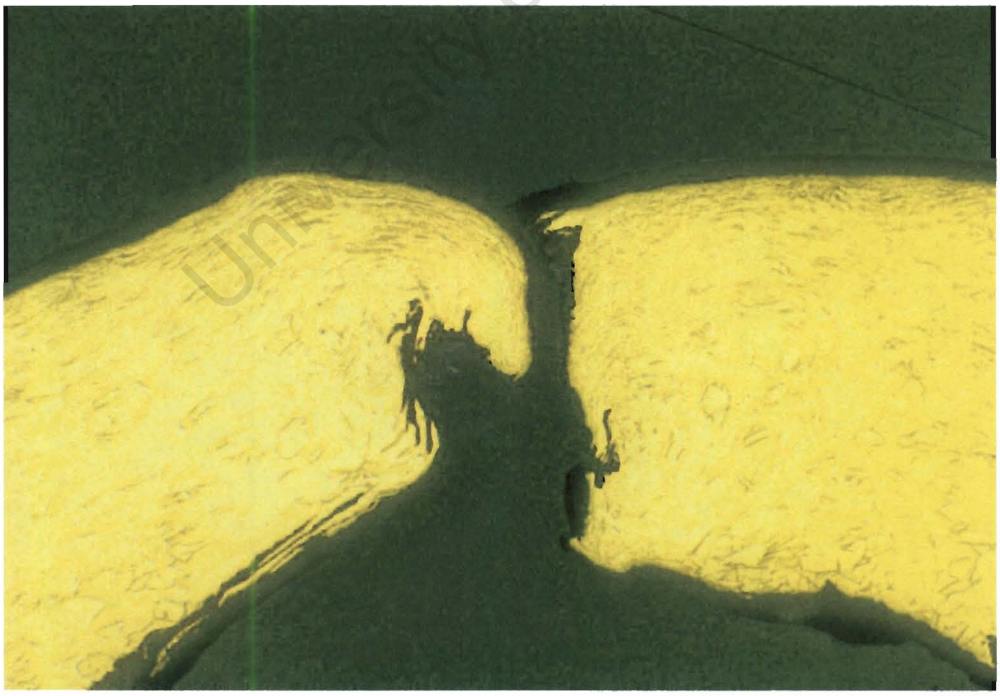


Figure 24: This is a metallographic section of the open join of a wrapped bead. The grains are relatively small, crumpled by cold woprking, and bent twinning is present. Cold working by folding the bead closed was the final stage of wrapped bead manufacture. (Magnification 84x)

Figure 25: This wire from the Great Zimbabwe Rhodes Collection is representative of wire found at all three sites. All the wire studied suggests that all wire was produced by beating it lengthwise to the desired length. No substantial evidence has yet been found for wire drawing. (Magnification 5x)

Figure 26: These are tacks from Great Zimbabwe. They were not yet used, since their heads are not splayed, as is seen on the following picture. (Magnification 5x)

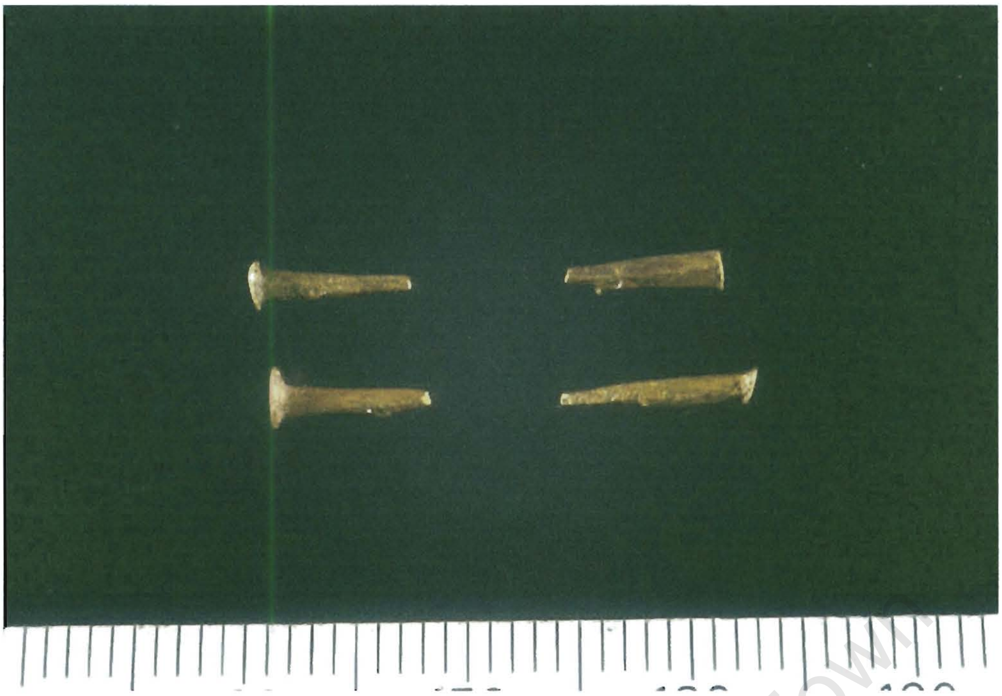


Figure 27: Three of these tacks have been used, since they have splayed heads. Only the one in the top right is unused. (Scale in mm.) (Photograph by D. Miller.)

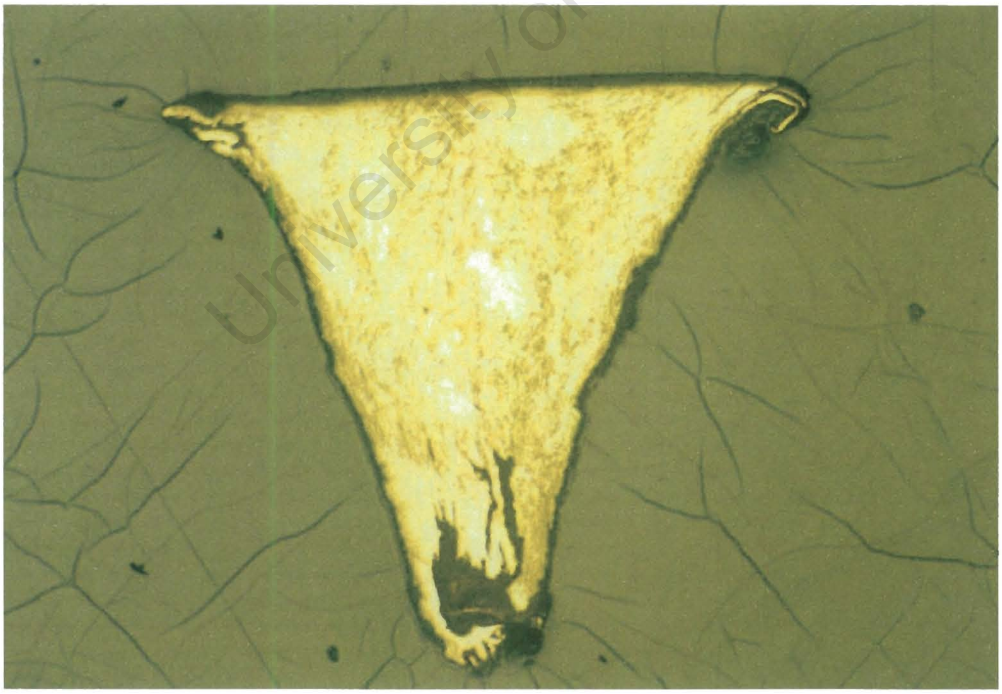


Figure 28: This is a metallographic section of a used tack, clearly showing the deformation as a result of the production and flattening of a head, and the deformation on the tip from impaction into a substrate, presumably wood. (Magnification 42x)

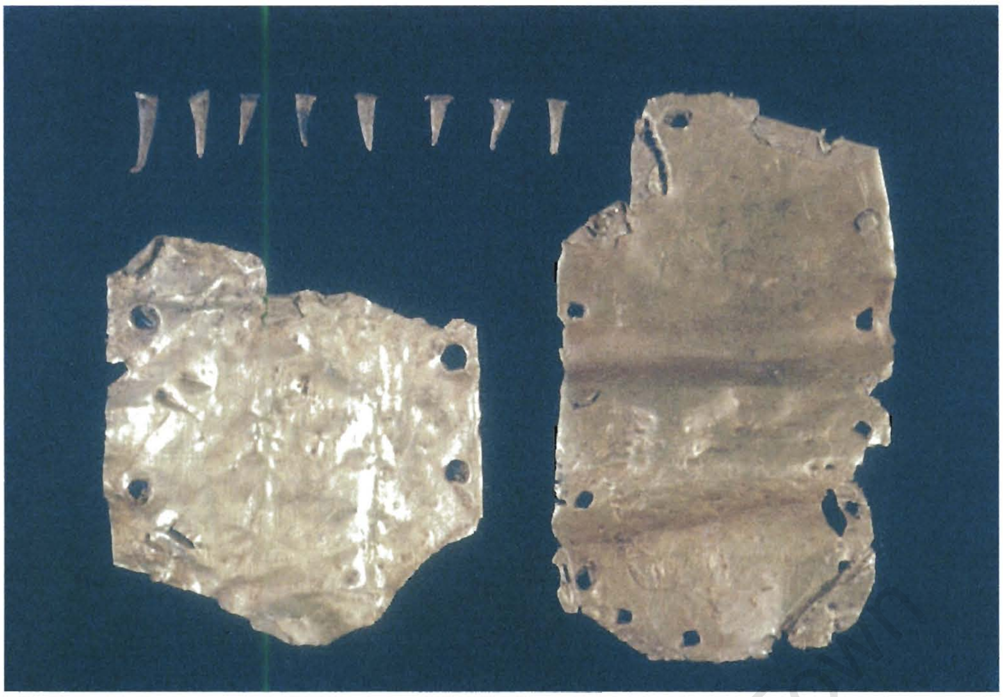


Figure 29: The tacks were used to attach plates of gold to a wooden substrate, with the tacks punched along the outer edges of the foil. The surfaces were then scratch burnished, resulting in a shine. (Magnification 1.4x) (Photograph by D. Miller.)

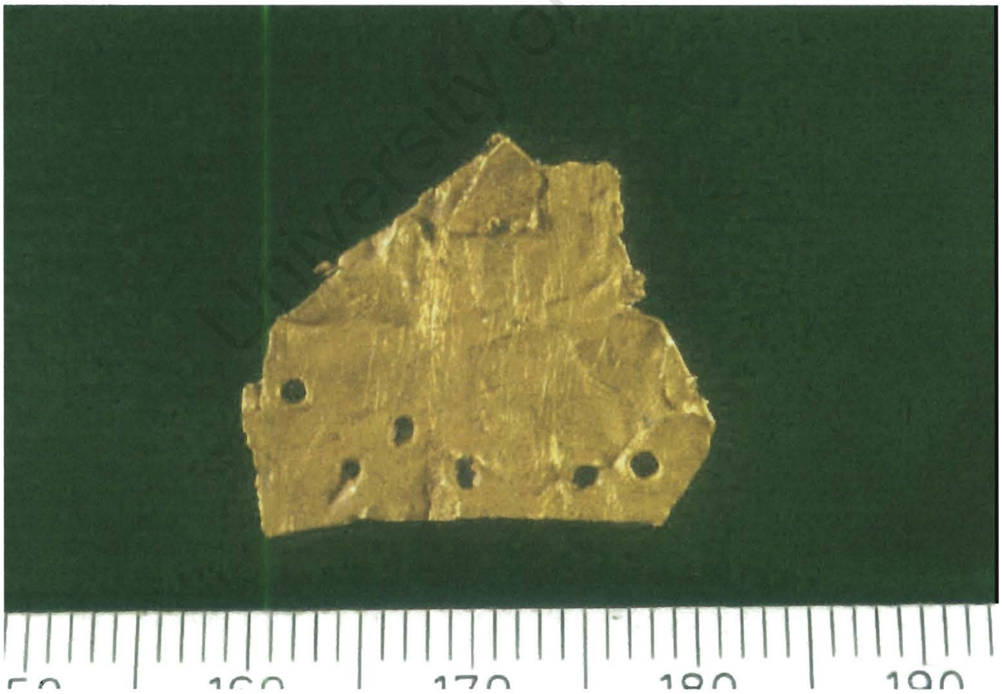


Figure 30: A close-up of a piece of foil, clearly showing evidence for scratch burnishing. This is the top side, since the punch marks are facing downward. (Scale in mm) (Photograph by D. Miller.)

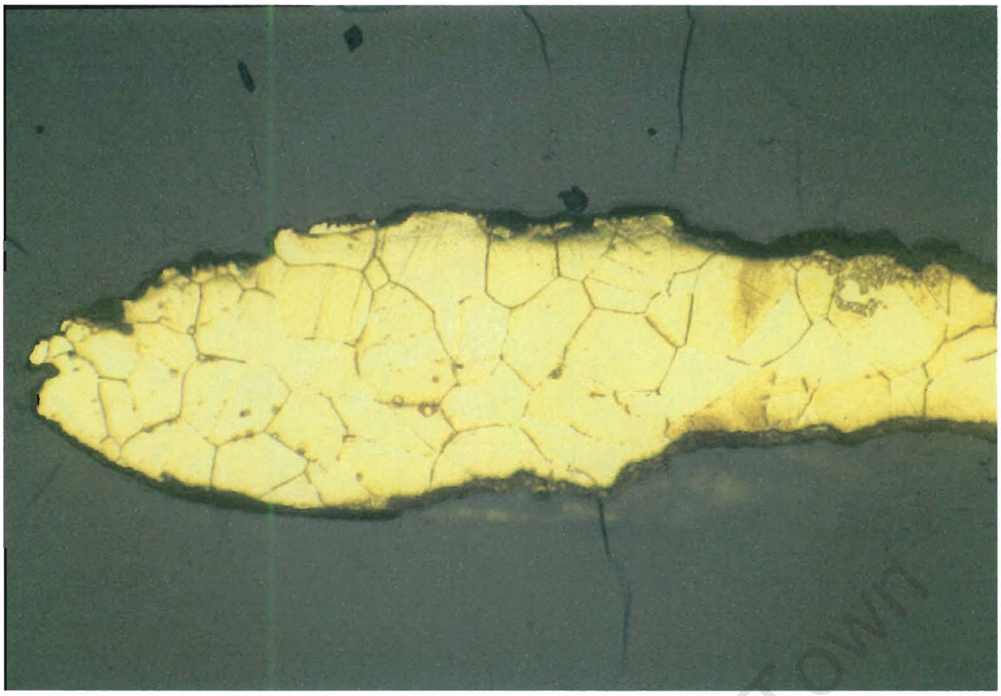


Figure 31: This is a metallographic section of a cross-section through a gold strip , cut from gold foil. The grains are recrystallised, equi-axed, and angular. Annealing twins are present, and the top layer has more evidence of deformation than the lower. Deformation of the top surface is most probably from scratch burnishing. (Magnification 84x)

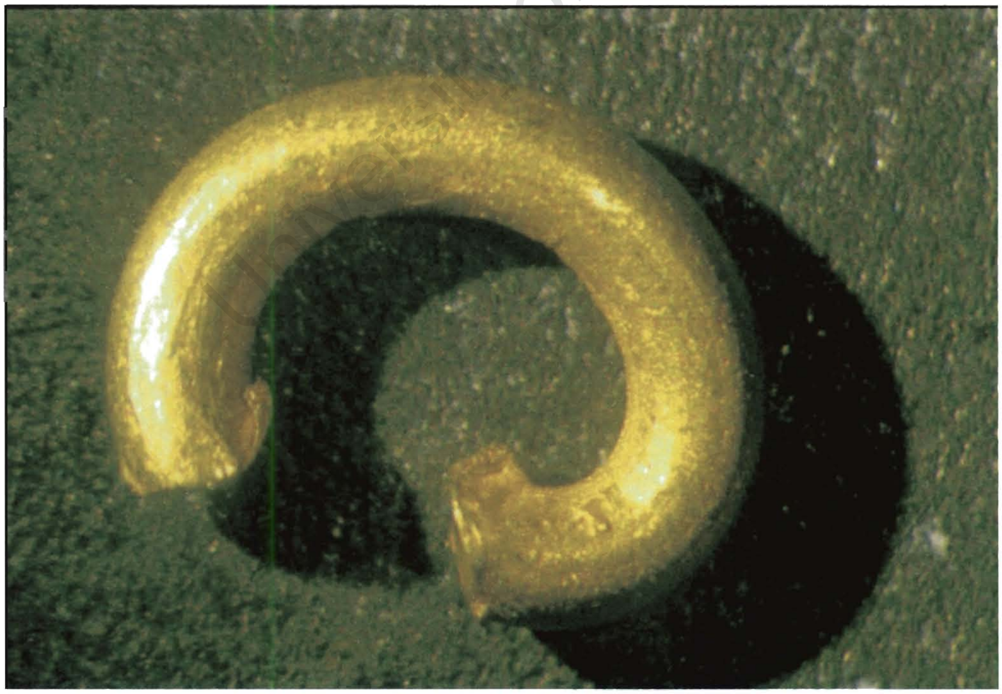


Figure 32: This is an example of a link. It is made of a strip of wire with the ends bent together, similarly to the way wrapped beads were made. (Magnification 18x)

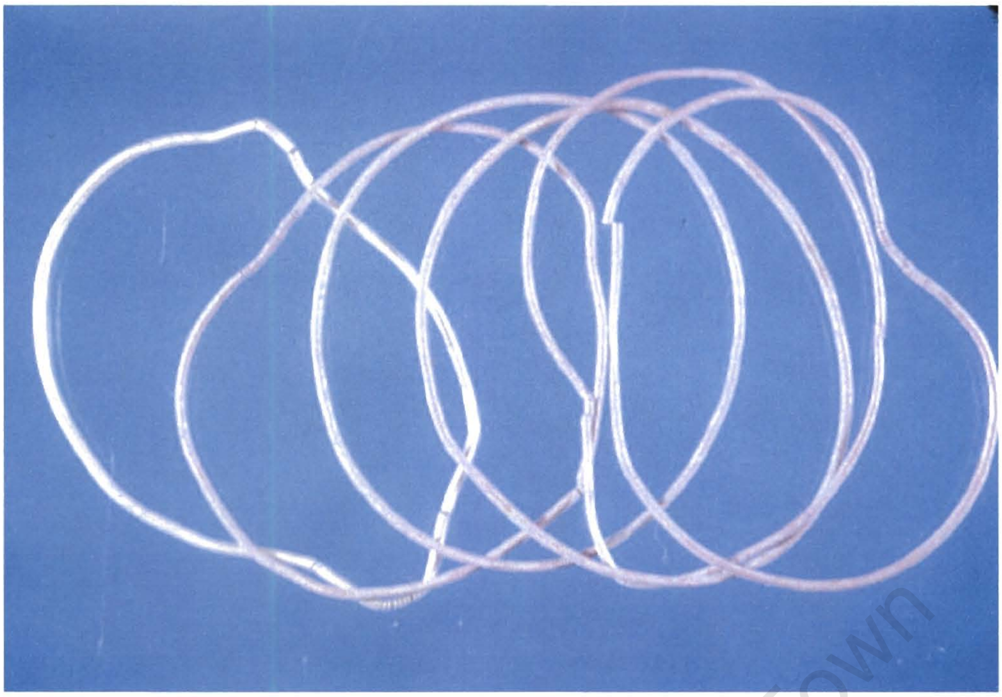


Figure 33: These are gold bangles made of coiled, or wound wire. They were worn around the long limbs. (Magnification 0.8x) (Photograph by D. Miller.)

Figure 34: This is a section of a coiled bangle. The outer edges have been flattened. It was made from beaten wire that originally was round. Through wear the outer surface became abraded and flattened. (Scale in mm.) (Photograph by D. Miller.)

Table 1 - Gold artefacts from Mapungubwe analysed at Anglo American Research Laboratories, Harvard University and the University of Cape Town.

Number	Object	Mass (g)	Anglo	Harvard	Sectioned?	%Ag
M870	bead	0.056	yes	no	no	-
M1118	bead	0.057	yes	no	no	-
M1231 A	bead	0.191	yes	no	yes	4
M1231 B	bead	0.099	yes	no	yes	4.5
M1231 C	bead	0.041	yes	no	yes	6.4
M1231 D	bead	0.037	yes	no	yes	6
M1231 E	bead	0.045	yes	no	yes	10.2
M1231 F	bead	0.201	yes	no	yes	12.4
M1231 G	bead	0.043	yes	no	yes	5
M1231 H	globule	0.555	yes	no	yes	3
M1231 I	helix	0.221	yes	no	yes	3.9
M1231 J	helix	0.175	yes	no	yes	3.8
M1231 K	helix	0.09	no	no	yes	3.1
M1231 L	strip	0.089	no	no	yes	3.6
M1231 M	sheet	0.037	no	no	yes	6.9
M1231 N	tack	0.062	yes	no	yes	3.9
M1231 O	tack	0.045	yes	no	yes	4.1
M1231 P	wire helix	0.155	yes	no	yes	8.3
M1231 Q	wire	0.042	no	no	yes	8.8
UCT A	tack	0.109	yes	no	yes	-
UCT B	tack	0.147	yes	no	no	-
UCT C	tack	0.111	yes	yes	yes	4.4
UCT D	tack	0.135	yes	yes	yes	6.8
UCT E	helix	0.302	yes	yes	yes	7.8
UCT F	sheet	0.368	no	yes	yes	5.5
UCT I	6 beads	1.718	6 beads	2 beads	2 beads	10.9
						4.5
UCT J	3 beads	0.378	3 beads	2 beads	2 beads	8.5
						3.7
UCT K	15 beads	0.872	14 beads	4 beads	4 beads	8.9
						4.9
						8.9
						4.7
UCT L	7 beads	0.121	5 beads	2 beads	no	-

Table 2: A metallographic description and method of fabrication of the artefacts from Mapungubwe.

Object	Structure	Constituents	Grain Size (ASTM)	Inclusions	Deformation	Fabrication
M1231A annular gold bead	wrapped bead, homogeneous, visible open join	bulk of material has angular recrystallised equi-axed grains with annealing twins	6-7	none	join: grains are elongated, severely cold worked outer: smeared layers, grain elongation inner: few cracks/protuberences that have been flattened (from stringing wear see L) preceded crystallisation	-strip cut from hammered sheet – annealed – wrapped around; ends worked cold – outer margin cold worked through use wear
M1231B annular gold bead	homogeneous, visible open join	the bulk grains are recyrstallised angular and equi-axed with annealing twins	+-5	none	join: elongated grain deformation outer: small amount of local deformation and smearing on outer margin. inner: some lamination and deformation due to smearing, strain lines on inner margins.	-strip cut from hammered sheet – strip annealed – strip hammered around cold - preserving rough inner surface – join hammered closed – outer surface burnished through use wear
M1231C annular gold bead	homogeneous, no visible join	recrystallised angular equi-axed grains; few strain lines present	+-4	none	outer: many slip bands and elongated grains on outer margin bulk: few slip bands inner; two voids opposite each other, and slight smearing present	- cast droplet perforated – annealed – cold working from use wear
M1231D gold bead	homogeneous, no visible join	recrystallised angular equi-axed grains - 4 stress fractures running through the cross section of the sample corresponding to punching/perforation marks	5-6	none	outer: strain lines due to cold work, elongation and deformation of outer margin grains bulk: 4 stress fractures correspond to 4 punch marks in bulk of material inner: burnished inner margin fused smearing areas present	-cast droplet perforated – annealed natural wear caused smearing and slip bands on outer margin
M1231E. annular gold bead	homogeneous, no visible join	recrystallised angular equi-axed grains, voids on inner margin, outer margin has strain lines, a few bent annealing twins are present	6-7	none	outer: strain lines and elongated grains present bulk: smallish grains with bent twins, inner: 4 voids corresponding to punch marks and elongated grains, smearing from stringing wear.	cast droplet punched cold – outer margin smoothed and smeared due to use wear
M1231F gold bead with five grooves	punched bead with pentagonal shaped hole and 5 outer grooves.	recrystallised angular equi-axed grains with straight twins, numerous slip bands	+-5	none	outer: severe deformation and grain flattening in base of grooves bulk: slip lines occur thoughout due to cold work inner: severe grain deformation and flattening, lamination due to smearing, originally round hole was deformed into pentagonal shape by the indentation of the 5 external grooves	-cast droplet perforated - annealed – five ornamental grooves impressed cold onto outer margin causing deformation and distortion of inner bore

M1231G gold bead with grooves	homogeneous, no visible join	recrystallised angular, equi-axed grains in the bulk of the metal numerous slip bands occur in the bulk of the metal; two voids occur on inner margin closest to two of the grooves and the third one is in the bulk,	larger grains +-5 smaller grains +-10	none	outer: 5 grooves with associated strain lines and elongated flattened grains occur, lamination possibly from smearing or natural use inner: lamination of inner margin from smearing in use	cast droplet-perforated/punched – 5grooves impressed cold onto outer margin, inner margin smoothed by smearing.
M1231H cast prill	numerous casting voids	rounded dendritic grain structure, withn numerous dendritic pores	---	none	-none – no cold work	casting of the droplet/prill – unworked cast droplet.
M1231I helical strip fragment	homogeneous	recrystallised, angular equi-axed grains no slip bands, annealing twins present, rough inner margins & smooth outer margins.	6-7	none	no visible deformation	strip cut from hammered sheet on rough anvil –coil cut from inside forming trapezoidal sections– outer surface burnished/flattened
M1231J helical strip fragment	homogeneous	recrystallised, angular & equi-axed grains with annealing twins; no slip bands, rough inner margins & smooth outer margins.	5-6	none	no visible deformation	strip cut from hammered sheet on rough anvil –coil cut from inside forming trapezoidal sections– outer surface burnished/flattened
M1231K helical strip fragment	homegeneous	recrystallised, angular equi-axed grains; No slip bands, voids; annealing twins present	+-3	none	deformation of equi-axed grains; both sides are rough	strip cut from hammered sheet – annealed – coil hammered around cold
M1231L strip fragment	homogeneous, smearing on one side, rough texture on outside, burnished texture on inside	recrystallised, angular & equi-axed grains with annealing twins	+-4	none	outer: smooth, no visible deformation bulk: annealing twins, no slip bands inner: rough numerous pits and protuberences from hammering on a rough anvil.	hammered sheet smeared/burnished on one side, sheet cut into strip
M1231M flat sheet fragment	homogeneous, two kinks in sheet representing a fold	recrystallised, angular & equi-axed grains; no slip bands; bent twins present, esp. in fold	+-8	none	outer: burnished edges on both margins, pitted bulk: bent twins, small grain size - 2 areas of interganular corrosion, high Ag content	hammered sheet rough on both sides, sheet bent at two places
M1231N wrought tack	homogeneous metal, but with two longitudinal cracks	two longitudinally running voids through length of sample. Flattened head	inner/ centre grains 5-6 outer grains 6-8.	none	head: severe cold working sides: one side is smoothened, other side is smeared bulk: two voids possibly being evidence of lamination occurs from tip to centre of nail, generally grains are warped.	wire hammered causing 4-sided wdge incoporating longitudinally running voids. This section was cut with chisel, tapered by hammering cold, head formed by hammering/cold work.

M1231O wrought tack	homogeneous	two longitudinally running voids with one large void in between the two at the tip; both sides smeared	8-9	none	head: grains flattened, edge smoothened sides: both sides smeared bulk: two voids running from tip to centre of nail - centre is slightly less cold worked than margin. Some residual angular grains with annealing twins.	wire hammered causing 4-sided wdge incoporating longitudinally running voids. This section was cut with chisel, tapered by hammering cold, head formed by hammering/cold work.
M1231P helical strip fragment	homogeneous, smeared outer margins	recrystallised, angular & equi-axed grains with annealing twins; no slip bands	5-6	none	bevelling/flattening of the sample outer margins	hammered wire – coiled – outer margins flattened by abrasion producing D-shaped cross-section – annealing.
M1231Q helical strip fragment	homogeneous, smeared outer margins	recrystallised, angular & equi-axed grains with annealing twins; no slip bands	5-6	none	bevelling/ flattening of the sample outer margins	hammered wire – coiled – outer margins flattened by abrasion producing D-shaped cross-section – annealing.
UCT C broken nail	homogeneous, smeared on one edge, smooth on the other	Strain lines, few bent twins, elongated, flattened grains in bulk of material, few residual slip bands, generally heavily deformed/cold worked	4-5	none	head: flattened, voids on outer edge, grains flattened, elongated sides: one smooth, other is smeared - heavy cold work thoughout, esp. at head	wire hammered causing 4-sided wdge incoporating longitudinally running voids. This section was cut with chisel, tapered by hammering cold, head formed by hammering/cold work.
UCT D broken nail	homogeneous, more smeared on one side than the other, point is heavily damaged.	Many slip bands, bent twins	centre 7-8 outer +-5	none	head: void occurs at one edge bulk: elongated grains run along length of sample - head not a badly worked as UCT C	wire hammered causing 4-sided wdge incoporating longitudinally running voids. This section was cut with chisel, tapered by hammering cold, head formed by hammering/cold work.
UCT F gold sheet (2 fragments left)	homogeneous,	Straight twins, constant grain size; no voids, angular grains with bent twins.	4-5	none	consistent grain size, all edges are smeared, pitted on both sides, heavily annealed	hammering out on rough anvil – annelaing – post-annealing deformation.
UCT Ka small annular bead	homogeneous, possible join, many voids	smeared outer margin, smooth inner, few voids, strain lines, heavy cold working esp. on inner and outer margins.	5-6	none	outer:smeared layers, two stress fractures running through bulk to inner margin, several strain lines bulk: one large void in bulk only, several smaller ones, few strain lines inner: generally smoothened edge but several strain lines, one void running from outer to inner margin.	strip cut from hammered sheet – annealed – strip bent around cold – outer margin smeared due to use
UCT Kb small annular bead	homogenous, possible join, few voids	several slip bands on outer margin; several voids on inner, few bent twins in bulk of material, some residual angular annealing grains.	inner 9-10 outer 8-9 centre +-6	none	outer: smeared, flattened, elongated grains, one void bulk: bent twins, strain lines inner: continuous voids along the circumference	strip cut from hammered sheet – strip bent around cold – annealed – smearing caused bent twins and voids on inner and outer margins

UCT Kc small annular bead	homogeneous	smearing on inner margin, one large cross-sectioned running void, bent twins, outer half grains smaller than inner	between 10 and 7-8.	none	outer: slip bands, elongated flattened grains, two voids due to smearing. bulk: slip bands, bent twins, elongated grains, one large void inner: smeared innner, one void, flattened elongated grains	strip cut from hammered sheet – strip bent around cold – annealed – smearing caused bent twins and voids on inner and outer margins
UCT Kd small annular bead	homogeneous, possible visible join	strain lines, bent twins, flattened grains through bulk of material	centre 6 very outer 10.	none	outer: flattened, elongated grains, smeared edge bulk: larger grains, bent twins, three voids inner: smearing from stringing wear, one void running towards bulk of material	strip cut from hammered sheet – bent around cold – smearing on outer margin due to smoothing of outer circumference, inner smearing due to stringing wear, bead damaged through previous analysis
UCT I1 Large annular bead	homogeneous	bent twins and strain lines in bulk of material, voids on inner margin, heavily cold worked but some residual angular grains with numerous slip bands	inner 9-10 outer 7-8 centre +-5	none	outer: grain crumpled, flattened and elongated due to punching bulk: strain lines, bent twins inner: crumpled grains, most of strain lines occur here, two voids on edge - cold working on outer and inner margins	hammering of strip of sheet – further cold worked – bent around – outer flattened – inner smeared
UCT I2 small annular bead	homogenous	strain lines and bent annealed twins in bulk of material	+-5	none	outer: smearing on part of outer layer, incorporating long laminous voids bulk: annealed bent twins, dendritic grain structure, small cracks caused by protuberences inner: flattenened grains, flattened	strip cut from hammered sheet - annealed - bent around cold - smearing due to use
UCT J1 small annular bead	homogeneous	bent twins and strain lines in bulk of material, voids on inner margin, heavily cold worked but some residual angular grains with numerous slip bands	5-6	none	outer: grain crumpled, flattened and elongated due to punching bulk: strain lines, bent twins inner: crumpled grains, most of strain lines occur here, two voids on edge - cold working on outer and inner margins	hammering of strip of sheet – further cold worked – bent around – outer flattened – inner smeared
UCT J2 small annular bead	homogeneous	mostly straight twins, several voids	+-6	none	outer: smearing caused voids, crumpled grains bulk: annealed bent twins, one large longitudinally running void inner: lamination and cracks with many voids - large voids near join, cold work aound the join.	hammering of strip resulting in many laminous voids – annealed – bent around cold – outer surface roughly burnished – inner surface smeared by use/stringing wear.

Table 3: Gold artefacts from Great Zimbabwe studied at the South African Musuem.

Sample No.	Description	Housed at?
SAM 7904	foil x 3	South African Museum
SAM 7905	wire section	South African Museum
SAM 7906	17 beads, offcuts	South African Museum
SAM 7907	13 sheet pieces	South African Museum
SAM 7908	14 rod sections	South African Museum
SAM 7909	42 tacks	South African Museum
SAM 7910	many wire pieces	South African Museum
SAM 7911	nine droplets	South African Museum
SAM 7912	49 beads, 7 links	South African Museum
SAM 11567	29 tacks, 1 link	South African Museum

Table 4: Gold artefacts from Thulamela studied at the University of Cape Town.

Sample No.	Description	Housed at?
TM 10	Wire	University of Cape Town
TM 26	wire section	University of Cape Town
TM 32	wire section	University of Cape Town
TM 38A	unwound coil section	University of Cape Town
TM 38B	wire section	University of Cape Town
TM 24	wire nodule section	University of Cape Town
TM 35A	bent gold wire	University of Cape Town
TM 33	sheet	University of Cape Town
TM 176A	cylindrical bead section	University of Cape Town
TM 176B	cylindrical bead section	University of Cape Town
TM 28A	cylindrical bead	University of Cape Town
TM 28B	cylindrical bead	University of Cape Town
TM 28C	cylindrical bead	University of Cape Town
TM 28D	cylindrical bead	University of Cape Town
TM 28E	cylindrical bead	University of Cape Town

Table 5: There is direct relationship between the final working process and the microhardness of an artefact.

Sample	Final working process	Average microhardness value (Hv)
M1231 H	Annealled prill	21
M1231 A	Cold work	48
M1231 B	Cold work	67
M1231 C	Cold work	56
UCT I1	Cold work	72
UCT J1	Cold work	70

Table 6: A presence and absence indicator for the gold artefacts analysed using trace element fingerprinting technology by Anglo American Research Laboratories. Only the metallic content in these artefacts are listed here. The unit 1 indicates presence.

Sample Number Mapungubwe						
	Fe	Ni	Cu	Zn	Pb	Hg
M1						
21	1	1	1	1	1	1
7			1	1	1	1
22			1	1	1	1
8			1		1	1
24			1	1	1	1
10			1		1	1
35			1	1	1	1
32			1	1	1	1
17			1		1	1
39			1	1	1	1
31	1	1	1	1	1	1
43			1			1
M1 a						
26			1	1	1	1
36			1	1	1	1
27			1	1	1	1
37			1	1	1	1
30			1	1	1	1
38			1	1	1	1
34			1	1	1	1
M2						
44			1		1	
47	1		1	1	1	
48	1		1	1	1	
66			1		1	
67			1		1	
68	1		1	1	1	
72			1		1	
74			1	1	1	
77			1	1	1	
81	1	1	1		1	
75	1	1	1	1		
78	1		1			
80		1	1	1	1	
82	1	1	1			
88	1		1			
	8	4	15	7	11	

M3						
46	1		1	1	1	1
49	1	1	1		1	1
50	1	1	1	1	1	1
52	1	1	1			1
53	1	1	1		1	1
54	1	1	1		1	1
55	1	1	1		1	1
59	1	1	1		1	1
60	1	1	1		1	1
63	1	1	1		1	1
64	1	1	1		1	1
65	1	1	1		1	1
61	1	1	1		1	1
70			1			1
56	1	1			1	1
11			1		1	1
12			1		1	1
15			1		1	1
18			1		1	1
57	1	1	1		1	1
58	1	1	1		1	1
73			1			1
87	1	1	1	1	1	1
89	1	1	1	1		1
23			1	1	1	1
Wire			1		1	1
2-Bead			1		1	1
	Fe	Ni	Cu	Zn	Pb	Hg
M3 a						
1			1		1	1
3			1		1	1
6			1		1	1
9			1		1	1
69	1	1	1	1	1	1
71			1		1	
84		1	1	1	1	
13			1		1	1
14			1		1	1
16			1		1	1
19			1	1	1	1
20			1		1	
29			1	1	1	1
62	1		1		1	1
86	1	1	1	1	1	
33			1	1	1	1
41			1	1	1	1
42			1	1	1	1

25	1		1	1	1	1
45			1		1	1
51	1	1	1		1	1
76			1	1		1
79	1	1	1	1	1	1
83	1	1	1		1	
85	1	1	1	1	1	1
	Fe	Ni	Cu	Zn	Pb	Hg
Mapungubwe Group One - New Group						
M 1231 C	1	1	1	1		
M 1231 D	1	1	1	1		
M 1231 E	1	1	1	1		
M 1231 F	1	1	1	1		
M 870	1	1	1	1		
M 1118	1	1	1	1		
Unnumbered bead 5	1	1	1	1		
Unnumbered bead 14	1	1	1	1		
M 1231 spiral	1	1	1	1		
M 1231 O	1	1	1	1		
Great Zimbabwe						
M1						
4			1		1	1
5	1		1	1		
6			1	1	1	1
7			1	1	1	1
8			1	1	1	1
9			1	1	1	1
10			1	1	1	1
11			1	1	1	1
12		1	1	1	1	1
13			1		1	1
14		1	1	1	1	1
15		1	1		1	1
16		1	1		1	1
17		1	1		1	1
18		1	1		1	1
19		1	1		1	1
M2						
M1231 I spiral				1	1	
M1231 J-1 spiral				1	1	
M1231 N- nail				1	1	
M1231 O- nail				1	1	
M1231 P spiral				1	1	

Map Unnumbered 1				1	1	
Map Unnumbered 2		1		1	1	
Map Unnumbered 3				1	1	
Map Unnumbered 4		1		1		
Map Unnumbered 5				1	1	
Map Unnumbered 6				1	1	
Map Unnumbered 7				1	1	
Map Unnumbered 8				1	1	
	Fe	Ni	Cu	Zn	Pb	Hg
M3						
M1231 A			1		1	1
M1231 B			1		1	1
M1231 G	1	1	1		1	1
M1231 H	1		1		1	1
M Unnumbered C			1		1	1
M Unnumbered D			1		1	1
M Unnumbered E			1		1	1
M (un) Nail 1			1		1	1
M (un) Nail 2			1		1	1
M (un) Bead 1			1		1	1
M (un) Bead 2			1		1	1
M (un) Bead 3			1		1	1
M (un) Bead 4			1		1	1
M (un) Bead 20		1	1		1	1
	Fe	Ni	Cu	Zn	Pb	Hg
Thulameia						
TM 10			1	1	1	1
TM 24			1	1	1	1
TM 26			1	1	1	1
TM 28A			1	1	1	1
TM 28B			1		1	1
TM 28C			1	1	1	1
TM 28D			1		1	1
TM 28E			1	1	1	1
TM 31			1		1	1
TM 32			1	1	1	1
TM 33			1	1	1	1
TM 35A			1	1	1	1
TM 38A			1	1	1	1
TM 38B			1	1	1	1
TM 39			1	1	1	1
TM 43			1		1	1
TM 176A			1		1	1
TM 176B			1	1	1	1

Table 7: Inventory of the presence or absence of metal jewellery artefacts from Iron Age sites in southern Africa (from Miller in press)

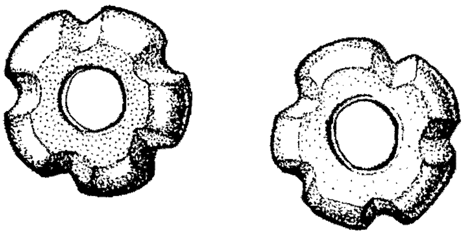
		Broederstroom	Divuyu	Nqoma	K2	Mapungubwe	Bosutswe	Great Zimbabwe	Thulamela
Bangles			Fe	Fe, Cu	Fe, Cu,	Fe, Cu,	Fe	Cu, Cu/Sn	Fe, Cu,
Beads	Punched					Au		Au	Au
Beads	Wrapped	Cu,Fe	Cu,Fe	Cu,Fe	Cu	Fe, Cu, Au	Cu, Fe, Cu/Sn	Au, Cu, Pb?	Au, Cu, Fe
Beads	Rolled					Au		Au	
Chains			Cu, Fe	Cu, Fe					
Helices			Cu, Fe	Cu, Fe	Fe, Cu	Cu, Fe, Au, Cu/Sn	Cu, Cu/Sn, Fe, Au	Cu, Fe, Cu/Sn, Au	Fe, Cu/Sn, Au
Links		Cu, Fe	Cu, Fe	Cu, Fe		Au	Cu	Au	Fe
Loops			Fe			Cu		Cu	Cu
Pendants		Fe		Fe	Fe	Fe			
Rings				Fe	Cu		Fe		Cu
Sheet						Au		Au	Au, Cu, Fe, Cu/Sn
Tacks						Au		Au	Au, Cu/Sn

South African Archaeological Society Goodwin Series **8**: 91–99, 2000

INDIGENOUS GOLD MINING IN SOUTHERN AFRICA: A REVIEW*

DUNCAN MILLER, NIRDEV DESAI
&
JULIA LEE-THORP
Department of Archaeology
University of Cape Town
Rondebosch 7701

E-mail: dmiller@beattie.uct.ac.za
& ndesai@beattie.uct.ac.za
& jlt@beattie.uct.ac.za



ABSTRACT

The history of gold mining and gold trade in southern Africa goes back nearly 1 000 years. Given the number of early gold mines and the records of lively trade on the east coast, the scale of precolonial production was clearly extensive and of considerable importance in the economies of some of the region's Late Iron Age kingdoms. Few archaeological studies of these gold mines exist, however, and reconstruction of the distribution and history of precolonial gold mining must rely heavily on a variety of historical sources, including oral traditions and the accounts of early colonial prospectors. Since the last comprehensive review of indigenous gold mining, by Summers in 1969, advances have occurred in the understanding of metal technologies in the Iron Age that enable us to place gold mining and gold working firmly within the context of indigenous technology. The main focus of this review is on mining, which is appropriate now, given the increasing interest in both indigenous technological legacies and in the development of small-scale and informal mining in the sub-continent. Hazards and limitations evident in the archaeological record can inform usefully the development of small-scale mining practices.

*Received July 1999, revised April 2000

Introduction

The earliest reliable historical account we have of gold originating from southern Africa appears to be that of al-Idrisi, writing in the mid-12th century AD (Axelson 1969). At this time, settlements on the Sofalan coast (Fig. 1), exported both gold and high quality iron to Arabia and India (Axelson 1969:6, 1973:20). This precedes by about a century the earliest recorded archaeological gold in southern Africa, the mid-13th century AD burials with gold jewellery at the archaeological site of Mapungubwe, on the Limpopo River (Meyer 1998:212). Indigenous gold production was well established by then, and according to contemporary records formed a noteworthy part of the trade with Islamic (Swahili) merchants on the east African coast (Axelson 1969, 1973).

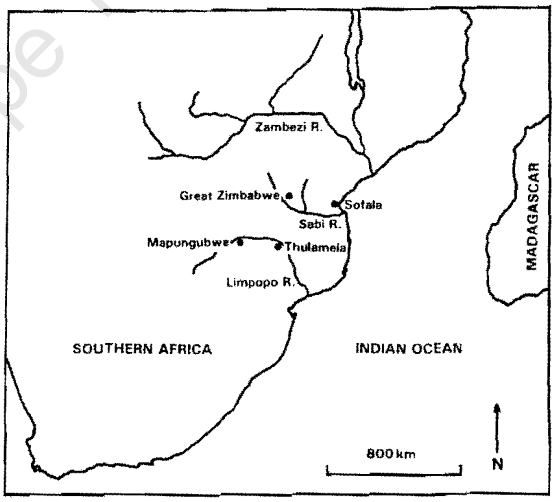


Fig. 1. Map of south-east African coast, showing the major rivers and archaeological sites mentioned in the text.

At the beginning of the 16th century AD, this trade was usurped and largely destroyed by the Portuguese, who waged war on the coastal Islamic traders and mounted various exploratory and military expeditions into the interior in attempts to locate and commandeer the sources of gold (Axelson 1973). This disruption, coupled with the slave trade, spread of disease, and internecine warfare in the interior, led to a drastic decline in indigenous gold production, which continued only as a marginal activity (Austen 1987; Pikirayi 1993; Swan 1994).

During the gold rush years of the late 19th and early 20th centuries, colonial gold prospectors in southern Africa soon found that they had been preceded in their discoveries. Evidence for earlier, but largely forgotten, gold mining was evident especially in Zimbabwe. Despite memories of gold mining among some of the local people (Wallis 1946), a widespread belief in the great antiquity of these earlier gold mines developed, and they came to be called 'ancient workings', because of their assumed association with the local stone ruins, then commonly believed to be of biblical age. The apparent mystery of their origins and the romantic allure of gold was an irresistible combination, and many imaginative theories were proposed to 'explain' their presence. It was variously suggested that Phoenicians, or the biblical figure King Solomon, had founded, developed and controlled the dynasty of gold miners, mining and trade. These romantic myths were greatly assisted in their elevation to quasi-historical status because colonists found it difficult to credit indigenous miners with the prospecting and working of the gold mines (Bent 1892).

This view began to change very slowly only after the systematic studies of Great Zimbabwe by MacIver (1906) and Caton-Thompson (1931). Historical studies such as Axelson's analysis of the available Portuguese records for the 16th century (Axelson 1969, 1973) and investigations on the east coast, such as Chittick's work at Kilwa (Chittick 1974), placed the gold trade firmly within the context of the Indian Ocean trade network which flourished in the first half of the 2nd millennium AD. Gradually the idea of great antiquity was discarded and the term 'ancient workings' was dropped in favour of 'archaeological' or 'precolonial' gold mines. Robinson excavated a number of undisturbed mining sites (Robinson 1961, 1966, 1967). The first major synthesis of precolonial gold mining in southern Africa by Summers in 1969 firmly discarded ideas about great antiquity and Phoenician or biblical origins. However Summers was not able to accept entirely the idea that gold mining developed locally, and was inclined to credit active foreign intervention in the form of Indian traders and miners (Summers 1969). This was based partly on the presence of a number of imported artefacts found in the mines, and partly on a perceived similarity between the rudimentary mining methods and those of early mines in India. The central role of early Indian prospectors and miners is still maintained by some (Hromník 1991), but most academic historians and archaeologists do not support this.

Subsequent syntheses have concentrated on the economic ramifications of the gold trade (Phimister 1974, 1976) and on the spatial correlation between mines and other archaeological sites (Swan 1994). Only recently has mining technology itself received renewed attention (Hammel *et al.* 2000). A complete assessment of precolonial gold mining should take account of the local and regional geological setting, archaeological surveys and excavations, and historical and oral evidence. We present a summary of the published literature on indigenous gold mining, bringing into our overview more recent work on mining technology and gold working in order to clarify the nature of this technology.

Geology and the Distribution of Gold Mines

Southern Africa has an abundance of gold deposits, most of which were formed during the Archaean Period of the Pre-Cambrian between 3 500 and 2 500 million years ago. In Zimbabwe, gold bearing rocks occur in the Basement Complex, consisting mostly of highly metamorphosed Basement Schists, which were mineralised some 3 500 to 2 900 million years ago. These 'gold belts' in Zimbabwe were the source of most gold that was mined in southern Africa during the Late Iron Age (Fig. 2). The erosion of primary sources, such as gold bearing (auriferous) quartz veins, has resulted in alluvial (placer) and eluvial (residual) deposits. Together, the quartz veins exposed in gold bearing reefs, and the alluvial and eluvial deposits form the sources of the gold ore.

Further south, three main belts of gold bearing rocks occur, originally dating from the Archaean Period. The earliest are the greenstone belts which include the Barberton Mountain Land, formed perhaps 3 500 million years ago (Hammerbeck 1976) and the Murchison Hills (Cairncross & Dixon 1995). The other main gold bearing deposit in South Africa is the more recent Witwatersrand Basin (Whiteside *et al.* 1976). This was an ancient alluvial fan and river system, into which were deposited sediments containing gold eroded about 2 500 million years ago from the older Archaean rocks. Subsequent burial, compaction and metamorphosis resulted in the formation of gold bearing reefs in these predominantly sedimentary rocks.

There are very few, and mostly anecdotal, reports of suspected precolonial gold mines in South Africa itself (Fripp 1912; Trevor 1912; De Vaal 1942; Mason 1962; Thain 1974; Friede 1980). This is puzzling when compared with the large number of known early gold mines in Zimbabwe, an estimated total of around four thousand (Summers 1969; Swan 1994). It is not clear whether simply fewer mines existed further south or whether they went unrecorded before being destroyed by early European prospectors. Most researchers have tended to the former view. The archaeological Zimbabwean gold mines are in auriferous quartz veins, in which the gold is often readily visible as yellow specks in the white quartz. Most of the South African gold ores are in the form of pebbly conglomerates, dark metamorphic schists and cherts, or are associated with sulphide minerals (Cairncross & Dixon 1995). This geological association may have made the recognition of the gold bearing nature of these ores and the extraction of the gold itself more difficult. Nevertheless, early colonial prospectors exploited rich alluvial and eluvial deposits in South Africa, and these would have been just as readily accessible to indigenous miners. Any trace of earlier working of these mines was probably obliterated by the first colonial prospectors, who used evidence of prior working as a convenient prospecting tool (Wallis 1946).

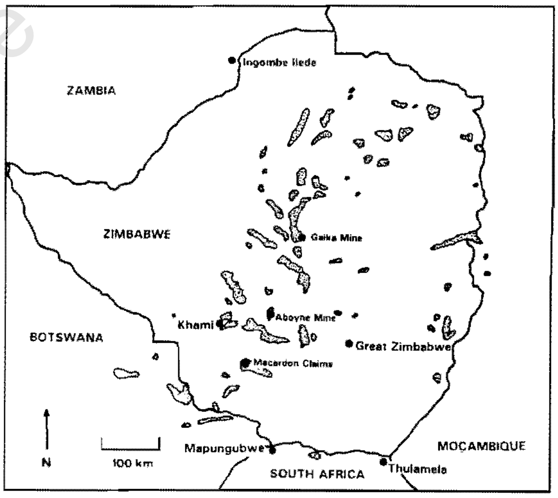


Fig. 2. Map of the Zimbabwean gold fields, showing the principal mining areas and archaeological sites mentioned in the text.

Location of Early Gold Mines

There are extensive Portuguese records from the late 15th century onwards of indigenous gold mining in southern Africa (Axelson 1960, 1969, 1973; Pikirayi 1993). In the documents studied and summarised by Axelson, there are numerous references to the dwindling quantities of gold reaching the coastal traders from the empire of 'Monomotapa' in the interior. In 1514, Antonio Fernandes made two extraordinary journeys from Sofala to the gold mining regions, covering most of what is now Zimbabwe (Axelson 1969:137–148). He not only visited a number of chiefs presiding over gold producing areas, but also visited gold mines. He saw alluvial gold nuggets and gold dust being extracted. He also recorded that the Islamic traders had well established trade routes along the major navigable rivers, and that the medium of exchange at trading fairs was gold. Subsequent expeditions recorded more details of the location of gold mines and the mining methods (Axelson 1973). These positive reports fuelled the Portuguese mission to wrest the lucrative gold trade from the Muslim and Indian traders, with disastrous results. The resulting warfare and disruption, coupled with the ongoing feuding between chiefs in the interior, led to a significant decline in gold production.

Nevertheless, gold production did continue. There are 18th century Dutch records of gold production in the Limpopo region (Liesegang 1977). In the 17th century, Barreto recorded gold mining in Manyika, and radiocarbon dates and dateable trade items found in archaeological mines in Zimbabwe indicate mining into the 19th century (Swan 1994:123–124). This is not surprising, because informal gold mining still takes place in Zimbabwe, in ways that appear to have changed very little. Writing about modern northern Zimbabwe, Pikirayi (1993:30–31) recorded that:

> In autumn and winter, with a return to dry conditions . . . some families travel to the gold mining areas and open up shafts and tunnels with simple tools. A mining village may grow to accommodate 50–100 miners and their families in a single season. Once a week, gold merchants from established mining concerns come to these villages to buy the unprocessed gold . . . Traders from places such as Harare bring cloth, beads and other articles of adornment to the mining villages and these products sell quickly. From this activity, we can draw a model of how historic Afro-Portuguese market places operated.

Early 19th century prospectors did not have access to the Portuguese records and the abandoned gold mines in Zimbabwe were relocated by European travellers in the latter part of the 19th century. In the course of explorations, which led to his finding Great Zimbabwe, Carl Mauch found gold reefs and abandoned mining pits (Mauch 1874). Later, Baines described their appearance in his Northern Goldfields Diary, written in 1877, and ascribed them to the Shona people (Wallis 1946). Although Mauch and Baines did not make a connection between the stone ruins and the mines, others soon did. Because the ruins were widely held to be non-indigenous, the 'ancient' mines came to be considered in the same light. These beliefs persisted, largely due to racial prejudice that could not conceive of indigenous enterprise on this scale.

Active prospecting for gold followed after Zimbabwe became a British colony in 1890. Claims were pegged on the old mines that were considered to be good prospects. A few reports found their way into the British-South Africa Company files, and thereafter into the Southern Rhodesian Geological Survey archives. Between 1897 and 1939, many of the pre-industrial gold mines were obliterated by modern mining activities. A number of artefacts such as iron picks, stone hammers, and pottery sherds found their way into museum collections, and a few mining engineers reported on the gold mines in their original state and on the finds associated with them (Fripp 1912; Trevor 1912, 1913). Much later, Mennell recorded his observations and recollections (Mennell & Summers 1955; Mennell 1957).

Early geologists and early mining engineers also remarked on the relative lack of precolonial gold mines in South Africa (Fripp 1912; Trevor 1912, 1913), despite the facts that the Mpumalanga region has abundant supplies of alluvial and reef gold, and that modern Gauteng and the Northern Province are renowned for their gold ore bodies. The absence of early gold mines identified in these regions is even more surprising when one considers that copper and tin were exploited successfully. Nevertheless, Liesegang's (1977) interpretation of Mahumane's account of gold mining shows that the apparent absence of precolonial gold mining in northern South Africa is not absolute.

Summers (1969) listed thirty-five distinct areas that contained gold deposits (Fig. 2), described the mining style and archaeological significance of some of the mines in these belts, and summarised early prospecting documents about mining of each region or site. He was the first to discuss the implications of the location of the early mines, observing that the gold mines were clustered near Great Zimbabwe-style buildings, and noting that pottery of the Gokomere Tradition was found in association with gold at earlier ruins (Summers 1969:124). Based on findings of some imported goods in the workings, he suggested that the miners were also traders. Subsequently, the work of Garlake (1967, 1968, 1973) and Huffman (1971, 1972a, 1972b) pointed to the importance of the gold trade in the economies of the interior. In addition to the presence of many dateable imports found in Iron Age contexts, they found a significant correlation between the growth and prosperity of states in Zimbabwe, and prosperity at the east coast trading settlements.

Swan (1994) used spatial correlation of mines to occupation sites in Zimbabwe in an attempt to establish the historic sequence of mining and settlement. If pottery of the same class was found in a mine and an occupational site, it was inferred that the two were contemporaneous and that the mines probably supported the occupants of the settlement. Proximity of mines to occupation sites was not one of the main criteria. Swan (1994) concluded that there were six distinct periods in the rise and fall of gold mining in Zimbabwe, starting with the rise of coastal trade towards the end of the 1st millennium AD.

It is difficult to determine the beginning of gold mining in southern Africa, not least because the first stages of any technology leave very little archaeological trace and so are even less likely to be found than later evidence. Trade beads have been found on some Early Iron Age sites of the 1st millennium AD and cited as evidence of established coastal trade (Swan 1994), but many of these beads have been identified as characteristically post-European contact, and therefore such beads must be intrusive into the older archaeological levels (Wood 2000).

As there was no direct correlation between any particular gold mine and the mid-2nd millennium Zimbabwean Tradition sites, Swan was of the opinion that the occupants of the elite sites of this period were not directly involved in mining. Nevertheless, evidence for gold melting and artefact manufacture, such as crucibles and other tools, have been found at many of these sites. The ruling elite probably acquired the gold processed at these sites by a variety of indirect means including taxes or even military force (Mudenge 1988; Swan 1994).

Prospecting

Various prospecting and mining techniques were employed by Iron Age gold miners. These have been summarised by Summers (1969) and Hammel *et al.* (2000). The presence of gold may have been revealed by gold particles in anthills and termite heaps (Summers 1969:162; Phimister 1976); by noting the growth of plants characteristically associated with gold bearing soils (Molomo 1992); or by following alluvial gold deposits through to the placer deposits and finally to the auriferous reef. There are numerous Portuguese records of alluvial gold recovery (see Axelson 1960, 1973; Summers 1969). Of course, the extent of alluvial mining, which has continued as an indigenous enterprise to the present, is impossible to assess because little indication of the former activity remains today. Ongoing trace element analysis is aimed at determining the regional sources of gold found in archaeological sites, but it lacks the resolution to enable specific source localities to be identified (Miller *et al.* in press).

The fact that scarcely any gold bearing quartz reefs have been found in the modern era, which had not already been discovered and worked by Iron Age miners in Zimbabwe, points to the efficiency of their prospecting (Summers 1969). This observation does not apply south of the Limpopo however, where many potential sources were ignored (Fripp 1912). Fripp also pointed out that the apparent extraordinary efficiency of the early prospectors in some areas may have been related to the hundreds of years in which they had to prospect (Fripp 1912). Prospecting for quartz reef outcrops with visible gold was apparently a relatively easy matter, and reefs with no visible showing at the surface were not exploited (Mennell & Summers 1955; Mennell 1957). The prospectors sought visible gold (Fripp 1912), which occurred at the surface where erosion and oxidation had taken place on the reef, leaving a zone of secondary enrichment. It is possible that early prospectors first found reefs by tracing alluvial gold up the rivers to the primary sources in the hills (Summers 1969). On the other hand, Iron Age miners were familiar with hard rock mining for copper ores, which was well established in southern Africa by AD 770 (Van der Merwe & Scully 1971) and visible gold in quartz reefs may have formed the initial target of prospecting in gold-rich areas.

Mining Techniques

Several very vivid Portuguese accounts of indigenous gold mining exist (Axelson 1973). Manuel Barreto, writing in the 17th century described both alluvial and underground mining:

> River gold is extracted all the year, but more abundantly during the rainy seasons, and at the end thereof, when the rivers are going down. The gold from the mines in Manica is also extracted all the year, but in Karanga only in the three months which are called *do crimo* . . . because in these months, after the harvests have been gathered, moderate rains begin, so that the miners have water for their use to wash and sift the gold. Afterwards . . . the rains increase, so that the *marondos*, that is the wells or holes in which they dig the gold, are flooded, and the work cannot be continued. Very often the *marondo* yields very little, but some of them yield from one to three thousand pastas (according to Axelson, a sheet of gold weighing about 100 mithqals, or 435 g). The method of extracting it is as follows: a countless number of Kafirs (*sic*) with their wives and children assemble in the place where they choose to open the *marondos*, the chief of each village forms a separate party with his people, and each begins to open his *marondo* in the fashion of a well. The mouth is so narrow that a man may stand with his legs extended from one side to the other. They make steps to go up and down within the circumference of the well, and on these the Kafirs (*sic*) station themselves, passing the *mataca*, or earth, which is dug away, from hand to hand, which the diggers pass to them in *pandes*, or wooden bowls. The first *mataca* does not contain any considerable quantity of gold, the *mataca* which contains it is well known, and when they come upon it, or upon gold in stone, as sometimes happens, they do not desist until it is exhausted, following the vein under the earth in every direction. Sometimes it happens that such a rush of water bursts into the mine that it is flooded, and it is impossible to extract the *mataca*, and still less the quartz, which has to be broken with great labour. Some of these *marondos*, containing infinite quantities of gold, are abandoned for want of skill to pump out the water. When the earth or quartz is taken out of the ground there are found in it many pieces and fragments of gold of notable size, and the earth which adheres to these pieces of gold is scented and very healthy. The stone is then ground to powder, and this powder, together with the *mataca* which contains gold, is washed in the neighbouring rivers until the water has washed away all the earth or stone powder, and the gold, being the heaviest, is left at the bottom of the bowl in small scales or very fine glittering sand (quoted in Axelson 1973:50).

The apparent similarity of mining methods employed in Zimbabwe and in southern India led to the speculation that mining was initiated by Indian prospectors (Summers 1969). The possible role of Indian miners in initiating, stimulating or controlling gold production and trade (Hromník 1991) is still contentious. Gold mining in India preceded that in southern Africa by at least 1 500 years (Biswas 1996:326) but any similarity in the gold mining techniques probably results from unavoidable geological constraints imposed on a rudimentary technology (Miller 1995). Two main methods of underground mining are distinguishable: open stopes (horizontal or inclined excavations), and vertical shafts with underground stopes. The latter appear to have a limited distribution, mainly in northeastern Zimbabwe. Earlier this was taken to indicate a distinct group of miners (Mennell & Summers 1955), but later it was recognised as simply a method used for exploiting less steeply dipping reefs (Summers 1969).

The open stope was by far the most commonly used. The weathered surface outcrop, which is believed to have been very rich because of concentration of the inert gold, was first removed, and then the dipping reef was attacked from both sides. Since the reefs were up to 1.5 m wide, a large trench resulted. This method is called side stoping, and was used where the reef was in relatively soft rock. Where the walls were hard rock, underhand stoping was used—only the reef was taken out, excavated from beneath the miner. These stopes tended to be much narrower (Summers 1969). Shaft mining consisted of sinking a shaft about 1 m in diameter until the reef was reached, and then exploiting it in all directions for a few metres. Another shaft was then sunk nearby and the operation repeated. Sometimes the chambers were connected. A combination of the above—open stopes with occasional shafts—was also used when the reef dipped between 25° and 50°. The shafts may have aided ventilation.

In the absence of explosives, fire setting was used to loosen ore-bearing deposits. Wood was banked against the rock face to be shattered, and lit, to crack the brittle quartz.

Quantities of charcoal found in the mines that have been investigated provided evidence for fire setting (Summers 1969).

Various mining engineers from Trevor (1912, 1913) onwards noted the regularity of backfilling or refilling, done with the rubble and chips of ore regarded as 'non-payable' ore. Ore yielding less than 60 g of gold per ton was evidently regarded as non-payable (Summers 1969). Fripp (1912) considered that this backfilling was predominantly the result of natural erosion and collapse but in many cases, it is obvious that mines were deliberately refilled. Portuguese documents noted the deliberate partial filling of shafts of mines at the top of the Umkondo Mine hill (Summers 1969). This was seen as a safety measure because abandoned open mines were hazardous for cattle. In the shaft mine category, backfilling may also have assisted in providing adequate ventilation by maintaining a strong through draught, for which only two shafts were required.

Shaft mining generally did not require artificial light; natural light would have been sufficient as most stopes were no deeper than 45 m. The form of lighting necessary for more steeply inclined stopes and the deeper mines (such as shaft mines with occasional stoping) is unresolved. Based on ethnographic data, Schofield suggested that euphorbia leaves or cassia pods might have been used as candles (Schofield 1942).

The tools used in copper, tin, gold and iron mining appear to be have been similar (Fripp 1912; Mason 1962; Summers 1969; Hammel *et al.* 2000). Hammers, iron crowbars, and stone or wooden wedges were the three most commonly used tools in gold mining (Summers 1969). Many stone hammers, made from fine-grained materials such as dolerite and sometimes greenstone were found. They were used to crack and pound the brittle quartz ore, as well as to drive in iron chisels, another fairly common occurrence in such mines. These were wrought iron or low carbon steel tools used to further crack and dislodge rock partially cracked by fire setting. Broader stone or wooden wedges were occasionally used in place of iron chisels. In one mine, an iron tool hafted into a wooden handle that was probably used as a pick, was found. Iron shovels, presumably used to scoop up loose rock, have also been found in some mines (Summers 1969).

Barreto described the removal of ore in wooden bowls (Axelson 1973). Summers (1969:171) described a wooden bucket with a carrying capacity of three litres and three holes on its sides suggesting that it was suspended for hoisting. Summers, citing ethnographic evidence, also suggested that shallow bowls made from palm leaves and covered on the underside with leather, may have been used for hoisting. No evidence for mechanical hoisting has been found and the ore was probably removed from the mines by hand. It was probably carried in baskets or wooden containers (Axelson 1973; Mudenge 1988).

Mining was a hazardous occupation. Backfilling helped to prevent cave-ins, as well as aiding ventilation, but collapses certainly did occur. Deaths from cave-ins have been recorded at several mines (Summers 1969:22–28). Several skeletons, including that of a young woman, were found in the Gaika mine, evidently the result of a series of collapses. Four skeletons were recovered from the Aboyne Mine during excavations. From the skeletons recovered, it has been noted that many of the miners were female. However, it has also been maintained that individual mines were managed and worked by a community, and that the entire community worked in the mines (Keith 1924; Summers 1969; Huffman 1974). This suggestion is supported by Barreto, who recorded that the whole village—men, women, and children—turned out to dig, under the guidance of the chief (Axelson 1973:50).

There were other problems that limited gold production and safety. Water seepage posed a great dilemma to early Zimbabwean miners, as 17th century Portuguese documents recorded (Summers 1969; Axelson 1973). Flooding of mines caused many mines to be abandoned before they were exhausted (Fripp 1912). Ventilation was also a significant problem, which Summers proposed to be the major limiting factor. It has been suggested, somewhat paradoxically, that fires assisted in freshening and cooling air through driving the circulation (Summers 1969), although the noxious gases produced by burning in confined spaces make this improbable. Fripp (1912) mentioned the possible use of baffles or constructed barriers underground to direct airflow and to keep the mine cooler. Use of baffles for this purpose was suggested also by Molomo (1992), but there does not appear to be any archaeological evidence to support their use.

Recovery of Gold from Ore

Gold-bearing quartz was crushed manually in order to extract the gold more easily (see Plate 2B, following p. 78). In 1877, Baines recorded roasting of the quartz to shatter it further before crushing it to a fine powder (Wallis 1946). The crushing was done with various devices—conventional grindstones like those used for grinding grain, round dolly holes or cup and ball mortars that were worked with a rotary movement, and rocking stones. Dolly holes have been found near the entrance of some mines, but more often at processing sites beside the nearest water (Summers 1969: 178–179). Some dolly holes, and a few portable cup and ball mortars have yielded small amounts of gold dust (Swan 1994:62). Rocking stones, such as the one depicted by Baines (Hall 1987:97; see Cairncross & Dixon 1995:22), are likely to have been used as well.

After crushing, the ore was washed. The lighter quartz was washed away by sluicing with water or the gold was concentrated by panning using a shallow wooden bowl. The latter is a traditional method of the Shona, still used for recovering alluvial gold (Summers 1969). The result was gold dust.

Gold Working

The considerable gold production was largely traded. It was not only sold as dust; often trinkets and gold beads were traded (Axelson 1960, 1973; Garlake 1973:177). Schofield reports that gold, after washing, was melted in a small clay crucible in a clay furnace (Schofield 1942) to produce nodules for fabrication into beads and other small objects. Gold was most commonly made into beads, beaten into sheets, or formed into wire (Fouché 1937; Phillipson & Fagan 1969). Crucibles containing traces of gold have been reported from numerous sites (Swan 1994:64–66), including Great Zimbabwe (Garlake 1973), Thulamela (Küsel 1992) and the coastal trading site of Chibuene in Mozambique (Sinclair 1987).

At Great Zimbabwe, many metal working tools, including some for gold, were found on the floor of one hut. They included three gold-containing crucibles and a pair of tongs (Hall & Neal 1902). Nearby in a low cave were found more crucibles and pebble burnishers for gold, the remains of gold bearing quartz, as well as copper ore and slag. These finds suggest that there was a special industrial area for metallurgy at Great Zimbabwe, and a degree of craft specialisation. Garlake believes that gold was probably in use at Great Zimbabwe over the same period as copper and bronze, as "it was treated identically" (Garlake 1973:117). Numerous gold objects in the form of beads and trinkets were recovered from Great Zimbabwe by Bent and Hall, apparently mostly from burials (Schofield 1942). Hall reputedly found 200 oz (about 6 kg) of gold altogether (Garlake 1973:116).

Evidence from the Macardon Claims suggests that gold beads and wire were manufactured there too (Summers 1969:179). Finished objects were found at other sites, including those associated with the 'gold burials' at Ingombe Ilede in Zambia (Chaplin 1962; Fagan 1969a). Although Ingombe Ilede yielded quantities of finished gold objects—beads, gold sheathing, wire—there was no evidence for gold working. Similar finds, also mostly from burials, were made at Mapungubwe, just south of the Limpopo (Fouché 1937; Huffman 1996; Meyer 1998). The Mapungubwe gold objects included gold beads, beaten gold attached to a backing with gold rivets, a gilded 'bowl', a gilded staff, a 'mace-head', numerous wound wire bangles and the famous gold rhinoceros (Fouché 1937; Fagan 1964; Meyer 1998). These represent elite insignia, used by the rulers of the last major phase of occupation at Mapungubwe, from about AD 1220 to AD 1290 (Meyer 1998:212–213).

Mining Production

Estimates of volumes of ore mined and Portuguese and Arabic documents have been used to provide various estimates of the production of various mines in the Zimbabwean region (Hall 1909; Rickard 1930; Summers 1969; Phimister 1976; Swan 1994). Caton-Thompson (1931) believed that it was impossible to calculate a meaningful total considering the large number of variables, such as the large region and vast time period under consideration. All the attempted estimates suffer from major uncertainties. The earliest Portuguese records claimed an exaggerated 850 tons per century (Axelson 1973:32), but later documents throw light only on the gold trade from the 16th century AD onwards, during the period in which the Munhumutapa state and gold production was in decline (Mudenge 1988). Another complicating factor is the unknown quantity of gold pillaged from graves and melted down as bullion (Swan 1994:71). The published estimates that have been made range from 775 tons per century to 39 tons per century for the period of most active production. The most recent estimate is that of Austin (1987:276) of 1.5 tons per year for the Muslim trade period, and 0.5 tons per year for the Portuguese period.

Trade

Gold was traded in the form of gold dust, beads and trinkets. Portuguese records and archaeological evidence suggest it was traded principally for glass beads, Chinese ceramics, and cloth (Axelson 1960, 1969, 1973; Huffman 1971, 1972a, 1988). Earlier trade networks operating in southern Africa preceded the 2nd millennium AD trade in gold. These had important economic and political consequences in the sub-continent and for the Indian Ocean maritime trade. With the advent of the Islamic maritime trade and the appearance of Islamic traders on the East African coast, a market for new commodities developed. Internally, a subsistence-oriented trade, closely associated with agricultural production and subservient to the local kinship system, evolved into a market-oriented trade that imbued a range of goods with new economic value. Imported luxury goods, such as beads and cloth, could be acquired in exchange for a large range of indigenous products, of which gold was only one. This trade provided a new means of capital accumulation and consumer demands, and resulted in the stimulation of economic specialisations such as gold mining. It is apparent that these economic phenomena apply particularly to the gold trade, but the entire trade system of the Late Iron Age probably fell somewhere between these two phases; there was a duality in the system (Duarte 1993). Part of the trade network was generated by unequal distribution of essential natural resources, such as iron, copper and salt (Fagan 1969b, 1972; Austin 1987), and might be considered as an internal inter-village trade network. This trade network must certainly have established early on, during the Early Iron Age. Somewhat later, the market-oriented trade grew up as a result of external demand for gold and ivory. There is no evidence that either of these two commodities had any indigenous value until the advent of the Islamic maritime trade on the east coast. The gold, ivory and slave export trade fulfilled some of the conditions for the development of new forms of wealth which grew along with the necessary military might to control them. The major changes were limited to one sector of the community, i.e. a rich, powerful elite. The development of the gold trade and the rise of the Zimbabwe culture are widely seen in this context, although the mainstay of the Zimbabwe culture was always agriculture and animal husbandry (Mudenge 1988, Pikirayi 1993).

Evidence of the diversity of trade goods comes from the Arab and Portuguese records (Axelson 1960, 1969, 1973; Austin 1987) and from archaeology. The Renders Ruin hoard, found by Hall in 1903 at Great Zimbabwe, provides some idea of the goods that were traded for gold. The hoard was a mix of local and imported objects. It has been interpreted as the trade goods of a Swahili trader (Garlake 1973), and included thousands of glass beads, brass wire, cowrie shells, iron tools, gold wire and beads, and some domestic objects of coastal origin. That such domestic objects have not been encountered more frequently suggests that visits by coastal traders to the interior may have been sporadic (Garlake 1973).

In general, glass beads are far the most abundant imported item found. They have been used by archaeologists as broad chronological indicators as well as trade route tracers. A few imported glass beads have been found in Early Iron Age sites dating from the 9th century AD but many of these appear to be intrusive, and isolated beads cannot be considered reliable indicators of established maritime trade (Wood 2000). Garlake defined three periods for different types of beads. The first period lasted from the 10th to 13th centuries AD, the second from the 13th to 15th centuries AD, and the third from the 15th century AD onwards. The beads have been thought to be Indian in origin (Garlake 1973). Work by Saitowitz (1998) and Saitowitz *et al.* (1996) indicated a possible Egyptian origin for some of the beads found at Mapungubwe. The current view of the archaeological bead assemblages from southern African Iron Age sites is available in Wood (2000, i.e. this volume).

Good chronological sequences have been established for imported ceramics. Garlake used the presence of Chinese celadon ware and absence of 'blue and white' ware to date Period III/IV at Great Zimbabwe to shortly before the mid-15th century (Garlake 1968). An Islamic coin from Kilwa, securely dated to AD 1320–1333, was found *in situ* at Great Zimbabwe (Huffman 1972b). Spindle whorls (used for making thread) were introduced to the Zimbabwean plateau about the 12th century AD. Of six pieces of cloth found with Iron Age burials, one was Indian and the other five were probably locally made (Huffman 1971). Some imports were recovered from within the gold mines. These included an Indian brass tumbler, which was thought to be 14th to 15th century AD, an Indian brass tray (18th century AD), and a Portuguese ivory carving (17th to 18th century AD) (Summers 1969:129). These items all provide evidence for trading contacts with the east coast. For details about the Islamic (Swahili) and later Portuguese trade on the coast the interested reader is referred to Freeman-Grenville (1962), Axelson (1960, 1969, 1973) and Duarte (1993), despite the latter's scepticism about the importance of gold in this trade. From these records, it is evident that the Sofalan coast was the major departure point for the exportation of Zimbabwean gold.

Discussion

Despite the difficulties of tracing the gold trade through imported beads and ceramics, a general chronology for the gold trade can be derived from the imported goods for which gold was exchanged (Huffman & Vogel 1991). The imported goods show that maritime trade increased from small beginnings late in the first millennium AD, was well established by the 10th century AD, and reached a peak in the 15th century AD. Gold appears in the archaeological record only in the mid-13th century AD. The Islamic records, which make more than a passing reference to gold from the land of Sofala, also date from this period. Therefore, it seems likely that initially the slaves, iron, copper, ivory, wood, animal skins and resins mentioned in early documentary records, were the principal exports and that gold became important only after the 11th or 12th century AD. This was the period of Mapungubwe, which controlled trade along the Limpopo, after which the focus of trade moved north to Zimbabwe, and the Sabi/Save and Zambezi Rivers.

The handful of radiocarbon dates for charcoal found in mines in Zimbabwe spans the 12th to 20th centuries AD (Summers 1969:134). There is ample evidence that gold mining continued despite major fluctuations in output throughout the turbulent period of Portuguese domination. The mid-19th century Nguni invasions largely put an end to systematic small-scale mining, scattered and demoralised the Mashona, and paved the way for European colonial exploitation (Wallis 1946; Miller 1999). Dutch documents of the early 18th century described the Venda kingdom of 'Inthowelle', whose people mined and traded gold. The 'Inthowelle' kingdom included the areas in modern Mpumalanga where gold is most likely to have been found and mined. The Dutch, who traded in gold, ivory, tin and copper from Delagoa Bay (Paver 1933) found that others, mainly the English, had traded from Delagoa Bay before them (Liesegang 1977). This observation suggests that gold mining south of the Limpopo may have been a later development than in Zimbabwe. Gold mining and trade may have become possible as a result of the rise of the kingdom of 'Inthowelle', whose name and location suggests that it may be synonymous with Thulamela (Küsel 1992; Verhoef & Küsel 1995).

Informal or small-scale gold mining persists to this day using techniques that are not substantially different from those recorded in early documents and the archaeological record. South African legislation has only recently recognised the role that small-scale and informal mining could play in the country's economy (Department of Minerals and Energy 1998), and is changing to remove the stigma associated with subsistence mining. The economic and social environment of mining is also changing, and it has been predicted that small-scale mining will play an increasingly important role in this segment of the economy (Steer 1990). In many other sub-Saharan countries, small-scale and informal mining plays a major part in raw material acquisition and the mining economy. Many of the southern African countries have small-scale miners' associations which concern themselves with the health, development, and technical education of indigenous miners. South Africa lags behind the rest of southern Africa in this respect. A recent case study of illegal informal gold mining near Barberton illustrated the typical problems faced by informal miners functioning at or below economic subistence level: the active interference and hostility of entrenched interests and authority; ignorance of the mineral laws and the claims process; a lack of training, effective tools and legally available land; and the employment of inefficient, unsafe and often environmentally damaging techniques (Hammel *et al.* 1999). Apart from diamond mining, the most profitable small-scale mining enterprises are those for gold, and here the physical and geological constraints often are identical to those that limited the exploitation of ore bodies by precolonial miners. In modern Zimbabwe, there is extensive panning for gold along various rivers, as well as underground mining (Pikirayi 1993; Van Straaten 1999). The specific circumstances of informal underground mining; shafts up to 30 m deep, with small galleries run out from the bottom to follow the reef, all worked by hand (Van Straaten 1999), present problems of safety, drainage and ventilation that are very similar to conditions in many of the precolonial workings.

Archaeological studies, like those of Summers (1969) and Swan (1994), provide important insights into the hazards and limitations of such mining. Small scale gold miners themselves, and the organisations that support the development of informal mining, received the results of a synthesis of this data enthusiastically at the Environmental Capacity Enhancement Programme Networking Conference held in 1998 in Harare, Zimbabwe. Considerable opportunities for research exist (Hammel *et al.* 2000). Certainly, not all the extant remains of precolonial mining have been recognised and identified. Recent studies of European Bronze Age mining have shown that even in highly industrialised countries, significant evidence for early mining can be recovered (Craddock 1993). Very few early mines have been excavated or their structure and dimensions well documented. Studies of early mining techniques take place in parallel with modern equivalents, in a form of ready-made experimental archaeology. Renewed attention to the legacy of precolonial mining is justified amply, not only for the archaeological information it may provide in documenting a thousand years' worth of indigenous technological enterprise, but for the lessons that may be learned about the prospects for the re-introduction of small-scale and informal mining as an increasingly important part of southern Africa's unfolding economic development.

Acknowledgements

Financial support from Anglo-American De Beers Chairman's Fund Educational Trust, De Beers Fund Educational Trust, the Foundation for Research Development (now part of the National Research Foundation) and the Centre for Science Development is acknowledged with gratitude. Opinions expressed in this paper and conclusions arrived at are those of the authors and not necessarily to be attributed to any of the supporting agencies. The three anonymous referees are thanked for their very helpful comments and suggestions.

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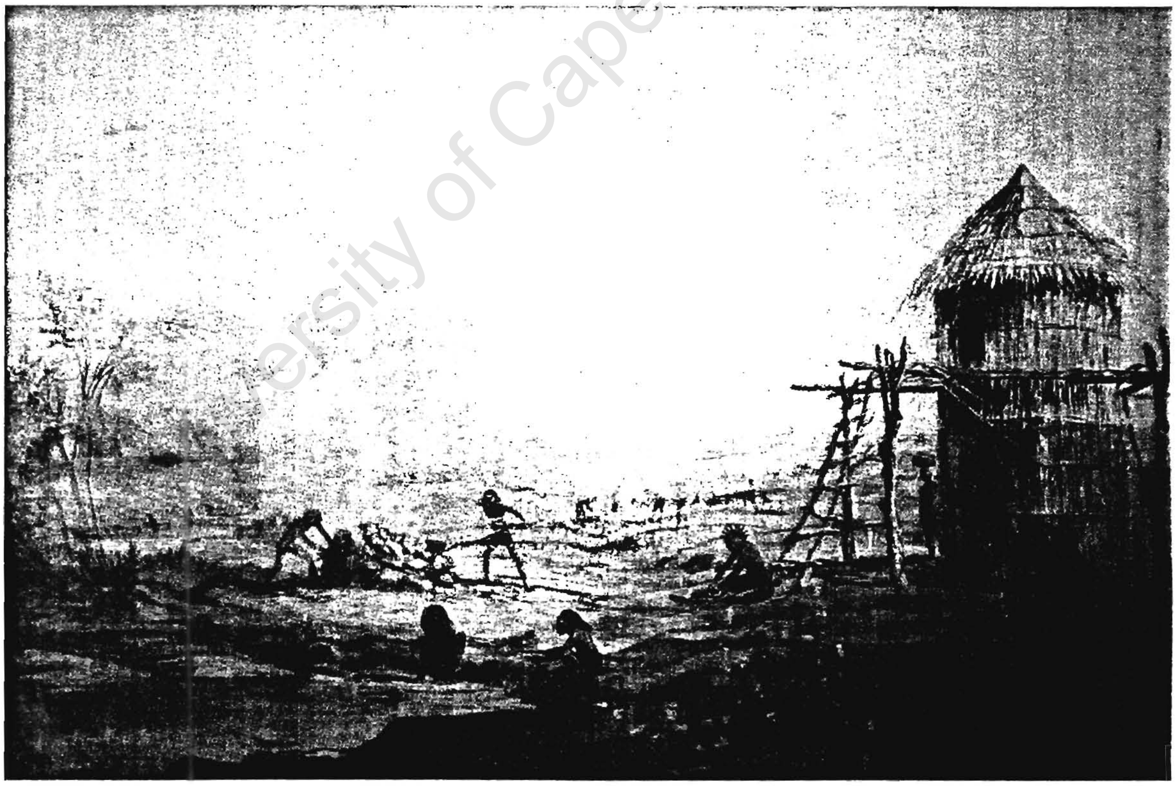

2B. Painting by Thomas Baines (date 1872), showing his reconstruction of Shona mining and gold processing. In the background, miners quarry a gold bearing quartz reef. In the middle, the quartz ore is roasted to promote fracture, before it is ground to powder on a grindstone. In the foreground, the gold bearing quartz powder is washed in the stream to remove the lighter quartz and concentrate the gold dust. (See Miller *et al.*, this volume. Reproduction courtesy of Port Elizabeth City Libraries.)

Trace-element study of gold from southern African archaeological sites

D. Miller[a*], N. Desai[a], D. Grigorova[b] and W. Smith[b]

THE HISTORY OF GOLD MINING AND ITS fabrication into jewellery and other items of adornment goes back at least 1000 years in southern Africa. Trace-element analysis of gold artefacts from the major archaeological sites of Mapungubwe, Bosutswe and Thulamela has led to fascinating insights, and an expansion of this analytical programme to seek answers to archaeological questions previously inaccessible to science.

Gold is frequently found in early second millennium AD archaeological assemblages in southern Africa. It was used exclusively for personal adornment and insignia, and most of it has been recovered from excavations of elite burial sites. The famous gold jewellery and ornamental objects from 10th to 13th century AD Mapungubwe and 13th to 15th century AD Great Zimbabwe have been studied non-destructively and described as the products of typically African fabrication technology.[1,2] Metallographic investigation has shown that the fabrication techniques were identical to those used for making similar copper items.

Evidence for gold processing is widespread, but excavations at only two sites, Great Zimbabwe and the 16th-century AD site of Thulamela (Fig. 1) in the northern Kruger National Park, South Africa, have produced evidence of smelting operations in the form of indigenous ceramic sherds that had been used as gold-melting crucibles and had adhering glassy slag containing gold droplets.[3,4]

Recently, the archaeological focus has been on the trace-element chemistry of gold from these sites.[5] Over one hundred individual gold objects from four sites (Mapungubwe, Bosutswe, Great Zimbabwe and Thulamela) have been analysed by laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS), their trace element profiles grouped, and compared with each other and reference material. The samples from any one site have distinctive patterns (or sets of patterns), which usually are unique, with the exception of one case where two sites have overlapping patterns. This pointed to distinct geological sources of the gold, with minimal mixing of material from discrete origins. The relatively high levels of platinum-group metals are characteristic of southern African gold, uncommon in material from elsewhere tested at Anglo American Research Laboratories.

Given the likelihood of some degree of mixture, and the paucity of well-provenanced historical alluvial samples, it is unlikely that trace-element sourcing will be able to identify distinct archaeological origins. Current research is directed at attempting to define regional comparative signatures in order to distinguish archaeological material derived from the various geological provinces of southern Africa.

The archaeological sites

Scattered across central southern Africa, in a broad band that includes the Zoutpansberg, the Limpopo Valley, eastern Botswana, and southern Zimbabwe, lie archaeological sites representing the former residences of elite chieftainships. These formed part of an interwoven social structure of metal-using farmers who occupied large parts of southern Africa from nearly two thousand years ago.[6] In the first millennium AD, local indigenous farming communities produced copper and iron for their own use in jewellery and utilitarian implements. In the second half of the first millennium, the southern African farming communities became increasingly involved in the Indian Ocean trade network, exporting various commodities through Arab middlemen in exchange for glass beads and cloth. Metal was an important export commodity, and around the beginning of the second millennium AD both gold and tin were added to the list of metals being mined in southern Africa.[7]

Trade benefited powerful chiefs, whose residences were strategically placed near the river valleys that provided access to the coast. They accumulated wealth and status, moved to occupy symbolically elevated and more readily defensible hilltop sites, and their residences became the centres of the first real southern African towns.[8]

Mapungubwe is an early example of such a town, dating from the 10th to the 13th centuries AD, situated in South Africa just south of the confluence of the Limpopo and Sashi rivers.

Towards the end of the main period of occupation at Mapungubwe, particularly wealthy and presumably powerful individuals were buried in graves on top of Mapungubwe hill.[6] In January 1933, exploration of the northwestern end of the hilltop led to the discovery of gold beads, helically wound gold bangles, decorative gold sheet perforated with holes for small tacks, and the parts of a rhinoceros made of gold sheet, all loose and near the surface.[9,10] A nearby grave was found, probably that of a man, with a

Fig. 1. The archaeological site of Thulamela in the northern Kruger National Park, with the partially reconstructed stonewalling of the royal enclosure.

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[a] Department of Archaeology, University of Cape Town, Private Bag, Rondebosch, 7701 South Africa.

[b] Anglo American Research Laboratories (Pty) Ltd, P.O. Box 106, Crown Mines, 2025 South Africa.

*Author for correspondence.
E-mail: dmiller@beattie.uct.ac.za

large number of corroded iron bangles ornamented with gold and glass beads around the arms and legs, about 130 helically wound gold wire bangles around the arms and neck, fragments of gold sheet (possibly from a head rest), golden sheeting that may have covered a wooden bowl, a hollow gold bangle, a gold ornamental circlet and pointed sheath of a staff, and quantities of loose gold and glass beads. The gold found was reported to have weighed about 2.3 kg (75 ounces) in total.[8]

In the summer of 1934/35, archaeologists from the University of Pretoria excavated the grave of a woman with iron wire arm and leg bracelets, on Mapungubwe hill. This was followed by the discovery of an entire graveyard on the western end of the hilltop, where 23 more burials were found. Two of these contained gold. One was that of a man buried facing west, with a gold 'sceptre' (probably part of a staff) in the crook of the right arm and 100 small gold beads from a disintegrated necklace. The other contained presumably a woman, buried with approximately 2 kg of gold. She was also buried facing west, with over 100 gold coiled-wire bangles around her legs, pieces of gold plating possibly from a head rest, and 12 000 gold beads around her neck, as well as a very large number of glass beads. The exciting story of these discoveries was published in 1937 by Professor Leo Fouché.[9]

The discovery of such large quantities of gold in only three burials, dating from 800 years ago, fuelled intense speculation for the past 50 years. South African archaeologists believe this gold and the gold found farther north in modern Zimbabwe was mined locally, but some believe that this gold was imported, perhaps even from India. We sought confirmation of the suspected indigenous source of this gold, but until recently it was not even theoretically possible to determine this.

At approximately the same time as Mapungubwe was occupied, other hilltop settlements were thriving elsewhere. The archaeological site of Bosutswe in modern eastern Botswana was one of these. Here too people were involved in trade networks, even at a significant distance from the Limpopo corridor to the coast. In the 1980s, archaeologists James Denbow and Edwin Wilmsen from the University of Texas excavated parts of the site. In layers with characteristic pottery similar to that from Mapungubwe, they came across a small helix made of gold. This must have been part of a bangle or other jewellery ornament, but is the only fragment of gold recovered from Bosutswe. We would like to know if this fragment came from Mapungubwe or whether the people living at Bosutswe had access to another source of gold.

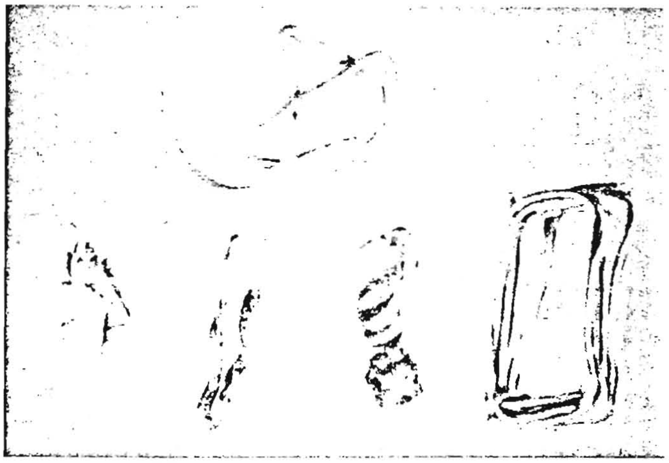

Fig. 2. Fragments of gold recovered from the royal midden, or rubbish dump, at Thulamela, including wire, a crumpled piece of gold sheet, and a fragment of a wound bangle (2× actual size).

Gold has been recovered from numerous other sites in southern Africa, including the famous stone-walled trading centre at the site of Great Zimbabwe,[11] but few of these have been excavated professionally by archaeologists. The 16th-century AD site of Thulamela in the northern Kruger National Park is an exception.[12] It was excavated in the mid-1990s by a team led by Sidney Miller, and the gold from it forms only the second substantial South African gold assemblage studied scientifically. A few gold beads, nodules, wire, and fragments of helically wound wire bangles (Fig. 2) were found in the excavation of a midden, or rubbish dump, associated with stone-walled ruins on top of Thulamela hill. This discovery was accompanied by the recovery of several fragments of indigenous pottery with adhering lumps of glassy slag with entrapped droplets of gold,[3] direct evidence of gold working in the hilltop settlement. Towards the end of the last season of excavation, Miller discovered two graves on the hilltop. The first was a woman, buried facing west and lying on her side, with a plaited gold bangle around one wrist and a string of 291 gold beads around her neck. Nearby was the grave of a man, adorned with a now very corroded iron necklace ornamented with a multitude of gold clips. This burial also included a number of gold bangles and fragments of gold sheeting with gold tacks (Fig. 3) that must have been attached to a soft base like a wooden bowl or head-rest, now completely decayed.

The gold recovered from Thulamela can be compared directly with that from Mapungubwe, although they are some

Fig. 3. Gold sheets and the gold tacks that held them to a wooden form, now decayed (actual size).

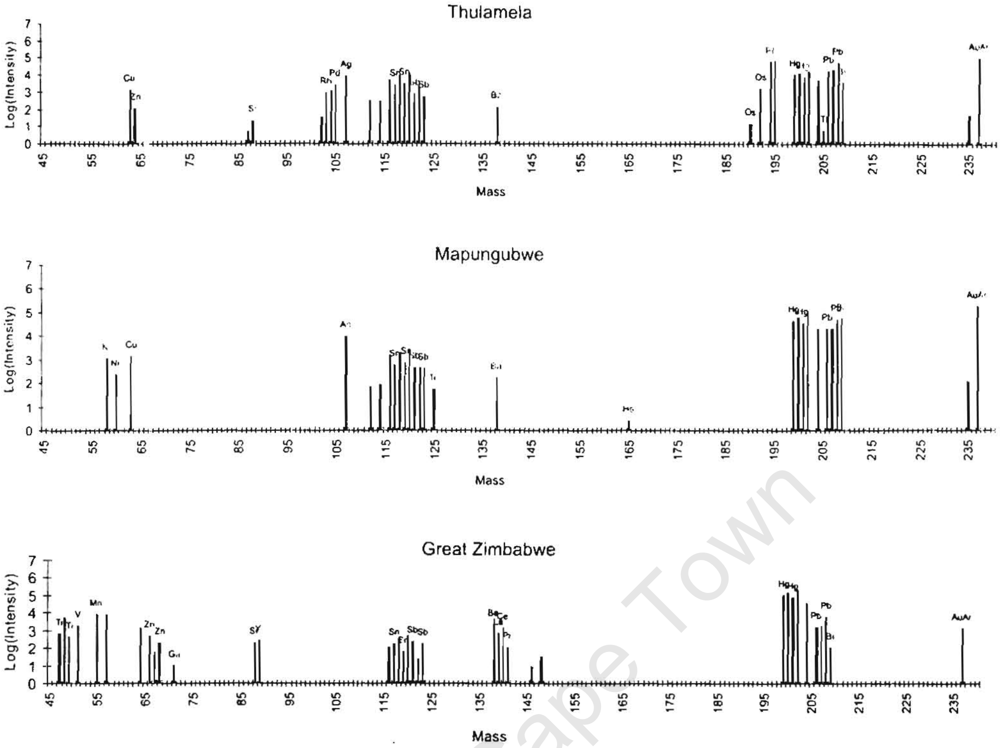

Fig. 4. Typical elemental signatures of gold artefacts from three archaeological sites, showing the similarity of the Thulamela and Mapungubwe signatures which may point to a common source of gold, and the distinct difference of the Great Zimbabwe sample from both of these. Great Zimbabwe probably received gold from a wider range of sources.

200 km apart and at least three hundred years separates the occupation of the two sites. Did the gold from Thulamela and Mapungubwe come from similar or different sources, and did the inhabitants of each site have access to only one or multiple sources of gold?

For the first time, archaeologists can answer such questions, using an instrumental technique for determining the characteristic chemical 'fingerprint' of the tiny quantities of impurities present in all gold.

Gold fingerprinting technology

Anglo American Research Laboratory's fingerprinting technique to identify gold was originally intended to detect crime.[13] Each year substantial amounts of gold stolen from South Africa's gold mines are recovered by the police. The problem is to know to which mine any particular gold belongs and should be returned. The solution to the problem was the development of a technique for reading the unique fingerprint of gold from any particular source, and comparing the impurity profile of the recovered gold with those of all known sources on file. The fingerprint of any particular gold source is as individual as our faces. Even if the gold from a few different sources has been mixed, the match with the individual origins can be determined. In practice this means that stolen bullion can often be identified with the individual mine shaft from which the gold came.

In LA-ICP mass spectrometry, a gold object is placed in the sample chamber of the spectrometer and a powerful laser beam vaporizes a tiny amount of the metal, leaving a very small hole. The vaporized gold, with its trace-element impurities, is swept up by a stream of inert gas and injected into a very hot plasma flame which separates the individual atoms and ions. These are sucked into the spectrometer detection system, where each atomic particle is sorted according to its mass/charge ratio and a detector records the presence or absence of each of the 234 naturally occurring isotopes. This information is fed to a computer which can produce a graphical fingerprint for the sample and also can compare this with the known characteristics of gold from various sources, stored in its memory. If the gold is from one of the known sources which has already been fingerprinted, then there should be a match, with a reasonable degree of statistical probability.[14]

This method is virtually non-destructive and valuable samples can be analysed this way, producing only minimal visible damage. The analysis does not seek to determine the absolute quantity of trace elements but only whether they are present or absent. It is simpler, quicker, and more reliable than other chemical analytical techniques because it does not depend on comparative analytical standards and complicated wet chemistry procedures to get the gold and all its impurities into solution.[15]

There are additional advantages when investigating archaeological samples. Quite large objects can be placed in the laser chamber and the holes caused by the laser are tiny. If the object is positioned carefully, the holes can be made in an inconspicuous place so that the minute damage is not visible. The laser can also be used as a drill to bore through any surface layer that has become contaminated or corroded with the passage of time. This allows the analyst to sample the unaltered original gold in the body of the object.

Analysis of archaeological materials

The LA-ICP-MS technique was applied to over a hundred individual gold objects from the sites of Mapungubwe, Bosutswe, Great Zimbabwe and Thulamela.[5] All the gold contained variable levels of silver and copper as significant impurities. The fingerprints of the gold artefacts from Mapungubwe fell into at least two, and possibly three, groups, defined on the basis of the presence or absence of strontium, rare-earth elements, platinum-group elements, barium and mercury. All the Thulamela gold had signatures that were similar to that of one of the Mapungubwe groups, with strontium, rare-earth elements, platinum-group elements, barium and mercury present (Fig. 4). The single gold sample from Bosutswe had a signature that was distinct.

The lack of any systematic patterning in the copper and silver levels in the gold, with silver varying up to 10% by weight, showed that no refining had been practised. It also showed that deliberate alloying to control the physical properties of the metal had not been done. In the Middle East and India, gold refining and deliberate alloying have been practised since at least the first millennium AD. This is one line of evidence that the southern African gold was probably locally produced. Other evidence pointing to the local production of this gold was the presence of platinum-group metals as significant trace impurities. These relatively high levels are characteristic of southern African gold, and relatively uncommon in material originating elsewhere.

The fact that the trace element fingerprint signatures at Mapungubwe grouped so clearly points to geologically distinct sources of the gold. If the gold had come from one source, or if the material from a diversity of sources had been thoroughly mixed together then one would expect a general blur of results, without distinct grouping of the fingerprints. One of the implications of this is that the Bosutswe sample represents gold from a completely distinct source. Another implication is that the source of Thulamela gold may have been exploited much earlier by the people of Mapungubwe. This interpretation is strengthened by the lead isotope ratio profiles of the Mapungubwe and Thulamela gold, which are similar to each other and distinct from either the Bosutswe or the naturally occurring average.

Future research

The next step is to compare the trace element fingerprints of the artefacts from the three sites in more detail with signatures of gold from various other regions, such as North Africa, the Middle East and India. This may confirm whether southern African archaeological gold was locally produced. We must assemble appropriate comparative material from known sources before this can be done reliably. The next stage will be to identify which region of southern Africa provided the gold for specific sites. This may be somewhat easier because some of the comparative fingerprint data for reef and alluvial gold is at hand, although there are large gaps for some regions where there were early gold mines, such as Mozambique. Far more difficult would be the task of trying to match individual gold artefacts to specific local geological sources. It is possible to source modern gold very precisely only because comparative samples of modern source material are readily available. Archaeological gold was probably recovered from alluvial deposits or surface quartz veins worked out by early miners. Looking for specimens of gold found by past prospectors and now preserved in museums may be fruitful, and this line of enquiry is being pursued.

The fingerprinting of archaeological gold artefacts is a potentially rich source of information, despite the difficulties of locating contemporary comparative material. The LA-ICP mass spectrometer fingerprinting technique promises to enable archaeologists to unravel the history of gold production and trade at a level of detail unimaginable until very recently.

We thank the University of Pretoria, the National Cultural History Museum, and the curator of the Rhodes Collection at Groote Schuur for access to gold samples, and the organizers of the 4th World Archaeological Congress held in January 1999 in Cape Town, where this work was first presented. We also wish to acknowledge financial support for archaeometallurgical research from Anglo American Chairman's Fund Educational Trust, De Beers Fund Educational Trust and the National Research Foundation (South Africa). Opinions and conclusions expressed in this paper are those of the authors and should not be attributed to any of the supporting agencies.

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In Brief...

People

At the third annual National Science and Technology Forum awards ceremony, the following individuals and organizations were recognized for outstanding achievements and contributions in the fields of science, engineering and technology:

- **Friedel Sellschop**, former deputy vice-chancellor for research at the University of the Witwatersrand, in the category of an individual over a lifetime.
- **Michel Albers** of Next Chimica (Pty) Ltd received his award in the category of an individual's contribution to research over the last two years.
- **Sadi Motsueyane**, of the CSIR's Technology for Development programme, was honoured in the category of an individual through activities other than research and innovation over the last two years.
- **Sasol Technology (Pty) Ltd** received the award for a corporate organization over the last ten years.
- The **Programme for Technical Careers** (PROTEC) was honoured in the category of a not-for-profit organization over the last three years.

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- The National Research Foundation has conferred its special awards for 2001 on the following young scientists: **Robert de Mello Koch** (theoretical and quantum physics, University of the Witwatersrand), **Jaco Greef** (behavioural and evolutionary ecology and biology, University of Pretoria), **Jens Gutzmer** (mineralogy and economic geology, Rand Afrikaans University), **Delia Marshall** (physics education, University of the Western Cape), **Dorrit Posel** (economics, University of Natal), **Maxwell Shamase** (education, KwaZulu-Natal Department of Education and Culture), and **Ignatius Swart** (religious studies, University of Transkei).
- **Patricia Whitelock** has been elected the new president of the South African Institute of Physics, the first women and the first astronomer to be so honoured. Dr Whitelock is deputy director of the South African Astronomical Observatory. The new vice-president of the SAIP is **Edmund Zingu**, vice-rector of the Mangosuthu Technikon in KwaZulu-Natal, the first black scientist to hold the post and the first from a technikon.