19TH CENTURY GLASS TRADE BEADS

From two Zulu royal residences

Sharma Jeanette Saitowitz

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ABSTRACT

This thesis is a formal analysis of beads from the two Zulu capitals of Mgungundlovu (occupied by Dingane between 1829 and 1838) and Ondini (held by Cetshwayo between 1873 and 1879). It contains a set of procedures for producing a bead taxonomy, most of which has been adopted from work done in North America, but some of which consists of analytical methods original to this study. The taxonomy is based on visual and physical screening of large collections, followed by chemical analysis. It provides a standardized system for South African bead studies.

Results of the analysis are employed for the following purposes:

1) To provide a database of the varieties of glass beads in circulation in Zululand for two relatively short periods of time in the nineteenth century.
2) To determine the spatial and temporal variability in relative abundance of bead types in the two sites. Subtle differences occur between beads excavated from one section of Mgungundlovu and another. Between 1838 and 1879 the bead preferences of the Zulu changed markedly. The early collection is dominated by white beads and the later one by pink.
3) To define a set of physico-chemical characteristics for 19th century European glass trade beads which provide useful information for comparative bead studies and insights into the history of glass making. Techniques are developed for screening large bead collections which provide information about glass composition. These techniques can be applied after minimal training. The results of compositional analysis are used to evaluate the bead taxonomy that was constructed by means of visual classification procedures. It is a test, therefore, of the classification procedures used by American bead analysts.
4) Finally, to compare whether or not the results obtained from Mgungundlovu and Ondini are congruent with the pictorial and ethnographic descriptions of glass beads in Zululand produced during the relevant parts of the 19th century.

It is concluded that the majority of the beads from Mgungundlovu and Ondini are most likely to have been of European origin, probably from the Venetian island of Murano. This restrictive conclusion provides an archaeological perspective on the European bead trade, since it is known that the major trade partners of the Zulu kingdom changed between 1838 and 1879.

I dedicate this thesis to the loving memory of my father

PREFACE

This study was supported by a Larger Research Grant from the Human Sciences Research Council. The Harry Oppenheimer Institute for African Studies funded my research on glass bead manufacture in Venice. I thank the Natal Museum, the Kwazulu Monuments Council, and the Natal Provincial Museums Service for making the bead samples available for study. I am grateful to Revil Mason (Archaeological Research Unit, University of the Witwatersrand) for allowing me to analyze various beads from the Van Riet Lowe bead collection. Andrie Meyer (University of Pretoria), Joan Broster, David Killick and Garth Sampson also contributed beads for elemental analysis. Kathy Skelly (Peabody Museum, Harvard) and Ann Porter (Robert Fleming Museum, University of Vermont) kindly arranged access to Zulu bead collections. Special thanks are extended to Karlis Karklins for verifying the classification and to Peter Francis for his discussion on glass beads. Staff members of the Societía Venezia Conterie and in particular Stephano Della Rosa made a valuable contribution towards my knowledge of bead manufacture and the important role South Africa played in the international bead trade.

I am grateful to Roger Summers and Nikki Thompson for their initial study and classification of Hall's Mgungundlovu sample and Rawlinson's Ondini collection.

I thank Dick Rickard and Marshall Otter of the Geochemistry Department for performing all the microprobe analyses for this study.

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Rob Rawlinson kindly allowed me to publish the drawings of his excavations at the main entrance of Mgungundovu and the *isigodlo* at Ondini. Charles Basson of the Geochemistry Department assisted with the photography of the beads and was responsible for photographing and printing superb black and white examples. Mike Herbert also contributed to the photography, and Cedric Poggenpoel kindly illustrated the schematic drawing of Mgungundlovu.

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CHAPTER 1

INTRODUCTION

This thesis evaluates the feasibility of large scale visual screening and typological classification of excavated glass beads, using standardized analytical procedures. The criteria were adopted from methods used by North American bead specialists. To these, specialized techniques of materials science have been added. The combination of techniques represents a new approach to the study of glass beads in southern Africa.

This approach has the advantage of establishing reliable benchmarks, which can be used by other researchers, for different varieties of beads in time and space. In this case, the beads that were analysed provide a database for two tightly dated time slices in Zululand in the 19th century.

Glass beads in Africa have the potential of providing meaningful information on historic contact with traders, missionaries, explorers etc. They also address historic and ethnographic questions of the nature of oral and pictorial accounts and the proveniencing of museum pieces.

The beads for this study were provided by the Archaeology Department, University of Cape Town; the University of Pretoria; the University of the Witwatersrand; D.Killick (Malawi); J.Broster (Transkei); the Natal Museum, uMgungundlovu Museum (Natal Provincial Administration) and the Kwazulu Monuments Council. Initial research on the bead assemblages from Mgungundlovu and Ondini was carried out by R.Summers and N. Thompson.

The beads provided by the University of Pretoria include samples from Bambandyanalo and Mapungubwe. Since these beads are from pot finds it is not certain that they necessarily date to the known periods of occupation at the sites (ca. 1000-1220 A.D. for Bambandyanalo and ca. 1220 A.D. Mapungubwe). They are possibly from much later occupation sequences (A.Meyer, pers.comm.).

The complete collection was consolidated and analysed at the University of Cape Town in the Archaeometry Laboratory, the Materials Research Laboratory and the

Geochemistry Department. The beads will finally be housed at Mgungundlovu and at the Kwazulu Cultural Museum, Ulundi.

During this investigation I studied beadmaking at Murano (Venice), and viewed relevant bead collections in Israel, Holland and the United Kingdom. Other important Zulu beadwork collections were also analyzed in the Peabody Museum, Harvard University and at the Fleming Museum, University of Vermont (Burlington). I also visited K.Karklins, D.Killick and P.Francis in North America to compare the Zulu taxonomy with their classification systems. This consultation proved invaluable and has provided a secure, internationally standardized system for South African bead studies. At the same time I found that the analytical procedures developed for this project (e.g., large scale density and refractive index measurements) have not been used by North American bead specialists.

BACKGROUND TO BEAD RESEARCH IN SOUTHERN AFRICA AND ELSEWHERE

During the first half of this century a strong tradition of glass bead studies was established in southern African archaeology. Beads offered a valuable method of dating, especially for Iron Age sites. Bead studies were begun by Randall- MacIver (1906) and Caton-Thompson at Great Zimbabwe (1934). This tradition was continued by Van Riet Lowe (1955), Schofield (1951), Summers (1958) and Kirkman (1974). Laidler (1934), who was a member of the original Mapungubwe team, attempted to enter the bead field, but his work attracted adverse comment from Caton-Thompson and he withdrew from this particular study in 1937 (R.Summers, unpublished manuscript). Clarence van Riet Lowe (Malan 1962:39) started an important reference collection of beads at the old Union Bureau of Archaeology (now housed at the Archaeology Department, University of the Witwatersrand). Van Riet Lowe (1955:4) advocated the use of physical, chemical and spectrographic analysis of plain glass beads, and stressed the dangers of relying on unaided visual examination. He quoted Caton-Thompson and others by saying "a bead expert must be versed not only in archaeology and history but also in chemistry and spectroscopic analysis". Van Riet Lowe's recommendations were not implemented until much later, however, when Du Toit (1961) and Claire Davison (1972) pioneered quantitative elemental analysis of glass beads from various sites in eastern and southern Africa. Using neutron activation analysis and X-ray fluorescent spectrometry Davison showed that *'garden roller'* and small Mapungubwe beads were chemically identical. Thus, the only glass beads that were made in southern Africa were made from melting together imported small beads in clay moulds.

During the 1960's interest in bead studies and bead collecting flourished elsewhere, particularly in North America with the rise of the "hippy" movement on the West Coast. Since that time, a Bead Museum has been established in Prescott, Arizona and a centre for Bead Research at Lake Placid in New York. The first International Bead Convention was held on the Queen Mary in September 1985 and there is a monthly bead journal. Several newsletters and a journal are published by various bead societies such as the Society of Bead Researchers in Canada, the Bead Museum, the Centre for Bead Research and also the Bead Study Trust in England.

South African beads have been described in numerous archaeological site reports, but very little research has been published since the 1960's. Interest in beads declined at this stage as new methods of dating, especially radiocarbon, became available. The study of glass beads, however, can provide tighter chronological precision than may be possible by radiocarbon dating for recent centuries, since the earliest dates of manufacture of many bead types is known from historical records. In addition, glass beads provide a powerful tool for studying trade interactions. The problem, in both instances, is that bead types need to be positively identified. This is not a trivial problem.

The stimulus for the present work came in part from the need to develop an efficient system using standardized criteria for glass bead studies, either archaeological or ethnographic, and to classify the glass trade beads excavated from sites in southern Africa.

THE HISTORY OF GLASS BEADS AND TRADE IN AFRICA.

The earliest known glass or glazed beads were manufactured in Egypt before 3 000 B.C. Glass beads produced for large commercial markets were a much later phenomenon. In Venice, for example, glass beads were first exported as trade items at the beginning of the 14th century (Dillon 1907:183).

Glass beads were brought to the East Coast of Africa by Arabs, Persians and Chinese merchants who had been trading in the Indian Ocean for thousands of years. Archaeological evidence confirms long-distance trading networks along the East African coast. The oldest trading harbour of the Muslim period has been dated to the early 9th century A.D. (Fage 1978:111). Arabs of southern Arabia and the Persian Gulf were the first to connect coastal Africa with the networks of maritime trade.

Evidence of Indian Ocean maritime trade networks can be found in southern Africa from early Iron Age sites. The best-known sites are distributed along the Limpopo River; beads appear here from 700 A.D. on.

Vasco da Gama's journey in 1497 marked the beginning of European expansion into Africa. He stopped at East African ports, including Delagoa Bay, where he traded with local inhabitants on his way to India (Sherr Duvin 1987:129). Delagoa Bay (Lourenco Marques, Maputo) was connected with coastal and inland trading networks into the interior of Mozambique and the northern Transvaal. By the end of the 18th century it had been occupied by Portuguese, Dutch, Austrian and English merchants trading in beads and cloth (Smith 1970:277).

Between 1799 and the middle of the 19th century New England merchants visited southern and eastern Africa in search of new markets. They carried cargoes of glass beads imported from France, England and Hamburg (Bennet 1965:538). It is not certain whether their supplies of beads originated from the sources also exploited by the Portuguese. By the beginning of the 19th century the trading networks of Delagoa Bay had extended to the eastern Cape frontier (Smith 1970:283).

It has been assumed that Delagoa commerce, dominated by the Portuguese, depended on the Zulu nation and that most of the ivory exported from this port was derived from Natal. Ivory exports from southern Africa in the 19th century were comparatively small, however. During Dingane's reign all trading activities were monopolized by the monarch. This posed many disadvantages for traders, because of the lack of competition and the king's limited demand for European merchandise (Okoye 1972:18).

Glass beads were one of the most lucrative items involved in the long distance trade networks that operated on both side of the African continent. Widespread and intricate trade networks existed along the East and West coasts and throughout the interior at the time of early European settlement. Beads were bartered for gold, ivory, slaves, palm-oil, coconut oil, incense, rhinoceros horn, timber and iron.

Photographs, illustrations, oral histories and written accounts record glass beads as part of the material culture of indigenous groups in southern Africa from the 15th century onward. The earliest pictorial records of beadwork in the form of simple neck and waist strings, and hair and ear decorations, were published in 1686 by Guy Tachard and in 1691 by A. de Laloubere (Wanless 1988:35). In 1719 Peter Kolbe published an account of the Cape of Good Hope in German, Dutch, French and English. The *frontispiece* of the first edition shows Dutch merchants bartering with Khoikoi, exchanging beads, tobacco and implements for cattle, fat tailed sheep, ivory tusks and tortoise shell (Schrire 1988:217).

Archival documents assign glass beads worn by Bantu communities in southern Africa according to various categories. These include beads that are used in magic, tribal ritual, beadwork, and royal beads. Beads also had strong sexual connotations. In South Africa heirloom beads were important to the Venda, Pedi, Zulu and Ndebele in rites of ancestor worship and as badges of rank (Penn 1987:31). Colour preferences, size and function have been recorded by early traders, missionaries, illustrators, shipwreck survivors, historians, archaeologists and ethnographers alike. Particular beads have been identified by colloquial names such as *'Umgazi'* (red or blood) and *'Itambo'* (white or bone).

Certain beads were worn exclusively by royalty. Smith (1973:98) has described "royal beads" selected by various Bantu chiefs according to their status and availability. Shaka is thought to have preferred a combination of white, black and red beads. Penn (1987:31) describes the *Ifambinga* bead (a pink or golden coloured bead) as being so special and honourable amongst Zulu Royalty "that no one could swear a more serious oath than on the Queen's Ifambinga beads".

ARCHAEOLOGICAL EXCAVATIONS AT MGUNGUNDLOVU AND ONDINI: TWO 19TH CENTURY ZULU SITES

Mgungundlovu and Ondini were two royal capitals in Zululand (Fig.1). They and their histories have been thoroughly documented in the history of the Zulu Kingdom and southern Africa by Lye (1975) and Gardiner (1966). Their large excavated bead assemblages provide benchmark data for a variety of investigations. Each site was occupied for a relatively short time span of about 10 years. Mgungundlovu was burned in 1838, and Ondini in 1879. More than 12 000 beads have thus far been recovered from Mgungundlovu and approximately 9 000 from Ondini.

The Ondini sample is represented by finds from 33 hut floors within the *Isigodlo* (royal quarters) and middens throughout the site. Mgungundlovu has been excavated by four different archaeologists and material has been collected from various areas of the site.

A formal description of the beads from these sites is a fundamental component of this thesis.

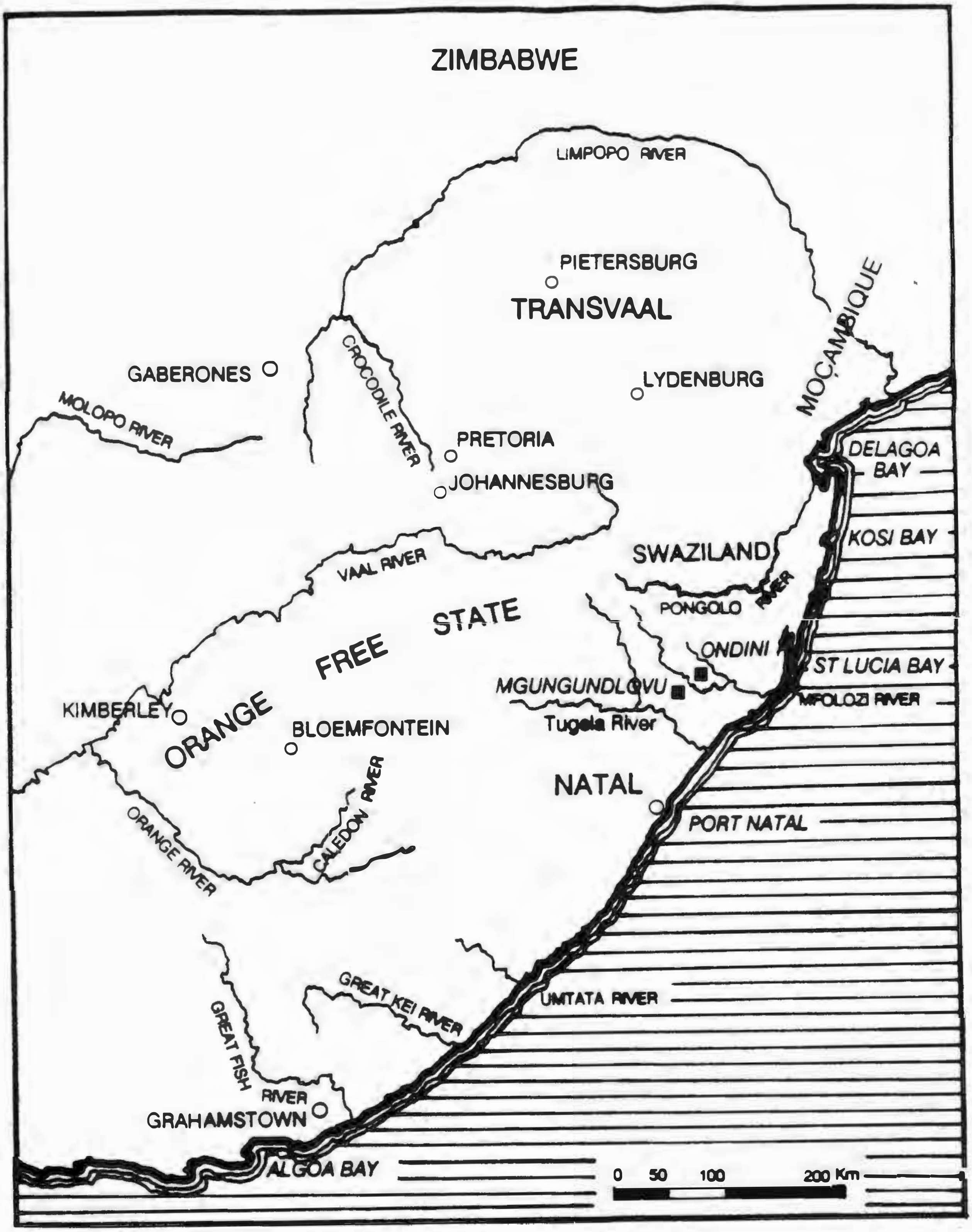


Fig.1. Map of southern Africa showing Mgungundlovu & Ondini.

OBJECTIVES

The principal objectives of this analysis of beads from Mgungundlovu and Ondini are as follows:

(i) To provide a classification scheme which can be applied to glass trade beads from Mgungundlovu and Ondini as well as other sites in southern Africa.

(ii) To undertake physical and chemical analysis of glass beads so as to check the accuracy of the classification and with a view to identifying the areas where beads were manufactured.

(iii) To examine the frequencies of beads excavated from different parts of Mgungundlovu and determine to what extent, if at all, the assemblages differ.

(iv) To compare the Mgungundlovu sample with the bead sample from Ondini some forty years later.

(v) To quantify the spatial and temporal variability of bead types between the two sites. Results obtained from initial statistical analysis can be used to establish whether or not samples from different excavations are comparable despite non-uniform methods of recovery. Spatial and temporal variability in the proportions of beads can then be examined.

CLASSIFICATION

Although many glass beads have been excavated from various South African sites, their analysis has not been satisfactory, primarily due to the absence of standardized methodology. The success of North American bead studies, however, has restored interest among archaeologists and ethnologists working on southern African material. The two large glass bead collections from Mgungundlovu and Ondini form the basis for analysis and demonstration of the procedures that South African researchers (archaeologists, historians, ethnographers) may find useful in further bead studies.

The beads were classified according to methods adapted from the work of knowledgeable bead specialists, mostly from North America. The system provides an explicit taxonomy which can be repeated by other researchers. The methodology is based primarily upon methods of manufacture and appearance. Several methods of glass bead manufacture are known (Kidd & Kidd, 1970; Karklins, 1985; Sprague, 1985; van der Sleen, 1967; Diderot, 1959). In the case of Mgungundlovu and Ondini at least three methods were involved, each of these methods and the physical attributes of beads are described in detail in Chapter 3.

PHYSICAL AND CHEMICAL ANALYSIS OF BEADS

Determining the origin of a particular bead is a challenging problem since the glass bead industry was a competitive enterprise and the historical records are incomplete. Many popular bead types and colours were imitated by various glasshouses in order to capture the market. Glass rods and blank beads were exported from major centres to other outlets for specialized finishing procedures. One should expect (or at least guard against the possibility) that apparently identical beads may have been made in different places. Compositional analysis can shed some light on this potential confusion. The results of an analytical investigation can also provide useful insights into the ability of 19th century glassmakers to reproduce almost the same type of glass for over 40 years. The analysis provides a breakdown of the raw materials used for specific bead types.

Information derived from physical and chemical analysis is used to test whether visual classification (based primarily on methods of manufacture and appearance) accurately reflect the compositional categories of the glass. Some beads that look alike do indeed have different glass compositions. This suggests multiple origins, either due to different glassmaking localities or changes in supplier's raw materials.

The analytical procedures used here include the determination of density (obtained by measuring the difference between the dry weight of a bead compared to its weight when immersed in a fluid) and refractive index (using a Rayner Dialdex refractometer). These methods are relatively simple to use and are non-destructive. Such simple techniques provide a means for screening large numbers of glass beads without resorting to the initial expense and technical complexity of instrumental analysis. They provide characteristics of the glass composition, as the microprobe elemental analysis of some of the beads show.

CHAPTER 2

GLASS BEADS AND TRADE

Historical background

According to Mehlman (1982:30), the earliest precursors of glass beads were made by Egyptian craftsmen prior to 3,000 B.C. These were vitreous blue or green tinted glazed *"faience"* (a manufacturing technique using ground quartz fused by an alkali and fired). After 3,000 B.C. glass making developed in western Asia in the region of Mesopotamia. During this early period of glass manufacture beads were made either by cutting small pieces from heated glass rods and decorating them, or by winding glass threads around an iron rod or wire and fusing the different layers. Glass beads were considered as valuable as gold and semi-precious stones, and were select objects of trade. *"Beadwork"* i.e. the use of coloured beads in the decoration of textiles, was first practised by the Copts in Egypt (Fleming & Honour 1979:65). The earliest known book written on glass and beadmaking was by a Florentine priest by the name of *Antonio Neri*, published in 1612.

Historical references to the production and export of glass beads as international trade commodities occurred for millennia. Explorers, traders and travellers exchanged glass beads for food, slaves, ivory, gold and land. It has been suggested that Manhattan Island was bought for trade beads and other goods worth $24 (Francis 1986:4).

Unfortunately, despite the commercial wealth involved in the bead export trade, little value was placed on the beads themselves. They were considered mere trifles. The skill and artistry involved in their production was not recognized and they were excluded from the ranks of glass *objets d'art*. The low status and large volume of bead exports resulted in incomplete historical documentation of bead origin and dates of manufacture. Export/import documents offer limited information except for quantities and destinations. Inventories often group miscellaneous fancy goods, such as beads (glass or metal), buttons (glass, bone or fish eye pearls) and blanket pins, etc., together as "haberdashery".

To aggravate the situation further, many bead manufacturers copied and produced the same types of beads in almost identical shapes, colours and sizes. They even used the same bead sample card numbers. Glass cullet, glass rods or blank beads were often made at one locality and then sent elsewhere for further processing. In addition, the same raw materials that were used to manufacture glass for bead production was exported to most major glass producing centres in Europe (Smith & Good 1982:14).

EUROPEAN GLASS BEAD CENTRES

Venice

The manufacture and export of glass beads played a vital role in the success of the Venetian glass industry. Beadmaking in Venice began around 1200-1300 A.D.(Kidd 1979:61). Documentary evidence shows that glass beads were used as trading items at the beginning of the 14th century. Dillon (1907:183) notes that glass beads were important trade items aboard galleys despatched annually from Venice to the Black Sea, Flanders and the Thames, where subsidiary centres for distribution were established. Venetians delivered their merchandise to those seaport towns where they had factories or agencies. They were not involved in the marketing or distribution of their wares; local merchants redirected the trade. Between 1512-1515, for example, Pires (1944:12) describes traders redirecting Venetian "glass of all kinds and colours, including glass beads" by river, under heavily armed escorts, from Alexandria warehouses to Cairo, to Tor, Mecca, Jidda and Aden. From there it was distributed to Cambay, Goa, Malabar, Bengal, Pegu and Siam.

By the 15th, century Venice and the German city of Idar-Obertsein were established bead producers capable of competing with the Indian industry, which was already in decline. They started manufacturing small *"seed"* beads and imitating designs that the Indians had been supplying to international markets for centuries. Francis (1982:34) has identified the Venetian copy of the original Indian-made, long opaque red ("Indian" red or Redwood on green core) compound bead, copied in the early

15th century. By the 17th and 18th centuries the Venetian glass bead industry and trading empire had reached considerable proportions. Venetian bead pattern lists for the 18th century alone carried 562 kinds of beads with a great number of sub-varieties (Kidd 1979:20).

In 1898, 17 glass producing factories in Murano consolidated to form the *Societá Veneziana Per L'industria Delle Conterie*, now referred to as "Societá Venezia Conterie". Only two factories, *Morassi* (which still exists today) and *Mazzega* refused to amalgamate with the other factories. It has been suggested by S.La Rosa (pers. comm.), that in order to compete with their opposition these small factories sold loose beads, as opposed to strung beads, at a reduced price to India and Pakistan.

The Societa Venezia Conterie (Murano), purchased a Czechoslovakian company named A. Sachse & Co. Gablonz, Boheme which also specialized in bead production. The Czechoslovakia factory specialized in stringing the beads on cotton thread and on wire. The beads strung on wire were used for making flowers and funeral wreaths (S.La Rosa. pers. comm.).

Bohemia (Czechoslovakia)

Bohemia, one of the provinces of present day Czechoslovakia, has a long history of glass making. According to Kidd (1979:39), archaeological excavations at Kroszwica recovered glass beads and other glass objects which were made on the site as early as the 10th century. Several glassworks in Bohemia, such as that of Count Kinsky in *Brogstein*, *Schlusselbach* (County Prachim), and *Halmbach*, produced glass beads similar to Venetian beads as well as several still larger ones in all colours and with "budded" surfaces and hexagonal beads. They were obtained from Bohemian traders at centres such as *Jablonec* (Gablonz), *Haye, Langenau, Steinschonau* and *Meisterdorf* (Bohn 1805:694).

France

In France, glass making and bead export was well established by the 17th century. By the middle of the 18th century the glass industry had expanded and the number of glasshouses had increased. Bead-making centres of this time included *Nevers, Dangu, Aubermesnil* and *Villers* (Kidd 1979:31). Several French glassworks produced glass corals and glass beads in 38 numbers and types. The are differentiated by various names such as *ambreades, gouttes de lait, cristaux faux, galets, grains, idis, loquis, margariettes, olivettes, pesant, rassade, verrots* and *contrebrodes,* and numerical sub-classifications as well. They are generally known as *verrotie* (Bohn 1805:695).

Glass beads were manufactured in other European centres such as Germany, Austria, England, Holland, Sweden, Russia and Spain.

GLASS BEAD TRADE

Europe and the New World

Glass beads were a major component of European trading items and were exported throughout the world for hundreds of years. Large quantities of beads made in Venice (Murano) were traded in Germany, France, Holland, Spain and Greece. Greece imported enormous amounts of beads and then re-exported them to Egypt. From there they often found their way to Arabia and across the Red Sea to Persia. Venetian beads were also exported to the Orient, via European East-India traders. They were sold in France and Great Britain for trade along the African coasts, and in India and America. According to Bohn (1805:695), "news received from Lord Macartney's ambassadorial tour, described Venetian made glass corals and buttons of various colours and shapes which had been used in China to distinguish different social classes". They were exported first to Canton and then redistributed from there to all corners of China.

The earliest supply of glass beads in the New World were made by Christopher Columbus, who traded them with the Indians on his landing in San Salvador in 1492

(Brain 1979:98). For many years the most widely quoted and best known incident in the history of the American bead trade was the purchase of Manhattan Island by the Dutch from the local Indians for trade beads and other fancy goods worth $24. According to Francis (1986:41), however, this information is tenuous as it lacks supporting documentary evidence.

When the Spanish arrived in the New World, Cortes presented glass beads described as "Margaritas in many designs and colours" to Montezuma in Mexico, and Pizzaro likewise presented a messenger of the Inca with, "some showy ornaments of glass and other toys which he brought for the purpose from Castile" (Smith & Good 1982:7-8). Unfortunately, detailed inventories describing the merchandise by colour, size, etc. are rarely available. Very often beads (either glass or metal) were grouped together and appear in the literature as "haberdashery".

Africa

Arabs of southern Arabia and the Persian Gulf were probably the first to connect coastal Africa with the network of maritime trade which operated across the Indian Ocean. After the 7th century, external relations with North-East Africa from Egypt to India and beyond were dominated by Muslim Arabs (Fage 1978:111). Archaeological artefacts in the form of trade goods were found at palaces, ports, mosques and harbours such as Fort Jesus and Gedi along the East Coast.

Archaeological evidence of the 7th-8th century show that both Kilwa (an island off Tanzania) and Chibuene (situated on the Mozambique coast between the mouths of the Zambesi and Limpopo rivers) had small settlements of fisher-farming people who possessed glass trade beads and Persian ceramics (Hall 1987:78). These were presumably African communities who had occasional trading contacts with visiting Arab seafarers and perhaps with others. The first authentic written evidence about the trade is the Arabic work of al-Idrisi, who compiled a book of travels based on the accounts of others. In this work, the South-east Coast is referred to as Sofala (probably from "*shoal*" in Arabic) and a specific point of contact between the mouths of the Zambesi and Limpopo rivers (*"Jabasta"*, at or near present Chibuene) is mentioned (Hall 1987:78).

By the late 12th century, the nature of the trade at Kilwa changed when the Shirazi dynasty established an Islamic city state at Kilwa and proceeded to control trade along the coast as far south as Sofala (by then a port by that name). South of Sofala, archaeological remains found at Manikweni (a stone ruin built in the characteristic style of the late Iron Age "Zimbabwe Culture" of the interior) suggest that the inhabitants were involved with long-distance trade (Davidson 1984:120). Glass beads resembling those from Zimbabwe and Mapungubwe were also excavated from a sand dune near Lourenco Marques (Juta 1956:9).

Ivory was the primary export from the eastern coast of Africa from as early as the 7th century A.D. India and later China emerged as the major market (Sheriff 1987:78). In India most of the ivory was used to make bride bangles, an essential ornament required particularly for upper class wedding trousseaus.

TRADE IN SOUTHERN AFRICA, 700-1880 A.D.

Evidence for the identity of seafaring traders who visited the Southeast coast of Africa during the 1st millennium A.D. is fragmentary. The *Periplus of the Erythraen Sea* (a guide to the ports of Arabia, East Africa and India) depicts Arab traders in the Indian Ocean from India to Tanzania in the 1st century A.D. The authenticity of this document, however, has frequently been questioned. Archaeological evidence for the origins of Indian Ocean trade networks can be found at Early Iron Age sites in the Lowveld (8th century) and inland sites overlooking the Limpopo River, particularly Schroda (ca. 800-900 A.D.), Skutwater (ca. 900-100 A.D.) and Bambandyanalo (ca. 1000-1220 A.D.).

Mapungubwe was built beneath the Mapungubwe hill in the 11th century. The town had been extended over the summit by the early 12th century. At the peak of its power (ca. 1220-1270), Mapungubwe had a dense settlement of commoners at its base, while its wealthy rulers occupied the summit (Hall 1987:75). In the late 13th century, the centre of power shifted to Great Zimbabwe (ca.1270-1420). The kings of Great Zimbabwe exercised political and economic control over an area which stretched from Botswana to Mozambique and included parts of the Transvaal. Trade items including large collections of glass beads have been excavated from all these sites.

Delagoa Bay

Glass beads from pre-Portuguese traders in southern Africa were brought to the East coast by Arabs, Persians and Chinese merchants who had been trading in the Indian Ocean for thousands of years. In 1497, Diaz discovered the Cape route to India, just 5 years after Columbus discovered the New World. In 1498, the journey of Vasco da Gama marked the beginning of European expansion into the African continent. He visited East African ports on his way to India and bartered beads in the town of Mozambique (Sherr Duvin 1987:129) located at Delagoa Bay (as is the case with Lourenco Marques and present Maputo). The Portuguese were the first Europeans to establish regular trade with Delagoa Bay. From the 16th century the trading station of Lourenco Marques represented the southern extent of Portugal's East African territories (Duffy 1959:205). By the early 19th century Delagoa Bay was changed from a relatively isolated area into one of the most important commercial centres on the East African coast.

Delagoa Bay was connected with coastal and inland trading networks into the interior of Mozambique and the northern Transvaal. By the beginning of the 19th century the trading hinterland of Delagoa Bay extended all the way to the eastern Cape frontier (Smith 1970:283). The growth of trade in Delagoa Bay during the second half of the 18th century was influenced by its connections with Natal and the ivory trade.

Towards the end of the 18th century Delagoa Bay was occupied by the Austrian Asiatic Company, the Dutch East India Company and English merchants trading in inexpensive beads and cloth from Surat (Smith 1970:277). By the end of the century American commerce had extended to South Africa and later to East Africa as well.

Following the American Revolution, trading conditions in Africa changed radically for New England merchants. Until then practically all trading activities were confined to the West African slave trade. It was during this period that New England vessels carried as cargo large quantities of glass beads imported from France, England and Hamburg (Bennet 1965:538).

In 1829 the town of Lourenco Marques (at Delagoa Bay) was a fortified trading post. Export goods included ivory, hippopotamus teeth, rhinoceros horns and slaves. The Africans exchanged these commodities for brass bangles, beads and cloth (Liesegang 1969:567).

South Africa

In December 1497, Vasco da Gama passed the last beacon, a cross, which his pioneer predecessor Batholemew Diaz had set up some 200 leagues to the east of the "Stormy Cape". He sailed northeast until the 25th of December, when he made land again. As that was Christmas day, in honour of his Saviour's birth the country was called *Tierra de Natal* or land of the nativity (Grout 1864:18).

By the second half of the 19th century Nguni speaking people from South Africa were trading with Dutch, English, French, Austrian and Portuguese traders calling at Delagoa Bay. The major trading item was ivory. East African and southern African ivory found an easy market in India and the United Kingdom, through Bombay. The extraordinary rise in the demand for ivory in England was related to the popularisation of items such as combs, piano keys and billiard balls. During the first half of the century South Africa supplied very small quantities of ivory to the U.K. (Fig.2). Over the next quarter of a century, however, it expanded its supply to over 50 tons a year (Sheriff 1987:87). These increases were probably brought about by India-based English merchants who may have been trading for ivory as far as Delagoa Bay.

In 1823 Captain King and Lieutenant Francis George Farewell of Bristol arrived to explore the coast and harbour of Port Natal and to engage in trade. Between 1824-1825 traders Henry Francis Fynn and Nathaniel Isaacs also arrived at Port Natal as well. Lieutenant Farewell reached the conclusion that the Africans around Delagoa Bay obtained their ivory from the Zulu (Okaye 1972:11). He anticipated that a settlement founded at Port Natal would attract ivory intended for the Delagoa Bay market.

From the rise of the Zulu Kingdom 1822 until the middle of the 19th century, all trading concessions were controlled exclusively by the reigning monarchs. This posed many disadvantages for the trader. The king's demand for European goods was limited and the chances for large profits were considerably reduced because of lack of competition among the Zulu. If competition had existed, the traders would have had the chance to demand a greater number of tusks for their goods (Okoye 1972:18). It is not clear how the kings maintained absolute control over the trading rights. According to Spohr (1965:69), Mpande (who reigned 1840-1872) experienced great difficulties with the Boers who were trading in Zululand without his permission.

Missionaries also played an important role as traders in southern Africa in the early 19th century. When they first arrived at the Cape in 1799 they brought "bibles in their right hands, and beads and buttons in their left" (Beck 1989:211). The men sent out by the London Missionary Society soon learned they would have to depend upon trade with the indigenous people if they were to survive in the interior.

The Zulu developed an elaborate tradition of beadwork, which gave importance to the trade. Examples of mid-19th century Zulu beadwork can be seen in the work of Angus. His elegant and meticulous pictorial details of Zulu heros, customs and material culture appeared as 30 coloured lithographs and 11 black and white drawings in *The Kafirs Illustrated* in 1849. Angus' book was above all a commercial venture aimed at a Victorian audience. In order to sell his work he had to refine the images of the "barbaric" subjects and demonstrate that the "kafirs" were good business in mid-19th century England (Kloppers 1989:69). The beadwork is likewise not entirely accurately rendered.

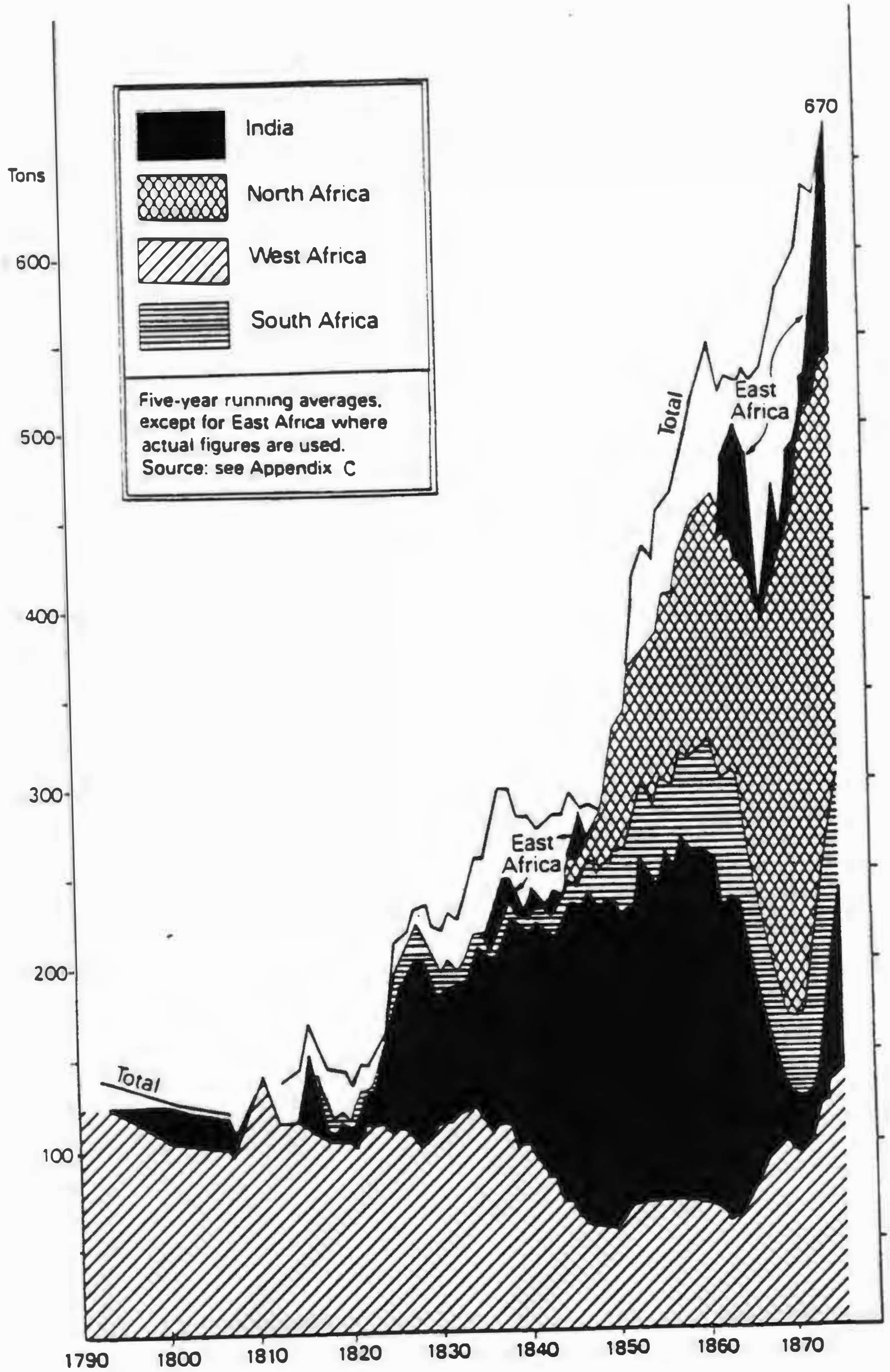


Fig.2. Ivory imports into the United Kingdom 1792-1875 (Sheriff 1987:89).

DISCUSSION

Historical records show that for centuries glass beads have played an important international role in the internal and external trading networks of European, North and South American, African, Arabian, Indian, and Chinese merchants. Unfortunately glass beads were always regarded as the "poor relatives" of European glass *objets d'art* and as such, were neglected in terms of historical documentation and museum representation.

Glass beads and cloth were amongst the most popular commercial items traded for gold, ivory, slaves, live-stock, skins, palm-oil etc. Ivory was the major trade commodity exported from the East Coast of Africa to India and China from as early as the 7th century. Arab traders from southern Arabia and the Persian Gulf were the first to engage coastal Africa with the maritime trade of the Indian Ocean. East African and South African ivory was popular with manufacturers because much it was much "softer" than the West African ivory and, therefore, easier to work (Sheriff 1987:87).

In 1477, Bartholemew Diaz discovered the Cape sea-route to India, just five years after Columbus landed in the New World. The next year, Vasco da Gama followed in Diaz' footsteps and opened the way for European expansionism into Africa. By 1498, he was trading with Delagoa Bay and East African ports on his way to India.

Written accounts describe Columbus trading European glass beads with the Indians. Vasco Da Gama also traded European merchandise, such as brass, beads and cloth, to the local inhabitants in exchange for ivory and provisions. It is not known whether Vasco Da Gama was trading European glass beads on his way <u>to</u> India or whether he was selling beads produced in India to African markets on his return voyage.

By the beginning of the 18th century other trading nations, such as the Dutch, Austrians, French and Americans and English were active in Delagoa Bay. During the time of Dingane (1828-1839), commerce at Delagoa Bay was dominated by the Portuguese, and depended on the ivory supplied by the Zulu.

Portuguese, and depended on the ivory supplied by the Zulu. During the reign of Cetshwayo, the major trade partners of the Zulu were the English at Port Natal.

Mgungundlovu (Dingane's royal residence) and Ondini (Cetshwayo's royal residence 1874-1879), and the bead assemblages they have yielded, form the subject of the next chapter.

CHAPTER 3

ARCHAEOLOGICAL EXCAVATIONS AT MGUNGUNDLOVU AND ONDINI: TWO 19TH CENTURY ZULU SITES

During the past fifteen years, controlled archaeological projects have been conducted at the 19th century Zulu capitals of Mgungundlovu and Ondini. In this chapter, the history and the archaeology of the two sites are discussed.

Architectural and spatial information from the sites have been investigated by the Archaeology Department of the University of Cape Town, and the Natal Museum. Work continues at Mgungundlovu under the auspices of the Natal Provincial Museums Service.

HISTORICAL BACKGROUND

Shaka kaSenzangakhona was the founder of one of the most powerful political organization in south-east Africa. Born in 1787, he ruled over the Zulu Kingdom from 1816 to 1828, and built two military capitals. Both of these were called kwaBulawayo, which means the "Place where there is killing" (Bergh & Bergh 1987:14). Shaka became famous for his battle tactics. The basic fighting formation was the horns of the buffalo. Within a few years of spectacular military achievement, c.1818-1822, Shaka had consolidated the Zulu Kingdom from numerous petty chiefdoms of the Thukela - Phongolo region (Webb & Wright 1978:ix).

Toward the latter part of his reign Shaka became despotic and autocratic, which resulted in discontent, mass killings and widespread upheaval throughout the kingdom. This is the period known in the Nguni languages as the *Mfecane*. Shaka was assassinated by two of his half-brothers, Dingane and Mhlanga, and Mbopha kaSitayi, his senior *inceku* (P. Colenbrander, unpublished manuscript).

The succession of the Zulu Kingdom was passed onto Dingane in 1828, and then to Mpande, in 1840. Mpande is often portrayed as an unworthy successor to Shaka and

Dingane. He has been described as "ineffectual, obese, peaceable and even cowardly". This stereotype (while containing some measure of truth) is largely the result of the limited attention his reign has received from historians (P.Colenbrander, unpublished manuscript). Mpande reigned from 1840-1872.

Cetshwayo kaMpande was the eldest of Mpande's sons. He ruled the independent Zulu kingdom from 1872-1879.

Mgungundlovu (1828-1839)

Mgungundlovu was the largest of several military complexes (amakhanda) built by Dingane kaSenzangakhona. Completed in the heart of the kingdom in 1828, it served as the royal residence of Dingane and his principal advisors. The internal affairs of the Zulu kingdom were coordinated from Mgungundlovu and a large military garrison was maintained there. In Zulu the name of the capital is thought to mean the secret meeting place of the elephant.

Mgungundlovu was built on a gently sloping hill side in the wooded savannas of the upper White Umfolozi River catchment (Fig.1), in the Makhosini valley. It was strategically and geographically well situated and had historical as well as national associations. The main entrance of the Royal residence opened in the direction of Nkosinkulu, named after the founder of the Zulu dynasty (Fig.4). It has been estimated that eight regiments were housed at Mgungundlovu and that between 1 400 and 1 700 beehive huts were constructed on the site (National Provincial Museums Service and National Monuments Council, n.d.). The site is also referred to as Dingaanskraal. The word kraal is derived from the Portuguese "coral/corral" and is supposed to have come to South Africa via Brazil (Spohr 1965:68). Trade was conducted with European entrepreneurs who approached the capital from Delagoa Bay in the north and from Port Natal in the south (Fig.1).

Mgungundlovu was described and illustrated by a number of European visitors to the site. These included Andrew Smith (Lye 1975), James Gardiner (1966) and Hofstede (1876) (Fig.3). James Stuart compiled a map of the town based on oral testimony of Zulu informants who had lived there (Webb & Wright 1977). From these sources and excavations at the site it is clear that Mgungundlovu was elliptical in shape, with two arcs of densely packed warrior houses enclosing a large open space (Fig.4). The isigodlo (a royal area) was situated at the head of the complex on the southern side of the site opposite the main entrance. The bachelors of the capital lived near the isigodlo. The principal general to Dingane i.e. the uNdhlela (Doke & Vilakazi, 1964:540) resided near the main stockfold (Campbell, n.d:17). It is estimated that the isigodlo contained about 150 huts (Parkington 1979:147). The isigodlo was separated from the rest of the complex and the huts were described as being larger and more perfect than any of the others (Bird, 1965:203).

Dingane's royal quarters are believed to have been situated on the east side of the isigodlo. In a letter written by Piet Retief on the 18th of November 1837, the king's house is described as a "beautiful habitation, spherical in shape and twenty feet in diameter. It is supported in the interior by 22 pillars which are entirely covered with beads". It is interesting to note the typographical error in this copy of Retief's letter (Campbell,n.d:16), in which 22 had been written instead of 2. One of the digits had been crossed out on the document. This inadvertent inaccuracy could have been the source from which authors such as Champion (Bird 1965) and Parkington & Cronin (1979:147) were led to believe that there were 22 pillars instead of only two.

Fig.3. Illustration depicting the murder of Piet Retief at Mgungundlovu (Hofstede 1876:38).

Entry to the royal capital was through the main entrance (isango) and narrow entrances situated in the palisade. The main entrance also served as the dividing line between the eastern and western sections of the complex. The distance between the main entrance and the furthermost hut of the isigodlo was 600 metres (Natal Provincial Museums Service and National Monuments Council, n.d.).

Outside the royal residence and above the isigodlo there were three small enclosures, probably all containing huts but apparently serving different purposes. This area is known collectively as bheje, though these enclosures were referred to individually as umvazana, bheje and kwambeceni. Bheje or Beja Magaozi is apparently derived from a chief who once defied Dingane (Cronin, n.d.:116) and hid away from him and his guards in a nearby forest. Umvazana and Kwambeceni were Bheje's children. Bheje was the biggest of the three enclosures and had eight huts; the two smaller ones had four huts each. An informant named Tununu Nonjiya, who carried the King's throne to the Bheje, reported that while only the Royal family and the King's beloved lived at Bheje, Dingane himself never slept there (Campbell n.d: 16). Nonjiya also reported that the Bheje contained mostly big huts and that many people lived in them. These people wore Mnaka on their necks and beautiful shining brasses and glass beads. Mnaka are hollow brass neck rings worn by the highest ranking people and the royal women (Krige, 1950:375).

Weapons were kept in armories built on piers called unyango (Campbell, n.d.:17). The poles of the storage huts were off the ground to prevent rats and insects from ruining the shields. The shields were all owned by the king. They were delivered to each soldier when they went out to war (Bird, 1965:203).

When Dingane put Mgungundlovu to the torch in 1839, in the face of an advancing Voortrekker commando, the heat of the burning wood superstructure and thatch of the beehive huts served to bake the clay floors, ensuring the preservation of many of them to the present day. In addition, extensive midden deposits survive above the isigodlo.

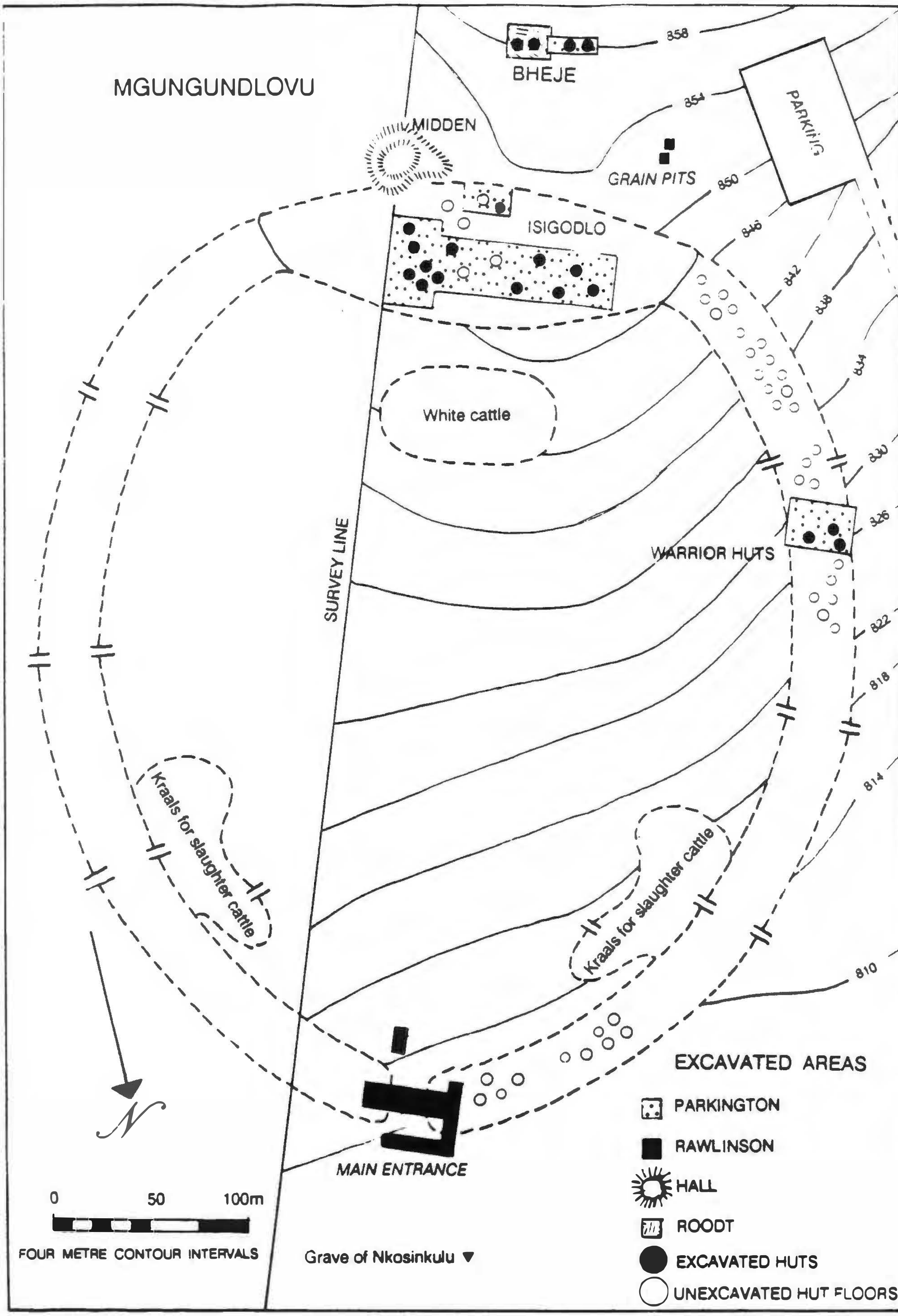


Fig.4. Schematic drawing of Mgungundlovu showing outline of the palisade and excavations at the site, based on survey by departments of Archaeology and Land Survey, University of Cape Town (Parkington & Cronin 1979).

Ondini (1872-1879)

Cetshwayo built his royal residence on the Ulundi plain overlooking the twin peaks of the Mabedlane and the hills of Zululand to the west. Dohne (1857:227) referred to the capital as uluNdi or oNdini, which is associated with the concept of height. During the reign of King Mpande and King Cetshwayo, many other royal military centres were built on the Ulundi plain and these were also called Ondini.

After the battle of Ulundi on the 4th of July 1879, Cetshwayo was defeated by the British and Ondini was burnt to the ground. As with the case of Mgungundlovu, the heat of the burning thatch sealed the hut floors for posterity.

Following the Anglo-British war Cetshwayo was deposed and civil war broke out. Three years later Zululand was annexed by the British and the power of the Zulu state was destroyed (Bergh & Bergh 1987:38).

EXCAVATION

Mgungundlovu

Within the past 15 years, four controlled excavation projects have been conducted at Mgungundlovu. In January 1974 and July 1975 a group from the Archaeology Department of the University of Cape Town and the Natal Museum undertook fieldwork in various parts of the site (Parkington & Cronin 1979). Their excavations included clay floors in the isigodlo areas, part of the isigodlo midden, hut floors from the bheje area, and hut floors in the section associated with warrior houses and the main entrance (Figs.4). The warrior area did not yield beads at all.

Additional areas of the isigodlo midden were excavated by Hall (Natal Museum) in 1978. Since 1985, further work has continued at the site under the auspices of the Natal Provincial Museums Service. Roodt is working on hut floors from the bheje areas as well as the isigodlo and the eastern side of Mgungundlovu. Rawlinson's excavation included hut floors and a refuse dump near the entrance to the site (Figs.5 & 6).

A total of 12 436 beads from the site were analyzed.

Ondini

According to reports, Cetshwayo ordered his kraal to be "built like Umgungundlovu and Natives were sent to Dingane's kraal to measure it and make it as far as possible the same" (Cronin,n.d:127). This included the isigodlo (a royal area), two arcs of warrior barracks for various regiments (fig.7), and a bheje area which has since been destroyed (R.Rawlinson, pers. comm).

Excavation of Ondini concentrated mainly in the isigodlo area (R.Rawlinson, unpublished thesis) where 33 hut floors were located (Fig.8). Refuse dumps were also excavated from different areas of the site. The bheje area has unfortunately been ploughed away and destroyed (R.Rawlinson pers.comm.). Ceramics and fauna were recovered from the site. A total of 9042 glass beads were recovered from midden deposits, hut floors and surface finds. Molten beads were found at Ondini as at Mgungundlovu.

The site is a national monument. A museum and amphitheatre have been built and a number of huts in the isigodlo have been reconstructed.

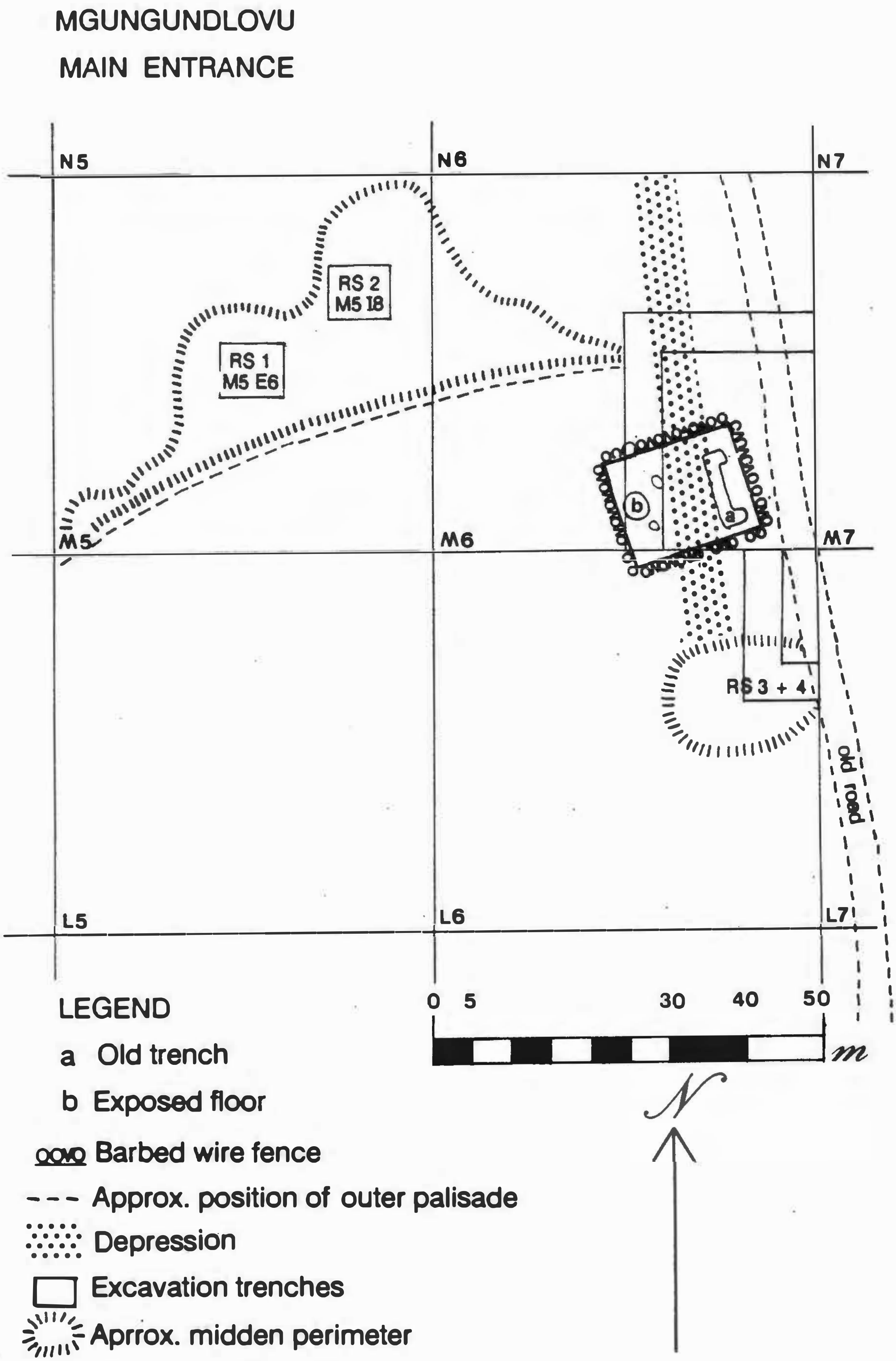


Fig. 5. Excavation of the main entrance at Mgungundlovu (R.Rawlinson).

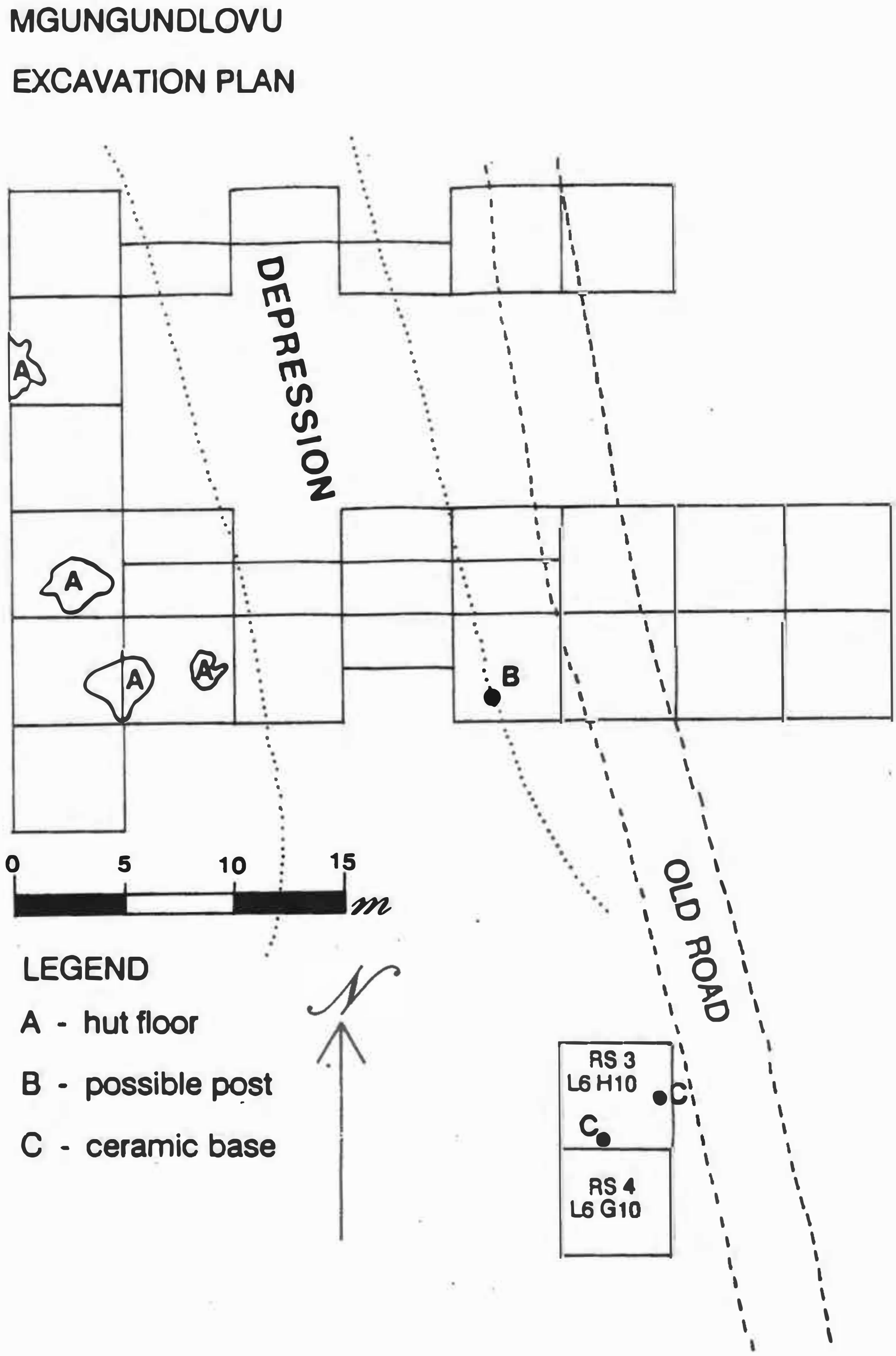
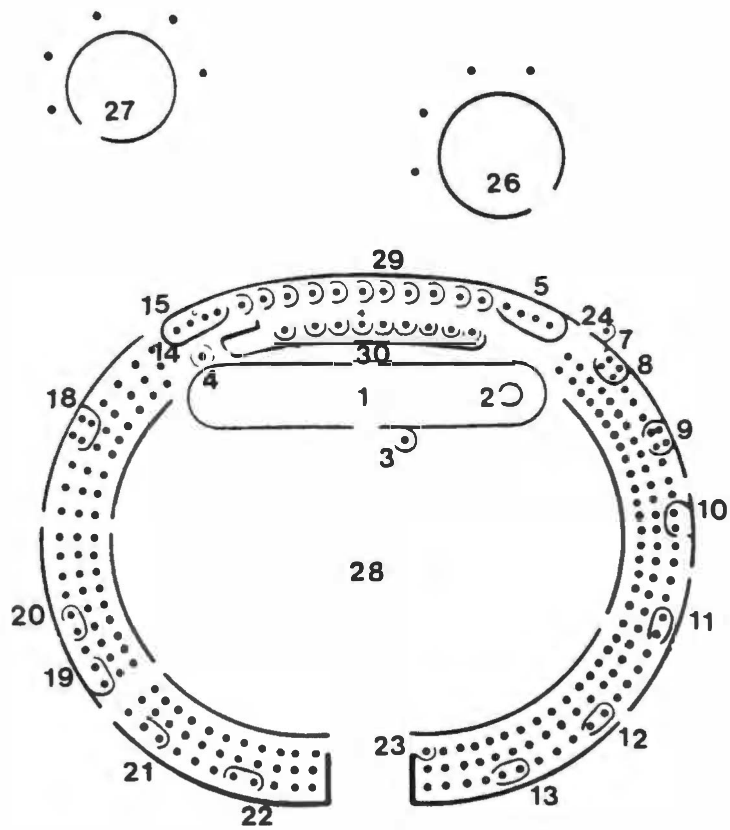


Fig.6. Mgungundlovu excavation plan of main entrance (R.Rawlinson).



Key:

No.1	The king's cattle enclosure.
No.2	The King's bathing enclosure.
No.3	The Gate-keeper's hut. The King went through this gate to inspect his troops.
No.4	The King's hut.
No.5 & 6	Huts of the isigodlo Esimhlope (the King's wives).
No.7	Guard hut for gate No.24.
No.8	Huts of the Council of the King, Chiefmen and princes.
No.9 10 & 11	Quarters of the "Induma" or Chief Officer
No.12	The Chief Army Officer's residence.
No.13	The Second Chief Officer's residence.
No.14	Cleaners hut.He also guarded gate No.15.
No.15	The gate used by the Royal women, "to relieve nature and for other business".
No.16 & 17	Not listed.
No.18	Huts of Princes, and others of high rank.
No.19	The residence of the Third Officer.
No.20 & 21	Residences of the Officers in charge of the middle section of Ondini.
No.22	The residence of the Second Officer.
No.23	The residence of the Sentinel who guarded the main entrance of Ondini.
No.24 & 25	Not listed.
No.26	Emaphothweni was the area where the King's cattle were milked & slaughtered.
No.27	The King's storage area.
No.28	Large parade area used for inspection.
No.29	Maids of Honour, Umdhlunkulu & handmaids huts.
No.30	Additional huts for the King's wives.

Fig. 7. Diagram of Ondini (Samuelson 1929:245).

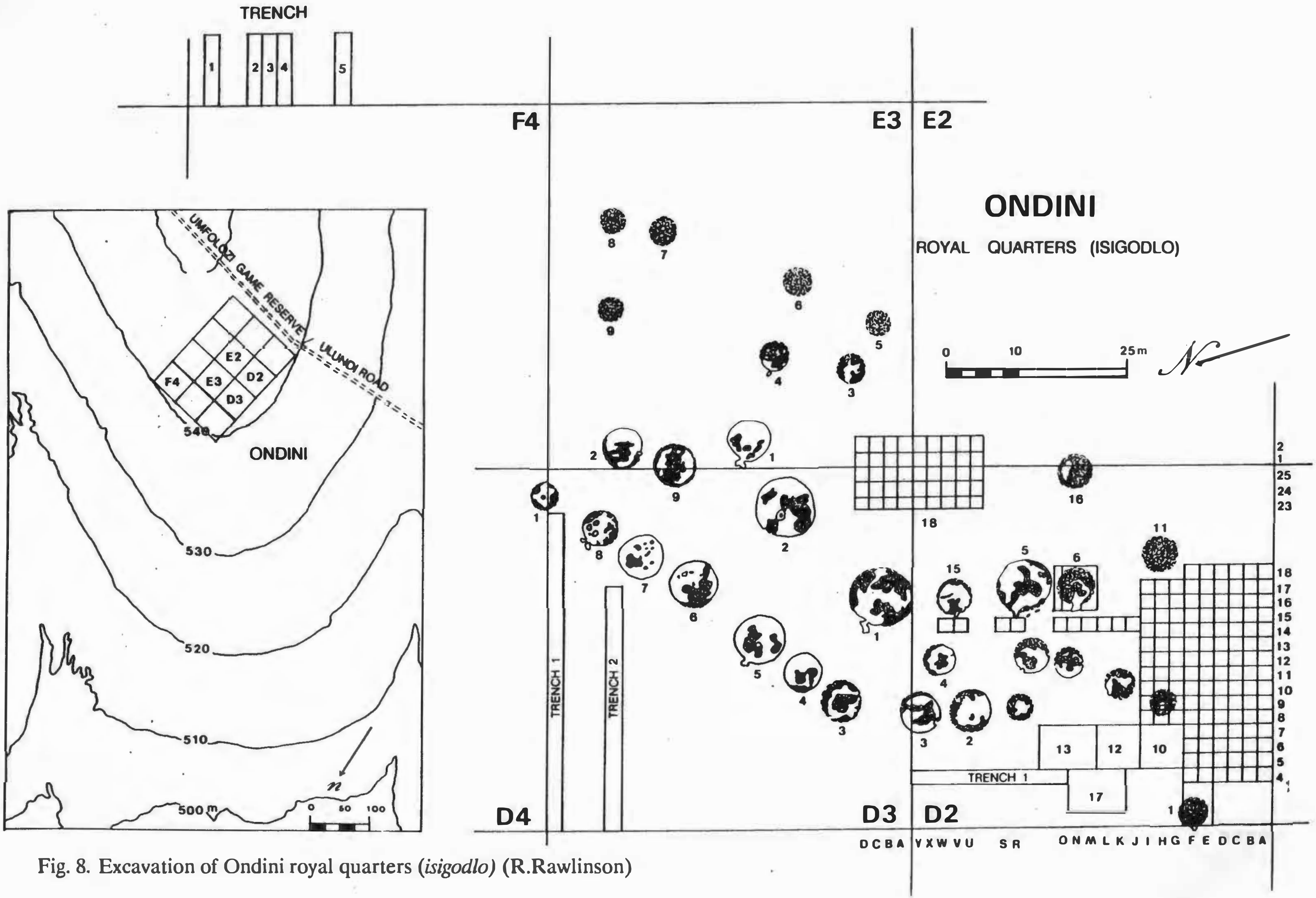


Fig. 8. Excavation of Ondini royal quarters (*isigodlo*) (R.Rawlinson)

RECOVERY METHODS

As far as can be ascertained, the recovery methods of various excavators at Mgungundlovu and Ondini were largely similar. Substantial samples of large objects such as ceramics and fauna were recovered from coarse-meshed sieving, and finer sieves of various screen sizes were used to recover glass beads. Due to time constraints, it was necessary to combine methods of retrieval to collect representative samples of beads and other objects. For example, in the case of Hall's excavation of the isigodlo midden at Mgungundlovu, all deposit was dry sieved, 61% being processed through a 5 x 5 mm mesh sieve, the remaining 39% through a 2,5 x 2,5 mm mesh, and a sample of the latter again through a fine mosquito net. This sampling strategy was designed to retrieve the full range of beads and other small objects present. In the case of Parkington's excavations at the same site, material was sieved through 12,7 x 12,7 mm (1/2 inch) as well as 3,2 x 3,2 mm (1/8 inch) mesh sieves. The procedures of Roodt and Rawlinson remain unknown. Fortunately, the bead statistics show that no major bias exists between the bead assemblages of the different excavators.

SPATIAL VARIABILITY OF BEADS AT MGUNGUNDLOVU AND ONDINI

Different assemblages of variously coloured beads from the Mgungundlovu excavations have been analysed. The results (discussed in Chapter 6) serve to identify the spatial variability in their proportions. Percentages from the total of all blue, yellow, green, pink, striped, opaque "Indian" red or "Indian red on green core" beads have been calculated. The results show that two samples obtained by different excavators from the isigodlo midden are essentially identical, but the bheje has a higher proportion of striped beads (Figs.36 & 37). Blue and green are relatively abundant in samples from the isigodlo. White is the predominant bead colour found at Mgungundlovu (Table 3).

Although the collection from Ondini has been obtained primarily from the isigodlo area, comparisons can be made between samples from the royal quarters and those from other areas at the site. The results show that mauve-pink beads are dominant in the isigodlo samples as well as in assemblages recovered from middens outside the royal quarters. Correlation coefficients have been calculated to quantify variability in the proportions of beads from different parts of the site (van der Merwe, et al 1989:102). These are described in detail in Table 7, Chapter 6.

DISCUSSION

The Mgungundlovu and Ondini collections comprise mainly monochrome, drawn beads. There are noticeable differences in the proportions of beads classified on the basis of colour. Whereas white beads are dominant at Mgungundlovu, mauve-pink is the most common colour at Ondini.

Statistical analysis shows that bead samples from different excavations at Mgungundlovu are comparable, but that spatial variability can be observed. The highest proportions of striped beads were found in the bheje area; blue and green are most abundant in the isigodlo huts and in samples from the entrance to the site. The defence of the main entrance, the most important and vulnerable area of the site was entrusted to senior officers or men of high rank. It was likely that they had more wives, who in turn, owned many beads of the type found among the royal women. This would explain the large quantity of beads found at the main entrance (H.Ngubane, pers.comm.).

The absence of beads in the warrior area may have been due to the fact that when men attained warrior rank, their personal adornment changed from beaded to feathered ornamentation (Brottem & Lang 1972:13). While one would not expect feathers to survive the rigours of time, glass beads certainly would have been present in the archaeological record had they been represented in the warrior area.

At Mgungundlovu, a cluster of four hundred and forty six "Indian" red or Redwood on green core beads (samples AA72 to AA83, Appendix iii) were found in the isigodlo midden. In one small area at the bheje, Parkington & Cronin (1979) excavated eight "eye " beads. In both instances all the beads looked similar. These occurrences suggest that either a string of beads or some type of beadwork decoration was swept away and discarded.

Twenty six large, wound, ruby Cornaline d'Aleppo on white/yellow cores were recovered from Mgungundlovu and 76 from the isigodlo area at Ondini. These beads also look remarkably similar.

Eight opercula of land molluscs were recovered from Mgungundlovu (Fig.9), and also a well made earthenware pottery "toggle". This artefact could have been used as a spinning whorl.

The formal classification of the glass beads from these two sites follows in the next Chapter.

Fig.9. Operculum of a land mollusc (Diameter = 6mm).

CHAPTER 4

VISUAL CLASSIFICATION

Initial studies of glass beads in southern Africa included the work of MacIver (1906), Caton-Thompson (1931) at Great Zimbabwe and Van Riet Lowe at Mapungubwe (1955). This tradition was continued by specialists such as Schofield (In Summers 1958), Du Toit (1961) and Davison (1972). After the introduction of radiocarbon analysis in the 1960's, however, the use of glass beads as a dating device for Iron Age studies declined.

Iron Age research in southern Africa has gained momentum since that time, and although many glass beads were collected from various sites, no formal attempt was made to standardize the classification procedures used by researchers. This limited the potential use of glass beads for comparative studies and dating purposes, and also invalidated much of the work that had already been done. Classification of glass beads, however, using repeatable systems, can provide better chronological precision than radiocarbon dating in recent centuries, since the earliest dates of manufacture of certain types are known. Classification of bead types also offers an insight into the consumer's choice of colour, size, shape and decoration. The proportions of these types provide a means of seriating sites in an area responding to the same stimuli of availability and consumer preference.

Formal classification of the bead collections from Mgungundlovu and Ondini was undertaken in the first instance to provide an efficient and repeatable method for screening and analysing large assemblages of glass beads which would also be explicit to other investigators. Simultaneously, such a classification provides a database for glass beads from two relatively short time periods in the 19th century, against which other collections can be compared and which can form the start of a 19th century bead seriation.

THE CLASSIFICATION SYSTEM

Classification of glass beads relies upon a number of criteria which provide a complete physical description. The classification used here has been adapted from the scheme produced by Kidd & Kidd (1970) and expanded by Karklins (1985). It consists of a series of componential paradigms, or levels of analysis, which are arranged in a taxonomic hierarchy (Fig. 10). Its end result is a series of unique subtypes, at least as far as can be determined by visual inspection.

The first level of classification divides the beads according to their methods of manufacture. Three techniques were involved in making the beads found at Mgungundlovu and Ondini. These are: (i) drawn; (ii) wound and (iii) blown. The second and third levels of classification depend on additional manufacturing modifications, which serve to divide the beads into classes. The vast majority of the beads in this study are of Class 11, which are drawn, rounded, simple monochromes. Additional levels of analysis divide and subdivide the beads into finer categories on the bases of shape, size, colour and appearance. Description of the methods and the physical characteristics involved in bead classification follow.

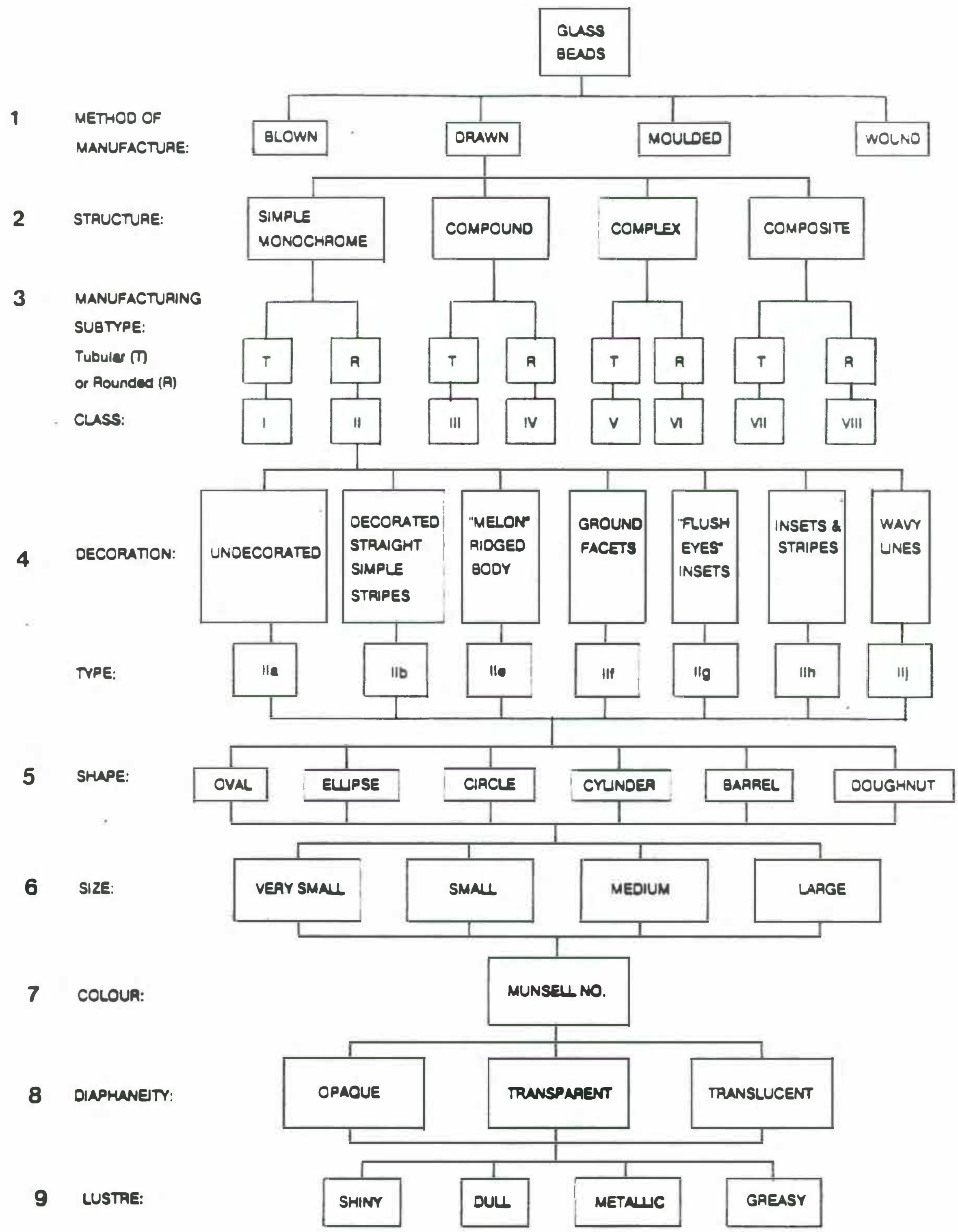


Fig.10. Flow-chart illustrating the procedures for visual bead analysis.

1. METHODS OF MANUFACTURE

(i) Drawn beads

Several descriptions of drawn bead manufacturing techniques have been published (Diderot 1959; van der Sleen 1967; Smith 1982; Sprague 1985). Different classes, types and varieties of drawn beads have been recorded by Kidd & Kidd (1970:50-61) and Karklins (1985:88-96).

Drawn beads are made from molten glass which has been perforated, drawn into hollow tubes, and then cooled (Fig. 11). The tubes are sorted, cut into more or less one metre lengths and then chopped into various sizes. Beads at this stage of manufacture tend to have sharp and uneven ends (Fig.11F). These beads would be classified as tubular.

Striped beads are made by placing solid glass tubes or rods of the required colour around the inside wall of an open, bucket-like container (Fig. 12). A "gather" of molten glass is blown into this open mould and the canes are incorporated into the matrix of the glass as stripes. The striped "gather" or bubble is reheated in the furnace and drawn into hollow tubes as described above.

The beads are washed, polished and finally sorted into their desired sizes by passing them through a series of graduated sieves. At least thirteen processes (including stringing and packaging) are involved in drawn bead manufacture.

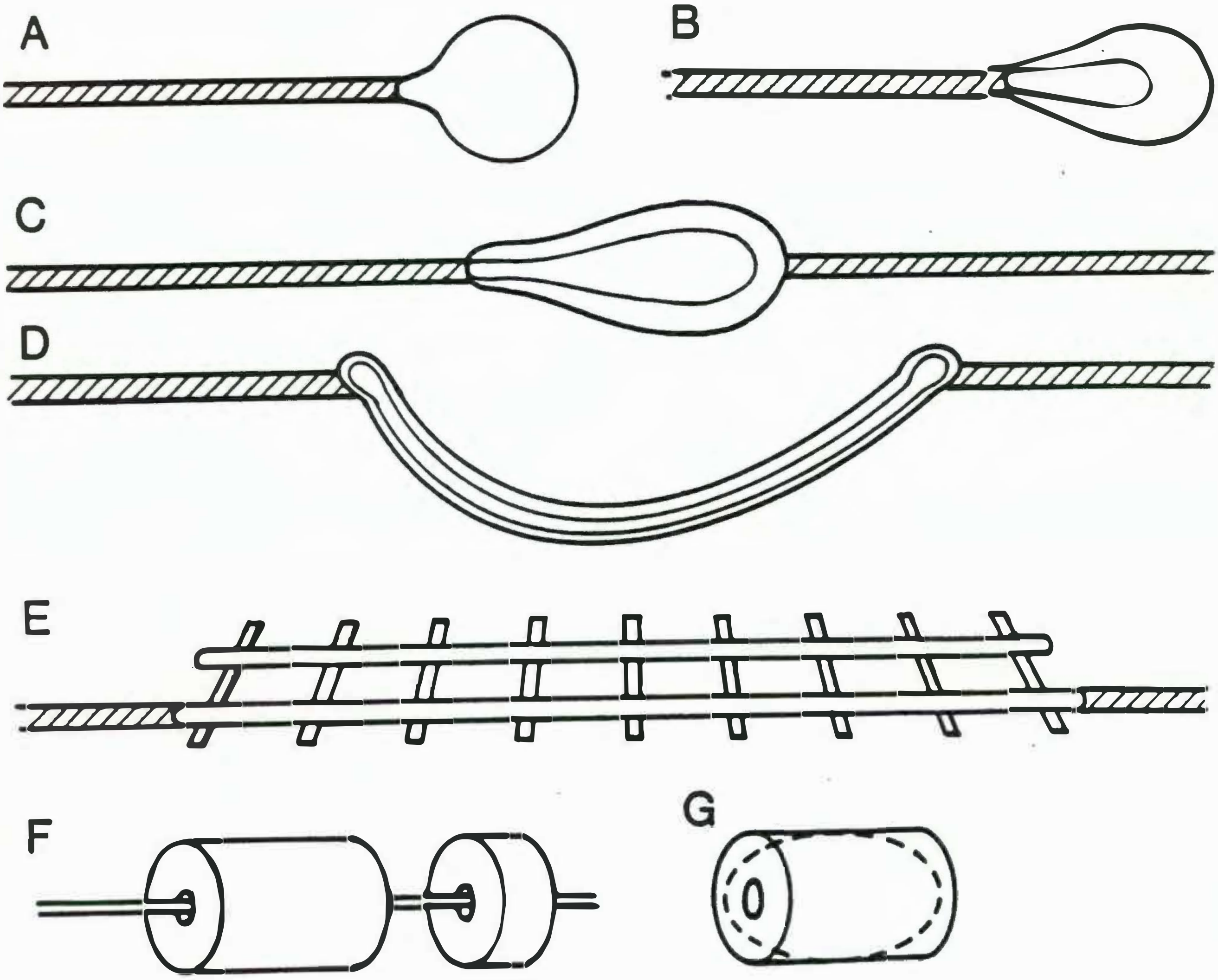
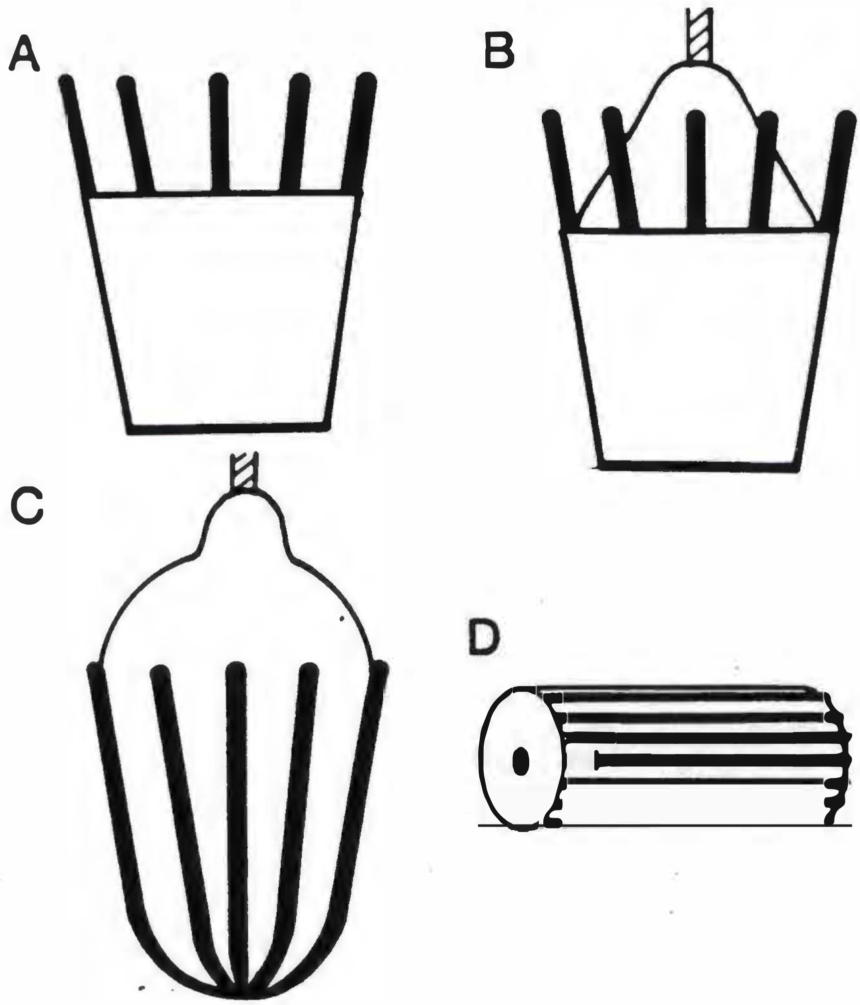


Fig.11. Drawn bead manufacture. Characteristic of drawn beads are bubbles in the glass which, if present are oriented parallel to the perforation.



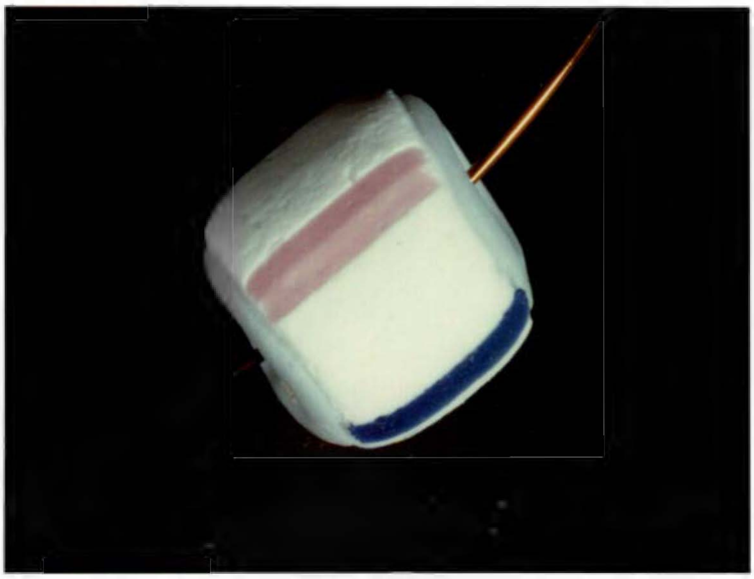


Fig.12. Striped bead manufacture. Drawing taken from Kidd & Kidd (1970:48).

Characteristic of drawn beads are bubbles in the glass, and striations on the surface, which, if present are oriented parallel to the perforation. Drawn beads are also referred to in the literature as Margarite (Polak 1975:57), tube or hollow canes (Karklins 1985:88), seed and pound beads (Orchard 1929:82), Mutisalah (Lamb 1965:36), millefiori (Harris 1984:1) and chevron (Francis 1988:5).

(ii) Wound beads

Wire-wound or wound glass beads are made from solid annealed glass rods, heated over a concentrated flame and wound around a rotating chalk-coated copper wire or iron mandrel until the desired size is obtained (Fig.13). The molten glass is cut, shaped, decorated and smoothed with iron tools or a half-mould (Sprague 1985:94) and can be removed from the wire or mandrel once it has cooled. The perforation may taper slightly if an iron mandrel is used. Different coloured thin glass filaments and glass powder can be applied to the surface for decoration (see Figs.13, 27 & 28). Alternatively, wound beads can be reworked into melon or other shapes while the glass is still molten, and malleable (Fig.32). Wound beads are produced individually and the finished product depends entirely on the glassmaker's skill and artistry.

Various methods of winding beads have been described by Francis (1988), Brain (1979) and Karklins (191985:100). Francis (1988:4), makes a distinction between the method described above and beads made by dipping the iron mandrel directly into molten glass in the furnace and twirling it around until the desired amount of glass has been wound or "gathered". These are known as furnace-wound beads and are described as "often being large with large bores, less perfect than other types of wound beads and sometimes less elaborately decorated".

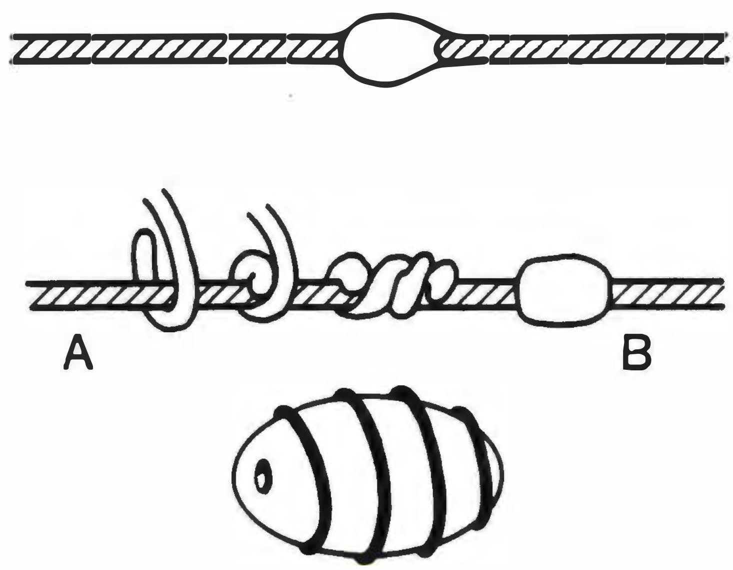


Fig.13. Wound beads. Recognized by swirl marks that run around the perforation, and elongated or round bubbles which are oriented like the swirl marks.

(iii) Blown beads

Blown beads were invented by French glassmakers in the middle of the 17th century to imitate natural pearls. Various methods for producing blown beads are described by a number of authors, including Francis (1988:7) and Sprague (1985:97). Basically, the inside of a minute blown glass sphere (resembling a Christmas bauble), was coated with a thin essence called essence d'orient. The latter was made from scales of whitebait, which produced a fine powder sediment when left standing in water. The appearance of the beads could be enhanced by the use of more essence d'orient, but this process was more expensive. To add weight and strength to the beads they were filled with wax, bored through the centre with a needle and strung for sale. The more expensive beads had a small paper tube placed in each bore to prevent the thread sticking to the wax. Imitation pearls or French *giresoles* were exported in large quantities to many countries. The factories in Maizel (Chaldonnais) and Paris produced imitations which were often indistinguishable from real pearls (Bohn 1805:691).

Blown beads are seldom found in archaeological collections because they are so fragile. Nevertheless, 3 blown beads were recovered from a midden deposit at Mgungundlovu (Figs. 14, 33 & 34) and were identified as such under the microscope during this study.

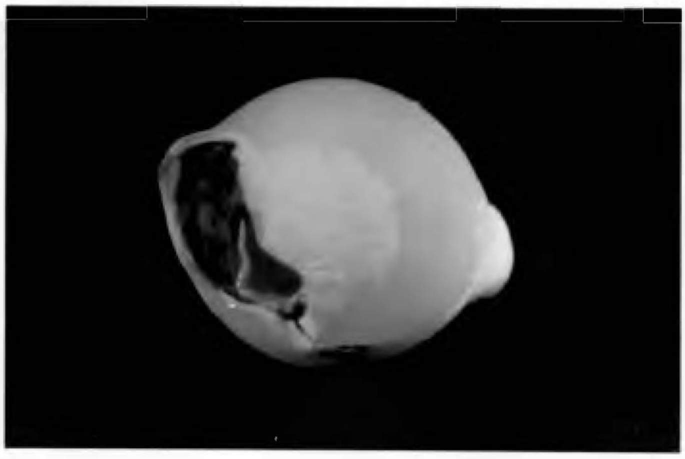


Fig.14. Blown bead from Mgungundlovu (Size: D=4.00mm L=5.80mm).

(1V) Mould-pressed

Basically, the method involves compressing soft and malleable glass into a mould. Two-piece moulds are pressed tightly closed and any residual glass is squeezed out at the joints. A moveable pin perforates the glass to form the bore (Fig. 15).

Mould-pressed beads can be identified by their uniformity of shape and the ridge or "seam" along the join. Elongated shapes, for example, have seams which run parallel to the perforation. The surface around the perforation area can often be crackled and the bore itself tapered.

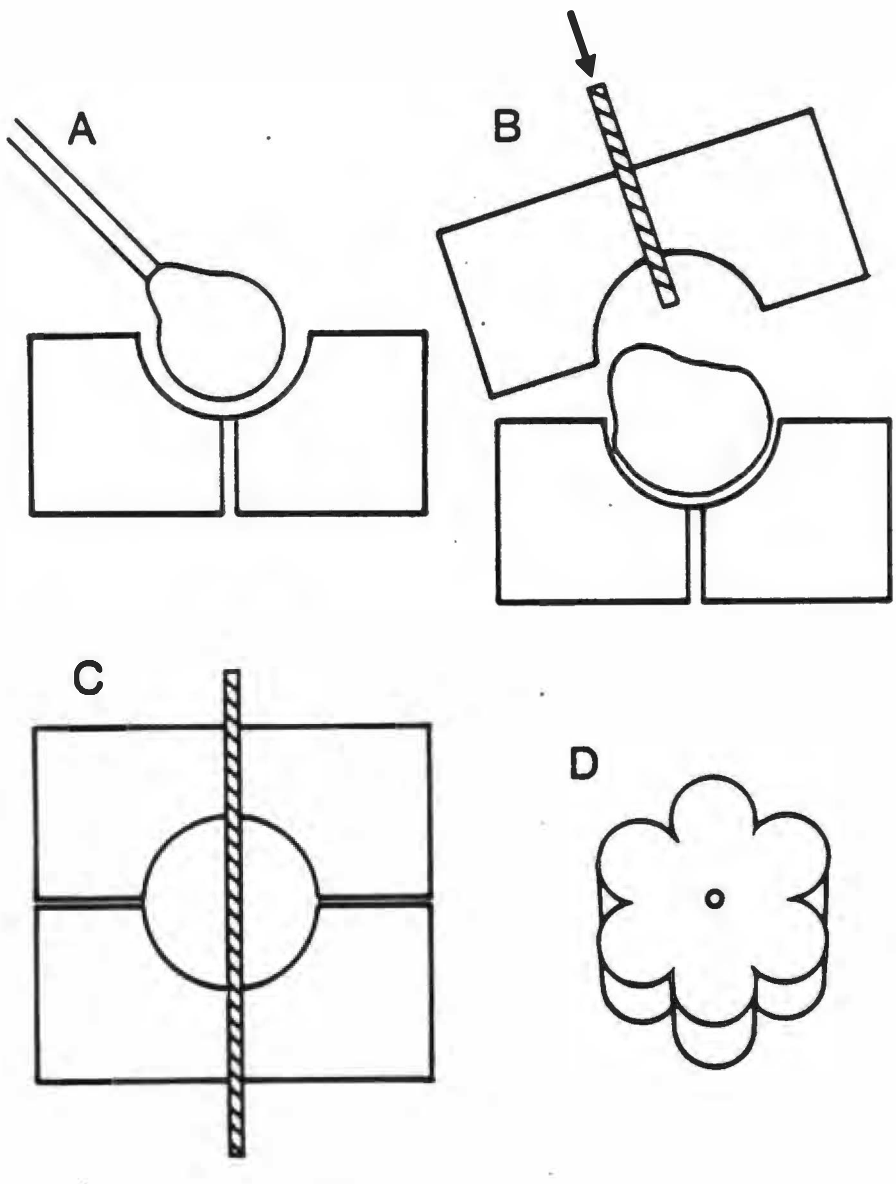


Fig.15. Mould-pressed bead manufacture.

2. STRUCTURE

Drawn beads can be distinguished on the basis of their structure, ranging from a simple monochrome bead composed of a single layer of glass, to a compound bead composed of two or more layers of undecorated glass. The Venetian "Chevron" bead type or star beads (a multiple-layered bead with a distinctive star-pattern when viewed from the end), are compound (multi-layered, up to seven layers of glass) drawn beads (Fig.16 & 19).

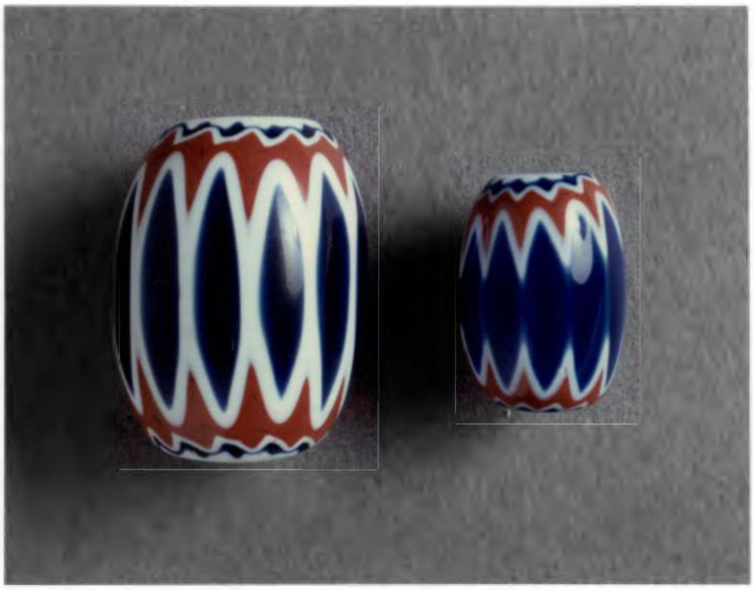


Fig.16. Venetian "Chevron" or star bead.

There are 4 structural categories:

Simple:	Beads composed of one undecorated layer of glass.
Compound:	Beads composed of two or more undecorated layers of glass.
Complex:	Simple beads with additional decoration such as stripes or other decorative inlays.
Composite:	examples are compound beads (multi-layered), decorated with stripes or other inlays.

The Mgungundlovu and Ondini assemblages do not include complex and composite beads. They comprise primarily monochrome, undecorated beads. Compound beads are present, composed of two undecorated layers of glass; one variety of compound bead is the *Cornaline d'Aleppo* (Figs. 17 & 18).

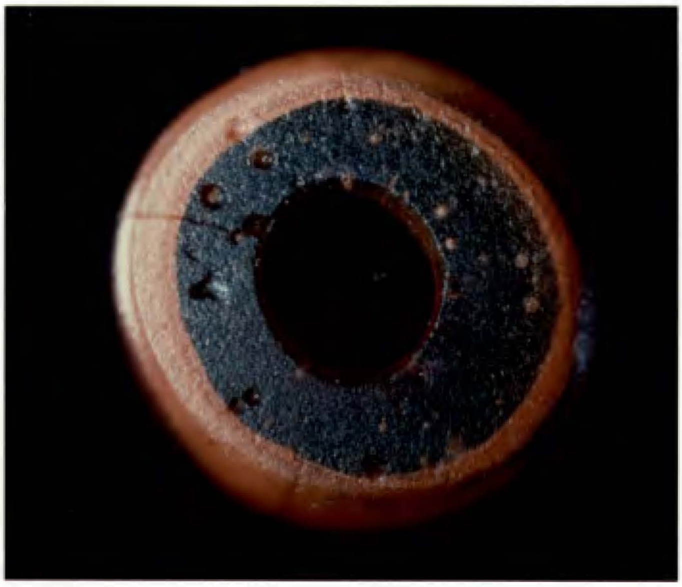


Fig.17. *Cornaline d'Aleppo* ("Indian" red or Redwood on green core variety).

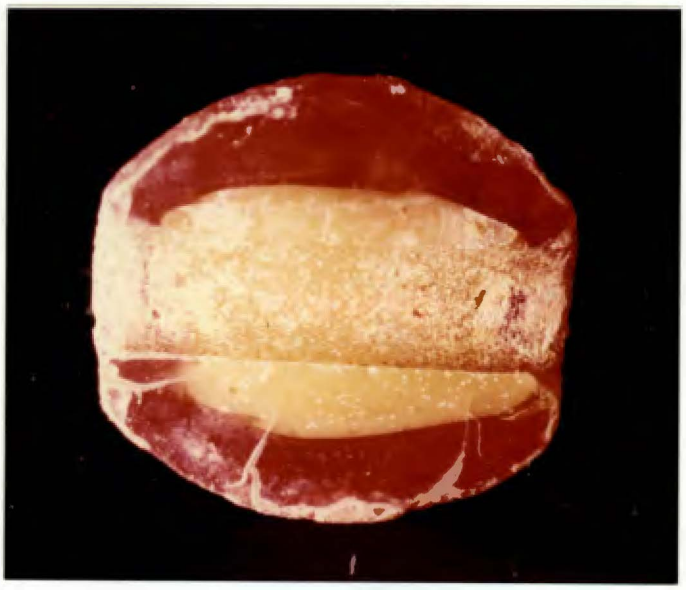


Fig.18. *Cornaline d'Aleppo* (transparent ruby on yellow/white core variety)

3. TUBULAR OR ROUNDED

After drawn beads have been chopped into the desired sizes, the ends are sharp: these can be modified by various methods. Softening the edges of the beads (Fig 11G) involves hot tumbling, cold tumbling, or grinding them individually on an abrasive wheel. The hot tumbling method involves "packing" the perforations with a mixture such as plaster and charcoal dust mixed with clay to prevent the perforations from closing once the glass has been reheated over a hot flame or in a furnace. Various packing mixtures are used, such as plaster of Paris and charcoal dust mixed with clay (Orchard 1929:85). Abrading the sharp edges using the cold tumbling method is obtained by rolling the bead in sand or other abrasive agents (Elizabeth Harris, pers. comm.).

The "Chevron" bead type is individually ground on an abrasive wheel, not only to round the edges but also to illuminate the internal star design (Fig 19). In some instances the surface of the bead is also ground or tumbled according to the desired surface effect (Fig 16).

Fig.19. The internal star of the "Chevron" bead.

4. DECORATION

Decoration is described simply on the basis of visual analysis. Decorated beads hold the most potential for dating and determining bead origins. According to Picard (1987:3) an estimated 200 000 to 300 000 different kinds of decorated beads have been produced by Venetian craftsmen, either experimentally, or in sets, custom made. The most common design element on drawn beads is striping (Figs.12, 21, 22 & 23). The grinding of facets is also common. Cornerless-hexagonal beads are drawn, tubular hexagonal beads which have been decorated with ground facets (Fig 20). These beads have been found on archaeological sites in North America and the Caribbean which span the period from 1700 - 1910 (K. Karklins pers.comm). They are also found at Iron Age sites throughout southern Africa.

Fig.20. Ground, faceted, cornerless-hexagonal beads from Mgungundlovu

Various other examples of decorated beads found at Mgungundlovu and Ondini are illustrated in Chapter 6 (Figs.24 to 32).

5. SHAPE

Shape nomenclature is usually self explanatory. Some examples, however, have been selected to clarify some of the terms (Karklins 1985:105). For example:

Tubular: A bead is classified as tubular if its length exceeds its diameter. It is also regarded as a tubular beads if it has broken, sharp ends that have not been altered by "tumbling". All tubular beads are assumed to have round cross-section unless otherwise noted.

Circular: Specimens are shaped like rings. They have diameters equal to or greater than their lengths.

Round: This category includes beads not only spheroidal, but also oblate and barrel-shaped. The latter should be designated round (oblate) and round(barrel-shaped), respectively.

Oval: Some oval beads are also barrel-shaped and should be recorded as oval (barrel-shaped).

Doughnut: These are beads in the wound category which look like a Lifesaver candy. Beads of this shape in the drawn category would be termed circular.

Beck's (1928) typology of geometric classification was used in addition to the above, particularly for describing the shape of faceted beads. Faceted beads are usually tubular in shape. Their corners are removed by means of grinding or moulding (Fig.20).

6. SIZE

The maximum diameters of beads were measured with vernier calipers. The following size classes of beads were used, based on those drawn up by Kidd & Kidd (1970:66):

Very small	Less than 2mm
Small	2 - 4mm
Medium	4 - 6mm
Large	6 - 10mm

Why should archaeologists measure the exact size of beads? Bead sizes were only standardized after 1822, when the first automatic tube-cutting machine was introduced (Francis 1988:19). Until then, all drawn beads were cut by hand. The size and uniformity of beads, therefore, depended on the dexterity of individual craftsmen. In addition, each bead manufacturer used his/her own set of screens for size sorting (Sprague 1985:19) and bead sizes or preferences changed. There is therefore no standard way of establishing size categories that correspond to those used by the factories. It is possible, of course, to impose arbitrary size categories (as above) and to use appropriate screens to sort an assemblage.

For purposes of precision in the classification developed here, the diameters and lengths of all the beads were measured to the nearest tenth of a millimetre, as suggested by Karklins (1988:19), Tables 4 & 5, Fig.35.

It is recommended for future bead research in southern Africa, that when dealing with large collections such as Mgungundlovu (n = 12436) and Ondini (n = 9042), summary statistics such as means, modes and ranges could be calculated for subsamples (e.g. 100 randomly selected beads of each variety in a collection). Such data would be quite adequate (particularly when dealing with simple, drawn, monochrome "seed beads") for presenting data for recording and comparative purposes. This consideration is especially important where time and labour costs are involved.

Bead size has been, and continues to be an important factor in beadmaking amongst South African societies. Caton Thompson (1932:242) for example, noted that smaller beads were preferred, probably because "they worked up more effectively into sewn patterns".

7. COLOUR

Colour is an important variable in bead classification and is used routinely in attribute analysis. It has played an important role in the history and development of glass technology and often determined the success or failure of a trader or an expedition, particularly amongst African societies. For the purpose of this project the colour was first described in familiar and widely understood terms such as pink, blue, green, etc. They were then coded according to standardized colours (Munsell Color 1976), and subsequently compared to a sample bead card obtained from the factory of the *Societa Venezia Conterie* factory in Murano (Venice). The sample card was dated 1913. When the surface of a glass bead was dull or eroded, it was moistened to accentuate its colour. Natural light was used for classification at all times.

Forty-two colour variations were distinguished in the Mgungundlovu and Ondini collections (Table 3).

The colour of glass can be affected by many factors. For example, buried glass is prone to leaching effects in acid soils, and the colour of glass is also affected by heat. These considerations would certainly concern beads from Mgungundlovu and Ondini, which were both burnt to the ground.

The two bead collections are distinct in their colour preferences, which are likely to reflect the personal tastes of King Dingane and King Cetshwayo and their royal courtiers. These choices are discussed in Chapter 3, within an historic and ethnographic context. The reasons for the colour choices are complex. Unlike eastern North America, where white, red and purple beads resembled white shell, red catlinite and wampum (K.Karklins, pers.comm.) there are no simple explanations.

8. DIAPHANEITY

Diaphaneity is the term used to describe the clarity of the glass. It includes the following categories:

Opaque: The bead is impenetrable to light except on the thinnest edges.

Transparent: The perforation is clearly visible when the bead is held sideways to the light.

Translucent: The bead transmits light but does not allow for vision through the glass.

According to Brain (1979:98), opacity in the glass may be due to the presence of tin oxide or other minerals; it may also result from some crystallization or from the presence of minute air bubbles in the glass.

The diaphaneity of the beads from Mgungundlovu and Ondini is presented in Tables 4 & 5, Fig.35.

9. LUSTRE

The lustre of a bead refers to the appearance of the glass surface in reflected light. The two most common types are shiny (glossy), and dull. Karklins (1985:112) has distinguished between metallic, greasy (the appearance of an oiled surface), and satiny finishes. The results recorded on the lustre of the beads from Mgungundlovu and Ondini is presented in Tables 4 & 5, Fig.35.

DISCUSSION

The classification system outlined in this chapter provides a standardized method for describing beads from South African Iron Age sites. As will be seen in Chapter 6, the beads found in southern Africa comprise only a restricted segment of a much larger taxonomy. Some 99% of the Mgungundlovu and Ondini assemblages can be classified as drawn, simple monochrome beads, type 11a, 11b and 1Va. This predominance makes the task of visual classification simpler, but it restricts the amount of information that can be obtained from it. In North America these types are paid limited attention. To extract more information from such simple, non-diagnostic bead types requires the additional complexity of compositional analysis.

CHAPTER 5

COMPOSITIONAL ANALYSIS

The classification system described in Chapter 4 depends on visual examination; it is adapted from standardized systems used by bead analysts elsewhere in the world. Beads from South African archaeological sites provide an additional challenge, requiring the complexity of compositional analysis. The beads which entered the region from 700 AD onwards are mostly small, simple, monochromes and are found in a limited range of colours. This is presumably due to the restricted number of varieties available in the Indian Ocean trade before European contact. The beads available to European traders were vastly more diverse, as can be seen in the assemblages from North American sites. In South Africa, however, centuries of Indian Ocean trade had set the pattern of consumer demand and restricted the types and varieties of beads that were acceptable. This pattern also caused European manufacturers to imitate the varieties already in circulation.

To extract more information from the Mgungundlovu and Ondini bead assemblages, a system of compositional analysis was developed for the purpose of this study. The obvious procedure for determining glass composition is chemical analysis, but this is not a practical approach when working with 21 475 beads. A procedure which provides information on the characteristics of glass composition was used to screen the bead collection: this involves measurements of density and refractive index. The results indicated that some of the types arrived at by means of visual inspection can be subdivided on the basis of glass composition, indicating diverse sources of manufacturers or raw materials. The chemical composition of selected beads were then more fully analysed.

Zulu bead dealers were not directly concerned with the composition of the beads on offer. Consistency of colour and quality determined acceptability. The raw materials used to produce beads nevertheless defined their value in more subtle ways. The success of the bead traders ultimately depended on glass chemistry and the skill of the bead craftsmen.

To understand the importance of glass bead composition requires technical knowledge of their manufacture and of the historical development of manufacturing techniques. A brief introduction to the subject is provided in this chapter, followed by a description of the analytical procedures applied to the Mgungundlovu and Ondini bead assemblages.

BEAD MANUFACTURE

The glass used for successful bead manufacture demands precise compositional properties. Rod glass, for example, must be accurately formulated in order to withstand further transformation and re-working. The viscosity parameters, chemical composition and thermal expansion rates are vital properties in glass production. Only within a specific viscosity range can glass be processed. Outside of this range it would be either too viscous or too fluid. The viscosity/temperature relationship of glass for bead manufacture must allow for successive hot and cold finishing operations within a wide range of temperatures. These operations include cutting or snapping the rod, followed by cold finishing such as grinding and polishing; heat processing the glass to a soft stage for *"tumbling"* or shaping into various objects which are then slowly cooled (annealed).

The white "crackled" bead is a good example of glass which does not meet optimum glass manufacturing requirements. The "crackling" or "crazing" effect is probably due to different chemical compositions. The core might have been made from slightly different chemical ingredients from the outer layer. On cooling, the latter layer would have contracted and "crazed". It is interesting to note that this may not occur with small beads where the outer layer is very thin. Thick layers of material are sensitive to "crazing". This particular bead variety has been reported from several sites in southern Africa, including those excavated from Malawi (Killick pers.comm) and Great Zimbabwe (Caton-Thompson 1931:231).

THERMAL EXPANSION

Thermal expansion describes the dimensional (volume) change with temperature. Thermal expansion and temperature are crucial parameters for bead manufacture particularly when different types of coloured glass or of rod glass, e.g. transparent and opaque are fused or mixed together. It is therefore essential that the glass properties are kept constant to allow for re-use, hot- processing or combining different layers of material. The mean values for different glasses of standard production have been measured at the Murano Glass Experimental Station (Societa Veneziana Conterie n.d:10). This is important data for glass manufacture, especially glass beadmaking.

> <u>Thermal expansion coefficient;</u> measured between 0 ^{0}C and 300 ^{0}C with an average of 1.04 x 10^{-7} $^0C^{-1}$. The average viscosity at the beginning of the glass making process is 10^4 Poise at 930 ^{0}C and 10^8 Poise at 650^{0}C at the end of the process. The mean annealing temperature should be 520^{0}C.

SOME RAW MATERIALS USED IN EARLY GLASS MANUFACTURE

Early glass production in Europe was regarded as a "specialist industry" or "high status activity" in the socio-economic hierarchy. Highly sophisticated and intricate techniques were involved and very often glass manufacture depended on long distance trading for the supply of raw materials

Until the end of the 17th century, the three principal constituents of glass were silica (SiO_2), alkali (either Na_2O or K_2O), and a stabilizer (either CaO or PbO). These compounds, in various combinations (with each other), were the main types of silicate glasses which remained in production until the 20th century. In the 20th century many other glass compositions have been developed, each with different characteristics (Jones & Sullivan 1985:10).

Red, bottle green, blue and yellow were the glass produced before the 11th century. In the 12th century a true green and a dirty purple-coloured glass were produced (Shaw 1968:9).

Glass colour depends not only on the colouring agents, but also on the purity of the materials, the way they are prepared, and the atmospheric conditions of the furnace during firing. Metallic oxides most commonly used to produce the colour of glass are iron, manganese, cobalt, copper, tin, uranium, nickel, chromium and gold.

SILICA (SiO_2)

Silica (sand or quartz) is the fundamental constituent of all commercial glass. It is widely distributed in nature, both in its free state and in the form of its compounds. The type of glass to be manufactured depends largely on the purity of the sand. In the case of optical glass and high quality crystal ware, the purity of the silica is the first consideration (Hodkin & Cousen 1925:65).

The amount of silica in the mix determines the minimum melting temperature of the glass. Because silica has a high melting temperature, it is necessary for economic reasons (e.g. fuel consumption and time), to lower the overall melting point. Alkalies such as soda, potassium and scrap glass (cullet) are used for this purpose. Grinding, and thoroughly mixing the raw materials will also help to reduce the melting temperature of silica (Henderson 1985:270).

SODIUM OXIDE (Na_2O)

Alkalies dissolve (or flux) sand or quartz grains, lowering the melting point of pure quartz from 1710 ^{0}C to a minimum liquidus temperature (Henderson 1985:271). Spanish "barilla", a soda ash (Na_2CO_3) derived from plants and found in salt marshes, was used to reduce the melting point of quartz. It was exported from Spain to glasshouses throughout Europe. Venice imported cargoes of "barilla" from Alicante for the Murano glasshouses in the 16th and 17th centuries, while glass blowers working in the manner of the Venetians in Flanders, England and France recognized its superiority over all other kinds (Smith & Good 1982:14).

POTASSIUM OXIDE (K_2O)

Like sodium compounds, potassium oxide also acts as a flux. If sodium oxide is replaced by potassium oxide, the resultant glass has a greater brilliance and a better colour, is generally harder and possesses a higher melting point than the soda glass (Hodkin & Cousen 1925:94). Potassium compounds are found in the ashes of wood and land plants and are used to produce many coloured glasses.

CALCIUM OXIDE (CaO)

Calcium oxide is most commonly used to give stability and resistance to the glass. Practically all analyses of pre-historic glass reveal the presence of calcium. Low-lead soda-lime-silica compositions contain up to 8% CaO, and lead glasses usually 2.5% (Henderson 1985:277). Calcium derivatives occur widely in nature as calcium oxide or lime. For example, calcium carbonate ($CaCO_3$) is found in many forms including sea-shells, limestone and chalk. German glasshouses in the seventeenth century were manufacturing opaque-white glass by the addition of calcined bone or horn. Two recipes include burned bones or stag's horns (Singer 1957:224). It was noted that the degree of opacity was affected by the amount of heating to which the glass had been subjected, and also by the proportion of ash in the batch.

LEAD OXIDE (PbO)

In Europe, lead was used in both transparent and opaque glass since before the Middle Ages. One of the earliest references to the use of lead in glass in the medieval period comes from a glass making workshop in Galitch, western Russia, dated to the 11th to 13th century A.D. (Henderson 1985:277).

Lead is generally added in the form of red lead (*Minimum* - Pb_3O_4) and litharge (white lead). Lead increases the density and refractive index of glass. Glass with a

Glass with a high lead content is particularly suitable for optical glass and tableware. Many colouring agents give better effects in lead glass than in lime glass (Hodkin & Cousin 1925:103). Lead carbonate used as an ingredient for manufacturing Italian glass beads was documented as early as 1805 (Bohn 1805:691).

COPPER (CuO)

The use of copper as a colourant to produce an opaque red colour in glass dates from the 15th century B.C. with examples from Nuzi in north-eastern Iraq (Henderson 1985:281). The preparation of this glass requires reducing conditions (i.e. rich in carbon monoxide). The factors which influence the final appearance of copper-containing glasses include the state of dispersion of the oxide, atmospheric conditions during firing, and the alumina and silica contents (Shaw 1986:61). In an experiment using a 19.06% PbO glass, the temperature and heat treatment together determine whether an opaque red, yellow or orange glass is produced (Henderson 1985:282). Copper carbonate (up to 5%) added to a raw, leadless glass produces a distinctive turquoise colour.

MANGANESE OXIDE (MgO_2)

According to Henderson (1985:283), when manganese oxide is found in glasses at the level of one percent or above, it was added deliberately as a manganese-rich compound. The colours produced by the addition of manganese are variable, depending on furnace conditions and the composition of the glass (i.e lime or lead glass). Small amounts of manganese in potash glass are used for decolouring glass by producing complementary colours.

GOLD (Au)

Gold chloride has been used as a glass pigment to manufacture transparent red glass or ruby glass in Germany since the end of the 17th century. Andrea Cassius (1640-1673) discovered that by adding tin chloride to a solution of gold chloride, a purple powder ("purple of Cassius") was precipitated. When glass was fused with this powder it produced a ruby glass. Bohn (1805:692), reported the use of minute quantities of gold in glass bead making and Singer (1957:225) recorded the following 18th century prescription for ruby glass :

> A gold ducat beaten out thin and cut into pieces and placed in a distilling apparatus with ½ an oz. of nitric acid, & 1½ oz of spirit of salt and 1 dram of sal ammoniac. This mixture should be subjected to heat until the gold is dissolved. The solution is then incorporated into a crystal-glass batch and reheated until the ruby colour achieved its full strength.

A patent was filed in 1755 specifying the use of an impure form of manganese dioxide and an alloy of copper and zinc. Added together, these elements resulted in a purplish colour rather than a ruby red glass.(Singer 1958:375).

The ruby glass beads, found at Mgungundlovu and Ondini, particularly the *Cornaline d'Aleppo* on a white core, are thought to contain minute quantities of gold. These beads in different varieties have been produced and widely distributed for centuries. The ruby on a white core bead has been recorded at sites throughout the world. Orchard (1929:87) reported them from the Pacific Northwest; Deagan (1987:116), recorded *Cornaline d'Aleppo* beads amongst the artefacts excavated in the Spanish colonies of Florida and the Caribbean ca 1580; Sher Dubin (1987:344) noted that in modern Guatemala, *Cornaline d'Aleppos* are still very popular because of their likeness to coral (coral was a highly valued material which was introduced by the Spaniards). Randall-MacIvor (1906:82) reported the *"Indian"* red or Redwood on green variety among the spoils of a wreck on the Irish coast in about 1820.

The name *Cornaline d'Aleppo* is derived from carnelian and Aleppo (Syria). Transparent ruby on white *Cornaline d'Aleppo* and "Indian red on green core beads were manufactured to imitate semi-precious agates, rubies and coral.

In Africa, *Cornaline d'Aleppo* beads have been found at many Iron Age sites including Dhlo-Dhlo (Randall-MacIvor 1906:82), Great Zimbabwe (Caton-Thompson 1931:233), Mapungubwe (Fouche 1937:105), Lorenco Marques (Juta 1956:10) and Phalaborwa (N.J.van der Merwe pers.comm.). Beck (1931:238), also documented ruby on white core beads from Egypt and the Sudan. In Van Riet Lowe's analysis of beads (1955:20) he identified

Cornaline d'Aleppo with "Umgazi" (meaning blood) beads that were manufactured for the first three decades of the 20th century by a Venetian firm using gold as a colourant for the transparent ruby red glass. Despite the fact that the glass was expensive to produce, it was a very popular bead. During the Great Depression years of the 1930's, however, Mussolini restricted the use of gold and the *"Umgazi"* was produced in a slightly lighter shade. Shortly after Mussolini invaded Abyssinia in 1936 he forbade the use of gold completely, preserving it exclusively for the national war effort. Mussolini maintained that the "Natives" would not know the difference, and instructed the manufacturers to find a substitute. The difference was noticed, however, and the substituted imitations were not acceptable. Once the secret was released that gold was used to obtain the rich colour Venice lost the monopoly of the market.

The success or failure of European expeditions of discovery depended heavily on the correct selection of glass trade beads. David Livingstone (1867:180), for example, commented in his diaries that particular types of beads were popular and highly valued in Africa over long periods of time. He described a red bead with a white centre of various sizes as "always being popular in every part of Africa".

METHOD

Various techniques are available to determine the compositional analysis of glass. These include refractive index, density measurements, X-ray fluorescence, proton-induced electron emission, inductively coupled plasma-atomic emission spectroscopy and neutron activation analysis. Each of these methods has advantages and disadvantages depending on what information is required. Davison (1972) selected neutron activation analysis and X-ray fluorescent spectrometry to determine the quantitative elemental composition of some 400 glass trade beads from various sites in eastern and southern Africa.

Saitowitz and Heckroodt (1985; 1988) used other physical and chemical analyses of glass to determine the properties of historic glass artefacts. Microprobe analysis was quantitative elemental composition of some 400 glass trade beads from various sites in eastern and southern Africa.

Saitowitz and Heckroodt (1985; 1988) used other physical and chemical analyses of glass to determine the properties of historic glass artefacts. Microprobe analysis was used to determine the chemical composition of the beads in this thesis. Chemical analysis of glass artefacts from archaeological sites is not new. The combination of techniques used in this study, however, are applied here for the first time in glass bead research.

REFRACTIVE INDEX (RI) AND DENSITY.

The refractive (RI) index of glass is a sensitive property which can be accurately measured. The advantage of using the RI method is that it is essentially non-destructive; only a surface area of a few millimetres is required for analysis. The refractometer operates on the principle of the angle of total internal reflection. A Dialdex refractometer and a monochromatic light source (sodium lamp) were used in this study.

A polished, scratch-free, flat surface was used to obtain the RI measurements. The "Spot method" is another technique which can be used on curved surfaces, instead of flat ones.

Sample preparation of the specimens depends largely on the size or amount of material available and also the technique which has been selected for compositional analysis. In this instance the majority of the beads were embedded in round epoxy resin discs for polishing, the size of which suited the design of the specimen stage of the microprobe. The diameters of the discs measured 20.5 mm. and they were 10mm. thick. An average of 5 to 7 small beads were mounted in one disc. Some of the larger beads were polished without mounting them in resin.

The density (mass per unit volume) of the beads was determined using a Xylene displacement method. Density measurements must not be confused with *specific gravity*. Specific gravity equals the ratio of the mass of a given volume of substance, to the mass of equal volume of water at 4^0 C and is numerically almost identical to the value of density of the substance. Specific gravity measurements of multicoloured beads were taken by Horace Beck (Caton-Thompson 1931:229-240) when he analysed beads excavated from the Zimbabwe ruins, Dhlo-Dhlo etc. The colours of the beads he looked at corresponded with the ones that were examined in this study. Beck's finding have been included for comparative purposes (See Chapter 6).

Both these physical properties (RI and density) are primarily dependent on the chemical composition of the glass and changes in the composition will affect these properties similarly, i.e. an increase in density will correspond to an increase in the RI. The density of glass depends, to a large degree, on the metal oxide composition, therefore density values are useful diagnostic measurements. Among silica based glasses, those containing higher proportions of heavy ions such as lead or barium show higher refractive indices (Holloway 1973:17).

The relative speed and ease with which the refractive index and density values can be determined makes it possible to measure a large number of specimens. Neither methods requires specialist services and they are inexpensive to use. Laboratory equipment such as polishing wheels, a balance measuring to three decimal places and an ultrasonic cleaner are necessary to set up routine analysis procedures.

CHEMICAL COMPOSITION

The principle of microprobe analysis is electron bombardment used to generate X-rays in the sample to be analysed. From the wavelength and intensity of the lines in the X-ray spectrum the elements present may be identified and their concentrations compared with those from standard samples of known composition. Standards used in this study were obtained from the Corning Museum of Glass (Brill 1971:110). The use of a finely focused electron beam gives the technique its advantage of enabling chemical analyses to be obtained on very small selected areas (Reed 1975:1). Areas of less than 30μm can be analysed. This is also an effective analytical tool for analysing two layered material, i.e. *compound* beads.

The aim of this preliminary investigation is to establish a routine analytical procedure for analyzing glass beads using the Cameca electron microprobe with 4 W.D.S. spectrometers (Department of Geochemistry, University of Cape Town). Elements with atomic numbers > 9 occurring in concentrations of ≈ 500 ppm (.05 wt.%) are routinely analyzed using the electron microprobe.

The common major elements determined in this work were sodium, potassium, silica, aluminium, iron, magnesium, calcium, lead, copper, tin, manganese, phosphorus and antimony. They were chosen because they were major constituents of soda-lime-silica, high-lead, high-barium and potash-lime-silica glass. Uranium and gold are were also selected as trace elements. Table 1., lists the range of concentrations of oxides in glass beads found in the literature (Davison 1972). Also listed are the compositional ranges of 4 glass standards produced by Corning Laboratories.

The following instrumental conditions were used:

Beam current:	10nA	
Accelerating voltage:	15kV	
Beam size:	20 microns	
Analyzing crystals:	TLAP	Na, Mg, Si, Al
	LIF200	Fe, Mn, Ni, Zn, Cu, Co, Pb
	PET	Ca, K, Ti Cr, S

WEIGHT % OXIDE

ANALYTE	RANGES IN STANDARD (Corning Museum)	RANGES IN LITERATURE (Davison 1972)	RANGES IN THIS STUDY	NOTES
Na_2O	1.00 - 17.0	8.70 - 17.0	0.74 - 17.9	
K_2O	1.10 - 11.6	0.34 - 0.87	0.32 - 17.6	Major
SiO_2	35.0 - 66.0	65.0 - 72.0	34.7 - 68.1	elements in
Al_2O_3	1.00 - 5.00	1.5 - 6.00	0.12 - 2.78	beads and/or
**Fe_2O_3	0.30 - 1.10	0.60 - 4.2	nd - 3.61	standards
MgO	1.10 - 4.10	0.17 - 3.6	nd - 2.05	
CaO	5.00 - 15.0	6.00 - 12.5	0.74 - 11.3	
P_2O_5	0.10 - 3.50	-	nd - 0.52	
**PbO	0.05 - 37.0	nd - 1.70	nd - 59.8	
CuO	0.40 - 2.70	nd - 0.80	nd - 2.86	
BaO	0.10 - 12.1	nd -.0.10	nd	
TiO_2	0.10 - 0.80	nd - 0.24	nd - 0.29	
**MnO	0.25 - 1.00	0.02 - 2.00	nd - 2.52	Significant
**Sb_2O_5	0.45 - 1.80	nd - 1.16	nd - 7.63	minor
**SnO	0.03 - 0.20	nd - 1.20	nd - 0.14	elements in
Cl	0.11 - 0.35	0.50 - 2.50	nd - 1.30	beads and/or
F			nd - 1.11	standards
SO_3	0.15 -.0.55		nd - 0.35	
Sr	0.02 - 0.25	nd - 0.03	-	Trace elements in
Sr	0.02 - 0.25	nd - 0.03	-	beads and/or
**CO	0.02 - 0.16	nd - 0.17	-	standards (as found
**Zn	0.04 - 0.20	nd - 0.07	-	in the literature)
V	.006 - 0.03	nd	-	were not determined
Ni	0.03 - 0.10	nd	-	in this preliminary
Zr	.005 - .025	nd - 0.05	-	study. May be
Cr	<.005 -	nd	-	analyzed on a
As	nd	<.03	-	routine basis if they
Ag	.003 - 0.01	-	-	are found in higher
Rb	.001 - 0.01	-	-	concentrations.
**Th	-	<0.01	-	
Sm	-	<.0009	-	
**Sc	-	<.0011	-	Au was not found
Ta	-	<.0002	-	in sufficient
Yb	-	<.0004	-	quantities in this
Au			nd	study. If present it
Bi	.001 - .005	-	-	would have to be
				determined at 30 kV.
**U	-	<.03	-	No standards
Hf	-	<.004	-	and/or not
B	0.02 - 0.20	-	-	possible to
Li	.005 - .03	-	-	determine on
				EMP

Table 1. Ranges of analytes in the literature and microprobe data in this study.

LOWER LIMIT OF DETECTION (LLD)

EFFECTIVE DETECTION LIMIT *

*Calculated for 20 second counting times on peak and background.

SiO_2	.10 wt%
TiO_2	.11 wt%
Al_2O_3	.10 wt%
FeO_3	.25 wt%
MgO	.10 wt%
CaO	.10 wt%
PbO	.40 wt%
CuO	.40 wt%
MnO	.20 wt%
Na_2O	.15 wt%
K_2O	.10 wt%
P_2O_5	.15 wt%
Sb_2O_5	.50 wt%
Cl	.10 wt%

N.b In some cases the reported values are lower than the listed LLD because they were counted for more than 20 seconds which increased precision.

2σ ERROR (95% CONFIDENCE LIMITS)

Relative 2Í error varies with concentration. In general:

wt% OXIDE	2σ ERROR
10 - 100%	< 1% 2%
1 - 10%	< 10%
< 1%	<50%

N.B. Reported values for volatile elements (especially Na & K) are generally lower than true concentration. As a result, the values for non- volatile elements may be slightly higher than the true concentration.

Table 2. Glass bead analyses counting statistics.

SUMMARY

Classifying 19th century South African glass bead collections is fraught with difficulties. The problems are due primarily to poorly provenienced museum collections, inadequate information on the dating and origins of the beads and also the limited representation of beads compared to the range available on world-wide markets at that time. In North America, monochrome, drawn, type 11a beads are generally ignored except for colour frequency studies because many of them have long temporal ranges and are of limited diagnostic value (K.Karklins, pers. comm.).

It is almost impossible to distinguish visually the differences between many of the popular bead types that were imitated by various manufacturers. To this end, a system of compositional analysis was developed to screen large numbers of beads and to determine the elemental composition of a selected sample. This made it possible to extract more information from the Mgungundlovu and Ondini bead assemblages and also to establish benchmarks for multicoloured 19th century European glass beads, thought to be Venetian. It also provided the opportunity to investigate the history of glass and bead making, and to examine some of the raw materials used in the composition. Of particular interest here was the use of gold, which has been documented in historical glassmaking for many years. One part by weight to 10 000 parts of glass, even one part per 50 000 is said to have produced a fine ruby glass (Hodkin & Cousin 1925:127). This sort of information cannot be verified without compositional analysis. Verification of the use of gold to produce ruby glass was applied particularly to the transparent ruby on white core beads i.e *Cornaline d'Aleppo*. Beads from other collections were also used for analysis as well. The results are presented in Chapter 6.

Refractive index and density measurements proved to be useful and efficient diagnostic tools for characterizing compositional differences between large numbers of beads. Although laboratory conditions are required, these methods are relatively inexpensive and non-destructive and do not require specialist competency.

CHAPTER 6

RESULTS

In this chapter the results of three methods of analysis are reported. Together, these sets of results provide thorough and complete data relevant to the glass beads excavated from Mgungundlovu and Ondini.

Beads from other collections were used for comparative purposes. These include Bambandyanalo and Mapungubwe (University of Pretoria), Phalaborwa (University of Cape Town) and Transkei (Joan Broster).

The results are presented in three sections:

I. Visual classification;
II. Statistical analysis; and
III. Compositional analysis

I. VISUAL CLASSIFICATION

INTRODUCTION

A total of 12 436 glass beads from Mgungundlovu and 9042 from Ondini were classified according to visual classification procedures described in Chapter 4. Four classes of drawn beads were noted according to whether or not their ends have been rounded and whether their construction is simple or compound. The predominant type of bead found in both collections comprises monochrome, drawn beads of type 11a.

The results of the visual classification presented here have been confirmed by Karlis Karklins. A descriptive list of the various classes and types of beads from these two collections follows. Numbered samples comply with the Kidd & Kidd (1970) typology. Karklin's classification have been indicated with an asterisk.

Type and bead reference number	Dia-phan-eity	Colour	Munsell No.	MGUNGUNDLUVO Excavator: Wall; Excavation: Tsigodlo midden	Parkington: Tsigodlo midden	Parkington: Tsigodlo huts	Parkington: Bheje	Roodt: Bheje	Rawlinson: Entrance	All: Total	ONDINI Rawlinson: Total	Rawlinson: Tsigodlo midden	Rawlinson: Non-isigodlo middens
IIa14	Op	White	N9.5/90.0/R	573	64	265	25	1077	578	2582	358	334	24
IIa12	Tsl	Oyster white	5 GY 9/1	1295	35	23	0	28	65	1446	1	1	0
IIa *	Tsp	Light grey	N 8.25/63.65R	49	0	0	0	1	12	62	17	17	0
IIa7	Op	Black	N 0.5/0.6R	216	5	15	0	2	51	289	1367	1356	11
IIa41	Op	Robin's egg blue	5 B 7/6	100	0	0	0	0	7	107	7	7	0
IIa	Tsp	Light turquoise	10 BG 8/4	3	0	0	0	0	6	9	3	3	0
IIa *	Op	Green	2.5 G 4/8	1207	64	33	1	32	50	1387	1273	1237	36
IIa *	Tsp	Dark green	2.5 G 3/6	295	14	10	1	3	18	341	78	78	0
IIa *	Tsl	Bright green	2.5 G 5/10	6	0	0	0	0	49	55	409	402	7
IIa	Tsl/Op	Dark jade green	10 G 4/6	28	0	0	0	0	59	87	44	43	1
IIa *	Op	Orchid mist	10 RP 8/4	1	2	0	2	228	0	233	370	369	1
IIa *	Op	Light orchid mist	5 RP 7/10	2	0	1	0	0	20	23	173	164	9
IIa	Op	Mauve pink	5 RP 6/8	0	1	0	2	77	.90	170	2181	2135	46
IIa *	Op	Cherry rose	5 R 6/6	0	2	0	0	12	11	25	832	827	5
IIa *	Op	Light cherry rose	10 R 8/4	1	0	0	0	1	0	2	31	31	0
IIa19	Op	Amber	7.5 YR 6/10	656	25	25	0	6	2	714	23	23	0
IIa	Tsl	Dull yellow	5 Y 8/6	348	21	13	2	16	26	426	188	177	11
IIa *	Tsp	Ruby	2.5 R 3/10	30	0	0	0	0	40	70	470	461	9
IIa	Op	Indian red	7.5 R 3/8	3	0	1	0	0	2	6	63	62	1
IIa56	Tsp	Bright navy	7.5 PB 2/8	265	13	134	1	12	157	582	213	210	3
IIa *	Op	Medium blue	5 PB 4/6	154	8	0	0	3	11	176	1	1	0
IIa *	Op	Pale blue	10 B 7/4 - 7/8	38	0	2	0	24	9	73	0	0	0
IIa *	Op	Cerulean	2.5 PB 4/10	0	0	1	0	0	96	97	1	1	0
IIa *	Tsp	Bright blue	7.5 B 4/8	142	10	8	2	78	30	270	23	23	0
IIa *	Op	Copen blue	7.5 B 4/12	27	0	0	0	0	15	42	0	0	0
IIa	Op	Shadow blue	2.5 PB 5/4	638	36	17	0	0	10	701	1	1	0
IIa *	Op	Medium Copen blue	5 PB 6/8	49	0	1	0	0	47	97	0	0	0
IIa59	Tsp	Rose wine	10 P 2/6	11	2	1	0	0	1	15	5	5	0
IIb	Op	4 navy blue stripes/white		38	3	9	0	17	68	135	2	2	0
IIb	Op	4 scarlet stripes/white		109	13	17	2	327	3	471	0	0	0
IIb	Op	4 turquoise stripes/white		6	1	0	0	30	0	37	0	0	0
IIb	Op	2 scarlet & 2 navy blue stripes/white		82	12	4	0	57	0	155	4	4	0
IIb	Op	2 scarlet & 2 turqoise stripes/white		18	0	0	0	5	0	23	0	0	0
IIb	Op	24 white stripes/navy blue		35	1	0	0	0	0	36	0	0	0
IIb	Op	2 orange & 2 turquoise stripes/white		0	0	0	0	0	0	0	20	16	4
If	Tsp	Multicoloured		43	1	0	0	0	3	47	2	2	0
IVa	Op	Indian red/green core		1002	38	13	0	2	24	1079	21	21	0
IVa	Tsp	Ruby/white core		101	9	7	1	27	37	182	753	731	22
WIb	Op/Tsp	Multicoloured		70	1	0	0	0	0	71	29	26	3
WIIIa	Tsp	Ruby on white core/yellow core		26	0	0	0	0	3	29	76	75	1
WIIIb	Op/Tsl	Eye beads/floral design		65	4	1	10	0	1	81	3	3	0
BIa	Tsl	Light grey		3	0	0	0	0	0	3	0	0	0
		TOTALS:		7735	385	601	49	2065	1601	12436	9042	8848	194

Table.3. Bead frequencies from Mgungundlovu and Ondini.

DRAWN BEADS

The majority of the drawn beads, type 11a described below are circular in shape.

Type If

Definition: Drawn, tubular, cornerless-hexagonal; the surfaces have been modified by grinding; approximately 20 facets on each bead

Structure: Simple

Size: Medium to large

Colour: Multicoloured:

Light grey (Munsell No.N 8.25/63.65R)
Bright green (Munsell No. 2.5G 5/10)
Bright navy (Munsell No. 7.5PB 2/8)
Medium blue (Munsell No. 5PB 4/6)
Rose wine (Munsell No. 10P 2/6)

Diaphaneity: Translucent

Frequency of occurrence:

Mgungundlovu n = 47
Ondini n = 2

Comments: The light grey beads have a milky white core and some of the bright navy beads have a medium blue core. K.Karklins (pers.comm) has determined the core dates for this type based on data from 19 short-occupation sites between 1781-1871.

Type 11a14 (Kidd & Kidd, 1970)

Definition: Drawn, monochrome, opaque.

Structure: Simple.

Size: Very small, small, medium & large

Colour: White (Munsell No. N9.5/90.0/R)

Diaphaneity: Opaque.

Frequency of occurrence:

Mgungundluvo n = 2582
Ondini n = 358

Comments: White is the predominant colour found at Mgungundlovu. They are present in the archaeological collections at York Factory, Manitoba, Canada and were probably made in Venice.

Type 11a12 (Kidd & Kidd, 1970)

Definition: Drawn, undecorated.

Structure: Simple.

Size: Very small, small, medium.

Colour: Oyster white (Munsell No. 5 GY9/1).

Diaphaneity: Opaque.

Frequency of occurrence:

Mgungundlovu n = 1446
Ondini n = 1

Comments: To the naked eye these beads appear to have lighter coloured cores. They have lower RI's and lighter density values than beads classified white (Table 22, Fig 40). They are present in York Factory collection and were probably made in Venice.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Small & medium.
Colour: Light Grey (Munsell No.N 8.25/63.65R).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 62
Ondini n = 1
Comments: Present at York Factory, Northern Manitoba, Canada and were probably made in Venice. No RI measurements were recorded. The mean density is 2.555.

Type 11a7 (Kidd & Kidd, 1970)
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Black (Munsell No. N 0.5/0.6R).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 289
Ondini n = 1367
Comments: Many more black beads were present in the Ondini collection than Mgungundlovu. Some of the beads were shiny (Tables 4 & 5, Fig.35). They are present in the York Factory collection and they were probably made in Venice.

Type 11a41 (Kidd & Kidd, 1970)
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Robin's egg blue (Munsell No.5 B7/6).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 28
Ondini n = 13677
Comments: They are present at York Factory, Canada and were probably made in Venice. No compositional analysis

Type 11a
Definition: Drawn, undecorated
Structure: Simple.
Size: Very small, small & medium.
Colour: Light turquoise (Munsell No. 10 BG8/4).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundluvo n = 107
Ondini n = 7
Comments: These beads are present in the York Factory collection. They appear on a dated Venetian sample bead card (1913), numbered 101. They were probably made in Venice. No compositional analysis

Type 11a
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Green (Munsell No.2.5G 4/8).
Diaphaneity: Opaque
Frequency of occurrence:
Mgungundlovu n = 1387
Ondini n = 1273
Comments: These were found at York Factory, Canada. The appear on a dated Venetian sample card (1913), numbered 120. They were probably made in Venice. Compositional analysis (Figure 38, Appendix vii).

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Dark green (Munsell No. 2.5G 3/6).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 341
Ondini n = 78
Comments: For compositional analysis see Table 27, Fig.38. Green beads contain high proportions of lead.

Type 11a
Definition: Drawn, undecorated
Structure: Simple
Size: Very small, small & medium.
Colour: Bright green (Munsell No.2.5G 5/10).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 55
Ondini n = 409
Comments: Note the difference in numbers between beads found at Mgungundlovu and Ondini.

Type 11a
Definition: Drawn, undecorated.
Structure: Simple
Size: Very small & small.
Colour: Dark jade green (Munsell No.10G 4/6).
Diaphaneity: Opaque & translucent.
Frequency of occurrence:
Mgungundlovu n = 87
Ondini n = 44
Comments: These beads were not present at York factory, Canada. They appear on a dated Venetian sample bead card (1913), numbered 121.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small & small.
Colour: Orchid mist (Munsell No.10RP 8/4).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 233
Ondini n = 370
Comments: These beads are present in the York Factory collection. They were probably made in Venice.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small & small.
Colour: Light orchid mist (Munsell No.5Rp 7/10).
Diaphaneity: Opaque.
Frequency of occurrence: Mgungundlovu n = 23
Ondini n = 173
Comments: These beads were found at the York Factory, Canada. They were probably made from the same glass batch to manufacture Orchid mist beads.

Type 11a
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small & small
Colour: Mauve pink (Munsell No.5Rp 6/8).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 170
Ondini n = 2181
Comments: Noteworthy difference in numbers between Mgungundlovu and Ondini. They appear on a dated Venetian sample bead card (1913), numbered 107. The were found at York Factory, Canada. They were probably made in Venice. No elemental analysis.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small & small.
Colour: Cherry rose (Munsell No. 5R 6/6).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 25
Ondini n = 832
Comments: No elemental analysis. Note the difference in numbers between Mgungundlovu and Ondini. They were not present in the York Factory collection. They are similar in colour to beads numbered 106 on a dated Venetian sample bead card (1913).

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small & small.
Colour: Light cherry rose (Munsell No. 10R 8/4).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 2
Ondini n = 31
Comments: The colour of these beads is very similar to Cherry rose. They were probably made from the same batch of glass.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Amber (Munsell No. 7.5Yr 6/10).
Diaphaneity: Opaque & translucent.
Frequency of occurrence:
Mgungundlovu n = 714
Ondini n = 23
Comments: A noticeable difference in numbers between the Mgungundlovu assemblage and Ondini. The colour is similar to beads numbered 105 on a Venetian sample bead card dated 1913. Elemental analysis shows high proportions of lead (Table 28). These beads were also found at York Factory, Canada. They were probably made in Venice.

Type 11a
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Dull yellow (Munsell No.5Y 8/6).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 426
Ondini n = 26
Comments: These beads contain high proportions of lead (Table 28, Fig.38). They were not present at York Factory, Canada.

Type 11a

Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small, medium & large (Tables 4 & 5).
Colour: Ruby (Munsell No.2.5R 3/10).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 70
Ondini n = 470
Comments: It is interesting to compare the elemental analysis of ruby glass in Tables 10 & 15.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium (Tables 4 & 5).
Colour: "Indian" red or Redwood.
Diaphaneity: Opaque
Frequency of occurrence:
Mgungundlovu n = 6
Ondini n = 63
Comments: Elemental analysis Tables 19 & 20. These beads have not appeared on any sample beads cards to date. They have been found in many Iron Age sites in southern Africa. They were not found at York Factory, Canada.

Type 11a56 (Kidd & Kidd, 1970).
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium (Tables 4 & 5).
Colour: Bright navy (Munsell No.7.5Pb 2/8).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 582
Ondini n = 213
Comments: Elemental analysis (Fig.38). These beads are present in the York Factory collection. They are similar in colour to bead numbered 119 on a Venetian sample bead card dated 1913. They were probably made in Venice.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Medium blue (Munsell No. 5Pb 4/6).
Diaphaneity: Opaque, translucent & transparent (Tables 4 & 5).
Frequency of occurrence:
Mgungundlovu n = 176
Ondini n = 1
Comments: These beads were not found at York Factory, Canada.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small & small
Colour: Cerulean blue.
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 97
Ondini n = 1
Comments: Found at York Factory, Canada.

Type 11a*
Definition: Drawn, undecorated
Structure: Simple
Size: Very small & small.
Colour: Bright blue (Munsell No.7.5B 4/8).
Diaphaneity: Opaque
Frequency of occurrence:
Mgungundlovu n = 270
Ondini n = 23
Comments: These beads were found at York Factory, Canada.

Type 11a*
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Copen blue (Munsell No.7.5B 4/12).
Diaphaneity: Opaque, translucent and transparent (Tables 4 & 5).
Frequency of occurrence:
Mgungundlovu n = 42
Ondini n = 0
Comments: These beads were found at the York Factory, Canada.

Type 11a
Definition: Drawn, undecorated.
Structure: Simple.
Size: Very small, small & medium.
Colour: Shadow blue (Munsell No.2.5Pb 5/4).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 701
Ondini n = 1
Comments: Noticeable difference in numbers between Mgungundlovu and Ondini. These beads were found at York Factory, Canada.

Type 11a
Definition: Drawn, undecorated.
Structure: Simple
Size: Very small, small & medium.
Colour: Medium copen blue (Munsell No.5Pb 6/8).
Diaphaneity: Opaque, translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 97
Ondini n = 0
Comments: These beads were found at the York Factory, Canada.

Type 11a59 (Kidd & Kidd, 1970).
Definition: Drawn, undecorated.
Structure: Simple.
Size: Small & medium.
Colour: Rose wine (Munsell No. 10P 2/6).
Diaphaneity: Translucent & transparent.
Frequency of occurrence:
Mgungundlovu n = 15
Ondini n = 5
Comments: These beads were found at the York Factory, Canada.

Type 11b*
Definition:Drawn.
Structure:Simple.
Size:Small & medium.
Colour:White decorated with 4 bright navy stripes.
Diaphaneity:Opaque
Frequency of occurrence: Mgungundlovu n = 135
Ondini n = 2
Comments:These blue and white striped beads appear on a Venetian sample bead card, numbered 94. They are were also found at the York Factory, Canada. Probably made in Venice.

Type 11b*
Definition: Drawn, decorated.
Structure: Simple.
Size: Very small & small.
Colour: White decorated with 4 straight transparent scarlet stripes.
Diaphaneity: Opaque
Frequency of occurrence:
Mgungundlovu n = 471
Ondini n = 0
Comments: Noticeable absence of these beads in the Ondini assemblage. Found at the York Factory, Canada.

Type 11b* (Fig.21).
Definition: Drawn, decorated.
Structure: Simple.
Size: Very small & small.
Colour: White decorated with 4 transparent bright turquoise stripes.
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 37
Ondini n = 0
Comments: These beads were not in the Ondini assemblage. They are present in the York Factory collection. Illustration (Fig.21) is of a bead excavated from the isigodlo midden, (Mgungundlovu BCD 678, 6F).

Type 11b* (Fig. 12).
Definition: Drawn.
Structure: Simple.
Size: Small
Colour: White with 2 transparent scarlet & 2 transparent bright navy stripes.
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 155
Ondini n = 4
Comments: An example of this particular bead is illustrated in Fig.12 (Mgungundlovu isigodlo midden EF 678, 3F). These beads were found at the York Factory, Canada.

Type 11b*
Definition: Drawn.
Structure: Simple.
Size: Very small & small.
Colour: White with 2 transparent bright turquoise & 2 transparent scarlet stripes.
Diaphaneity:Opaque
Frequency of occurrence:
Mgungundlovu n = 23
Ondini n = 0
Comments:

Type 11b* (Fig. 22).
Definition: Drawn, decorated.
Structure: Simple
Size: Small & medium.
Colour: Bright navy with 24 thin opaque white stripes.
Diaphaneity: Transparent.
Frequency of occurrence:
Mgungundlovu n = 36
Ondini n = 0
Comments: These beads appear on a dated Venetian sample bead card (1913), numbered 92. Examples of the beads were recovered from the *isigodlo* midden at Mgungundlovu.

Type 11b*
Definition: Drawn, decorated.
Structure: Simple.
Size: Small
Colour: White with 2 transparent bright turquoise & 2 translucent russet orange stripes.
Diaphaneity: Opaque
Frequency of occurrence:
Mgungundlovu n = 0
Ondini n = 20
Comments: None of these beads were found in the Mgungundlovu assemblage.

Type 11b (Fig.23).
Definition: Drawn, decorated
Structure: Simple.
Size: Small.
Colour: Bright navy with 4 opaque white & 4 opaque "Indian" red or Redwood stripes.
Diaphaneity: Translucent.
Frequency of occurrence:
Mgungundlovu n = 1
Ondini n = 0
Comments: This bead was recovered from the *isigodlo* midden at Mgungundlovu.

Type 1Va6 (Kidd & Kidd, 1970) (Fig. 17).
Definition: Drawn, undecorated.
Structure: Compound.
Size: Very small, small & medium.
Colour: "Indian" red or Redwood on a green core (Munsell No.7.5R 3/8).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 1079
Ondini n = 21
Comments: There is a noticeable difference in numbers between the two assemblages. The bead were present in the York Factory collection. For elemental analysis refer to Tables 16.17 & 18. Illustrated in Fig.17).

Type 1Va9 (Kidd & Kidd, 1970).
Definition: Drawn, undecorated.
Structure: Compound.
Size: Very small, small & medium.
Colour: Ruby on a white core (Munsell No. 2.5R 3/10).
Diaphaneity: Transparent
Frequency of occurrence:
Mgungundlovu n = 182
Ondini n = 753
Comments: These are referred to in the text as ruby *Cornaline d'Aleppo* on a white core. For elemental analysis refer to Tables 8,9,10, 11,12 & 13 and Fig.39.

WOUND BEADS

Type W1b*
Definition: Wound, undecorated, monochrome.
Structure: Simple.
Size: Medium & large.
Colour: Multicoloured.
Diaphaneity: Opaque & translucent.
Frequency of occurrence:
Mgungundlovu n = 71
Ondini n = 29

Type W111b* (Fig.18).
Definition: Wound, undecorated.
Structure: Compound.
Size: Medium & large
Colour: Ruby on white/yellow core (2.5R 3/10).
Diaphaneity: Transparent.
Frequency of occurrence:
Mgungundlovu n = 29
Ondini n.= 76

Type W111b*(Figs.24 to 32).
Definition: Wound, decorated with inlaid decoration.
Structure: Simple.
Size: Large.
Colour: Multicoloured monochrome beads with surface decoration.
Diaphaneity: Opaque & translucent.
Frequency of occurrence:
Mgungundlovu n = 81
Ondini n = 3
Comments: See Figs.24-32).

BLOWN BEADS

Type Bla*(Figs.14,33 & 34).
Definition: Blown, undecorated.
Structure: Simple
Size: Medium.
Colour: Light grey (Munsell No.N0.5/0.6R).
Diaphaneity: Opaque.
Frequency of occurrence:
Mgungundlovu n = 3
Ondini n = 0

Description: 11b; barrel-shaped; four transparent turquoise green stripes on opaque white.
Size:L: = 2.8mm D: = 3.5mm
Diaphaneity: Opaque.

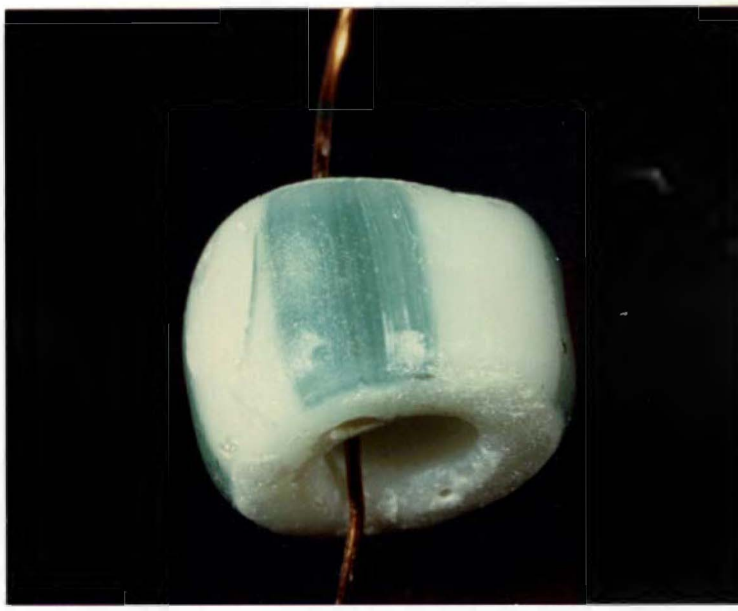


Fig.21. Striped drawn bead from the isigodlo midden BCD 678 6F (Mgungundlovu).

Description: 11b; round; bright navy blue with 24 thin white stripes. Made in Italy.
Size: L: = 3.5mm D: = 4.0mm.
Diaphaneity:Transparent.

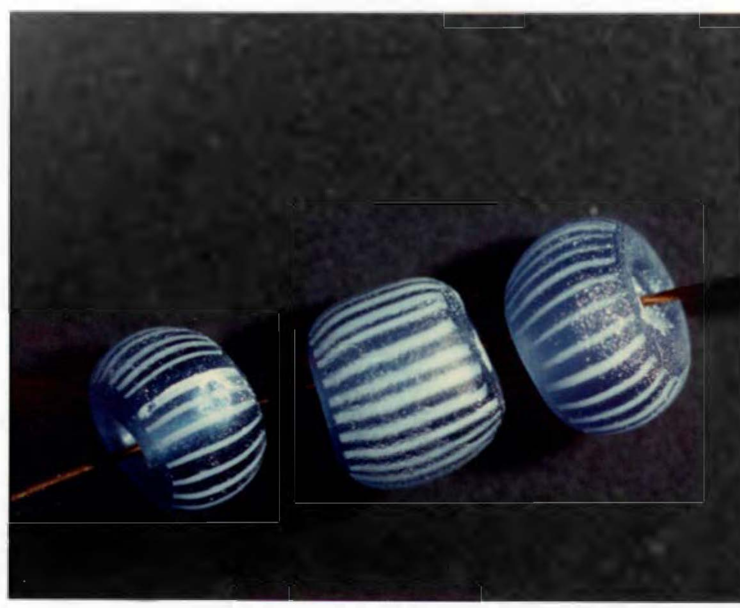


Fig.22. Striped drawn beads isigodlo midden EF 45 9F (Mgungundlovu).

Description: 11b; barrel-shaped; bright navy with 4 opaque white stripes & 4 opaque "Indian" red or Redwood stripes.
Size:L: = 2.8mm D: = 3.5mm.
Diaphaneity: Opaque.

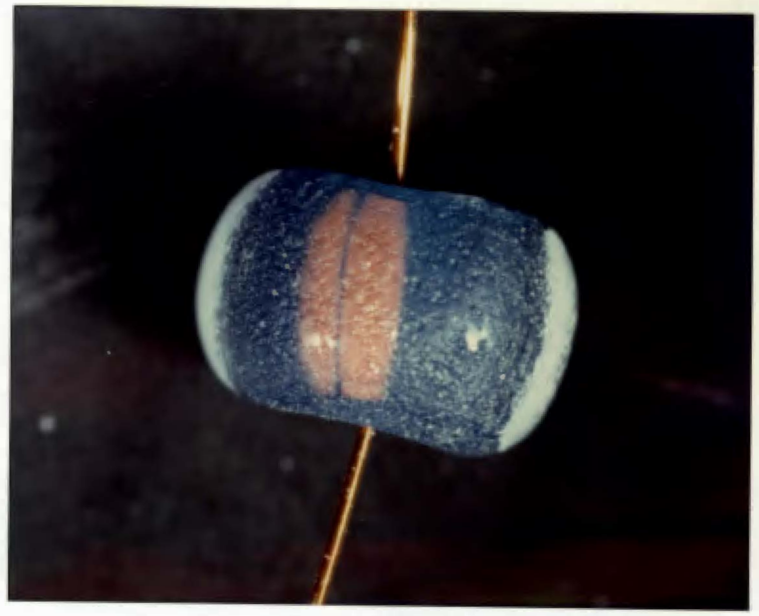


Fig.23. Striped drawn bead from the *isigodlo* midden BCD 678 2F (Mgungundlovu).

Description: W111b; round "Eye" bead with transparent bright navy and ochre inlaid decoration on opaque white.
Size:L: = 110.mm
D: = 110.mm.

Fig.24. "Eye" bead from Hut 190 in the *bheje* area (Mgungundlovu).

Description: W111b; round "Eye" bead. Opaque black with transparent turquoise on opaque white & scarlet on opaque white inlaid decoration.
Made in Italy.
Size:L: =80mm D: =87mm.

Fig.25. "Eye" bead from the *isigodlo* midden GH 678 6C (Mgungundlovu).

Description: W11B; barrel-shaped; translucent red with brown on opaque white inlaid decoration.
Size:L: =5.5mm D: =5.5.

Fig.26. "Eye" bead from Ondini (Hut floor 4, K20 E3).

Description: W111b; round; white with a translucent bright navy floral spray encircling the equator.
Size: L: = 92mm. D: = 95mm
Diaphaneity: Opaque.

Fig.27. "Fancy" wound bead from *isigodlo* midden BCD 678, 7F (Mgungundlovu).

Description: W111b; round; white with 2 transparent scarlet floral sprays and 2 green floral sprays set parallel to the perforation. Made in Venice (Picard 1987:3).
Size: L: = 100mm. D: = 100mm.
Diaphaneity: Opaque.

Fig.28. "Fancy" wound bead from the *isigodlo* midden BCD 678 7F (Mgungundlovu).

Description: As above (Fig.28). W111b; round; white with 2 transparent scarlet floral sprays and 2 blue floral sprays set parallel to the perforation. Made in Venice (Picard 1987:3).
Size: L: = 93mm. D: = 110mm.
Diaphaneity: Opaque.

Fig.29. "Fancy" wound bead from the *isigodlo* midden EF 45 9C Mgungundlovu .

Description: W111b; barrel-shaped; black with "trailed" or "combed" decoration. Made in Italy (K.Karklins, pers.comm).
Size: L: = 101mm D: = 136mm. Diaphaneity: Opaque.

Fig.30. "Fancy" wound bead from the *isigodlo* midden GH 678, 6C (Mgungundlovu).

Description: W111b; globular:; white with a translucent scarlet filament encircling the equator. Size: L: = 110mm D: = 100mm . Diaphaneity: Opaque.

Fig.31. "Fancy" wound bead from the *isigodlo* midden EF 45, 7C. (Mgungundlovu).

Description: W11e; round; "Melon" bead; layered white and turquoise Size:D:65mm L:60mm. Diaphaneity: Opaque.

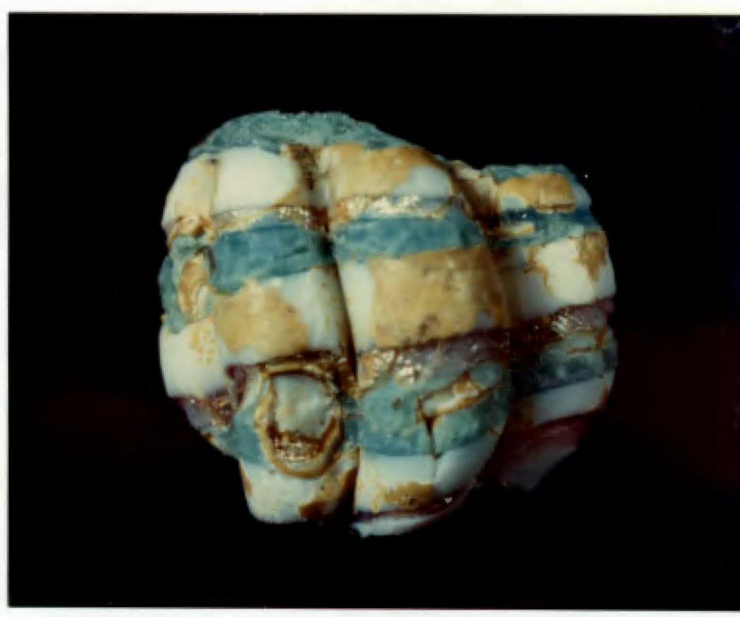


Fig.32. Wound "Melon" bead from Ondini (E3.3).

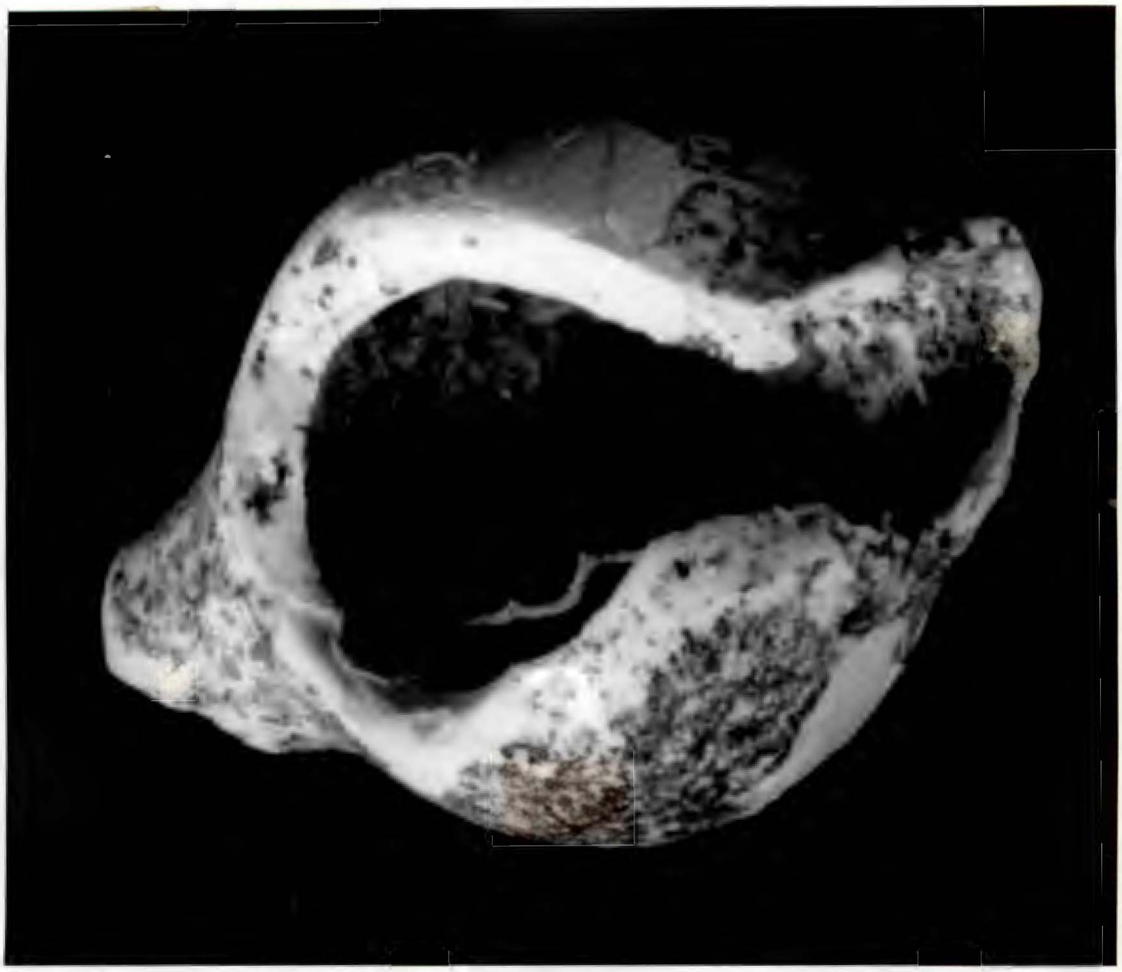


Fig.33. "Blown" bead from the *isigodlo* midden BCD 678 6F (Mgungundlovu).

Description: Bla; blown, round, , light grey.
Size:L: = 4.7mm D: = 4.9mm
Diaphaneity: Opaque.

Fig.34. "Blown" bead from the *isigodlo* midden BCD 678 6F (Mgungundlovu).

Description: Bla; blown, round, , light grey.
Size:L: = 4.2mm D: = 4.0mm
Diaphaneity: Opaque.

DISCUSSION OF VISUAL CLASSIFICATION

The results of this classification provide an efficient and repeatable method for screening large assemblages of glass trade beads. It provides a database for glass beads from two time slices in the 19th century, against which other archaeological, ethnographic and historical collections may be compared.

The glass beads classified from these two sites represent a narrow range of types compared to the range of beads that was available on world-wide markets at the time. The dominant type of beads excavated from Mgungundlovu and Ondini is monochrome, type 11a. Types 11b and 1Va are the next most frequently occurring. Most of the others (including 1f, W1b and W11a) account for less than 1% of the beads in each sample. Blown beads (type Bla) and decorated beads of type W111b e.g. "eye" beads and "floral designs" are generally rare, although a cluster of "eye" beads were recovered from one house floor at Mgungundlovu. Ruby Cornaline d'Aleppo on white/yellow core, cornerless-hexagonal and striped drawn beads were also found in the two assemblages. "Indian" red or Redwood on green core beads were recovered from Mgungundlovu, but very few from Ondini.

Although many of the bead varieties found at Mgungundlovu and Ondini are very similar, there is a marked difference in colour preference between the two sites. The Mgungundlovu sample is characterized by a high proportion of white beads, contrasting with assemblages from Ondini, where pink is the dominant colour. It is not clear whether this dramatic shift from white to pink is due to change in supply or whether it was a local phenomenon based on consumer demand. Although it has been argued that the value of different beads depended on scarcity, it is unlikely that this argument would hold for glass trade beads of the late 19th century, particularly the Ondini collection. By this time the bead market had been saturated and the exchange value of beads depleted. Smith (1970:286) believes that, in some places in southern Africa, glass beads had completely lost their purchasing power by the 1830's.

It is likely that certain beads were reserved exclusively for members of the Royal family. A pink bead, referred to by Smith (1973:98) as *imFaminga* (also spelt *Mfibingo* or *Ifibinga*) was noted for its importance amongst the Swazi royalty and the courtiers of King Mpande. The archaeological record shows that pink beads were present at Mgungundlovu, particularly in the bheje area, thus they were also available in Dingane's time. Historical accounts recorded that Dingane wore beaded garments made from pink as well as white beads, though he probably preferred the latter (Bird 1965:285).

The sizes of most of the beads from Mgungundlovu and Ondini are between 3.5 - 4.0mm (mean 3.75mm) (Tables 4 & 5, Fig. 35). Those found at Ondini were slightly smaller than those from Mgungundlovu. It has been suggested (K.Karklins pers. comm.) that the quality of bead production improved with the advent of the Industrial Revolution. Bead sizes became smaller as fine needles and cottons replaced bone awls and sinew. The size of the beads between Mgungundlovu and Ondini did not change all that noticeably, however. In addition very small beads (less than 2mm) were found at Mgungundlovu.

MGUNGUNDLOVU

BEAD TYPE	COLOUR		SIZE (mm) FREQUENCIES				DIAPHANEITY FREQUENCIES			LUSTRE FREQUENCIES	
		VS	S	M	L	SIZE	O	TL	TP	S	D
11a	WHITE	101	2440	41	0	2.95	2582	0	0	12	2570
11a	OYSTER WHITE	43	1365	38	0	2.99	1446	0	0	257	1446
11a	LIGHT GREY	0	43	20	0	3.63	3	4	55	21	41
11a	BLACK	0	258	31	0	3.21	289	0	0	84	205
11a	ROBIN'S EGG BLUE	3	98	6	0	3.06	90	0	17	13	94
11a	LIGHT TURQUOISE	0	8	1	0	3.22	8	0	1	0	9
11a	GREEN	6	1340	41	0	3.05	1362	20	5	63	1324
11a	DARK GREEN	0	335	6	0	3.04	92	114	135	56	285
11a	BRIGHT GREEN	0	55	0	0	3.00	25	20	0	25	20
11a	DARK JADE GREEN	0	44	0	0	3.00	30	14	0	1	43
11a	ORCHID MIST	0	256	0	0	3.00	233	0	0	0	233
11a	MAUVE PINK	0	170	0	0	3.00	170	0	0	0	170
11a	CHERRY ROSE	25	0	0	0	1.00	25	0	0	0	25
11a	LIGHT CHERRY ROSE	2	0	0	0	1.00	2	0	0	0	2
11a	AMBER	0	630	84	0	3.24	647	67	0	17	627
11a	DULL YELLOW	0	403	23	0	3.11	405	15	6	8	311
11a	RUBY	0	69	1	0	3.03	1	64	5	4	66
11a	INDIAN RED	0	4	2	0	3.67	6	0	0	4	2
11a	BRIGHT NAVY	5	530	47	0	3.14	431	91	70	85	487
11a	MEDIUM BLUE	2	157	17	0	3.17	140	23	13	153	17
11a	CERULEAN BLUE	2	65	6	0	3.11	29	31	13	10	63
11a	BRIGHT BLUE	7	297	0	0	2.95	304	0	0	0	304
11a	COPEN BLUE	1	40	1	0	3.00	32	7	3	7	35
11a	SHADOW BLUE	8	643	51	0	3.12	681	13	7	618	83
11a	MEDIUM COPEN BLUE	2	67	6	0	3.11	20	40	13	10	63
11a	ROSE WINE	0	9	6	0	3.80	0	12	3	6	9
11b	4 NAVY BLUE STRIPES/WHITE	0	133	2	0	3.03	135	0	0	0	135
11b	4 SCARLET STRIPES/WHITE	91	380	0	0	2.61	471	0	0	471	0
11b	4 TURQUOISE STRIPES/WHITE	11	26	0	0	2.41	37	0	0	0	37
11b	2 SCARLET & 2 NAVY BLUE STRIPES/WHITE	0	155	0	0	3.00	155	0	0	0	155
11b	2 SCARLET & 2 TURQUOISE STRIPES/WHITE	9	10	0	0	2.05	23	0	0	0	23
11b	24 WHITE STRIPES/NAVY BLUE	0	33	3	0	3.17	0	36	0	6	30
11b	2 ORANGE & 2 TURQUOISE STRIPES WHITE	0	0	0	0	0.00	0	0	0	0	0
If	MULTICOLOURED	0	0	4	43	6.83	0	43	0	0	0
1Va	INDIAN RED ON GREEN CORE	5	978	96	0	3.17	1079	0	0	154	945
1Va	RUBY CORNALINE D'ALEPPO ON WHITE CORE	0	156	26	0	3.29	167	8	7	9	173
W1b	MULTICOLOURED	0	0	12	59	6.66	50	21	0	0	71
W111a	RUBY CORNALINE D'ALEPPO ON WHITE CORE	0	0	11	18	6.24	29	0	0	0	29
W111b	EYE BEADS/FLORAL DESIGN	0	0	0	81	7.00	81	0	0	0	81
Bla	LIGHT GREY	0	0	3	0	5.00	3	0	0	0	3

Table 4. Sizes, diaphaneity and lustre of beads from Mgungundlovu.

ONDINI

BEAD TYPE	COLOUR	SIZE (mm) FREQUENCIES					DIAPHANEITY LUSTRE FREQUENCIES				
		VS	S	M	L	SIZE	O	TL	TP	S	D
11a	WHITE	59	299	0	0	2.67	358	0	0	46	312
11a	OYSTER WHITE	0	1	0	0	3.00	1	0	0	4	1
11a	LIGHT GREY	2	15	0	0	2.76	1	3	13	15	2
11a	BLACK	232	1135	0	0	2.66	1367	0	0	739	628
11a	ROBIN'S EGG BLUE	3	4	0	0	2.14	5	2	0	3	4
11a	LIGHT TURQUOISE	1	2	0	0	2.33	1	2	0	2	1
11a	GREEN	157	1116	0	0	2.75	1273	0	0	97	1176
11a	DARK GREEN	3	75	0	0	2.92	76	0	2	11	67
11a	BRIGHT GREEN	87	322	0	0	2.57	170	210	29	200	209
11a	DARK JADE GREEN	3	40	1	0	2.91	32	12	0	15	29
11a	ORCHID MIST	121	249	0	0	2.35	364	6	0	90	280
11a	LIGHT ORCHID MIST	164	9	0	0	1.10	173	0	0	100	73
11a	MAUVE PINK	322	1859	0	0	2.70	2181	0	0	445	1736
11a	CHERRY ROSE	462	370	0	0	1.89	832	0	0	132	700
11a	LIGHT CHERRY ROSE	12	19	0	0	2.23	31	0	0	11	20
11a	AMBER	4	19	0	0	2.65	15	1	7	14	9
11a	DULL YELLOW	49	139	0	0	2.48	179	8	1	9	179
11a	RUBY	117	353	0	0	2.50	3	40	457	327	167
11a	INDIAN RED	10	53	0	0	2.68	63	0	0	53	10
11a	BRIGHT NAVY	0	0	0	0		0	0	0	0	0
11a	MEDIUM BLUE	0	1	0	0	3.00	1	0	0	0	1
11a	PALE BLUE	0	0	0	0		0	0	0	0	0
11a	CERULEAN BLUE	0	1	0	0	3.00	0	1	0	1	0
11a	BRIGHT BLUE	9	14	0	0	2.22	23	0	0	19	4
11a	COPEN BLUE	0	0	0	0		0	0	0	0	0
11a	SHADOW BLUE	0	0	0	0		1	0	0	0	1
11a	MEDIUM COPEN BLUE	0	0	0	0		0	0	0	0	0
11a	ROSE WINE	0	5	0	0	3.00	3	2	0	2	3
11b	4 NAVY BLUE STRIPES/WHITE	2	0	0	0	1.00	2	0	0	2	0
11b	4 SCARLET STRIPES/WHITE	0	0	0	0		0	0	0	0	0
11b	4 TURQUOISE STRIPES/WHITE	0	0	0	0		0	0	0	0	0
11b	2 SCARLET & 2 NAVY BLUE STRIPES	0	4	0	0	3.00	4	0	0	0	4
11b	2 SCARLET & 2 TURQUOISE STRIPES/WHITE	0	0	0	0		0	0	0	0	0
11b	24 WHITE STRIPES/NAVY BLUE	0	0	0	0		0	0	0	0	0
11b	2 ORANGE & 2 TURQUOISE STRIPES/WHITE	0	20	0	0	3.00	20	0	0	0	20
1f	MULTICOLOURED	0	0	0	2	7.00	0	2	0	0	2
1Va	INDIAN RED ON GREEN CORE	0	21	0	0	3.00	21	0	0	0	21
1Va	UMGAZI	224	529	0	0	2.41	7	0	746	511	242
W1b	MULTICOLOURED	0	0	0	29	7.00	0	29	0	9	20
W111a	RUBY CORNALINE D'ALEPPO ON WHITE/YELLOW CORE	0		19	57	6.50	8	68	0	40	36
W111b	EYE BEADS/FLORAL DESIGN	0	0	0	3	7.00	0	3	0	0	3

Table 5. Sizes, diaphaneity and lustre of beads from Ondini.

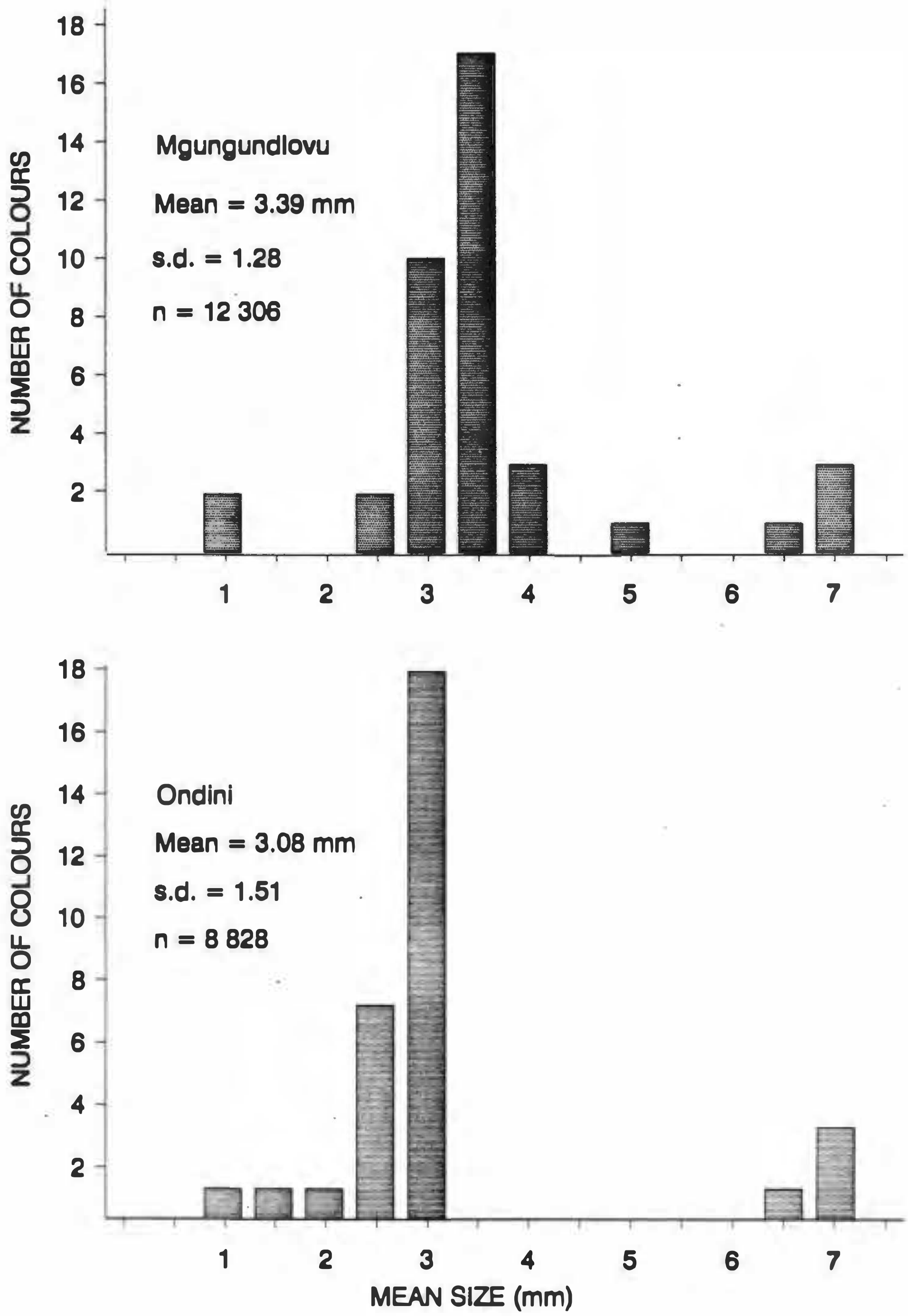


Fig.35. Histograms of bead sizes from Mgungundluvo and Ondini.

II. STATISTICAL ANALYSES OF BEADS

INTRODUCTION

For purposes of statistical analysis, comparisons have been made of the Mgungundlovu and Ondini bead assemblages based on type/variety and also on appearance (colour, diaphaneity). Comparisons were also made of beads found in different areas of Mgungundlovu, and between the beads recovered by different excavators. The beads recovered from the royal midden at Mgungundlovu by Hall provide a temporal sequence for the ten-year occupation of the site.

Statistical analysis of bead colours is provided in Figs.36 & 37). In choosing 9 bead colours from the total of 42 varieties which occur in the two assemblages, the criterion of historical relevance has been applied. At Mgungundlovu, beads such as black, scarlet (ruby), "Indian" red or Redwood on green core, white and striped beads have been reported as beads reserved exclusively for King Dingane (Mackeurtan 1930:168). Other historical references to Zulu beads occur in Angus' *The Kafirs Illustrated* (1849). Elegant and meticulous coloured illustrations of Zulu heroes with beadwork are portrayed. Various studies suggest that royal blue, red and white beads were preferred by Mpande, Dingane's successor, who reigned from 1840 to 1874. A preliminary account of this statistical analysis has been published (van der Merwe *et al* 1989).

BEAD FREQUENCIES

Percentages of beads classified according to procedures described in Chapter 4. are listed in Table 6. Irrespective of the area from which samples were obtained, 11a is consistently the dominant type. This type, corresponding to Beck's (1928) "short circular barrel I.B.1.b" accounts for 79.3% of all the beads from the *isigodlo* midden excavated by Hall, corresponding closely to the proportion of 11a beads (78,4%)

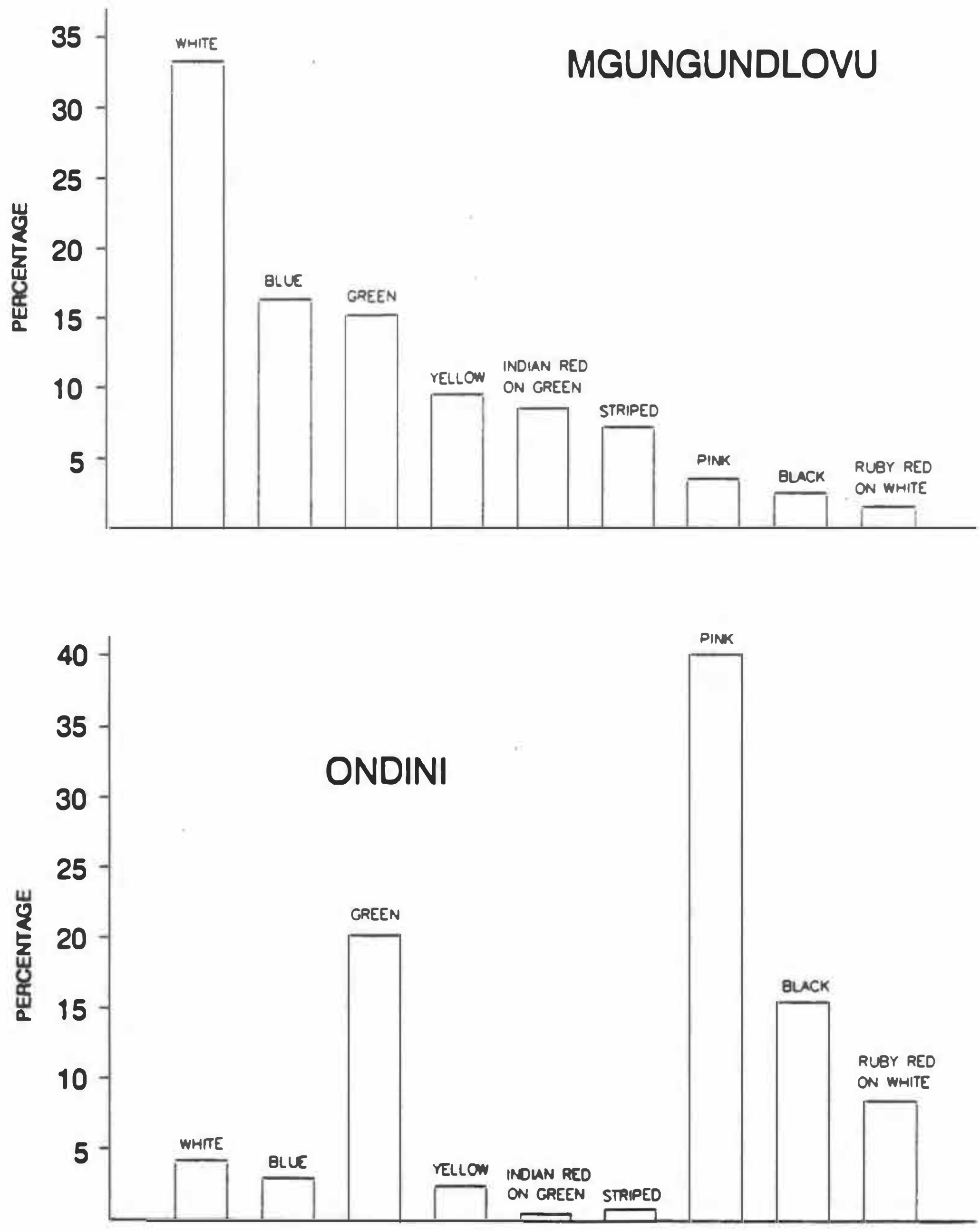


Figure 36. Histograms illustrating white, blue, green, yellow, "Indian" red (or Redwood) on green,striped, pink, black and ruby red on white *(Cornaline d'Aleppo)* beads at Mgungundlovu and Ondini

from part of the *isigodlo* midden excavated by Parkington. The proportions of 11a beads are also high in samples from huts in the *isigodlo*, the *bheje* and the entrance to the site. 11b and 1Va are the next most frequently occurring types. Most of the others (including If, W1b, and W11a tend to account for less than 1% of the beads in each sample. Blown beads (type BIa) and decorated beads of type W111b e.g. "eye beads" are generally rare, although a cluster of such beads was recovered from the *bheje* (Parkington & Cronin 1979:143).

Tables 3,4 & 5 list bead frequencies of all types found at Mgungundlovu and Ondini, classified by colour and diaphaneity. It is clear that white is the most common colour at Mgungundlovu, irrespective of the area from which samples were obtained. Other common colours include green (Munsell No. 2.5G 4/8), "Indian" red or Redwood on green core (Munsell No.7.5R 3/8), amber (Munsell No.7.5YR 6/10), shadow blue (Munsell No.2.5PB 5/4) and bright navy blue (Munsell No.7.5PB 2/8). At Ondini, pink beads are dominant followed by black, green (Munsell No. 2.5G 4/8), and ruby *Cornaline d'Aleppo* on white core (outer layer Munsell No. 2.5R 3/10).

Pearson's correlation coefficients (r) have been calculated from percentages of all bead types to determine the degree of similarity between bead assemblages from different excavated areas at Mgungundlovu and Ondini (Table 7). A strong correlation coefficient (r=0,98) has been obtained for the comparison between isigodlo midden samples excavated by Hall and Parkington. Comparison between two samples from different excavations in the bheje, excavated by Parkington and Roodt respectively, also yielded a high correlation coefficient (r=0,89). These strong correlation coefficients are found despite potential sampling bias associated with different methods of recovery.

More detailed analyses lead to the identification of variability in the spatial distribution of beads of different colours.

Mgungundlovu Excavation	Type: Excavator	If	IIa	IIb	IVa	WIb	WIIIa	WIIIb	BIa	TOTAL	n
Isigodlo midden	Hall	0.56	79.34	3.72	14.26	0.90	0.34	0.84	0.04	100	7,735
Isigodlo midden	Parkington	0.26	78.44	7.79	12.21	0.26	0.00	1.04	0.00	100	385
Isigodlo huts	Parkington	0.00	91.51	4.99	3.33	0.00	0.00	0.17	0.00	100	601
Bheje	Parkington	0.00	73.47	4.08	2.04	0.00	0.00	20.41	0.00	100	49
Bheje	Roodt	0.00	77.48	21.11	1.40	0.00	0.00	0.00	0.00	100	2,065
Entrance	Rawlinson	0.19	91.32	4.43	3.81	0.00	0.19	0.06	0.00	100	1,601
Total	All	0.38	81,13	6.89	10.14	0.57	0.23	0.66	0.02	100	12,436
Ondini excavation											
Total	Rawlinson	0.02	90.05	0.25	8.50	0.29	0.85	0.03	0.00	100	9,042
Isigodlo midden	Rawlinson	0.00	84.54	2.06	11.34	1.55	0.52	0.00	0.00	100	8,848
Non-isigodlo	Rawlinson	0.02	89.94	0.29	8.56	0.32	0.84	0.03	0.00	100	194

Table 6. Percentages of beads from Mgungundlovu and Ondini using Karklins' (1985) typology.

	MGUNGUNDLUVO							ONDINI		
Excavator:	Hall	Parkington			Roodt	Rawlinson		Rawlinson		
Excavation:	Isigodlo midden	Isigodlo midden	Isigodlo huts	Bheje	Bheje	Entrance	Total Mgungundlovu	Total Ondini	Isigodlo midden	Non-isigodlo middens
Sample size:	7735	385	601	49	2065	1601	12436	9042	8848	194
Sample #:	1	2	3	4	5	6	7	8	9	10
1	1,00									
2	0,98	1,00								
3	0,76	0,77	1,00							
4	0,66	0,69	0,83	1,00						
5	0,66	0,71	0,85	0,89	1,00					
6	0,70	0,72	0,94	0,87	0,88	1,00				
7	0,94	0,95	0,90	0,83	0,87	0,88	1,00			
8	0,16	0,17	0,08	0,08	0,09	0,18	0,15	1,00		
9	0,15	0,16	0,08	0,08	0,08	0,17	0,14	0,99	1,00	
10	0,40	0,44	0,31	0,32	0,31	0,41	0,41	0,87	0,86	1,00

Table 7. Correlation coefficient matrix obtained from percentages of beads of all types from Mgungundlovu and Ondini (as listed in Table 3), white beads grouped together.

SPATIAL VARIABILITY AT MGUNGUNDLOVU AND ONDINI

Histograms of bead frequencies shown in Fig.36. serve to identify spatial variability in the proportions of variously coloured beads represented in different assemblages from Mgungundlovu. Percentages in this case have been calculated from the total of all blue, yellow, green, pink, striped, opaque "Indian" red or Redwood on green beads. The results show that the two samples from the isigodlo midden are essentially identical, but the bheje has a relatively high proportion of striped beads. Blue and green are relatively abundant in samples from the *isigodlo* huts and in those from Rawlinson's excavations near the entrance to the site.

Although the bead collection from Ondini has been obtained primarily from the isigodlo area at this site, comparisons can be made between samples from the royal quarters and those from other areas at the site. Results shown in Table 3 show that mauve pink beads are dominant in the isigodlo samples as well as in assemblages obtained from middens outside the royal quarters. A correlation coefficient of $r = 0{,}86$ has been obtained from comparison of the relative abundances of beads of all types in *isigodlo* and non-*isigodlo* midden areas at Ondini.

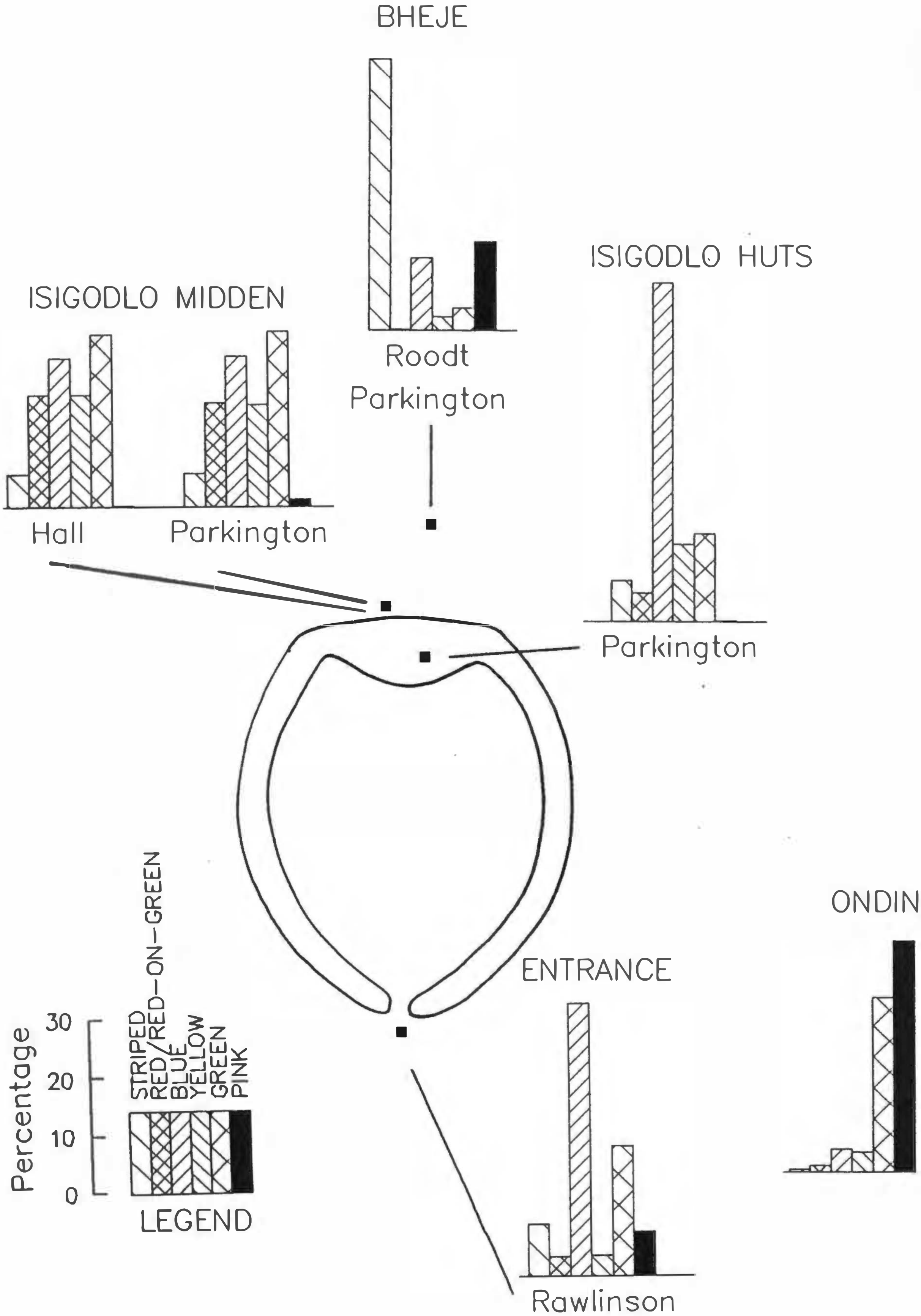


Fig.36. Histograms illustrating spatial variability in the proportions of beads from different parts of Mgungundlovu.

TEMPORAL VARIABILITY

Hall's excavations in the *isigodlo* midden provide an opportunity to identify temporal variability over the period 1829-1838 in the proportions of various colours of beads. Results from a sequence of ten spits from square BCD 6,7,8 indicate that samples near the base of the midden have relatively high proportions of green beads of type 11a with Munsell colour 2.5G 4/8. By contrast, consistently lower proportions of these beads (generally less than 20%) are found in later parts of the sequence. Blue beads with Munsell colour 2.5PB 5/4 account for approximately 5% of the samples in the lower spits, increasing to about 10% in the upper spits. Similar trends are identifiable in a sequence of spits excavated in square GH 1,2,3 in a different part of the midden. However, proportions of white beads are almost constant.

COMPARISONS BETWEEN MGUNGUNDLOVU AND ONDINI

As is the case of Mgungundlovu, the bead collection from Ondini comprises primarily type 11a beads (Table 6). However, there are noticeable differences in the proportions of beads classified on the basis of colour. Whereas white beads are dominant at Mgungundlovu, pink is the most common colour at Ondini. Munsell colours for various shades of pink beads are given in Table 3. At Ondini, the most commonly represented colour is 'mauve pink' (Munsell N. 5RP 6/8). Other pink beads have Munsell numbers 10RP 8/4 and 5R 6/6. Correlation coefficients based on proportions of all bead types (Table 7) indicate that the Mgungundlovu samples are more similar to each other than any of them are to the Ondini samples. Coefficients obtained from comparison of bead samples from isigodlo middens at Mgungundlovu and Ondini are less than 0.16, contrasting with r values generally greater than 0.70 in the case of comparison of samples from different parts of Mgungundlovu. Conversely, the *isigodlo* and *'non-isigodlo'* midden sample from Ondini are more similar to each other than either is to any of the assemblages from Mgungundlovu (Table 7). However, correlation coefficients indicate that the

Mgungundlovu samples are slightly more similar to material from non-isigodlo middens at Ondini than they are to isigodlo assemblages from that site.

DISCUSSION OF STATISTICAL ANALYSES

The bead collection from Mgungundlovu is comprised mainly of monochrome, drawn beads of type 11a beads the dominant colour being white. Correlation coefficients have been calculated to quantify variability in proportions of beads from different parts of the site. Results obtained from an initial statistical analysis serve to show that bead samples from different excavations are comparable, despite non-uniform methods of recovery.

Temporal trends have been identified in a sequence of samples from Mgungundlovu, even though the site was occupied for a period of ten years. Spatial variability at the site has also been observed. The highest proportions of striped beads have been documented in the bheje area: blue and green are most abundant in the *isigodlo* huts and in samples from the entrance to the site.

A marked contrast has been found between assemblages from Mgungundlovu and Ondini. The samples from the latter site are characterized by high proportions of pink beads, contrasting with assemblages from Mgungundlovu (not only the isigodlo samples from this site), where white is the dominant colour.

Many of the varieties of beads excavated from Mgungundlovu and Ondini are present in the archaeological collections from the York Factory, northern Manitoba, Canada. This was the Hudson Bay Company's main depot, which operated from 1792 to 1957 (Karklins, pers.comm). The majority of the beads were probably manufactured on the island of Murano, near Venice. Details of these findings are presented in the next section of this Chapter.

III. ELEMENTAL COMPOSITION

INTRODUCTION

The elemental composition of beads of various colours were determined, and the RI and density values were measured (Fig.38).

Refractive index

Total analysed: 145

Consisting of 46 *Cornaline d'Aleppo* (Fig 40.), 7 ruby, 16 "Indian" red or Redwood on green, 16 "Indian" red or Redwood, 15 blue, 21 white (Fig.41.), 16 green and 8 yellow beads (Appendix i to viii).

Density

Total analysed: 216

Consisting of 71 *Cornaline d'Aleppo*, 8 ruby, 28 "Indian" red or Redwood on green, 24 "Indian" red or Redwood, 17 blue, 25 white, 34 green and 9 beads (Appendix i to viii).

Microprobe

Of the above, a total of 45 were analysed by microprobe for elemental composition. These include 11 *Cornaline d'Aleppo*, 4 ruby, 5 "Indian" red or Redwood on green, 4 blue, 4 white, 7 green and 4 yellow.

Seventy one beads of a variety known as *Cornaline d'Aleppo* were selected for analysis (Appendix i). This type of bead has been documented both in the history of beadmaking as well as trade throughout the world. These beads were excavated from both Mgungundlovu and Ondini. For the purpose of this study, they are referred to as ruby *Cornaline d'Aleppo* on a white core and "Umgazi" beads. 49 beads were chosen for elemental analysis. 17 examples from Mgungundlovu and 19 from Ondini. 15 beads from other collections such as Mapungubwe, Bambandyanalo (University of Pretoria), Phalaborwa (University of Cape Town), Malawi (D.Killick), Italy (Venice) and Transkei (J.Broster). were analysed for comparative purposes.

Analytical results for another ancient and well documented variety of *Cornaline d'Aleppo* bead were obtained. A total of 28 "Indian" red or Redwood on a green core beads, supposedly the predecessor of the ruby *Cornaline d'Aleppo* on a white core, were analysed by microprobe. The majority were from Mgungundlovu.

Tables and figures showing the results of physical and chemical analyses for every variety of bead are presented thus; firstly the RI and density measurements and then the chemical analysis. Discussion follows each reference. Where-ever possible, specific gravity measurements reported by Beck (Caton-Thompson 1931:233) of beads similar to the ones described in this work have been included.

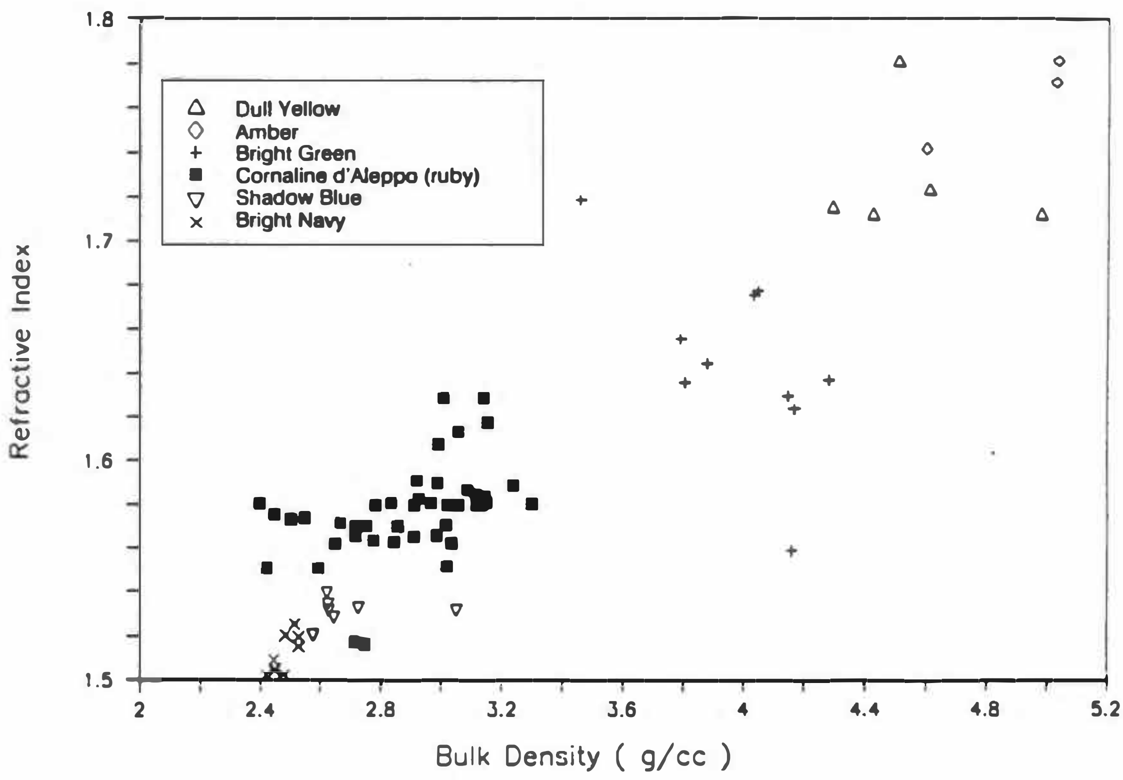


Fig.38. Refractive index and density results of dull yellow, amber, dark green (translucent), ruby *Cornaline d'Aleppo*, shadow blue and bright navy beads.

1. RUBY ON WHITE *CORNALINE D'ALEPPO*

(Type 1Va & W111a)

(Colour: Outer layer, ruby, Munsell No.2.5R 3/10)

These beads have been classified as ruby *Cornaline d'Aleppo* on white or yellow cores. They are now referred to as ruby on white *Cornaline d'Aleppo*. They are numbered 810 on a Venetian sample bead card, dated 1913. The card was labelled Cape card V1.

The colour of the outer layer is ruby, and the inside core is opaque white. The structure of the beads is compound. They were manufactured either by the wound method (type W111a) or drawn (type 1V). Beads of this type were found at both Mgungundlovu and Ondini (Fig.39).

The results of 15 samples from other collections were obtained for comparative analysis (Tables 8,9 & 10, Fig.39, Appendix i). These include beads from Bambandyanalo and Mapungubwe (Van Riet Lowe collection), Malawi, Phalaborwa and Joan Broster (Transkei).

ORIGIN	NO.OF SAMPLES	R I RUBY	STANDARD DEVIATION	R I WHITE	STANDARD DEVIATION
MG	15	1.579	0.026	1.537	0.015
ONDINI	2	1.579	0.000	1.538	0.000
OTHER	6	1.589	0.013	1.526	0.012
MODERN	5	1.550	0.031	1.5199	0.009

TABLE 8. Refractive indices for ruby on white *Cornalines*. The outer layer is ruby colour (Munsell No. 2.5.R 3/10.) on an opaque white core.

ORIGIN	NO. OF BEADS	MEAN DENSITY	STANDARD DEVIATION
MG	15	3.009	0.663
ONDINI	2	3.038	0.000
OTHER	6	2.888	0.080
MODERN	5	2.759	0.111

TABLE 9. Density values for ruby on white *Cornalines.*

	AA116 MG Ruby White	AA122 MG Ruby White	AA131 MG Ruby White	AA136 MG Ruby White	AA155 MG Ruby White	AA241 WITS Ruby white
SiO_2	58.0 41.9	56.5 37.4	57.2 40.0	45.7 45.2	60.3 44.3	63.6 64.9
TiO_2	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Al_2O	0.37 0.32	0.32 0.32	0.37 0.27	0.40 0.41	0.55 0.72	1.37 4.68
Fe_2O_3	0.20 0.18	ND ND	ND 0.30	ND 0.34	ND ND	ND ND
MgO	0.13 ND	0.18 ND	0.19 0.21	0.33 0.24	ND ND	ND ND
CaO	2.24 2.60	2.22 2.22	2.28 2.66	3.23 2.90	1.66 2.07	2.67 1.48
PbO	17.3 38.0	17.4 42.2	17.5 39.3	28.7 25.4	9.61 34.6	ND ND
CuO	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
MnO	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Na_2O	1.98 2.76	2.22 2.02	2.19 2.63	3.09 3.44	4.15 4.84	14.70 15.10
K_2O	12.5 7.54	12.8 6.80	12.2 7.10	10.8 9.25	9.00 5.87	3.52 1.64
P_2O_5	0.18 0.23	0.22 ND	0.20 0.20	0.37 0.20	ND ND	ND ND
Sb_2O_5	ND ND	0.21 ND	ND ND	0.80 ND	ND ND	ND ND
Cl	0.77 0.61	0.74 0.48	0.81 0.49	0.35 0.49	0.10 0.10	0.08 0.10
TOTAL	93.82 94.14	92.60 91.44	93.15 93.15	92.97 87.87	86.17 92.50	85.94 87.90

TABLE 10. Microprobe analysis of ruby on white *Cornaline d'Aleppo.* The white and ruby glass have been separately analysed. MG = Mgungundlovu; Wits = Van Riet Lowe collection (1936).

DISCUSSION OF RUBY ON WHITE CORE *CORNALINE D'ALEPPO*

The RI's and density values of glass beads found at Mgungundlovu and Ondini are remarkably similar. The RI results for the ruby glass of beads from Malawi and Phalaborwa are slightly higher (Appendix i). The 2 "modern" beads from the Transkei (Joan Broster collection) have lower RI's than all the rest.

Preliminary chemical analysis results show significant proportions of lead in the ruby and white glasses of the ruby on white core *Cornaline d'Aleppo* beads from Mgungundlovu. The lead content of the white core exceeds that of the ruby (Table 10). In the majority of the samples the potassium contents are higher than sodium.

The modern sample (AA241, Appendix i), from the Van Riet Lowe collection is compositionally very different. This bead (Venetian sample card No. 210) is unusual in the fact that no lead was detected. A high sodium and alumina content was noted instead.

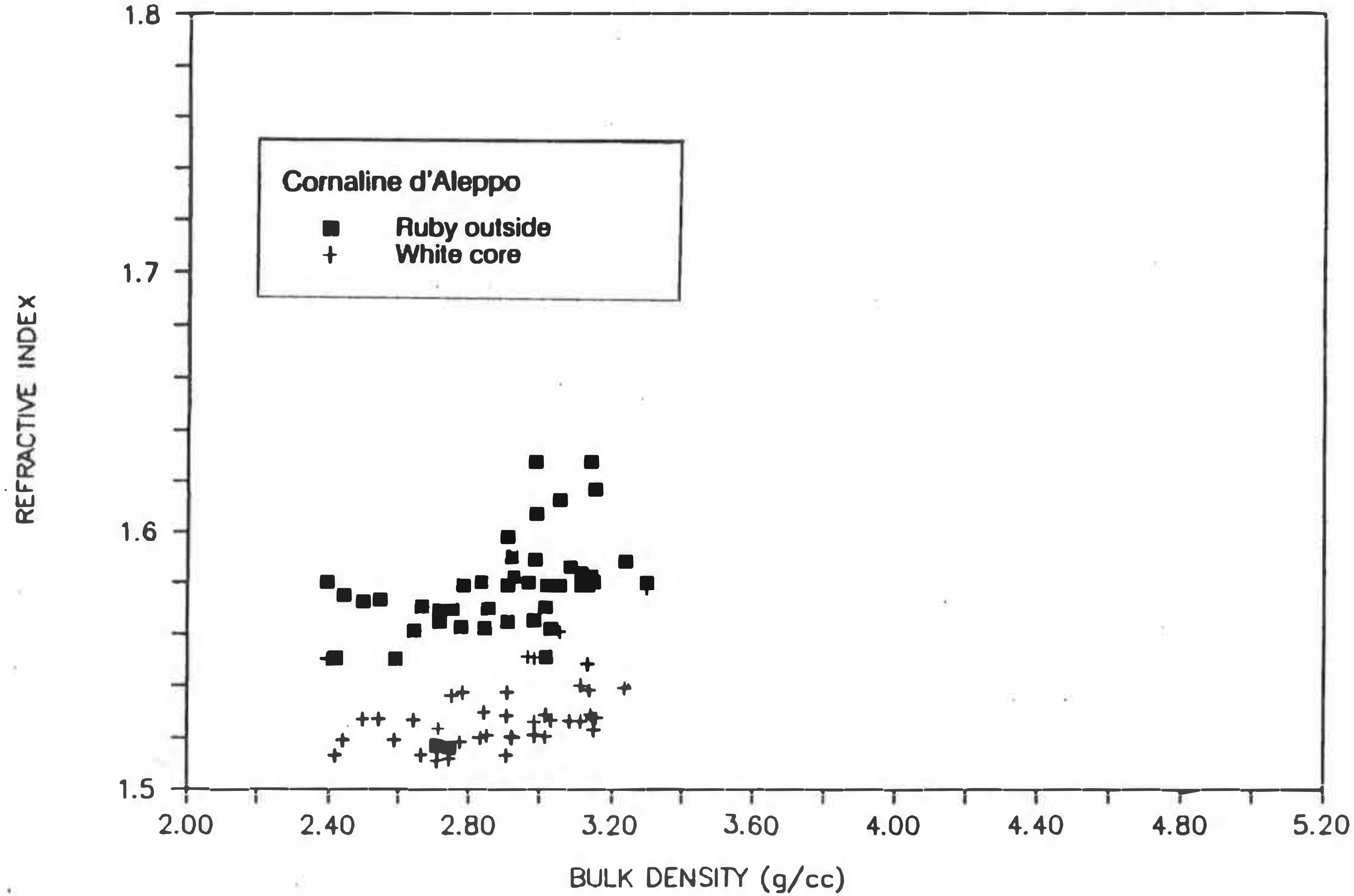


Fig.39. RI and density analysis of ruby *Cornaline d'Aleppo* & "Umgazi" on white core.

2. "UMGAZI"

(Type 1Va & W111a)

(Colour: Outer layer, brownish red, Munsell No. 7.5R 3/8)

The "Umgazi" is a compound bead, with a reddish/brown (now referred to as red) outer layer (Munsell No.7.5 R 3/8) on a white core. The results of 19 RI's and 25 density measurements were obtained (see Tables 11 & 12, Appendix i). Elemental analysis taken of the outer layer and the white core of the beads were recorded separately (Table 13). One bead from a Venetian sample card dated 1913 was used for analysis (sample AA290, Table 13). This bead was named "Umgazi" on the card and numbered 115. Colloquially "Umgazi" means blood or the colour red.

ORIGIN	NO. OF BEADS	MEAN R I RED	STANDARD DEVIATION	MEAN R I WHITE	STD DEVIATION
MG	2	1.561	0.000	1.520	0.007
ONDINI	13	1.530	0.021	1.530	0.016
OTHER	3	1.572	0.001	1.520	0.007
MODERN	1	1.590	-	1.520	

TABLE 11. Refractive index results for "Umgazi". The outer transparent layer is red (Munsell No.7.5 R 3/8) the inside core is opaque white.

ORIGIN	NO. OF BEADS	MEAN DENSITY	STANDARD DEVIATION
MG	2	3.038	-
ONDINI	19	2.911	0.185
OTHER	3	2.639	0.071
MODERN	1	2.917-	-

TABLE 12. Density results for "Umgazi" beads.

	AA290 Murano Red white	AA144 Ondini Red white	AA161 Ondini Red white	AA165 Ondini Red white	AA167 Ondini Red white
SiO_2	62.20 47.50	60.50 43.30	56.30 49.60	52.65 ND	60.20 43.90
TiO_2	ND ND	ND ND	ND ND	ND ND	ND ND
Al_2O	0.67 0.45	0.38 0.39	0.61 0.54	0.46 ND	0.30 0.27
Fe_2O_3	0.18 ND	ND ND	0.55 0.30	0.54 ND	ND ND
MgO	ND ND	0.30 0.22	0.34 0.48	0.17 ND	0.34 0.32
CaO	1.04 0.74	2.58 2.83	2.92 3.34	1.62 ND	2.43 2.44
PbO	10.6 34.1	12.40 35.10	17.2 27.50	20.10 ND	13.30 35.90
CuO	ND ND	ND ND	ND ND	ND ND	ND ND
MnO	ND ND	ND ND	ND ND	ND ND	ND ND
Na_2O	5.34 5.52	2.67 2.97	4.99 8.38	4.87 ND	2.62 3.51
K_2O	10.3 4.69	11.40 5.22	9.29 2.81	9.84 ND	0.80 4.73
P_2O_5	ND ND	ND ND	0.24 0.28	0.18 ND	0.19 0.26
Sb_2O_5	0.82 ND	ND ND	0.61 2.77	1.02 ND	0.68 ND
Cl	0.04 ND	0.42 0.36	0.42 0.68	0.28 ND	0.45 0.34
TOTAL	91.54 93.00	90.65 90.39	93.47 96.68	91.73 ND	91.31 91.67

TABLE 13. Microprobe analysis of "Umgazi" beads. The white and red glass have been separately analysed.

DISCUSSION OF "UMGAZI" BEADS

The visual distinction made between the ruby on white *Cornaline d'Aleppo* and the reddish-brown "Umgazi" was not supported by the microprobe. While the RI and density values of the ruby on white *Cornaline d'Aleppo* were slightly higher than those of the "Umgazi", the elemental analysis did not show major differences. The RI, density and elemental composition of an "Umgazi" bead from the Venetian sample card are also closely similar (Sample AA290): The RI for the transparent red glass is 1.590; for the white glass it is 1.520. It is also lead enriched (Table 13).

Gold, documented in historical glassmaking for making ruby glass occurs in the sample in trace amounts only. Unfortunately these amounts cannot be determined using the electron microprobe. A more sensitive analytical procedure (e.g. plasma mass spectrometry) will have to be used to measure the gold content.

According to Van Riet Lowe (1955:20), the "Umgazi" bead is the same variety that Mussolini had discontinued because the gold used to produce it was needed for the war effort in 1936.

3. RUBY

(Types 11a & W1b)
(Colour: Munsell No.2.5R 3/10)

Density, RI and elemental composition were measured for 7 transparent, ruby colour beads (Munsell No 2.5R 3/10). The main purpose was to compare the glass of this bead with the outer layer of the ruby and reddish brown glass of the ruby *Cornaline d'Aleppo* on white and the "Umgazi" bead. Visually the colours are similar. There is a strong likelihood, therefore, that the glasses are similar.

The elemental analysis includes a "modern" bead from the Van Riet Lowe collection (Sample AA249, Table 14, Appendix ii).

ORIGIN	NO. OF BEADS	MEAN R I	STANDARD DEVIATION	MEAN R I	STD DEVIATION
MG	5	1.5551	0.146	2.810	0.146
van Riet Lowe	2	1.510	0.017	2.651	0.011

TABLE 14. RI and density measurements of ruby beads.

	AA205 MG Ruby	AA287 MG Ruby	AA297 MG Ruby	AA249 WITS Ruby
SiO_2	48.10	61.50	49.10	69.90
TiO_2	0.14	ND	0.12	ND
Al_2O_3	0.22	0.36	0.26	0.28
Fe_2O_3	0.28	0.28	0.37	ND
MgO	0.15	0.34	0.10	ND
CaO	9.37	2.16	9.17	2.80
PbO	18.80	9.05	20.00	ND
CuO	ND	ND	ND	ND
MnO	0.36	ND	0.43	ND
Na_2O	0.70	3.22	0.74	11.9
K_2O	17.7	13.00	17.60	5.31
P_2O_5	0.17	0.22	0.16	ND
Sb_2O_5	ND	1.45	ND	ND
Cl	0.31	0.33	0.27	0.17
TOTAL	96.30	91.91	98.32	90.36

TABLE 15. Microprobe analysis of transparent ruby beads (Munsell No. 2.5 R 3/10). MG = Mgungundlovu; WITS = Van Riet Lowe collection (1936).

DISCUSSION OF RUBY BEADS

Beads AA205 and AA297 (Table 15.) are almost the same (a potassium-silica-lime-lead glass). Sample AA287 is similar but has low calcium. Sample AA249 is a type 11a, bead which was manufactured in Czechoslovakia (Van Riet Lowe collection, Wits). It is a soda-silica glass . "Umgazi" beads are potassium-lead-silica glass which are similar but not the same as samples AA205 and AA297.

4. "INDIAN" RED OR REDWOOD ON GREEN

(Type 1Va)

(Colour: Munsell No. 7.5R 3/8)

Twenty eight opaque, "Indian" red on a green core beads were examined to determine their RI and density properties (see Tables 16 & 17, Appendix iii). The majority of the beads came from the Mgungundlovu assemblage.

Now referred to as "Indian" red or Redwood on green, all the samples examined were manufactured with a thin, opaque "Indian" red outer layer over a transparent apple-green or a clear glass core. The clear core in some of the beads has swirls or small blobs of "Indian" red glass. Some of the samples have an additional thin coating of clear glass over the outer layer of "Indian" red glass. None of these beads appear on any manufacturer's sample cards.

ORIGIN	NO. OF STD BEADS	MEAN R I INDIAN RED	STANDARD DEVIATION	MEAN R I GREEN	STANDARD DEVIATION
MG	26	1.540	0.003	1.700	0.106
Mapungubwe	1	1.538	-	1.569	-
Haaskraal	1	1.538	-	1.568	

TABLE 16 Refractive index results for "Indian" red or Redwood on green beads (type 1Va).

ORIGIN	NO. OF BEADS	MEAN DENSITY	STANDARD DEVIATION
MG	25	2.621	0.106
Mapungubwe	2	2.575	-
Haaskraal	1	2.532	-

TABLE 17 Density measurements for "Indian" red or Redwood on green beads

	AA16 MG Red Green	AA19a MG Red Green	AA66 MG Red Green	AA81 MG Red Green	AA299 MG Red Green
SiO_2	64.59 59.50	64.70 61.00	58.30 60.70	65.40 60.60	68.1 63.5
TiO_2	0.14 0.14	ND...ND	0.11 ND	ND 0.13	0.29 0.21
Al_2O	1.47 1.68	1.10 1.29	1.57 1.42	1.10 1.48	2.78 2.26
Fe_2O_3	O.76 1.48	0.59 2.18	1.14 1.77	0.79 1.75	1.80 2.18
MgO	1.91 1.84	1.80 1.87	1.69 1.54	1.72 1.93	1.73 2.05
CaO	10.10 9.14	9.27 8.79	8.66 7.84	8.50 9.06	4.45 7.40
PbO	ND 1.38	ND 1.55	6.12 3.21	ND 1.35	ND 1.50
CuO	0.52 1.51	0.66 1.37	0.77 1.05	1.33 1.42	0.75 1.08
MnO	ND 0.28	ND 0.48	ND 0.24	ND 0.68	ND 1.15
Na_2O	12.00 11.60	11.70 11.4	12.7 13.00	12.20 12.40	15.7 14.8
K_2O	3.62 3.38	4.44 3.75	3.44 3.58	3.18 2.78	2.34 1.94
P_2O_5	0.70 0.66	0.82 0.54	0.52 0.55	0.74 0.79	0.43 0.46
Sb_2O_5	ND 3.20	ND 0.84	ND ND	1.15 0.56	0.50 0.75
Cl	1.28 1.02	1.16 0.98	1.21 1.19	1.04 1.07	1.30 1.08
TOTAL	97.30 96.81	96.24 96.04	96.23 96.09	97.15 95.86	100.17 100.53

TABLE 18. Microprobe analysis of "Indian" red or Redwood on green core beads.

DISCUSSION OF "INDIAN" RED OR REDWOOD ON GREEN

Beck reported the specific gravity of "Indian" red or Redwood on green beads between 2.4 and 2.5. (Caton-Thompson 1931:233). The density results of the two samples from Mapungubwe and Haaskraal also fall within that range. The density measurements for Mgungundlovu are slightly higher (Table 17). The RI values for beads from Mapungubwe and Haaskraal (Zeekoe valley, Richmond, Cape) are almost identical.

Both the red and green are soda-silica-lime glasses. It is interesting to note that in most instances, lead has not been detected in the chemical composition of the "Indian" red or Redwood glass of the outer cores. Contrary to expectations, the RI values of the green inner core and the elemental analysis show that about 1.5% lead is present. The results of sample AA66, from Mapungubwe (Appendix iv), however, show that lead is present in both colours. It is, therefore, no longer possible to generalize or assume that beads of this type were manufactured to defray costs by covering an "inexpensive" glass core with a more valuable type, such as the "Indian" red or Redwood glass (although the lead content is much lower).

Nine beads, samples AA72, AA74, AA75, AA76, AA78, AA79, AA81, AA82 and AA83 (see Appendix iii) were excavated from one small area in the *isigodlo* midden at Mgungundlovu (GH 123,4,F). The RI and density results are consistent. Chemical analysis shows lead present in the green core. Magnesium (MgO) and Calcium (CaO) are present in all samples (Table 18).

Only 21 of this particular type of bead were recovered from Ondini.

5. "INDIAN" RED OR REDWOOD BEADS

(Type 11a)

(Colour: Munsell No.7.5R 3/8)

"Indian" red or Redwood beads are drawn, type 11a, opaque brick colour beads. Colour descriptions for these beads in the literature include: Terra-cotta red, ox-blood red, sealing wax red, brick-red etc. They have also been referred to as "Mutisalah" (Lamb 1965:36). Although these beads usually appear to be made of solid, opaque, "Indian" red or Redwood glass, some sectioned and polished samples revealed a inner core of varying shades of transparent glass including light yellow. It was very difficult to discern the difference on the refractometer between the inner core and the very thin outer layer of "Indian" red or Redwood glass. RI measurements were therefore taken at points across the entire surface of the sample (Table 19, Appendix iv).

The density and RI measurements for twenty four "Indian" red beads have been recorded from Mgungundlovu and Ondini and other sites including Mapungubwe (Northern Transvaal), Shikumbu (Eastern Transvaal) and Bolahla (Lesotho). "Indian" red or Redwood beads from the Van Riet Lowe collection, including examples from Zanzibar, Java and Sofala were also examined (Table 19 & 20, Appendix iv).

ORIGIN	NO. OF BEADS	MEAN R I	STANDARD DEVIATION	MEAN DENSITY	STD DEVIATION
MG	4	1.542	0.013	3.043	0.7631
ONDINI	11	1.5431	0.010	2.6854	0.326
OTHER	7	1.5490	0.021	2.620	0.230

TABLE 19. RI and density properties of "Indian" red or Redwood beads.

	AA255 Shikumbu Indian red	AA28 Ondini Indian red	AA9 Ondini Indian red	AA236 MG Indian red	AA239 MG Indian red	AA13 MG Indian red
SiO_2	59.5	58.4	61.20	61.6	57.2	65.6
TiO_2	0.07	0.14	ND	ND	0.16	ND
Al_2O	0.88	2.31	0.91	0.87	2.59	0.89
Fe_2O_3	3.61	2.88	3.29	3.42	3.08	0.60
MgO	0.94	1.10	1.02	1.01	1.20	1.48
CaO	4.98	4.17	4.50	4.52	4.46	8.51
PbO	6.55	3.51	3.44	3.13	4.32	ND
CuO	2.86	2.40	3.32	3.85	1.43	1.98
MnO	0.97	2.52	0.22	0.26	2.78	ND
Na_2O	13.7	17.9	14.70	14.4	15.8	11.6
K_2O	3.31	1.40	2.26	2.31	1.63	4.62
P_2O_5	0.43	0.18	0.36	0.36	0.28	0.55
Sb_2O_5	ND	0.32	ND	0.20	0.29	ND
Cl	1.0	0.95	1.25	1.23	0.96	1.20
TOTAL	99.09	98.67	97.46	97.16	96.18	97.03

TABLE 20. Microprobe analysis of "Indian" red or Redwood beads. MG = Mgungundlovu.

DISCUSSION OF "INDIAN" RED OR REDWOOD BEADS

Chemical analysis of an "Indian" red or Redwood bead from Shikumba, in the Kruger Game Reserve, Eastern Transvaal (Sample AA255, Appendix iv) shows that the lead content of the glass is noticeably higher than other samples of the same type. Results of specimen AA13, excavated from the *bheje* area at Mgungundlovu, reveal an absence of lead altogether. This information confirms the relatively low RI measurements (Table 19). The chemical composition of this bead is more consistent with a soda-lime-silica glass (Table 20).

It is surprising that the chemical composition of "Indian" red or Redwood glass used to manufacture two different types of beads (the compound, "Indian" red or Redwood on green and the simple monochrome), was not as similar as was expected. The simple, "Indian" red or Redwood bead contained higher proportions of iron (Fe_2O_3), copper (CuO) and lead (PbO). Both glasses had MgO in the composition.

6. WHITE BEADS

(Type 11a)

(Colour:	White	=	Munsell No. N9.5/90.0/R)
	Oyster	=	Munsell No. 5Gy 9/1
	Light Grey	=	Munsell No. N8.25/63.65R)

The RI and density measurements of 25 white beads from Mgungundlovu and Ondini have been recorded (Table 21). The RI's range from 1.528 to 1.610 and the densities from 2.618 to 4.687 (Appendix v). The results include more than one type of glass (Fig.40, Table 21 & 22).

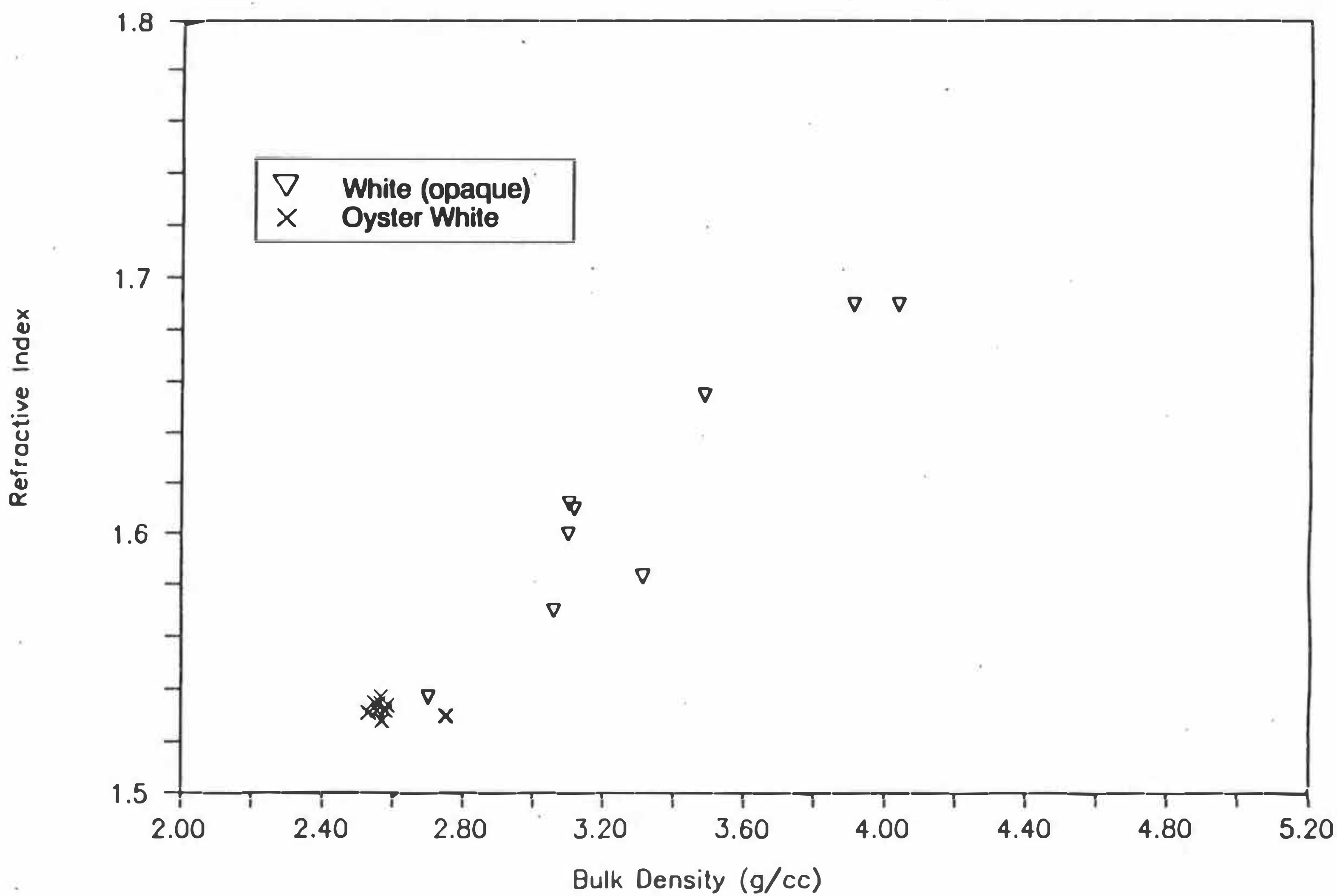


Fig.40. RI and density values for white beads

ORIGIN	NO. OF BEADS	MEAN R I	STANDARD DEVIATION	MEAN DENSITY	STANDARD DEVIATION
WHITE	9	1.607	0.044	3.216	0.314
OYSTER	11	1.585	0.002	2.661	0.249
LIGHT GREY	5	-	-	2.555	0.1232

TABLE 21. White = Munsell No. N9.5/90.0/R
Oyster = Munsell No.5GY 9/1
Light Grey = Munsell No. N8.25/63.65R

	AA87 MG Oyster	AA84 MG Oyster	AA203 MG Oyster	AA199 MG White
SiO_2	62.9	62.0	60.1	44.8
TiO_2	0.11	ND	ND	ND
Al_2O	1.69	O.89	1.34	2.59
Fe_2O_3	1.03	0.54	0.81	ND
MgO	1.94	1.45	1.71	ND
CaO	8.92	7.96	9.08	0.79
PbO	ND	ND	ND	29.0
CuO	ND	ND	ND	ND
MnO	ND	ND	ND	ND
Na_2O	10.1	9.44	9.07	8.67
K_2O	3.21	5.70	5.31	1.87
P_2O_5	0.52	1.02	0.74	ND
Sb_2O_5	7.63	7.63	7.24	ND
Cl	0.76	0.76	0.66	0.20
TOTAL	99.08	95.32	96.06	87.92

TABLE 22. Microprobe analysis of white beads

DISCUSSION OF WHITE BEADS

The refractive indices of white beads range from 1.528 to 1.610 and the density measurements vary from 2.618 to 4.687 (Table 21). Beck (Caton-Thompson 1931:233 & 240) recorded white beads with fairly high specific gravity measurements of 3.2. He also identified two white beads, which although similar in appearance, had a lower specific gravity of between 2.5 and 2.55. The density measurements of white beads in this study fall within the range as well.

Interesting results are seen in the group of beads classified as white (Munsell No. 9.5/90.0% R) and oyster (Munsell No.5GY 9/1). The oyster variety cluster tightly while the white beads are more scattered (Fig.40). Sample number AA203 (Appendix v) was classified as a white bead. The RI and density measurements, however, are more consistent with oyster beads and should have been classified accordingly.

No lead was detected in the oyster bead variety while a substantial amount was recorded in the white glass composition. Calcium (CaO), Sodium (Na_2O) and Antimony (Sb_2O_5) were also recorded (Table 22).

7. BLUE BEADS

(Type 1f, 11a & W1b)

(Colour:	Bright Navy =	Munsell No. 7.5PB 2/8)
	Shadow Blue =	Munsell No. 2.5PB 5/4

There is a noticeable variation in colour amongst the blue beads. The range is from bright navy blue beads to light shadow blue beads. 582 bright navy beads were excavated from Mgungundlovu and 213 from Ondini. 701 light shadow blue were recovered from Mgungundlovu and only 1 from Ondini.

RI results were obtained for 9 bright navy beads and 6 shadow blue beads. Of the 9 bright navy colour, 2 were hexagonal, faceted beads, and 2 were undecorated wound beads (Tables 23 & 24, Fig.38. Appendix vi). Although faceted beads are usually visually distinct, variation does occur in the colour of the glass. Similar beads were described by Horace Beck (Caton-Thompson 1931:238) as having originated from Europe and being "of no great age". Their specific gravity varies between 1.42 to 2.46. Physical and chemical analysis was undertaken for these particular beads to establish whether the composition of the glass was significantly different, or whether it was due to slight variations in the batches of glass.

The vast majority of the shadow blue beads were excavated from Mgungundlovu. The RI and density of 4 of these beads were measured. Beads of this variety were recovered from Nagome, Phalaborwa (University of Cape Town) and Mapungubwe (treasure pot, Van Riet Lowe collection) and their results have been included for comparative analysis.

ORIGIN	NO. OF BEADS	MEAN R I	STANDARD DEVIATION	MEAN DENSITY	STANDARD DEVIATION
Mgungundlovu	6	1.508	0.006	2.479	0.035
Ondini	2	1.522	-	3.955	-
Phalaborwa 1	1.5020	-	2.422	-	

TABLE 23. RI and density measurements for bright navy beads (Munsell No. 2.5 R 3/10).

ORIGIN	NO. OF BEADS	MEAN R I	STANDARD DEVIATION	MEAN DENSITY	STANDARD DEVIATION
Mgungundlovu	4	1.531	0.007	2.621	0.032
Phalaborwa	2	1.530	-	2.8073	-
Mapungubwe	1	1.528	-	2.644	-

TABLE 24. RI and density measurements for shadow blue beads (Munsell No. 2.5 PB 5/4).

	AA324 MG Shadow blue	AA340 MG Shadow blue	AA313 MG Bright navy	AA342 MG Bright navy
SiO_2	61.20	64.70	72.70	63.4
TiO_2	ND	ND	ND	ND
Al_2O	1.51	1.21	0.48	1.02
Fe_2O_3	0.80	0.80	ND	0.50
MgO	1.83	1.64	0.28	0.50
CaO	10.20	9.24	7.52	0.61
PbO	ND	ND	ND	11.3
CuO	ND	ND	ND	ND
MnO	ND	ND	0.36	0.03
Na_2O	10.70	10.90	0.62	2.50
K_2O	3.68	4.95	15.0	17.30
P_2O_5	0.47	0.52	0.22	0.45
Sb_2O_5	6.13	4.15	ND	ND
Cl	0.78	0.82	0.11	0.26
TOTAL	96.94	98.93	97.29	98.86

TABLE 25. Microprobe analysis of shadow blue (Munsell No. 2.5PB 5/4) and bright navy beads (Munsell No. 7.5PB 2/8).

DISCUSSION OF BRIGHT NAVY & SHADOW BLUE BEADS

The chemical composition of shadow blue beads found at Mgungundlovu are remarkably similar. The results are typically those of soda-lime-silica glass (Table 25). Although there is no data on the chemical composition of the same variety of bead found at Phalaborwa, the RI measurements correspond tightly with those from Mgungundlovu. It would be interesting to see what chemical similarities/differences there are in beads covering a longer time span than Mgungundlovu and Ondini. Physical analysis of bright navy beads found at Mgungundlovu and Ondini indicate discrete changes of glass composition. Sample AA342 is lead enriched while the same colour bead from the same site has no lead in it at all. In addition, the RI and density measurements of the beads from Ondini are higher than those from Mgungundlovu. Noteworthy changes would suggest different manufacturers.

8. GREEN AND YELLOW BEADS

(Type 11a)

(Colour:	dark green	=	Munsell No.2.5G 3/6)
	green	=	Munsell No.2.5G 4/8
	amber	=	Munsell No.7.5YR 6/10
	dull yellow	=	Munsell No.5Y 8/6)

The physical properties of 34 transparent dark green (Munsell No. 2.5 G 3/6), as well as opaque green (Munsell No.2.5 G 4/8) glass beads were analysed for this project (Tables 26 & 27, Fig.38 & Appendix vii & viii).

Two variations of yellow beads were selected for analysis. Both were made from opaque glass. They are; amber (Munsell No. 7.5 YR 6/10) and dull yellow beads (Munsell No. 5 Y 8/6). The RI and density values of 9 beads have been determined

ORIGIN	NO. OF BEADS	MEAN R I	STANDARD DEVIATION	MEAN DENSITY	STANDARD DEVIATION
MG dark green (translucent)	15	1.6381	0.0162	3.850	0.357
Ondini dark green (translucent)	1	1.635-	-	3.797-	-
Phalaborwa dark green (translucent)	4	1.718	-	3.528	0.210
Kwazulu Dark green (translucent)	2	1.513-	-	2.760	-.
MG green (opaque)	3	1.676	0.001	4.404	0.446
MG amber	3	1.763-	0.017-	4.887	0.204
MG dull yellow	2	1.745	0.034	3.290	0.041
Ondini dull yellow	3	1.715	0.004	4.618	0.2443

TABLE 26. RI and density results for green and yellow glass beads.

	AA181 MG GREEN	AA188 MG GREEN	AA194 Phalaborwa GREEN	AA186 MG GREEN	AA323 MG GREEN	AA90 Ondini GREEN	AA307 Ondini GREEN
SiO_2	42.7	38.3	34.7	40.6	36.2	40.30	37.30
TiO_2	ND	ND	ND	ND	ND	ND	ND
Al_2O	0.49	0.44	0.20	0.48	O.42	0.35	0.19
Fe_2O_3	0.49	0.41	ND	0.70	0.42	ND	ND
MgO	0.59	0.30	ND	0.54	0.52	O.33	0.14
CaO	3.62	2.70	0.95	0.54	3.10	1.79	1.42
PbO	40.50	50.9	57.5	45.40	50.50	46.10	49.40
CuO	2.27	1.54	2.08	2.27	2.12	1.72	1.62
MnO	ND	ND	ND	ND	ND	ND	ND
Na_2O	4.40	3.34	2.15	4.28	3.84	3.45	3.66
K_2O	2.34	1.62	0.32	1.90	1.70	2.11	1.22
P_2O_5	0.30	0.16	ND	0.30	0.28	ND	ND
Sb_2O_5	ND	ND	0.76	ND	ND	0.76	0.73
Cl	0.70	0.55	0.57	0.65	0.77	0.79	0.52
TOTAL	98.4	100.27	99.43.	100.27	99.85	97.7	96.2

TABLE 27. Microprobe analysis of green beads.

	AA94 Ondini Dull yellow	AA95 Ondini Dull yellow	AA321 MG Amber	AA327 MG Dull yellow
SiO_2	33.60	35.0	27.30	34.60
TiO_2	ND	ND	ND	ND
Al_2O	0.10	0.12	0.18	0.43
Fe_2O_3	ND	ND	0.43	0.33
MgO	ND	ND	ND	0.32
CaO	0.54	1.10	0.72	2.48
PbO	62.70	59.80	68.20	57.60
CuO	ND	ND	ND	ND
MnO	ND	ND	ND	ND
Na_2O	1.12	1.17	0.52	1.83
K_2O	0.54	2.27	0.32	1.78
P_2O_5	ND	ND	ND	ND
Sb_2O_5	ND	0.41	ND	ND
Cl	0.12	0.10	ND	0.51
TOTAL	98.72	99.97	97.67	99.88

TABLE 28. Microprobe analysis of yellow opaque beads. Note the high lead content.

DISCUSSION OF GREEN AND YELLOW BEADS

The RI and density values for green and yellow glass in this study are much higher than for any others (Table 26 & Fig.38). The lead content is considerably higher as well (more than 50%) (Tables 27 & 28). Bohn (1805:691-695) recorded green and yellow beads as having the heaviest masses compared to other coloured beads. A bundle of green and yellow beads of 12 strings weighed six ounces, for example, while a bundle of white, black or blue bead weighed only three ounces. This depended on whether or not lead carbonates were used to produce the beads. Except for the two modern bead from Kwazulu (Appendix vii), the results obtained here compare with these criteria.

Beck (Caton-Thompson 1931:234) noted certain green beads which looked identical in appearance but which had different specific gravity. Some had low specific gravity (below 2.4), while others had values above 2.7.

CONCLUSION OF COMPOSITIONAL ANALYSES

The results of these analyses show that two distinct types of glasses were used in beadmaking during the 19th century. The major components of one of the glasses was soda-lime-silica (ruby, Table 15: "Indian" red or Redwood, Table 20: oyster, Table 22: shadow blue & bright navy, Table 25) and the other was high-lead (ruby on white Cornaline d'Aleppo, Table 10: Umgazi", Table 13: ruby, Table 15: "Indian" red or Redwood on green, Table 18: "Indian" red or Redwood, Table 20: white, Table 22: bright navy, Table 25: and green & yellow, Table 27 & 28). The potassium content of the soda-silica glass varied from 3-17%. The potassium content of the lead glass is lower than the soda-lime-silica glass. Predictably, chemical analysis of the beads showed that when the lead content in the glass increased, the silica content decreased. Among silica based glasses, those containing higher proportions of heavy elements such as lead or barium show higher refractive indices. The differences suggest that the beads could have been manufactured at different sources.

Many of the beads were lead enriched, particularly the green and yellow beads. Significant amounts of lead were also found in the outer ruby layer of the *Cornaline d'Aleppo* beads and also in the white cores. The lead content of the white core, however, exceeds that of the ruby (Table.10). In the majority of the samples of these two colours the amounts of potassium are higher than sodium. The green core of the "Indian" red or Redwood on green beads also contains lead (Samples AA16, AA19a AA81 & AA299, Table 18). Refractive index and density results of these samples were also generally elevated with higher lead content. Chemical analyses correlate well with the RI and density measurements. Holloway (1973:17), describes certain criteria from which glass technologists can estimate to within a few percent the effect of a change in composition on the refractive index.

"Indian" red or Redwood on green, "Indian" red or Redwood, oyster and shadow blue beads have high manganese content compared to the rest. Levels of 1% more suggest that it was added deliberately as a manganese-rich compound (Henderson (1985:283). The effect of this element in the glass is complex. Manganese could have been introduced into the recipes of the two varieties of "Indian" red or Redwood glass with the iron (Tables 18 & 20). The colour can depend on furnace conditions and the composition of the glass itself, i.e., soda-lime-glass or lead glass. Manganese is used for making mauve and black glass as well. Small amounts in potash glass are used for decolouring.

Two varieties of *Cornaline d'Aleppo* beads (compound, type 1Va and W111a) were initially classified as ruby *Cornaline d'Aleppo* on white core and "Umgazi" (transparent reddish brown on a white opaque core). The difference between ruby *Cornaline d'Aleppo* and "Umgazi" beads was made by visual selection and also by comparison against similar beads which appeared in a Venetian sample bead card dated 1913. Each bead was designated a separate catalogue number on the card. The the ruby *Cornaline d'Aleppo* bead was numbered 810 and the "Umgazi", which is more brownish in colour, numbered 115.

The distinction made between the ruby of the Cornaline and the reddish colour of the Umgazi, however, was not supported by physical and chemical analysis. There were no significant elemental differences between the glass composition of the two varieties. The disparity, therefore, must be due to trace element variation. The beads were subsequently all classified as ruby *Cornaline d'Aleppo* on white. The modern bead from the Van Riet Lowe collection is the only example of this type of bead that is compositionally different. Sample AA241 (Venetian sample card No.210) (Appendix i) is unusual in the fact that it has no lead at all. It is high in sodium and alumina instead. Zinc is prominent as well.

It is interesting to note the similarities between the drawn, ruby glass beads, type 11a, and the outside ruby colour of the compound *Cornaline d'Aleppo* on white. Except for sample AA249 (Table 15), the ruby glass in both these varieties have noticeable lead content.

Gold, documented in historical glassmaking and thought to have been responsible for the ruby colour, occurs in the sample in trace amounts only. These amounts cannot be determined using the electron microprobe. Other methods, which go beyond the scope of this thesis, will have to be investigated for this analysis. Atomic absorption spectrophotometry would be a likely alternative, although sample preparation could be problematic. This method requires liquid samples which means that the glass has to be digested in hydrofluoric acid. This is highly toxic. Our laboratory is not equipped at the moment to handle such preparations.

The low totals of the chemical analysis are due in part to volatilization of sodium and potassium. They are also incomplete because of the elements which have not been analysed. A qualitative scan of the elements detectable on the electron microprobe (i.e. atomic #s > 9) did not show significant quantities of other elements. It is likely, therefore, that the missing elements are light elements such as boron.

CHAPTER 7

CONCLUSIONS

In this thesis, more than 22 000 glass trade beads excavated from two important 19th century historical Zulu sites were analyzed. The methods involved both traditional archaeological procedures such as large scale visual screening and typological classification, as well as specialized techniques of materials science. Visual classification methods were adapted from the work of North American bead researchers. These procedures offer South African bead researchers a standardized basis for visual classification and comparative analysis.

Specific techniques of materials science using refractive index and density measurements were used to characterize various glass types found in the collections. The elemental composition of the glass was determined by means of the electron microprobe. These results provide benchmarks for glass beads in the South African archaeological record and also for European beadmaking in the 19th century. Compositional analysis also confirmed whether beads which *"look"* very similar are in fact made of the same material. In many cases, the glass composition is, in fact, different. This information suggests that various factories and glassmakers were involved in manufacturing the beads.

The dates of the Royal residences (Mgungundlovu 1828 - 1839; Ondini 1874 -1879) provide data for two short time slices in the 19th century. This information is unique for Iron Age archaeology in southern Africa and also for the study of glass trade beads in general. They serve as markers for ethnographic collections, and provide insights into the societies that used glass beads as trading items. They also provide valuable information on glassmaking history and bead manufacture in Europe.

Statistical analysis of beads from Mgungundlovu illustrate subtle differences in spatial distribution as well as temporal changes within a relatively short period of time. Comparison of the Mgungundlovu and Ondini assemblages show that essentially the same bead types are present in both. The vast preponderance of the beads are of Type 11a, i.e., simple drawn monochromes. Since many other bead types were available at the time, this is clearly the result of consumer preference in the Zulu kingdom, which forms part of a wider tradition in the Iron Age of southern Africa. Colour preferences were markedly different at the two sites, however. The majority of beads at Mgungundlovu were various shades of white, while at Ondini the most popular colour was pink. It is interesting to note that this "pink shift" occurred during the same period among some American Indian groups who preferred monochrome beads, particularly the Dakota Sioux. This observation is admittedly based on a brief, subjective study of the bead collections of Harvard Peabody Museum, but suggests strongly that the change was introduced by the manufacturers and found fertile ground among consumers on two different continents.

OVERVIEW

THE BEAD TRADE

During the 18th and 19th centuries Delagoa Bay had been the trading ground for many nations, including the Dutch, Austrians, French and Americans. During the time of Dingane, however, Delagoa Bay commerce was dominated by the Portuguese. It has been assumed that this trade depended on ivory supplied by the Zulu nation. Many varieties of trade beads were probably introduced into the area by the different merchants and the Zulu would have had some knowledge of the range of beads available on the market. Ondini, on the other hand, traded only with the British from Port Natal some forty years later. It is somewhat surprising that compositional analysis of the beads showed that, besides colour differences, the bead types were remarkably similar. The one exception are the *blown* beads, or imitation pearls, which were probably manufactured in France.

Reports of shipwreck survivors have been used as evidence for colour preference, currency rates and the exchange value of a particular type of bead. Detailed accounts of survivors have been used by Smith (1970:20), who reported the change of preference in bead colours. From some of these accounts he noted that the exchange value of a particular type of bead seemed to last for relatively short periods. Within little more than a hundred years, red beads were reported as being popular at Delagoa Bay, then white and finally blue and yellow. He believes that the same preferences held true in the interior.

Contrary to these reports David Livingstone (1867:180), commented in his diaries that certain beads were valued and popular in Africa over long periods of time. He described a red bead with a white centre (probably ruby *Cornaline d'Aleppo* on white core) of various sizes as "always being popular in every part of Africa". Details of this particular bead are discussed below.

VISUAL CLASSIFICATION

The beads from these two sites were analysed according to methods adapted from bead specialists in North America. These included methods of manufacture, type, shape, size colour, diaphaneity and lustre. The results of the classification were confirmed by Karlis Karklins in Canada. The majority of the simple, monochrome drawn beads and decorated wound beads are typologically similar to beads produced on the island of Murano, near Venice. Many of the beads are known from the York Factory, northern Manitoba, Canada (K.Karklins, pers.comm.). This site represents the Hudson Bay Company's main depot which operated from 1792 to 1957. This evidence illustrates the temporal and wide spatial distribution of these beads on two continents.

The *blown* beads recovered from Mgungundlovu are probably the only examples of this type ever recorded from South African Iron Age sites. The fact that they survived the rigours of both time and excavation are indeed a credit to the archaeology fraternity and the assistants who were involved in the bead analysis.

COMPOSITIONAL ANALYSIS

The main objectives of this study were:

1. To provide an independent test of the accuracy of standardized visual screening methods;
2. to provide routine methods for compositional analysis without using expensive and specialist expertise; and
3. to contribute toward the history of glassmaking.

Refractive index methods developed for this study provide useful, precise diagnostic information on the physical properties of particular glass beads. High RI's are associated with high mass density. It can, therefore, be predicted that as the unit weight of a sample increases, variations in the glass can be expected. Density analysis are not particularly suitable for measuring small samples with dry weights of less than 0.03 grams, or specimens with more than one type of glass. Only the average measurement for composite glass can be calculated from these samples. Fortunately, RI analytical procedures avoid these problems, regardless of the size or weight of the sample.

Physical analysis of glass beads using RI and bulk density measurements is simple, non-destructive and inexpensive even for large numbers of beads. Specialist operators are not required. The results provide reliable indicators of the characteristics of the glass without the expense of chemical analysis. They provide a basis for informed selection of beads for elemental analysis.

The electron microprobe can be set up for routine elemental analysis. It is most suitable for small samples with multi-layered glass such as compound beads. Sample preparation does not involve complex procedures. The method is restricted however, by problems caused by volatilization of sodium and it cannot detect light elements such as boron and lithium. Further investigation is required for developing other techniques to supply this information.

Characteristics of different glass types have been distinguished using RI and density measurements and useful results have been obtained. Chemical analysis showed two distinct types of glass. One type was a soda-lime-silica type and the other was a high lead type. The group of beads classified as oyster (Munsell No.5 GY 9/1) and white (Munsell No N 9.5/90.0% R) are good examples. The oyster variety fits a tight cluster while the white bead results are more scattered. The oyster beads have relatively low RI and density measurements. Chemical analysis shows these to be soda-lime-silica glass. Some of the white beads are lead enriched. Differences between soda-lime-silica and lead glass suggests different factories or sources of origin.

Compositional analysis of some of the beads from Mgungundlovu and Ondini showed that the bead varieties were remarkably similar. This indicates consistency of manufacture over forty years, suggesting that either:

a. the supply of raw materials for making the glass for the beads was uninterrupted for forty years, or
b. glassmakers were skilled in reproducing the same glass composition without the sophistication provided by modern computers, or they compensated successfully if there were interruption in trade and availability of the raw materials.

Most methods of glass making and colouring relied on the skill of the glass-maker and his control over the quality and preparation of the raw materials, their use in correct proportions and the furnace conditions used for production. Copper oxide, for example, can produce two different colours according to the furnace conditions. In a reducing atmosphere, Cu produces an "Indian" red colour but under oxidizing conditions it produces blue or green tinted glass.

Some colours depend on lead additives for their success. Many of the glass beads analysed here were rich in lead, particularly the green and yellow beads. The transparent light green or apple green cores of the "Indian" red or Redwood on green beads are also made from glass containing lead. Very small changes in colourants will give different intensities of colour. Spectral analysis would be useful to show the differences. The potential of this method for future bead research will have to be investigated.

ARCHAEOLOGY

Glass beads were recovered from various localities at Mgungundlovu including the *isigodlo* (royal quarters), the *isigodlo* midden, the *bheje*, warrior huts and the main entrance of the Royal capital. The Ondini sample is represented by finds from hut floors within the *isigodlo*, and middens throughout the site.

The beads show a dramatic shift within forty years from a preponderance of white beads found at Mgungundlovu to pink ones at Ondini. Pink beads were present in the archaeological record at Mgungundlovu, but in small numbers. If the question of supply is pertinent to the explanation, then it seems highly unlikely that a shortage of a particular colour would have extended for more than 10 years.

It is not exactly clear either why "Indian" red or Redwood on green beads were so poorly represented at Ondini (n=21) compared to Mgungundlovu (n=1079). Admittedly, 446 of such beads were found together in one cluster in the *isigodlo* midden. The most obvious interpretation for this occurrence is that a string of newly acquired beads broke and that they were swept up with the rubbish. Schofield would have attributed this to his conviction that when beads became more common their individual value diminished and so they appeared more frequently in middens. When beads were rare and valuable they would have been carefully treasured and therefore would not have found their way into rubbish heaps (R.Summers unpublished manuscript).

It might well have been that the "Indian" red or Redwood on green beads were not as sought after by the time of Cetshwayo as they had been earlier. It is more than likely that the ruby on white core *Cornaline d'Aleppo* bead became more fashionable, and replaced the "Indian" red or Redwood on green type. Sprague (1985:94) noted that from personal observation, the chronology for this bead type began in North America with the "Indian" red or Redwood on green core which was replaced by a dark ivory center with a brick red outer layer i.e "Indian" red or

Redwood. By 1860 the core had become white and by 1880 the outer layer became a much more brilliant red due to the introduction of modern dyes.

It should be noted that ruby on white core *Cornaline d'Aleppo* beads were recovered from both Mgungundlovu (n = 182) and Ondini (n = 753). Compositional analysis of 36 samples from this collection showed a remarkable similarity between the glass composition. Even more remarkable is the comparison between these specimens, and 21 beads of the same type from Ondini. Analysis also showed that the only brilliant outer layered red bead with a noticeably different chemical composition was a modern bead from the Van Riet Lowe collection (1935). This bead was the only example with high calcium and alumina content and no lead in either the white or ruby coloured glass.

It would appear, therefore, that *Cornaline d'Aleppo* beads with white cores arrived in southern Africa much earlier than 1860. The evidence for this particular bead does not support Killick's suggestion (in De Corse 1989:45) that beads in southern and eastern Africa have similar distributions to trade beads in North America during the 19th century. These bead must have arrived in South Africa before they did in North America.

Detailed analysis of glass beads found at Mgungundlovu have been used successfully to assess the occurrence of historical accounts. According to an early trader, Dingane allowed the Zulu to wear only black, brick-colour, or blue beads; scarlet, tambours and striped beads were called the King's beads and were reserved for his use only (Makeurtan 1930:168). These bead types were found at Mgungundlovu and subtle differences in distribution were observed. The majority of the striped beads were recovered from the *bheje* area and the *isigodlo* midden. However, there were also striped beads found at the entrance and the *isigodlo* huts. They were presumably the property of royal wives and important men (or their wives).

Ludlow (1882:78) noticed that because large red beads had been reserved for King Cetshwayo's wives and daughters, many women were interested in obtaining this particular type. 76 large red beads (W111a *ruby red Cornaline d'Aleppo on white/yellow cores*) were found in the *isigodlo* area of Ondini, compared to 26 at Mgungundlovu.

CONCLUSIONS AND FUTURE DIRECTIONS

This study applied two different sets of procedures to classify large numbers of glass beads which were excavated from 19th century Zulu royal residences in Natal. The first method followed traditional visual classification based on formal taxonomy and the second used physicochemical analysis to test the visual selection process. Certain types of beads chosen for analysis were produced for over a hundred years. The results provided useful insights into the history of glass making and the ingredients that were used. They also provide a separate source for testing written records.

Glass beads can provide better understanding of the social, political and economic importance of the inhabitants of a site within the hierarchy of similar sites. In this instance glass beads have been documented for two Zulu royal residences. Future work should include archaeological investigations from Zulu homesteads and villages. The documentation of distribution and internal trade networks using glass beads as indicators can make a useful contribution to the history, ethnography and archaeology of southern Africa. It would be useful to compare the Royal residences with other homesteads in the Zulu kingdom, confirming the distribution of imported material amongst the Zulu nation. Such studies might also assist in clarifying the controversial issue of 'bead currency'. As Schofield pointed out (1958:228), trade beads probably had different values at different places at the same time.

Benchmarks for glass trade beads, such as the two from Mgungundlovu and Ondini, must be further documented for future comparative analysis. This will contribute towards the knowledge and understanding of a dynamic international infrastructure in which South Africa played a vital role.

The lack of factory site material made it difficult to source the beads with accuracy. Comparison with assemblages elsewhere suggest that the majority of the beads came from Venice. If so, then the manufacturers were making different types of glass. The results of this study provide a detailed characterization of the beads arriving in one part of Africa during two securely dated short periods in the 19th century. Future research can build on these two data points.

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APPENDIX

(i)

CORNALINE D'ALEPPO

SAMPLE NO	SITE	EXCAVATOR	COLOUR	COMMON NAME CORNALINE	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	REFRACTIVE INDEX SCARLET	WHITE	LENGTH (mm)	DIAM (mm)	TYPE KARKLINS 1985
AA116	MG	HALL	2.5 R 3/10	CORNALINE	0.1050	0.0743	0.8720	2.982	1.565	1.526	3.10	4.10	1Va
AA117	MG	HALL	2.5 R 3/10	CORNALINE	0.0759	0.0534	0.8720	2.941			2.90	4.10	1Va
AA118	MG	RAWLINSON	7.5 R 3/8	UMGAZI	0.0269	0.0172	0.8720	2.418	1.550	1.513	1.90	3.00	1Va
AA119	MG	HALL	2.5 R 3/10	CORNALINE	0.0792	0.0556	0.8720	2.926			4.10	3.80	1Va
AA122	MG	PARKINGTON	2.5 R 3/10	CORNALINE	0.0910	0.0655	0.8720	3.111	1.584	1.540	3.70	4.10	1Va
AA123	MG	HALL	2.5 R 3/10	CORNALINE	0.1318	0.0949	0.8720	3.114			3.20	4.60	1Va
AA124	MG	RAWLINSON	7.5 R 3/8	UMGAZI	0.0717	0.0479	0.8720	2.627			2.80	4.10	1Va
AA125	MG	RAWLINSON	7.5 R 3/8U	UMGAZI	0.1519	0.1085	0.8720	3.052	1.579	1.560	3.10	5.10	1Va
AA127	MG	HALL	2.5 R 3/10	CORNALINE	0.8259	0.5966	0.8720	3.140	1.582	1.528	8.40	6.90	W111a
AA129	MG	RAWLINSON	7.5 R 3/8	UMGAZI	0.0299	0.0198	0.8720	2.581			1.80	3.10	1Va
AA130	MG	HALL	2.5 R 3/10	CORNALINE	0.1866	0.1334	0.8720	3.058			4.10	5.00	1Va
AA131	MG	HALL	2.5 R 3/10	CORNALINE	0.1564	0.1112	0.8720	3.017	1.579	1.528	3.10	4.20	1Va
AA132	MG	HALL	2.5 R 3/10	CORNALINE	0.1127	0.0800	0.8720	3.005			3.10	4.20	1Va
AA133	MG	HALL	2.5 R 3/10	CORNALINE	0.1850	0.1338	0.8720	3.150			BROKEN	BROKEN	W111a
AA134	MG	HALL	2.5 R 3/10	CORNALINE	0.0568	0.0394	0.8720	2.846			2.20	3.80	1Va
AA135	MG	HALL	2.5 R 3/10	CORNALINE	0.0719	0.0514	0.8720	3.058			3.20	3.90	1Va
AA136	MG	HALL	2.5 R 3/10	CORNALINE	0.5752	0.3657	0.8720	2.394	1.580	1.550	9.40	6.70	W111a
AA137	MG	HALL	2.5 R 3/10	CORNALINE	0.1490	0.1064	0.8720	3.050			4.40	4.80	1Va
AA138	MG	HALL	2.5 R 3/10	CORNALINE	0.7949	0.5752	0.8720	3.155	1.500	1.527	8.35	7.8	W111a
AA139	MG	HALL	2.5 R 3/10	CORNALINE	0.0672	0.0476	0.8720	2.989			2.70	4.20	1Va
AA141	MG	HALL	2.5 R 3/10	CORNALINE	0.0842	0.0547	0.8720	2.488			2.90	5.50	1Va
AA143	MG	ROODT	7.5 R 3/8	UMGAZI	0.0219	0.0144	0.8720	2.546			2.10	2.20	1Va
AA145	MG	ROODT	2.5 R 3/10	CORNALINE	0.1032	0.0746	0.8720	3.146	1.580	1.527	3.10	4.40	1Va
AA146	MG	RAWLINSON	7.5 R 3/8	UMGAZI	0.0283	0.0184	0.8720	2.492			1.90	3.10	1Va
AA147	MG	RAWLINSON	7.5 R 3/8	UMGAZI	0.0424	0.0285	0.8720	2.659			2.50	3.50	1Va
AA148	MG	ROODT	7.5 R 3/8	UMGAZI	0.0481	0.034	0.8720	2.974			2.20	3.00	1Va
AA149	MG	PARKINGTON	7.5 R 3/8	UMGAZI	0.0549	0.0383	0.8720	2.883			2.20	3.00	1Va
AA150	MG	HALL	2.5 R 3/10	CORNALINE	0.0435	0.0297	0.8720	2.748	1.569	1.536	3.00	3.20	1Va
AA151	MG	HALL	2.5 R 3/10	CORN/MAUV	0.6147	0.4490	0.8720	3.234	1.588	1.539	2.90	3.00	W111a
AA155	MG	HALL	7.5 R 3/8	UMGAZI	0.0252	0.0164	0.8720	2.497	1.572	1.527	3.10	2.40	1Va
AA156	MG	ROODT	2.5 R 3/10	CORNALINE	0.0252	0.0162	0.8720	2.441	1.575	1.519	2.00	2.90	1Va
AA157	MG	ROODT	2.5 R 3/10	CORNALINE	1.4946	1.0784	0.8720	3.131	1.579	1.548	10.50	11.90	W111a
AA159	MG	RAWLINSON	2.5 R 3/10	CORNALINE	0.0908	0.0640	0.8720	2.954			4.00	3.60	1Va
AA160	MG	HALL	2.5 R 3/10	CORNALINE	0.1647	0.1191	0.8720	3.149	1.617	1.523	3.90	5.10	1Va
AA292	MG	PARKINGTON	7.5 R 3/8	UMGAZI	0.1194	0.0867	0.8587	3.135	1.628	1.538	3.40	4.60	1Va
AA298	MG	ROODT	7.5 R 3/8	UMG/YELL	1.0665	0.7888	0.8587	3.297	1.579	1.577	3.90	3.70	W111a
							MEAN	2.900	1.577	1.535			
							S.0	0.263	0.025	0.015			
							C.V	9.097	1.634	1.012			
							n	36	17	17			
AA128	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0274	0.0178	0.8720	2.488			1.90	3.00	1Va
AA142	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.3349	0.2404	0.8609	3.050	1.612	1.580	7.10	6.80	W111a
AA144	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0294	0.0197	0.8720	2.643	1.561	1.526	2.10	2.90	1Va
AA161	ONDINI	RAWLINSON	7.5 R 3/8	UMG/YELL	0.4454	0.3194	0.8720	3.082	1.586	1.526	BROKEN	BROKEN	W111a
AA162	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0114	0.0079	0.8720	2.840	1.562	1.529	1.50	2.00	1Va
AA163	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0266	0.0189	0.8720	3.012	1.570	1.528	2.00	2.90	1Va
AA164	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0173	0.0121	0.8720	2.901			1.90	2.50	1Va
AA165	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.2782	0.1907	0.8720	2.772	1.563	1.518	BROKEN	BROKEN	W111a
AA167	ONDINI	RAWLINSON	2.5 R 3/10	CORNALINE	0.0257	0.0185	0.8720	3.112	1.579	1.526	2.00	2.50	1Va
AA168	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0179	0.0133	0.8720	3.393			1.80	2.50	1Va
AA169	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0070	0.0049	0.8720	2.906	1.564	1.528	1.10	2.00	1Va
AA170	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0191	0.0134	0.8720	2.922			1.50	2.80	1Va
AA171	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0149	0.0103	0.8720	2.824			1.80	2.10	1Va
AA172	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0112	0.0076	0.8720	2.712	1.565	1.515	1.40	2.10	1Va
AA173	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0657	0.0461	0.8720	2.923	1.582	1.520	2.50	4.00	1Va
AA174	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0065	0.0046	0.8720	2.983	1.628	1.520	1.60	1.80	1Va
AA175	ONDINI	RAWLINSON	7.5 R 3/10	UMGAZI	0.0250	0.0173	0.8720	2.831			1.90	3.00	1Va
AA280	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0158	0.0113	0.8587	3.015	1.551	1.520	1.55	1.60	1Va
AA306	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.0300	0.0215	0.8587	3.030	1.561	1.526	2.10	3.25	1Va
AA308	ONDINI	RAWLINSON	7.5 R 3/8	UMGAZI	0.6557	0.4670	0.8587	2.983	1.589	1.550	3.85	2.30	W111a
AA332	ONDINI	RAWLINSON	2.5 R 3/10	CORN/PINK	0.8164	0.5793	0.8608	2.964	1.580	1.551	BROKEN	BROKEN	W111a
							MEAN	2.923	1.577	1.531			
							S.D.	0.182	0.020	0.016			
							C.V.	6.224	1.274	1.073			
							n	21	15	15			
AA333	MALAWI	KILLICK	2.5 R 3/10	CORNALINE	1.2973	0.9244	0.8608	2.994	1.609	1.550	BROKEN	BROKEN	W111a
AA120	PHALABORWA	V D MERWE	7.5 R 3/8	UMGAZI	0.0210	0.0138	0.8720	2.543	1.573	1.527	1.10	3.10	1Va
AA121	BAMBANDYANALO	FOUCHE	7.5 R 3/8	UMGAZI	0.0342	0.0230	0.8720	2.662	1.571	1.513	2.00	3.20	1Va
AA126	PHALABORWA	V D MERWE	2.5 R 3/10	CORNALINE	0.2106	0.1456	0.8720	2.831	1.580	1.520	4.10	6.00	1Va
AA126	PHALABORWA	V D MERWE	2.5 R 3/10	CORNALINE	0.2106	0.1456	0.8720	2.831	1.580	1.519	4.10	6.00	1Va
AA152	PHALABORWA	V D MERWE	2.5 R 3/10	CORNALINE	0.0287	0.0197	0.8720	2.780	1.579	1.537	6.30	7.50	1Va
AA154	PHALABORWA	V D MERWE	7.5 R 3/8	UMGAZI	0.0448	0.0304	0.8720	2.712	1.569	1.523	1.50	2.80	1Va
AA166	MAPUNGUBWE	FOUCHE	2.5 R 3/10	CORNALINE	0.0070	0.0049	0.8720	2.906	1.579	1.513	2.00	2.90	1Va
AA331	PHALABORWA	V D MERWE	2.5 R 3/10	CORNALINE	0.1058	0.0753	0.8608	2.986	1.607	1.521	2.70	4.90	1Va
							MEAN	2.781	1.579	1.521			
							S.0	0.131	0.011				
							C.V	4.721	0.695				
				MODERN CORNALINE			n	8	8				
AA38	TRANSKEI	BROSTER	6.2 R 3/12	MOD CORN	0.0146	0.0099	0.8720	2.708	1.517	1.511	1.90	2.00	1Va
AA38a	TRANSKEI	BROSTER	6.2 R 3/12	MOD CORN	0.0129	0.0088	0.8720	2.743	1.516	1.512	1.80	2.00	1Va
AA241	WITS	V R LOWE	6.2 R 3/12	MOD CORN	0.3200	0.2122	0.8720	2.588	1.550	1.519	4.40	7.40	1Va
AA242	V R L	WITS	6.25 R 4/14	MOD CORN	0.0118	0.0082	0.8700	2.851	1.569	1.520	1.50	2.40	1Va
AA290	MURANO	SAITOWITZ	7.5 R 3/8	UMGAZI	0.0513	0.0362	0.8587	2.917	1.590	1.520	2.40	3.75	1Va
AA330	WITS	V R LOWE	6.2 R 3/12	MOD CORN	0.9676	0.6810	0.8608	2.906	1.598	1.537	7.10	7.70	W111a
							MEAN	2.786	1.556	1.520			
*	UNM =	UNMOUNTED					S.D.	0.117	0.032	0.008			
							C.V.	4.215	2.073	0.560			
							n	6	6	6			

APPENDIX

(ii)

RUBY

SAMPLE NO	SITE	EXCAVATOR	COLOUR RUBY	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARKLINS '85
AA204	MG	HALL	2.5 R 3/10	RUBY	0.2955	0.2085	0.8574	2.9122	2.00	2.90	1.5740	W1a
AA205	MG	HALL	2.5 R 3/10	RUBY	0.1867	0.1327	0.8574	2.9644	5.20	6.00	1.5700	W1a
AA206	MG	RAWLINSON	2.5 R 3/10	RUBY	0.0196	0.0132	0.8599	2.6334	1.50	3.00		11a
AA207	MG	RAWLINSON	2.5 R 3/10	RUBY	0.0253	0.0170	0.8574	2.6135	2.00	3.00	1.5190	11a
AA287	MG	RAWLINSON	2.5 R 3/10	RUBY	0.0229	0.0158	0.8608	2.7764	2.89	3.00	1.5210	11a
AA297	MG	PARKINGTON	2.5 R 3/10	RUBY	0.1737	0.1232	0.8608	2.9608	5.03	5.01	1.5720	11a
							MEAN	2.8101			1.5512	
							S.D	0.1460			0.0255	
							C.V	5.1962			1.6448	
							n	6			5	
AA246	WITS	V R LOWE	2.5 R 3/10	RUBY	0.0893	0.0603	0.8574	2.6402	4.00	4.70	1.5100	11a
AA249	WITS	V R LOWE	2.5 R 3/10	RUBY	0.1503	0.1019	0.8574	2.6625	4.40	5.20	1.5100	11a
							MEAN	2.6514		MEAN	1.5100	
							S.D	0.0112		S.D		
							C.V	0.4214		C.V		
							n	2		n	2	

* UNM = UNMOUNTED

APPENDIX

(iii)

INDIAN RED ON GREEN

SAMPLE NO	SITE	EXCAVATOR	COLOUR INDIAN RED ON GREEN	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	REFR INDEX	LENGTH (mm)	DIAM (mm)	TYPE KARK 1985
AA15	MAP	FOUCHE	10 R 4/8	INDIAN/G	0.0829	0.0552	0.8628	2.582	1.538	2.90	4.40	1Va
AA16	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0268	0.0182	0.8626	2.688	1.537	1.60	2.90	1Va
AA16A	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0217	0.0142	0.8626	2.495		1.50	2.50	1Va
AA17	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0389	0.0257	0.8626	2.542		1.60	2.90	1Va
AA18	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0432	0.0290	0.8626	2.624	1.543	2.30	3.01	1Va
AA19	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0640	0.0423	0.8626	2.544	1.539	3.21	3.60	1Va
AA19A	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0388	0.0258	0.8626	2.574	1.539	2.50	3.50	1Va
AA21	MG	ROODT	10 R 4/8	INDIAN/G	0.0395	0.0279	0.8626	2.937	1.544	2.10	3.10	1Va
AA55	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0348	0.0233	0.8626	2.610		2.45	3.30	1Va
AA64	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0325	0.0216	0.8626	2.572		2.40	3.20	1Va
AA65	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0343	0.0232	0.8626	2.665		2.30	3.20	1Va
AA66	MAP	FOUCHE	10 R 4/8	INDIAN/G	0.0470	0.0314	0.8626	2.598	1.543	2.90	3.20	1Va
AA67	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.0304	0.0202	0.8626	2.570		1.01	2.01	1Va
AA69	MG	ROODT	10 R 4/8	INDIAN/G	0.0271	0.0180	0.8626	2.568		2.00	3.00	1Va
AA72	MG	HALL	10 R 4/8	INDIAN/G	0.0359	0.0238	0.8626	2.559	1.546	2.20	3.30	1Va
AA74	MG	HALL	10 R 4/8	INDIAN/G	0.0356	0.0236	0.8626	2.559	1.540	2.25	3.35	1Va
AA75	MG	HALL	10 R 4/8	INDIAN/G	0.0418	0.0277	0.8626	2.557		2.70	3.30	1Va
AA76	MG	HALL	10 R 4/8	INDIAN/G	0.0269	0.0178	0.8626	2.549	1.537	1.75	1.32	1Va
AA78	MG	HALL	10 R 4/8	INDIAN/G	0.0697	0.0461	0.8626	2.547		3.00	3.40	1Va
AA79	MG	HALL	10 R 4/8	INDIAN/G	0.0396	0.0265	0.8626	2.607		2.51	3.40	1Va
AA81	MG	HALL	10 R 4/8	INDIAN/G	0.4060	0.2730	0.8599	2.625	1.539	2.60	3.50	1Va
AA82	MG	HALL	10 R 4/8	INDIAN/G	0.4990	0.3340	0.8599	2.600		2.70	3.60	1Va
AA83	MG	HALL	10 R 4/8	INDIAN/G	0.4840	0.3260	0.8599	2.634		2.65	3.55	1Va
AA240	HAAS	SAMPSON	10 R 4/8	INDIAN/G	0.1089	0.0714	0.8720	2.532	1.538	3.50	4.40	1Va
AA299	MG	RAWLINSON	10 R 4/8	INDIAN/G	0.0989	0.0664	0.8608	2.619	1.535	3.20	4.70	1Va
AA300	MG	PARKINGTON	10 R 4/8	INDIAN/G	0.1028	0.0700	0.8608	2.697	1.540	3.90	4.30	1Va
AA301	MG	PARKINGTON	10 R 4/8	INDIAN/R	0.0426	0.0294	0.8608	2.778	1.541	2.56	3.55	1Va
AA311	MG	HALL	10 R 4/8	INDIAN/G	0.0831	0.0589	0.8574	2.944	1.536	2.56	4.56	1Va
							MEAN	2.621	1.540			
							S.D	0.106	0.003			
							C.V	4.028	0.196			
							n	28	16			

APPENDIX.

(iv)

<u>INDIAN RED</u>

SAMPLE NO	SITE	EXCAVATOR	COLOUR INDIAN RED	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY (g/cc)	BULK DENSITY (g/cc)	R.I.	LENGTH (mm)	DIAM (mm)	TYPE KARKLINS '85
AA13	MG	ROODT	7.5 R 3/8	INDIAN/R	0.0481	0.0304	0.8626	2.344	1.522	2.5	5.57	1Va
AA14	MG	PARKINGTON	7.5 R 3/8	INDIAN/R	0.0298	0.0241	0.8626	4.509	1.559	2.5	3.00	1Va
AA23	MG	ROODT	7.5 R 3/8	INDIAN/R	0.0271	0.0175	0.8626	2.435		2.0	3.00	1Va
AA236	MG	HALL	7.5 R 3/8	INDIAN/R	0.0307	0.0204	0.8720	2.599	1.538	2.2	3.30	1Va
AA239	MG	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0091	0.0063	0.8720	2.834	1.549	1.4	2.30	1Va
AA312	MG	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0462	0.0350	0.8574	3.536		2.5	3.57	1Va
							MEAN	3.043	1.542			
							S.D	0.763	0.013			
							C.V	25.076	0.901			
							n	6	4			
AA6	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0304	0.0203	0.8626	2.596		2.10	3.40	1Va
AA8	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0390	0.0261	0.8626	2.607		2.50	3.41	1Va
AA9	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0365	0.0246	0.8626	2.645	1.522	2.40	3.40	1Va
AA24	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0317	0.0213	0.8626	2.629	1.550	2.30	3.20	1Va
AA28	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0157	0.0112	0.8626	3.009	1.561	1.70	2.60	1Va
AA31	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0094	0.0063	0.8626	2.615	1.541	1.50	2.50	1Va
AA32	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0130	0.0081	0.8626	2.288	1.542	1.50	2.50	1Va
AA237	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0111	0.0076	0.8720	2.765	1.541	1.60	2.40	1Va
AA238	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0115	0.0075	0.8720	2.507	1.552	1.50	2.40	1Va
AA295	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0374	0.0283	0.8608	3.537	1.540	2.52	3.25	1Va
AA309	ONDINI	RAWLINSON	7.5 R 3/8	INDIAN/R	0.0407	0.0257	0.8608	2.335	1.539	2.45	3.51	1Va
							MEAN	2.685	1.543			
							S.D	0.326	0.010			
							C.V	12.161	0.658			
							n	11	9			
AA2	SOFALA	V R L	7.5 R 3/8	INDIAN/R	0.0252	0.0162	0.8626	2.415		3.00	5.00	1Va
AA3	JAVA	V R L	7.5 R 3/8	INDIAN/R	0.1440	0.0959	0.8626	2.582		4.04	5.05	1Va
AA4	ZANZIBAR	V R L	7.5 R 3/8	INDIAN/R	0.1575	0.1012	0.8626	2.413		4.40	5.50	1Va
AA5	MAPUNGUBWE	FOUCHE	7.5 R 3/8	INDIAN/R	0.1344	0.0877	0.8626	2.482		2.02	4.53	1Va
AA80	BOLAHLA	PARKINGTON	7.5 R 3/8	INDIAN/R	0.0418	0.0287	0.8626	2.752	1.539	2.55	3.56	1Va
AA255	SHIKUMBU	MEYER	7.5 R 3/8	INDIAN/R	0.0493	0.0357	0.8602	3.118	1.579	2.60	3.10	1Va
AA256	MAPUNGUBWE	MEYER	7.5 R 3/8	INDIAN/R	0.0183	0.0122	0.8602	2.580	1.529	2.50	3.00	1Va
							MEAN	2.620	1.549			
							S.D	0.230	0.021			
							C.V	8.800	1.394			
							n	7	3			

APPENDIX
(v)

WHITE

SAMPLE NO	SITE	EXCAVATOR	COLOUR	COMMON NAME OYSTER WHITE	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENS (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARKLINS '85
AA84	MG	HALL	5 GY 9/1	OYSTER WHITE	0.3530	0.2350	0.8599	2.5724	2.00	3.10	1.5280	11a
AA87	MG	HALL	5 GY 9/1	OYSTER WHITE	0.4060	0.2700	0.8599	2.5671	2.60	3.50	1.5350	
AA87	MG	HALL	5 GY 9/1	OYSTER WHITE	0.4060	0.2700	0.8599	2.5671	2.20	4.50	1.5350	11a
AA210	MG	HALL	5 GY 9/1	OYSTER WHITE	0.0245	0.0163	0.8602	2.5701	1.70	3.00	1.5370	11a
AA216	MG	HALL	5 GY 9/1	OYSTER WHITE	0.0283	0.0212	0.8602	3.4287	1.90	2.90		11a
AA285	MG	HALL	5 GY 9/1	OYSTER WHITE	0.0368	0.0244	0.8596	2.5511	2.70	3.10	1.5350	11a
AA286	MG	HALL	5 GY 9/1	OYSTER WHITE	0.0526	0.0362	0.8596	2.7570	3.15	3.45	1.5300	11a
AA316	MG	ROODT	5 GY 9/1	OYSTER WHITE	0.0464	0.0310	0.8596	2.5900	2.71	3.12	1.5340	11a
AA317	MG	PARKINGTON	5 GY 9/1	OYSTER WHITE	0.0592	0.0395	0.8596	2.5832	2.56	4.00	1.5320	11a
AA319	MG	RAWLINSON	5 GY 9/1	OYSTER WHITE	0.0732	0.0486	0.8596	2.5578	3.30	4.38	1.5320	11a
AA320	MG	PARKINGTON	5 GY 9/1	OYSTER WHITE	0.0684	0.0452	0.8596	2.5343	2.57	4.10	1.5310	11a
							MEAN	2.6617			2.5850	
							S.D	0.2490			0.0026	
							C.V	9.3561			0.1015	
							n	11			10	

LIGHT GREY

SAMPLE NO	SITE	EXCAVATOR	COLOUR	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENS (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARKLINS '85
AA198	MG	HALL	N 8.25/63.65 R	LIGHT GREY	0.3834	0.2517	0.8602	2.5042	6.10	7.00		11a
AA212	MG	HALL	N 8.25/63.65 R	LIGHT GREY	0.0240	0.0165	0.8602	2.7526	2.50	2.70		11a
AA223	MG	HALL	N 8.25/63.65 R	LIGHT GREY	0.4409	0.2837	0.8591	2.4095	6.20	2.50		1f
AA224	MG	HALL	N 8.25/63.65 R	LIGHT GREY	0.0380	0.0256	0.8602	2.6361	2.60	3.50		11a
AA225	MG	HALL	N 8.25/63.65 R	OYSTER/CORE	0.4177	0.2725	0.8602	2.4746	5.70	7.30		1f
							MEAN	2.5554				
							S.D	0.1232				
							C.V	4.8200				
							n	5				

WHITE

SAMPLE NO	SITE	EXCAVATOR	COLOUR	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENS (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARKLINS '85
AA199	MG	RAWLINSON	N 9.5/90.0%R	WHITE	0.0794	0.0588	0.8602	3.3155	2.10	4.20	1.5832	11a
AA202	MG	PARKINGTON	N 9.5/90.0%R	WHITE	0.0512	0.0386	0.8587	3.4872	2.10	3.20	1.6550	11a
AA203	MG	PARKINGTON	N 9.5/90.0%R	WHITE	0.0390	0.0266	0.8602	2.7055	2.00	3.10	1.5370	11a
AA211	MG	HALL	N 9.5/90.0%R	WHITE	0.4000	0.3120	0.8602	3.9100	5.60	6.20	1.6900	11a
AA213	MG	RAWLINSON	N 9.5/90.0%R	WHITE	0.1449	0.1047	0.8602	3.1006	2.70	5.50	1.6000	11a
AA214	MG	RAWLINSON	N 9.5/90.0%R	WHITE	0.0974	0.0708	0.8602	3.1498	3.00	4.50		11a
AA282	MG	RAWLINSON	N 9.5/90.0%R	WHITE	0.0556	0.0402	0.8596	3.1035	3.85	3.15	1.6120	11a
AA284	MG	HALL	N 9.5/90.0%R	WHITE	0.0417	0.0302	0.8596	3.1170	2.45	3.20	1.6100	11a
AA318	MG	RAWLINSON	N 9.5/90.0%R	WHITE	0.1614	0.1161	0.8596	3.0627	3.55	5.06	1.5700	11a
							MEAN	3.2169			1.60715	
							S.D	0.3144			0.0449	
							C.V	9.7724			2.7923	
							n					
AA219	ONDINI	RAWLINSON	N 9.5.90.0% R	WHITE	0.0244	0.0192	0.8602	4.0363	1.80	2.70	1.6900	10 11a
AA348	PHALABORWA	V.D.MERWE	5 GY 9/1	OYSTER WHITE	0.0528	0.0363	0.8608	2.7546	3.40	4.00	1.5300	42 11a
AA102	V R LOWE	SAITOWITZ	N 9.5/90.0%R	WHITE	0.2254	0.1615	0.8574	3.0244	4.40	5.04	1.5510	28 11a

APPENDIX

(vi)

BRIGHT NAVY

SAMPLE NO	SITE	EXCAVATOR	COLOUR	COMMON NAME BRIGHT NAVY	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARLINS '85
AA313	MG	ROODT	7.5PB 2/8	BRIGHT NAVY	0.5002	0.3250	0.8574	2.4479	5.05	7.90	1.5040	1f
AA314	MG	HALL	7.5PB 2/8	BRIGHT NAVY	0.5598	0.3638	0.8574	2.4488	10.10	8.20	1.5050	1f
AA315	MG	HALL	7.5PB 2/8	BRIGHT NAVY	0.1190	0.0779	0.8574	2.4825	4.81	4.92	1.5000	1f
AA342	MG	HALL	7.5PB 2/8	BRIGHT NAVY	0.1879	0.1239	0.8608	2.5273	4.00	6.50	1.5150	W1a
AA343	MG	HALL	7.5PB 2/8	BRIGHT NAVY	0.1970	0.1299	0.8608	2.5272	4.00	6.40	1.5190	W1a
AA344	MG	HALL	7.5PB 2/8	BRIGHT NAVY	0.7173	0.4647	0.8608	2.4444	7.50	7.90	1.5090	11a
							MEAN	2.4797			1.5087	
							S.D	0.0359			0.0065	
							C.V	1.4484			0.4341	
							n	6			6	
AA345	ONDINI	RAWLINSON	7.5PB 2/8	BRIGHT NAVY	1.8397	1.2098	0.8608	2.5141	11.10	12.50	1.5250	W1a
AA346	ONDINI	RAWLINSON	7.5PB 2/8	BRIGHT NAVY	0.9383	0.6132	0.8608	2.4844	BROKEN	BROKEN	1.5200	W1a
							MEAN	3.9554			1.5225	
							S.D	0.0148			0.0025	
							C.V	0.3747			0.1642	
							n	2			2	
AA347	PHALABORWA	V D MERWE	7.5PB 2/8	BRIGHT NAVY	1.0763	0.6938	0.8608	2.4222	8.40	9.80	1.5020	1f

SHADOW BLUE

AA324	MG	HALL	2.5PB 5/4	SHADOW BLUE	0.1273	0.0848	0.8596	2.5748	4.01	4.81	1.5200	11a
AA334	MG	HALL	2.5PB 5/4	SHADOW BLUE	0.0754	0.0512	0.8608	2.6820	3.30	4.10		11a
AA335	MG	HALL	2.5PB 5/4	SHADOW BLUE	0.0938	0.0630	0.8608	2.6215	3.30	4.40	1.5390	11a
AA336	MG	HALL	2.5PB 5/4	SHADOW BLUE	0.1031	0.0693	0.8608	2.6257	3.90	4.10	1.5340	11a
AA337	MG	HALL	2.5PB 5/4	SHADOW BLUE	0.0797	0.0533	0.8608	2.5987	3.60	3.70		11a
AA338	MG	HALL	2.5PB 5/4	SHADOW BLUE	0.0925	0.0622	0.8608	2.6279	3.60	4.40	1.5310	11a
							MEAN	2.6218			1.5310	
							S.D	0.0327			0.0070	
							C.V	1.2479			0.4549	
							n	6			4	
AA339	PHALABORWA	V D MERWE	2.5PB 5/4	SHADOW BLUE	0.0263	0.0180	0.8608	2.7276	2.20	3.10	1.5320	11a
AA340	PHALABORWA	V D MERWE	2.5PB 5/4	SHADOW BLUE	0.0248	0.0178	0.8608	3.0497	2.4	3.1	1.5310	11a
AA341	MAPUNGUBWE	FOUCHE	2.5PB 5/4	SHADOW BLUE	0.0467	0.0315	0.8608	2.6447	2.7	3.3	1.5280	11a
							MEAN	2.807			1.5303	
							S.D	0.174			0.0017	
							C.V	6.222			0.1111	
							n	3			3	

* UNM = UNMOUNTED

APPENDIX

(vii)

DARK GREEN (TRANSLUCENT)

SAMPLE NO	SITE	EXCAVATOR	COLOUR DARK GREEN	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	R.I.	LENGTH (mm)	DIAM (mm)	TYPE KARKLINS '85
AA111	MG	HALL	2.5 G 3/6	DARK GREEN	0.0519	0.0415	0.8599	4.291		1.80	2.50	11a
AA178	MG	HALL	2.5 G 3/6	DARK GREEN	0.0803	0.0632	0.8604	4.040	1.677	2.90	3.90	11a
AA181	MG	ROODT	2.5 G 3/6	DARK GREEN	0.0393	0.0314	0.8591	4.273	1.636	3.00	3.10	11a
AA182	MG	HALL	2.5 G 3/6	DARK GREEN	0.0646	0.0508	0.8604	4.027	1.675	2.50	3.60	11a
AA183	MG	HALL	2.5 G 3/6	DARK GREEN	0.0410	0.0323	0.8604	4.054		2.00	3.00	11a
AA184	MG	RAWLINSON	2.5 G 3/6	DARK GREEN	0.0555	0.0430	0.8720	3.871	1.644	2.20	3.70	11a
AA186	MG	HALL	2.5 G 3/6	DARK GREEN	0.0608	0.0482	0.8604	4.151	1.558	2.00	3.20	11a
AA187	MG	HALL	2.5 G 3/6	DARK GREEN	0.0522	0.0414	0.8604	4.158	1.623	1.90	3.50	11a
AA188	MG	HALL	2.5 G 3/6	DARK GREEN	0.0731	0.0577	0.8720	4.139	1.629	2.90	3.60	11a
AA189	MG	HALL	2.5 G 3/6	DARK GREEN	0.0692	0.0513	0.8604	3.326		2.20	3.90	11a
AA190	MG	HALL	2.5 G 3/6	DARK GREEN	0.0271	0.0206	0.8604	3.587		1.80	3.10	11a
AA192	MG	HALL	2.5 G 3/6	DARK GREEN	0.0682	0.0525	0.8604	3.737	1.662	3.00	3.00	11a
AA266	MG	HALL	2.5 G 3/6	DARK GREEN	0.0523	0.0399	0.8604	3.628		2.80	3.20	11a
AA273	MG(LEACHED)	HALL	2.5 G 3/6	DARK GREEN	0.1203	0.0886	0.8604	3.265		3.70	4.40	11a
AA274	MG	PARKINGTON	2.5 G 3/6	DARK GREEN	0.0820	0.0600	0.8604	3.206		3.00	3.70	11a
							MEAN	3.850	1.638			
							S.D	0.357	0.016			
							C.V	9.278	0.990			
							n	15	8			
AA90	ONDINI	RAWLINSON	2.5 G 3/6	DARK GREEN	0.1590	0.1230	0.8599	3.797	1.635	4.50	4.60	11a
AA194	PHALABORWA	V D MERWE	2.5 G 3/6	DARK GREEN	0.0313	0.0235	0.8604	3.452	1.718	1.90	3.00	11a
AA195	PHALABORWA	V D MERWE	2.5 G 3/6	DARK GREEN	0.0397	0.0309	0.8604	3.881		2.00	2.80	11a
AA196	PHALABORWA	V D MERWE	2.5 G 3/6	DARK GREEN	0.0313	0.0232	0.8604	3.324		1.90	2.60	11a
AA197	PHALABORWA	V D MERWE	2.5 G 3/6	DARK GREEN	0.0297	0.0223	0.8604	3.453		1.90	3.00	11a
							MEAN	3.528	1.718			
							S.D	0.210				
							C.V	5.972				
							n	4				
AA176	KWAZULU	SAITOWITZ	2.5 G 3/6	DARK GREEN	0.0134	0.0093	0.8591	2.807	1.513	1.80	2.20	11a
AA177	KWAZULU	SAITOWITZ	2.5 G 3/6	DARK GREEN	0.0123	0.0084	0.8604	2.713		1.50	2.10	11a
							MEAN	2.760	1.513			

BRIGHT GREEN (TRANSLUCENT)

AA185	MG	RAWLINSON	2.5 G 5/10	BRIGHT GREEN	0.1617	0.1065	0.8591	2.516	1.512	4.60	4.90	1f
AA90	ONDINI	RAWLINSON	2.5 G 5/10	BRIGHT GREEN	0.1591	0.1231	0.8599	3.800	1.725	3.60	3.80	11a

GREEN (OPAQUE)

SAMPLE	SITE	EXCAVATOR	COLOUR	COMMON NAME	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARKLINS '85
				DARK GREEN								
AA268	MG	HALL	2.5 G 3/6	DARK GREEN	0.0621	0.0501	0.8604	4.452	2.41	3.62		11a
AA304	MG	HALL	2.5 G 3/6	DARK GREEN	0.0968	0.0783	0.8574	4.926	2.86	4.56	1.675	11a
AA323	MG	HALL	2.5 G 3/6	DARK GREEN	0.1499	0.1163	0.8596	3.834	3.01	4.72	1.678	11a
							MEAN	4.404		MEAN	1.676	
							S.D	0.446		S.D	0.001	
							C.V	10.034		C.V	0.089	
				BRIGHT GREEN			n	3		n	2	
AA293	ONDINI	RAWLINSON	2.5 G 5/10	BRIGHT GRN	0.0157	0.0131	0.8587	5.185	1.52	2.08	1.704	11a
				DARK JADE								
AA270	MG	HALL	10 RP 8/4	DARK JADE	0.0513	0.0366	0.8604	3.002	2.41	3.44		11a
AA272	MG	HALL	10 RP 8/4	DARK JADE	0.0602	0.0452	0.8604	3.453	2.53	3.51		11a
							MEAN	3.227				
							S.D	0.225				
							C.V	6.977				
				GREEN			n	2				
AA267	MG	HALL	2.5 G 4/8	GREEN	0.0583	0.0437	0.8604	3.435	2.10	3.40		11a
AA269	MG	ROODT	2.5 G 4/8	GREEN	0.0371	0.0266	0.8604	3.040	2.11	3.54		11a
AA271	MG	HALL	2.5 G 4/8	GREEN	0.0475	0.0357	0.8604	3.463	2.56	2.92		11a
AA304	MG	HALL	2.5 G 3/6	GREEN	0.0949	0.0748	0.8587	4.056	2.81	4.51		11a
AA350	MG	HALL	2.5 G 3/6	GREEN	0.0663	0.0531	0.8608	4.323	2.40	3.55	1.670	11a
							MEAN	3.663		MEAN	1.670	
							S.D	0.462				
							C.V	12.621				
							n	5				
AA307	ONDINI	RAWLINSON	2.5 G 3/6	GREEN	0.0211	0.0162	8574	3.6921	1.7	2.7	1.672	11a

* UNM = UNMOUNTED

APPENDIX

(viii)

YELLOW

SAMPLE NO	SITE	EXCAVATOR	COLOUR	COMMON NAME AMBER	DRY MASS (g)	WET MASS (g)	XYLENE DENSITY	BULK DENSITY (g/cc)	LENGTH (mm)	DIAM (mm)	R.I.	TYPE KARKLINS '85
AA321	MG	HALL	7.5 YR 9/10	AMBER	0.1511	0.1253	0.8596	5.0343	3.00	4.00	1.7800	11a
AA322	MG	HALL	7.5 YR 9/10	AMBER	0.1843	0.1528	0.8596	5.0293	3.20	4.50	1.7700	11a
AA325	MG	HALL	7.5 YR 9/10	AMBER	0.2602	0.2115	0.8608	4.5992	4.00	4.80	1.7400	11a
							MEAN	4.8876			1.7633	
							S.D	0.2040			0.0170	
							C.V	4.1731			0.9639	
				DULL YELLOW			n	3			3	
AA327	MG	HALL	5 Y 8/6	DULL YELLOW	0.0920	0.0741	0.8608	4.4242	2.70	3.80	1.7110	11a
AA329	MG	HALL	5 Y 8/6	DULL YELLOW	0.1330	0.1076	0.8608	4.5073	3.20	4.20	1.7800	11a
							MEAN	3.2903			1.7455	
							S.D	0.0416			0.0345	
							C.V	1.2630			1.9765	
							n	2			2	
AA94	ONDINI	RAWLINSON	5 Y 8/6	DULL YELLOW	2.6800	2.1800	0.8599	4.6091	1.70	2.70	1.7220	11a
AA95	ONDINI	RAWLINSON	5 Y 8/6	DULL YELLOW	0.1680	0.1390	0.8599	4.9815	1.50	2.30	1.7110	11a
AA326	ONDINI	RAWLINSON	5 Y 8/6	DULL YELLOW	0.0320	0.0260	0.8608	4.5909	1.90	2.80		11a
AA328	ONDINI	RAWLINSON	5 Y 8/6	DULL YELLOW	4.1940	3.3530	0.8608	4.2927	11.50	12.60	1.7140	W1a
							MEAN	4.6186			1.7157	
							S.D	0.2443			0.0046	
							C.V	5.2895			0.2706	
							n	4			3	

* UNM = UNMOUNTED