THE APPLICATION OF COMPOSITIONAL ANALYSIS TO PROVENANCE STUDIES OF ARCHAEOLOGICAL POTTERY IN SOUTHERN AFRICA: A GEOCHEMICAL PERSPECTIVE USING XRF SPECTROSCOPY

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„The past is hidden outside the realm, beyond the reach of the intellect, in some material object which we do not suspect."
M. Proust

ABSTRACT

Pottery arrived in the South African archaeological record some 2000 years ago. There are two major traditions of pottery making although they may have had the same origins. The first is that of the Khoisan peoples who inhabited the drier coastal and inland areas. They were mobile pastoralists who spent their year in independent groups in the search for water and grazing for their animals. Their pottery, although distinct, is not easy to classify into discrete spatial and temporal phases which is probably a reflection on their migratory lifestyle and lack of any centralised political authority.

The second group were Bantu-speaking farmers, also referred to in archaeological terms as the Iron Age. They spread through the wetter areas suitable for farming and lived in more settled communities many of which reached urban status with thousands of inhabitants. Their pottery, in terms of decoration, is highly formalised and, in contrast to the Khoisan, is organised into well defined discrete phases with temporal and geographical coherence.

Both groups were involved in trade and exchange networks which, for certain Iron Age communities, became continental in scale and resulted in major social transformations taking place in their society. This thesis looks at the problem of sourcing pottery in order to measure the direction and intensity of these networks. The main objective is to assess the viability of sourcing studies in different parts of the country.

The first problem deals with the role of additives such as temper and whether this can mask the original clay signature. Experiments were conducted which show that temper can alter the original clay chemical profile but the scale will depend upon the difference in composition and the amount of temper used. Other problems deal with diagenesis: burial can alter the composition under certain circumstances but at present only phosphorus can be definitely seen to be a contaminant.

A number of provenance case studies centred on various regions in southern Africa are presented.

Each one presents its own specific methodological problems. The most successful results came from two localities. The first, Mutokolwe, in the Soutpansberg, and the second, a succession of sites including Schroda, K2 and Mapungubwe in the Limpopo Valley provided definite evidence to confirm on geochemical grounds that a number of pots were non-local. The other case studies were geochemically successful but indicated that certain regions, for geological reasons, might not be suitable for undertaking provenance studies. Recommendations are made for future research in this promising field.

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CHAPTER 1. INTRODUCTION: BACKGROUND, OBJECTIVES AND ANALYTICAL METHODS

Of all the objects that can be traded or exchanged in the context of southern Africa prehistory, pottery is the most plentiful, is ubiquitous and is stylistically variable in a consistent way over space and time. Whilst there were major trading links over the sub continent with respect to products such as gold, tin, glass beads and ivory, it is pottery that can yield insights into the social and political aspects of pre-colonial society. By defining the spatial and chronological relationships between stylistic traditions and provenanced imports, it may eventually be possible to determine the direction and intensity of social and economic interaction through which social change may have occurred.

1.1 POTTERY IN SOUTHERN AFRICA

At the time of the first European contacts in southern Africa, the indigenous people were using if not making ceramic vessels for storage, cooking and other household activities. There were two major pottery traditions, which closely followed the main cultural and linguistic divisions in the region. The first group is the Khoisan, nomadic herders and hunter-gatherers who roamed across the landscape in the drier southwestern areas of the country searching for plant foods, game, water and grazing for their domestic stock (Schapera 1930; Wilson 1969; Elphick 1985; Barnard 1992; Sadr 2003) as well as working metal if not actual mining although metals were probably obtained by trade (Goodwin 1956). Mining for the mineral specularite was also carried out (Thackeray et al. 1983). This tradition arrived in South Africa approximately 2000 years ago (Sealy & Yates 1994; Bousman 1998; Sadr 1998; Mitchell 2002). Khoisan pottery is characterised by pointed bases, lugs and spouts: decoration is unusual and not nearly as common or as systematic and standardized as Iron Age wares (Rudner 1968, n.d.) although recent research is beginning to identify spatial and chronological characteristics (Sampson 1988; Ridings & Sampson 1990; Sadr & Smith 1991; Sadr & Sampson 1999).

The second group are the Bantu-speaking or Iron Age farmers many of whom by the time of contact were settled in large communities and towns, engaged in agriculture and animal husbandry, mining and working metals (Schapera 1930; Wilson & Thompson 1969; Hammond-Tooke, W.D. 1974; Hammond-Tooke, D. 1993). Many of these groups were also involved in major formal trade networks both internally and with the east coast. Gold, ivory, tin and copper were exported whilst glass beads, cloth and occasional Chinese celadon vessels were imported (Evers 1974; De Vaal 1984, 1985; Meyer & Esterhuizen 1994). The earliest Iron Age pottery is dated to between 250-430 AD (Mitchell 2002).

Whilst Khoisan communities for the most part seem to have lost the knowledge of making and firing pots by the 20th Century, some information on manufacture and use can still be gleaned from early traveller's accounts (Vedder 1923; Rudner 1968, n.d.; du Pisani & Jacobson 1985; Bollong et al. 1997b).

Many rural Bantu-speaking Iron Age communities, however, have retained this knowledge up until the present and although the use of European goods has replaced traditional wares in many places, much information has been obtained from modern eye witness accounts (Martin 1941; Lawton 1967; Huffman 1972; Otto 1978; Woods 1982, 1984a, b; Dreyer 1988; Jacobson et al. 1998b) to name a few. Lawton (1967) is the most comprehensive summary of known knowledge up until the mid 1960's.

Whilst there are some similarities in the production of pottery by these two groups there are major differences in other areas. The two traditions have in common the fact that all pottery was made by hand. Clay was not levigated but was generally "cleaned" of any lumps or other inclusions deemed unacceptable by hand picking the clay. Temper was often added. This can vary from crushed potsherds, to grit, or more rarely bone and charcoal. Vessels were formed generally by coiling strips or patching small pieces of clay together then smoothing them down. Firing was carried out either in the open or in pits with wood or dung as fuel.

Amongst Bantu-speaking farmers, pottery was made by women (Lawton 1967). This is also the case for the Khoisan (Bollong et al. 1997b) although there is evidence that amongst the Dama of Namibia pottery was made by men (Vedder 1923; du Pisani & Jacobson 1985). The location of clay sources were generally kept confidential by potters in all regions resulting in each potter in a community having a different source or several sources. This only matters if the sources come from different geochemical substrates but it does need to be borne in mind.

For farmers, women potters learn the craft from their mothers and teach their daughters. In any residential community, not every women is necessarily a potter but one or more may supply the whole of that community (e.g., Martin 1941). There are specific shapes of vessels for different functions (Lawton 1967; Huffman 1972) which are common amongst all traditions.

For the Iron Age and generally for modern farmers, decoration varies between groups (Huffman 1980b, 2002b), which means that it is a means of expressing group identity. Thus it is possible to recognise a Zulu or a Kavango pot from the relevant community's characteristic decoration (Lawton 1967). This, of course, does not necessarily mean that the social conditions for decorating pots are exactly the same today as in the past.

The two traditions suggest somewhat different objectives for any provenance project. As the Khoisan were nomadic people, it is possible that their vessels travelled with them especially for those who owned stock and used them as pack animals. There is a famous scene painted by S. Daniell in 1801 showing a group of Namaqua herders close to the Orange River preparing to break camp and showing two ceramic pots suspended from a pole on an ox (illustrated in Deacon & Deacon 1999: figure 10.15). For San hunter-gatherers, who had to carry their possessions with them when on the move, pottery may have been cached pending a return visit to the site. Another fact to consider is the debate over whether there is a difference between Khoi (herder) pottery and San (hunter-gatherer) pottery (Bollong et al. 1997b). Fibre tempered pottery from the Karoo is thought to be characteristic of the latter whilst grit tempered pottery of the former. Of course, the difference could be functional in that fibre tempered wares were used for cooking and the other types for drinking or storage (Bollong et al. 1993, 1997b; Sampson & Vogel 1996). These issues will be dealt with later.

Another feature of Khoisan society is the existence of reciprocal gift exchange known as *hxaro*

(Wiessner 1982; Mitchell 2003). This is a system of delayed reciprocal gift exchange practised by Khoisan communities throughout southern Africa. Gifts were given to partners on the understanding that it would be reciprocated at some future point in time. These obligations bound people together in cross country links whereby marriage partners might be obtained or gifts, information or access to resources might be shared at some future point in times of crisis. In this manner, gift items could be passed onto partners who in turn passed them on over hundreds of kilometres.

It is recorded in Bleek & Lloyd (Bleek & Lloyd 1911 quoted in Bollong et al. 1997) that pots formed part of the hxaro gift exchange system. There is also a phenomenon noticed in archaeological excavations of Later Stone Age sites that often potsherds are found, the sum total of which could not equal a single whole vessel and are very often quite dissimilar to each other. These could be “keepsakes” resulting from hxaro exchange.

For the archaeological past, the Iron Age has been divided into a series of spatial and chronological ceramic traditions with defined spatial boundaries and often demonstrating changes over time which can be gradual or well defined and which are related to social groups or formations (Evers 1988; Denbow 1990, 1999; Klapwijk & Huffman 1996; Whitelaw 1996, 1997; Whitelaw & Moon 1996; Calabrese 2000; Huffman 2002a, b; Mitchell 2002).

What this means practically is that any unit of ceramic analysis, whether a facies, phase or tradition (Huffman 2002b) will have a discrete spatial and chronological presence. This allows any sherd decorated in the style of another tradition to be visually and quickly identified as an “import”. This raises the question of how and why they were there. Were they in fact made locally rather than imported? There is little in the literature to suggest that pots were actually traded further afield than the local community. In fact, the belief (verbally expressed to me by a number of researchers) was that pottery was produced solely for domestic consumption. The only way they could have travelled around the landscape was if they were used as containers or perhaps gifts. However, figure 1.1 is a photographic postcard showing a group of Ovambo pottery dealers or traders (Tontopfhändler) which was taken about 1900 in Ovamboland, Namibia (Jacobson et al. 1985). It would appear from a close examination of the photograph that

Gibion, d. 8. 6. 05

Franz Spenker, Hamburg 19

Ovambo Tontopfhändler.

Deutſch-Süd-Weſt-Afrika.

Herzliche Grüße sendet aus dem fernen Lande
Dein Freund H. Laake 3/2

Figure 1.1. Namibian postcard from approximately 1900 showing “Ovambo pottery traders”.

approximately 25 pots are being carried by the group. If the caption is accurate, this suggests that in this region at any rate, traders roamed the countryside with pots for sale. Alternatively, perhaps the pots were made at a clay source some distance from the community and were being carried home after firing although I believe that it is unlikely that the photographer would have misunderstood or misrepresented the situation.

It might be opportune at this stage to define what is meant by “trade” and “exchange”. Trading or exchanging goods must be almost as old as humanity itself. By the time we have written records these activities had developed into extremely sophisticated undertakings. Although I sometimes use “trade” and “exchange” interchangeably, they are in effect opposite ends of a continuum with occasional side branches. Basically, by “trade” I mean a formal exchange of goods (or services or even people) based upon some mutually agreed value; by “exchange”, more informal transfers of such items, generally not on a commercial basis but having some form of social prerogative. The former might or might not be associated with a market place but essentially it was a business transaction in which either a fixed value was placed on an item or else a value was negotiated.

Exchange has social implications associated with strong ritual and symbolic meanings reflecting the norms of society whether in pre-literate societies (Mauss 1974) or the classical world (von Reden 1995) or even our own society, e.g., exchanging Christmas gifts or giving to charity. Exchange includes actions such as the exchange of gifts on a personal basis (hxaro), tribute as a sign of political allegiance, ritual gift giving: there are a myriad of forms. Often articles are not so much exchanged for themselves but form a secondary aspect to exchange or even trade, i.e., pots used as containers for goods or for food carried on journeys. It may not always be possible to separate out these different uses.

In summary then, there are a number of reasons for pottery, apart from other objects, to move around the landscape. Amongst Khoisan communities, the most basic relates to their nomadic way of life in that pots followed their owners from one camp to another. On a social level, pots, and perhaps even sherds, being used as part of the hxaro gift exchange system. As a trade item, pots would have been obtained through barter. Other informal exchanges would also have taken place: pots used to transport food or other objects, or even as tribute.

For the Iron Age which was a semi-sedentary society, the pattern is somewhat different. Large Iron Age sites have yielded literally tons of sherds indicating extensive usage (and breakage) of pottery. The question arises with respect to the larger settlements and towns whether production became a specialised activity with a few specialist potters providing the needs of the entire settlement. This could result in fewer clay sources being used, assuming they were large enough to cope with the production. Alternatively, limited sources might require pottery to be imported from afar. Marriage is another reason to explain the movement of pottery or rather to account for the presence of an imported style in a site. For example, Loubser (Loubser 1991) has suggested that women tend to marry “up” (socially speaking) and that the Venda language and culture developed as a result of Sotho-speaking women marrying into the higher status Khami tradition in the Soutpansberg. These women brought their distinctive pottery styles with them and eventually the Moloko and Khami styles blended to form the distinctive Tavhatshena tradition which was the forerunner to Venda. What is implied here is that it was not the pot that was imported but the style (Loubser 1991). This will be further discussed in sections 1.2.1 and 4.5. Of course, pots could also have been physically carried in by a bride from her original home (Van Warmelo & Phophi 1967: 1095).

Perhaps the most common reason of all to have someone else’s pot at your homestead is borrowing. Amongst the Venda, for example, there are rules for the correct social behaviour relating to the borrowing of all kinds of household implements from one’s neighbours (Van Warmelo & Phophi 1967: 1075-7), so this behaviour must be quite a common occurrence. If pots break whilst borrowed, they enter the archaeological record. Although the definition of neighbour does not necessarily mean that it is someone right next door but can be the homestead over the next hill, it also needs to be remembered that such wares could all originate from the same source.

Huffman (Huffman 1986, 1996; Huffman & Hanisch 1987) has made a close study of settlement hierarchies and has identified five levels of political importance in the larger states such as the Mapungubwe or Khami traditions for example. A feature of the Iron Age was that authority was vested in chiefs who themselves were ranked in a hierarchal order of increasing rank. One of the duties of a chief was to preside over courts (hearing cases and appeals from lower court judgements), meet with councillors and participate in ritual matters (such as initiation or rain making). This would have necessitated people travelling to the various centres for such events. It is not unlikely that pottery would have travelled with them either as containers, as gifts for the local ward headman or chief or even as payment (or associated with the payment) of court fines.

A further factor is that the larger centres would have acted as trade entrepots and as such would have attracted traders and middlemen in the industry. It is not unreasonable to assume that these traders might have settled locally in order to carry out their business. Once again, the pottery they made or used might reflect their home styles. De Vaal (1984, 1985) has described the old trade routes linking these settlements and known from the very earliest days in the former Transvaal, routes subsequently followed by the earliest Voortrekkers in their travels. These routes must have been of some antiquity. It would be of great interest if someone fit and energetic would follow these routes on the ground today and note the archaeology associated with them.

Apart from pottery, clay was also used to manufacture figurines used in rituals such as initiation ceremonies and as children’s toys (Voigt 1983; van Schalkwyk & Hanisch 2002). A second class of ritual object is represented by fired clay masks which were undoubtedly used in rituals (Inskeep & Maggs 1975; van Schalkwyk et al. 1997). Although the figurines are usually unfired and the clay probably not as carefully prepared as clay used for making fired vessels, nevertheless they are as useful for provenance studies as pottery as they probably represent local clays. This will be discussed more fully later.

In summary, pottery is ubiquitous since its introduction: two thousand years ago for Khoisan and marginally later for the Iron Age. Its spread throughout the drier southwestern regions was either by migrating herders who passed on their skills directly to the local hunter-gatherer Khoisan groups they came into contact with on their migration or by the transference of the knowledge and techniques of pottery making from one group to another (Mitchell 2002; Sadr 2003). The Iron Age spread with migrating Bantu-speaking farmers in several streams from the north during which time they settled higher rainfall areas suitable for growing crops (Huffman 1970, 1980a, 1989, 1990; Herbert & Huffman 1993; Huffman & Herbert 1994). For the latter, pottery use was extensive and formed part of nearly every aspect of daily and ritual life. The secrets locked in the clay fabric can, under the right circumstances, reveal much about daily life, trade, exchange, ritual and gender relations.

1.2 PROVENANCING

The basic assumption underlying chemical provenancing is that the object being provenanced can be matched to its source material by virtue of the fact that they both have the same chemical composition which is unique for each source. In practice, however, this can be far more complex for some materials than for others. This section will deal with the more theoretical issues, definitions, objectives and a summary of previous work in southern Africa. The technical problems will be dealt with in the following chapters.

All the samples analysed in this study were done so in terms of a permit received from the then National Monuments Council, now the South African Heritage Resources Agency.

Table 1.1. Exchange and trade: a model. See text for explanation.

Explanatory models in ceramic provenance studies				
Model	Found in	Regional style	Made in	Interpretation
A. Visual stylistic analysis only				
A1	X	X	X	No inter-site movement
A2	X	Y	Y or ?X	Movement of vessel from Y to X or style Y copied at X
B. Combined stylistic and chemical analysis of vessel				
B1	X	X	X	No movement
B2	X	X	X_2	Movement of vessel within region X
B3	X	Y	Y	Movement of vessel from Y to X
B4	X	Y	X	Movement of idea from Y to X
B5	X	X	Y	Movement of idea from X to Y: then vessel from Y to X

1.2.1 Integrating Style and Chemistry

It was already pointed out that archaeologists classify pottery into traditions or phases. For the Iron Age, this is currently based on the system developed by Huffman (1980b, 2002b) in which decoration layout, vessel profile and motif are combined to reconstruct stylistic types which are specific to a tradition or phase.

The analysis of Khoisan pottery is much less developed and a somewhat different system is in use. This is really a function of the lack of a systematic decorative style such as present in Iron Age wares. In all fairness, though, it needs to be said that most excavated Khoisan pottery is terribly fragmented, much more so than Iron Age wares, making analysis more difficult. For the western Cape, decoration is one element but the size of the vessels and the presence of lugs and spouts are also included in the analysis. Thus far, only a chronological sequence has been developed (Sadr & Smith 1991). Sampson (1988) has proposed spatial boundaries based on decoration style for fibre tempered sherds found in the Seacow River Valley but until well defined spatial boundaries are developed over larger areas for specific types, one cannot really define imports. As a vessel type, fibre tempered bowls are currently only known from the interior thus their presence elsewhere could constitute an import.

The presence of a non-local style in an assemblage, based purely on a visual analysis, can be regarded either as an import or a local imitation but there would be no way to confirm which alternative. Let us look at a theoretical example. Assuming a style X is found in site X, it must be assumed that it was made locally. A sherd in style Y, (which is similar to that from a neighbouring stylistic region called Y) also found at site X, would suggest either an import or a copy of the neighbouring style. This would conform to Cases A1 and A2 in Table 1.1.

When one adds a chemical analysis to the stylistic analysis, however, a far deeper and more nuanced interpretation is possible. Assuming that style Y is found in a region (Y) which has quite a different geochemistry to region X, then any pots made in that region would be distinguishable from those of region X on the basis of its composition.

Table 1.1 demonstrates a number of idealised models to illustrate the inferences which can be drawn from synthesising decoration style with the geochemical profile of a vessel. Model B1 represents a local style made locally. Model B2 represents the movement of style X pottery within the region. B3 represents the confirmation that a non-local style had been made elsewhere and imported.

Model B4 is an imported style made locally. Perhaps what one is looking at here is a woman who has married into the local community from elsewhere and who makes her original style pottery for her own use. One would expect to find low frequencies of such sherds and probably associated with household areas associated with women's activities.

Model B5: a sherd found at site X in the X style but made in region Y. What is probably seen here is a gift or even tribute being brought to site X from a different stylistic area but which was made in the style of X. This case is different from B2 in that it can be shown that the pot or sherd originates in a different stylistic area.

These models are not simply theoretical exercises but provide a framework with which the results of the different case studies can be interpreted. This in turn can lead to deeper insights into the nature of social and economic interaction between communities although at present the Iron Age is probably more suitable for studying because of the well defined stylistic boundaries which are found and which enable stylistic imports to be recognised. Khoisan studies have some potential but more work still needs to be done.

1.2.2 Previous Work

The first study to use chemical analysis to provenance pottery from southern Africa was carried out on sherds from Namibia using Neutron Activation Analysis (Boulle & Peisach 1977). Subsequent work followed this up by using PIXE (Particle-induced x-ray emission spectroscopy) at the then Van de Graaff Group at Faure in the western Cape (Boulle & Peisach 1979; Boulle et al. 1979; Jacobson & Peisach 1982; Peisach et al. 1982a, b, 1990, 1991b; Gihwala et al. 1984, 1985a, b; Jacobson 1985; Jacobson et al. 1985, 1991, 1994c, 1996b; Peisach 1986; Bollong et al. 1997a). These covered a wide set of topics from pre-colonial Namibian and South African pottery to the study of Chinese and Dutch colonial ceramics imported into the 18th Century Cape.

Some of the very earliest studies, whilst being technically sound, did not always have a reliable interpretive basis as little was then understood about the geochemical variability of local clay sources and it is likely that the statistical outliers picked up by the multivariate analyses may not always represent imported items but perhaps local clay variability. Experience gained in this early research did provide a valuable lesson for the framing of future research procedures.

Subsequent to this, XRF became the analytical method of choice (Bollong et al. 1993; Jacobson et al. 1994f, 1995a, c, 1998b, 1999, 2002a, c, d, f, g; Punyadeera et al. 1997, 1999; Pillay et al. 2000; Jacobson & van der Westhuizen 2002a) for a variety of reasons (Jacobson et al. 1994f, 1995c) including, most importantly, the problem of sampling. PIXE uses a beam similar to that of the microprobe and this can be problematical with coarse grained as well as tempered pottery when a bulk analysis is needed. PIXE is also very much a surface technique and this can present problems if the surface is treated in any way, is contaminated or damaged.

XRF offers the advantage of a standardised methodology which can be readily repeated as well as, at that time, the advantage of obtaining accurate absolute values for the elements analysed which included a number not available by PIXE (e.g., phosphorus). For PIXE, each experiment at that time had to be treated on its own merits and was a once off event: data was not interchangeable as it was in the form of counts which were dependent of the parameters of each set up, i.e., deadtime, current, charge, distance and geometry of sample relative to beam, etc. In the absence of standards and suitable procedures, counts were not the equivalent of absolute measurements. PIXE, on the other hand, can be carried out non-destructively which can be a boon for small or scarce sherds which archaeologists do not wish destroyed. To restate the problem, until the data generated by either system can be accessed for statistical purposes by the other, it is best to stay with one system.

XRF spectrometers are also widely available in contrast to PIXE for which only three are available South Africa. XRF analyses can be carried out anywhere and, as long as standard sample preparation techniques are followed and suitable standards are used for calibration, the results will be comparable.

Other techniques which have been used include fire assay (Punyadeera 1996) and thin section petrography (Miller 1991; Jordan et al. 1998). Miller (1991) also reviews a number of student projects that used a variety of analytical techniques on pottery most of which were inconclusive but which do hint at the huge scope of not only provenance studies but also materials analysis relating to various aspects of pottery manufacture and use.

It should also be noted that a number of case studies presented here have already been presented as conference papers and posters or else published in conference proceedings, journals or books (Peisach et al. 1991a; Bollong et al. 1993; Jacobson & van der Westhuizen 1994, 1996a, b, c, 2002a, b, 2004; Jacobson et al. 1994a, b, d, e, f, 1995a, b, c, 1996a, b, 1998a, b, c, d, 1999, 2000, 2002a, b, c, d, e, f, g, 2003; Jacobson 2003).

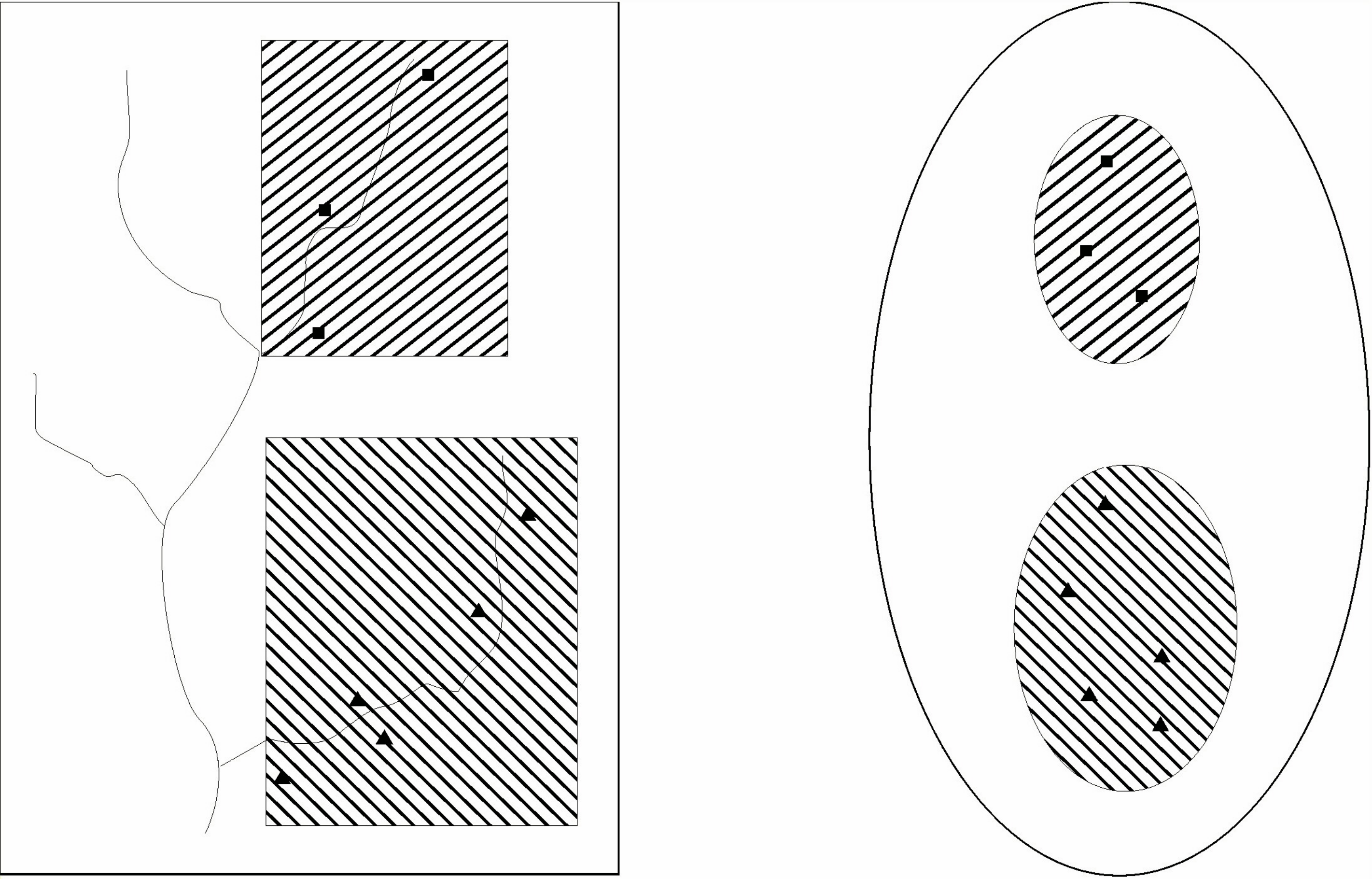
1.3 OBJECTIVES

The criteria for choosing the specific case studies to be discussed in Chapter 4 was simply the availability of pottery from archaeological excavations and museum collections for analysis. The ideal situation would have been to combine the analysis of pottery from a site together with clays from the area so that the data from the pots could be definitively linked to them. A pottery only analysis for any one site or group of sites could produce separate groups or sub-groups of chemically similar specimens which, in the absence of any knowledge of local clays, might be difficult to say with any confidence which represented local clays or which were imports. On the other hand, to collect a complete representative sample of all clays from an area would have been both difficult if not impossible in terms of time and completeness as well as cost. This is apart from the problem that the chemical profile of a fired clay could be altered as a result of clay preparation, use, diagenesis, contamination or the addition of temper to the original clay. These problems will be dealt with in the next chapter. A knowledge of the local geology and its geochemistry would also assist in recognising imports. There are times, however, when such information is not always available. Under these circumstances, therefore, there is a need for a theoretical framework with which to evaluate and interpret the geochemical data before any archaeological interpretation can be made.

1.3.1 Geochemical interpretation

After the lessons of the early PIXE research discussed above, I deemed it prudent to first carefully define the geochemical background to any interpretation. To start off with, a “source” is defined as an ambiguous word (Arnold et al. 1991) . Does it refer to a region, a village or a specific clay pit? Is it possible for any pot to be unambiguously linked to a specific clay source? It has already been briefly mentioned that the composition of a pot does not just represent a clay but also the input of the potter with regards such activities as clay preparation, choice of temper, etc. There is also the problem of usage and post-discard changes to the pot. The compositional profile, then, “encodes both natural and cultural information” (Arnold et al. 1991: 84). Under these circumstances where definite clay sources are unknown, it might be more realistic to start off by regarding “source” on a regional basis. It might not be possible, therefore, to determine whether pottery was being imported from the site next door unless there is a major geochemical discontinuity between the sites, but regional provenance studies are as relevant and can provide significant new information.

This approach is referred to as the “hierarchical approach” (Arnold et al. 1991) and is illustrated in figure 1.2. This means that a group of sites within a geographic area with similar geology (and hence similar clay sources) are linked together in a compositional space. Two or more groups may be further linked together if necessary. The range of variability within one group will be such that it will be different from another compositional group thus allowing imports from the other group to be identified. To define the generalised compositional space of an area does not mean that the sites have to be all of the same age or from the same stylistic tradition, only that the pots were made locally. Conversely, the same stylistic tradition, if widespread, can and probably does, occupy different compositional spaces. Of course, chemically distinct outliers may very well show up in the analysis and the question then becomes whether they represent the outer limits to local variability or whether they are unrecognised imported vessels (i.e., those that are stylistically indistinct from a local site’s wares). Reference must therefore always be made to the local geology in order to try to explain these occurrences and if necessary to analyse additional samples.



Geographic Space

Compositional Space

Figure 1.2. Graphic depiction of the meaning of compositional variability. On the left are a number of archaeological sites or clay sources. The shaded areas represent different geochemical regions whilst the sources within represent the range of variability within each region. This is referred to as geographical space. The right illustrates how these sources might be represented in compositional space. Taken from Arnold et al. (1991).

In this context it might be of interest to note that a worldwide survey has shown that most potters travel no further than 7 km and many no further than 1 km from home to fetch clay (Arnold 1985). It is very important to also note that the verification of such a regional compositional group is an empirical issue. Naturally enough, one's first working hypothesis can be theoretical in nature but it has to be tested against data, redefined in terms of the data and retested as more data becomes available.

It is not only the composition of the clays that serve to define a compositional space; the behavioural influences in preparing the clay also count. This will include such matters as the use of temper which could influence the composition. These behavioural patterns could change over time and influence the definition of the compositional space so this needs to be taken into account as well. Ultimately, its a question of numbers. If enough samples from synchronous sites are available, the problem could be eliminated.

Emphasis, then, will be on regional discovery, that is, sherds from sites from a smaller or larger region, defined in terms of their local geological context will be analysed irrespective of age or culture in order to obtain a regional pattern of variability. In other words, each case will be evaluated on its own merits. The initial interpretation of the data will be made in geochemical terms using multivariate statistics to detect groupings of the data set as well as outliers. Whether the area under consideration is suitable for further provenance studies will be assessed and recommendations made with this regard. Then, and only then, will any relevant archaeological interpretations be made where possible.

1.3.2 Archaeological interpretation

Once the geochemical evaluation of the data has been undertaken, it then becomes possible to provide an archaeological interpretation assuming that the interpretive value of the sherds warrants this. This will be further discussed in section 3.2. At the very least, one will be able to identify imported vessels. However, pots are not imported or other, foreign styles emulated for trivial reasons. Any interpretation, therefore, should be integrated with other information obtained from the site such as the type of site, its ranking in terms of a regional settlement hierarchy (e.g., Huffman & Hanisch 1987), the location within the site where the sherd was found, i.e., is it a public or private area. Interpretation of the chemical data also needs to be framed in terms of the larger archaeological project and this means, ultimately, that the analyst needs to work in close collaboration with the archaeologist on each study.

1.4 ANALYTICAL METHODS

1.4.1 Analytical techniques

Previous work in South Africa had been carried out by PIXE but XRF was felt to be more suitable for a number of reasons. These include the fact that it is a well established procedure with a standardised methodology, is widely available and that it is less prone to sampling problems than PIXE (Jacobson et al. 1994f). As the sherd samples were large enough for destructive analysis, this posed no problem.

A Phillips PW 1404 XRF apparatus was used for the analysis. All samples were prepared according to the techniques of Norrish & Hutton (Norrish & Hutton 1969). Very briefly, this consists of initially grinding the sherds to a fine powder at -300 mesh; 10 grams is then pressed into a powder briquette, bound with Mowiol and a boric acid backing for the analysis of trace elements and Na. The rest of the powder is heated to 110°C for a minimum of 12 hours in order to determine moisture content (H_2O-) by weight loss. Then the sample is heated to 1000°C for 3 hours to similarly determine loss on ignition (LOI), i.e., all the C, CO_2 and crystalline water which is expelled. This remainder is then combined with Spectroflux 105 and melted to form a glass bead for which the major elements (in oxide form) are determined. International geological standards were used for calibration. The following major elements were analysed as oxides in weight per cent: SiO_2 TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O and P_2O_5 whilst the traces Rb, Sr, Y, Zr, Nb, Cu, Ni, Zn, V, Cr and Co were measured in parts per million (ppm).

Microprobe analyses were performed on a thin section with a Cameca Camebax Microbeam electron microprobe using a 5 μm beam diameter, 15 kV accelerating voltage, 40 nA beam current and mineral standards with PAP intensity correction techniques (Pouchou & Picoir 1984).

For the statistical analysis and discussion of the data, P_2O_5, H_2O- and LOI are removed from the oxide total and the remaining elements are recalculated to 100%. In the case of P_2O_5, this element is removed (unless it is the object of the analysis) because it has been shown that clay objects, e.g., figurines and pots, as well as other objects such as seeds, are easily and regularly contaminated by this element (Freestone et al. 1985). Further discussion of this can be found below in Chapter 2, section 2.5.

1.4.2 SARM 69

During the course of this research it became obvious that there existed no suitable reference material specifically for ceramic analysis although a number of laboratories had their own in-house standards. It was therefore decided to develop a certified Reference Material in a cooperative project between the Geology Department, University of the Free State, the McGregor Museum, Kimberley and Mintek. Known as SARM 69 (Ceramic-1), it was developed in cooperation with Mintek and the South African Bureau of Standards.

The advantage of a ceramic certified reference material, apart from easy availability, is that it can be used to calibrate analyses between different laboratories and especially between those using different techniques particularly when these can differ in their precision and accuracy for certain elements. This makes it now possible to combine data from different laboratories working on the same or similar problems or geographical areas.

The ceramic sample (sherds) had been excavated from a Type V Late Iron Age site in the northern Free State in 1960 by T. Maggs (Maggs 1976). The material was stored at the National Museum in Bloemfontein from whence 80 kg was retrieved for this project. The sample was sent to Mintek who were responsible for the milling, homogenisation, bottling and testing. Samples were subsequently distributed to laboratories in a number of different countries. Eventually nineteen laboratories from nine countries took part in the collaborative analytical testing project.

The analytical results were submitted to Mintek who prepared the final certification of the material (see Appendix 1 for a copy of the certificate). Certified values are now available for fifteen elements as well as tentative values for a further twelve (Jacobson et al. 2002g). This is the first ever fully certified reference material prepared from archaeological ceramics specifically for the analysis of archaeological ceramics to be made available commercially.

1.4.3 Statistical analysis

Correspondence Analysis (CA) was used as the exploratory multivariate statistical technique of choice to determine clusters and outliers in the data. It has the advantage of being able to map both the rows (i.e., samples) and columns (i.e., elements) of a data matrix onto one scatter plot so that one can get a visual understanding of the elemental composition underlying the clustering of the samples (Peisach et al. 1982a; Greenacre 1984, 1986; Bollong et al. 1997a). This in turn can give an insight into the geochemistry of the clay and hence the rocks from which the clay was formed. A comparison between CA and other multivariate and clustering techniques carried out on the PIXE data of a set of Khoisan ceramics showed that it obtained the most complete separation of the samples (Bollong et al. 1997).

Before analysis, each element's data is divided by an average crustal value (Mason 1966) for that element in order to eliminate the influence of scale (e.g., percent, ppm).

CHAPTER 2. THE RELATIONSHIP BETWEEN CLAYS AND POTS

A basic assumption of pottery provenance studies assumes that the chemical compositional profile of the pot reflects the profile of the clay from which it was made. This, however, can and has been challenged as there are a number of processes in the sequence from a raw clay to the archaeological sherd which could alter the original chemical signature such that the two are no longer recognisably the same (Neff et al. 1988, 1989; Arnold et al. 1991). These include the preparation of the clay, its firing, the usage of the vessel, any diagenetic effects that can occur after being discarded and buried after use. This section will present a review of the various issues which can lead to problems in the direct provenancing of a vessel to a clay source as well as data which show that, under certain very specific conditions and stages in this process, a fired vessel can be directly and unambiguously linked to its source clay.

2.1 THE PREPARATION OF THE CLAY

In South Africa, the preparation of clay is quite straightforward. The clay is collected, dried, pounded and any large bits removed. Water is added and the mixture kneaded. Temper might be added to strengthen the clay (see below) and the pot is shaped by hand either by means of coils or slabs. The pot is then allowed to dry before firing (Lawton 1967). The outer surface may be burnished with a smooth stone or piece of bone, decorated with incised or stamped patterns, or even painted or burnished with graphite or a red wash. Once the shaped clay vessel has dried, it is then fired.

2.2 FIRING OF A VESSEL

In southern Africa, firing was usually carried out in a pit or in the open. No kilns were used. An investigation by Woods (Woods 1982) in northern Namibia where traditional pottery manufacture was practised, showed that temperatures measured on fires made with dung varied from 818° to 849°C (n=3). Other open firing temperatures reached a maximum of 920°C. Temperatures peaked and cooled very quickly and firing times were short, approximately 2-3 hours.

Of interest for this study is the effect of firing on the bulk composition of a clay. Experimental work (Kilikoglou et al. 1988; Cogswell et al. 1996) has found that firing temperature has no effect on composition. These tests included temperatures up to 1100°C which were higher than the temperatures obtained by Woods (Woods 1982) for open firing but which also exceed the temperatures to which sherds exposed in the laboratory when measuring for LOI (Section 1.4). One can assume also that cooking over an open fire is unlikely to have any effect either.

2.3 TEMPER

Temper or grog or "filler" as some have called it (e.g. Lawton 1967) is the deliberate addition of any non-plastic material to a clay, excluding any naturally occurring gritty component. It is often used by potters to improve the quality of the clay with which they are working although not all clays may need this additive (Lawton 1967). Its importance to the manufacturing process is that it allows the unfired clay vessel to dry without shrinking or cracking or even bursting during the firing process. Such usage very often depends upon a potter's skill and experience. Lawton (1967) and Woods (Woods 1984a, b) both describe potters "tasting" the clay in order to decide whether to add temper and the amount needed. Obviously, they are assessing the “grittiness” of the clay. It is also suggested that temper may have been added to improve some functional aspect required of the vessel. Skibo et al. (1989) have carried out a series of experiments on organic tempered wares and found that they can be up to 34% lighter and less prone to breaking when dropped, ideal attributes for people who had to carry their possessions with them when on the move. Heating effectiveness was also better than for untempered pots but not as good as grit tempered ones, a point emphasised by Bollong et al. (1993).

Rudner (Rudner, J. 1968, 1979), however, explicitly suggested a cultural factor by equating grass tempered pottery with San hunter-gatherers ("Bushmen") and quartz tempering with Khoi herders ("Hottentot pottery”). Whatever the reason, temper can theoretically obscure or alter the original clay chemical composition with obvious consequences for provenance studies.

Various kinds of temper are known. Modern ethnographic observations made in southern Africa by Lawton (1967) include mixed clays, grit, crushed potsherds, asbestos ore, sand, ferricrete and calcrete whilst Burchell (Burchell 1822) and Bleek and Lloyd (Bleek & Lloyd 1911) described Karoo "Bushman" using grass, blood or ash. In addition, charcoal, bone, marine shell, feldspar, mica, quartz (up to 5 mm or more in size) and other minerals have been recorded in sherds either through visual examination or in thin section (Rudner, I. 1965; Rudner, J. 1968, 1979; Woods 1984a; Denbow 1990; Bollong et al. 1993).

The amount of temper added also varied. One of Woods' (Woods 1984b) informants from the Kavango, Namibia, used temper (in the form of crushed potsherds) and clay in the ratio of 2 to 3 respectively. Lawton (1967) described a mix of clay and crushed "soft stone" in equal amounts by a potter at Tamposstad, some 15km NE of Groot Marico. No doubt the amount needed depended on the individual potter's assessment of the requirements for any clay or a particular batch of clay.

As the addition of a temper can change a clay's composition and as the addition of different types of temper to the same clay by different potters could result in several different compositions, it is important to understand its exact influence on chemical composition. Otherwise, there is the danger that the "temper effect" could result in vessels being attributed to more clay sources than is the case and in an extreme situation, to a source far removed from the actual locality of the site with the resulting, erroneous, implication that the vessel was imported.

If one knows the composition of a local clay and various types of potential tempers, the various combinations involving types and amounts of temper can be modelled in order to assess the compositional deviation of a tempered clay from the original clay if in fact there is a difference. This latter is an important point. If the composition of a temper matches that of the clay to which it is added, no difference will result. Conversely, even if a temper differs greatly from a clay, the difference between the mixed and unmixed clay might be insignificant if only limited amounts of temper are added.

Whilst naturally occurring grit should be accepted as part of the clay signature, deliberately added temper, however, need not be a totally negative factor, as it could provide a fingerprint identifying specific potters assuming they had their own, individualistic tempering practices. This begs the question, however, of how chemically different a tempered clay will be from a similar but untempered clay. Theoretical simulations carried out by Neff et al. (Neff et al. 1988, 1989) showed a linear relationship between the amount of temper and the clay. The deciding factors were the amount of temper relative to the clay and the difference in concentration between the temper and the clay. Thus, pure quartz would dilute the concentrations of all elements but increase the amount of SiO_2 depending upon the two factors mentioned above. A grit or crushed sherd temper (e.g. Jacobson et al. 1998b, 1999) that has a similar composition as the clay to which it is added (as a result of being made previously from the same clay) would result in no alteration to the chemical profile of that clay. To demonstrate this empirically, a number of experiments were carried out by mixing a clay sample with various types of tempers.

The clay came from the farm Nonnashoek (Dreyer 1988). (See section 2.6 for further details). The “black clay”sample was used in the experiment and eight random samples were analysed to obtain an average value (Table 2.1) for its composition. These eight samples were additional to the sample originally analysed together with the white clay and potsherds and reported in section 2.6 and Jacobson et al. (1998b, 1999). Although these values suggest a degree of variability in the clay, note must be made of the fact that small samples (approx 30 gm) were taken from the approximately 2 kg bulk sample without any attempt at homogenisation and allocated to each temper for subsequent crushing, weighing and mixing although each temper was crushed (and thus homogenised) in a single operation. Therefore, some variability could have been introduced into the clay samples. This is not a major problem as it is more likely to replicate real life practice i.e. variability between pots or batches of pots. With the benefit of hindsight clay homogenisation could have been carried out as any vessel is obviously larger than a 30 gm sample and the raw clay is mixed and kneaded by the potter but hopefully the mean value will be a reasonably true reflection of the bulk value.

Table 2.1. Summary statistics for the eight black clay samples used in the temper study.

	Mean	SD	CV%	n	min	max
SiO_2	74.11	3.79	5.1	8	69.97	82.49
TiO_2	0.54	0.06	11.1	8	0.42	0.62
Al_2O_3	15.40	2.28	14.8	8	10.29	18.04
Fe_2O_3	6.54	1.05	16.1	8	4.44	7.58
MnO	0.03	0.01	33.3	8	0.02	0.05
MgO	0.82	0.16	19.5	8	0.57	0.99
CaO	0.56	0.09	16.1	8	0.36	0.67
Na_2O	0.19	0.05	26.3	8	0.13	0.25
K_2O	1.78	0.27	15.2	8	1.20	2.01
P_2O_5	0.03	0.00	0.00	8	0.02	0.03
TOTAL	100.00					
Rb	121	17.2	14.2	8	84	138
Sr	75	9.4	12.7	8	54	85
Y	34	5.0	14.9	8	23	39
Zr	209	16.9	8.1	8	192	235
Nb	10	2.3	23.5	8	7	13
Cu	16	3.7	23.4	8	10	22
Ni	31	3.6	11.8	8	26	36
Zn	61	7.4	12.2	8	45	71
V	90	9.1	10.1	8	71	102
Cr	96	6.5	6.8	8	87	107
Co	12	2.4	19.3	8	9	16

Five different tempers were used, namely, granite, andesite, quartz, charcoal and bone (Table 2.2). Various ratios of clay to temper were used for the different experiments. As there is a linear relationship between clay and temper (Neff et al. 1988, 1989), theoretical values were calculated excluding the charcoal and bone tempers for which no suitable standards or compositional estimates were available.

Table 2.2. The five temper samples.

Granite	Unprovenanced cobble
Andesite	Handaxe from the Vaal River gravels near Barkly West
Quartz	Pure laboratory quartz
Charcoal	Collected from a braai spot in Kimberley
Bone	Dried cattle long bones which had been boiled for soup and then discarded in a dump

The granite, andesite and quartz tempers illustrate very nicely the fact that the amount of enrichment or dilution for any element depends upon the amount of temper added as well as its absolute value (Tables 2.3-2.5). One example: in Table 2.3, when 33.33% granite temper is added to the clay, SiO_2 shows no change as the two values are close but the value for Na_2O is significantly enriched (the clay has a Na_2O content of 0.19% whilst the granite temper has 4.06%). Even a five percent addition of temper would significantly enrich the value for Na_2O.

Quartz temper acts somewhat differently. In this case (Table 2.5) it is pure SiO_2 and apart from enriching the clay's SiO_2, it dilutes all the other elements. As an example of what the enrichment/dilution would look like when subjected to a correspondence analysis, figure 2.1 shows the clays, the andesite and granite experimental results as well as the theoretical results in one analysis. Note the linear patterns between the clay and each of the two tempers which is mapped to the first two axes. By continually adding temper to the clay the end of the trend is reached when the clay disappears and only the temper remains. This linear pattern, rather than a "cloud" of points, indicates that significant tempering has occurred in ever increasing amounts. An example will be discussed under the case studies.

With reference to the elemental concentrations of bone, there is an extensive range of articles on the composition of human bone particularly for Ca and P but there are no consistent or reliable

Table 2.3. Data for the mixing of granite temper with the black clay.

A. Major elements

		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	TOTAL
Clay (n=8)		74.11	0.54	15.40	6.54	0.03	0.82	0.56	0.19	1.78	0.03	100.00
Temper (n=2)	t3	74.66	0.15	13.95	1.44	0.04	0.23	1.27	4.06	4.16	0.04	100.00
Ratio T/C		1.01	0.28	0.91	0.22	1.33	0.28	2.27	21.37	2.34	1.33	
Theoretical values												
% Temper												
4.76%		74.15	0.52	15.33	6.30	0.03	0.79	0.59	0.37	1.89	0.03	100.01
9.99%		74.16	0.50	15.26	6.03	0.03	0.76	0.63	0.58	2.02	0.03	100.01
16.67%		74.20	0.47	15.16	5.69	0.03	0.72	0.68	0.84	2.18	0.03	100.01
23.10%		74.25	0.45	15.07	5.36	0.03	0.68	0.72	1.08	2.33	0.03	100.01
28.60%		74.27	0.43	14.99	5.08	0.03	0.65	0.76	1.30	2.46	0.03	100.00
33.33%		74.30	0.41	14.92	4.84	0.03	0.62	0.80	1.48	2.57	0.03	100.00
Experimental values												
Sample No	% Temper											
t5 (n=3)	4.76%	74.76	0.49	15.31	5.60	0.04	0.79	0.61	0.46	1.91	0.03	100.00
t7 (n=2)	9.99%	74.61	0.47	15.24	5.32	0.05	0.77	0.65	0.80	2.06	0.03	100.00
t9 (n=3)	16.67%	73.80	0.45	15.22	4.92	0.04	1.10	0.74	1.34	2.35	0.04	100.00
t11 (n=2)	23.10%	74.45	0.41	14.95	4.44	0.04	0.62	0.80	1.75	2.51	0.03	100.00
t13 (n=2)	28.60%	74.21	0.38	15.04	4.20	0.04	0.56	0.85	2.03	2.66	0.03	100.00
t15 (n=2)	33.33%	74.28	0.37	14.88	3.91	0.04	0.56	0.89	2.27	2.76	0.04	100.00
Ratio E/T												
t5	4.76%	1.01	0.94	1.00	0.89	1.33	1.00	1.03	1.24	1.01	1.00	
t7	9.99%	1.01	0.94	1.00	0.88	1.67	1.01	1.03	1.38	1.02	1.00	
t9	16.67%	0.99	0.96	1.00	0.86	1.33	1.53	1.09	1.60	1.08	1.33	
t11	23.10%	1.00	0.91	0.99	0.83	1.33	0.91	1.11	1.62	1.08	1.00	
t13	28.60%	1.00	0.88	1.00	0.83	1.33	0.86	1.12	1.56	1.08	1.00	
t15	33.33%	1.00	0.90	1.00	0.81	1.33	0.90	1.11	1.53	1.07	1.33	

Table 2.3 continued.

B. Trace elements

		Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
Clay (n=8)		121	75	34	209	10	16	31	61	90	96	12
Temper (n=2)	t3	61	284	0	119	1	54	2	34	10	9	3
Ratio T/C		0.50	3.79	0.00	0.57	0.10	3.38	0.06	0.56	0.11	0.09	0.25

Theoretical values

% temper		Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
4.76%		118	85	32	205	10	18	30	60	86	92	12
9.99%		115	96	31	200	9	20	28	58	82	87	11
16.67%		111	110	28	194	8	22	26	56	77	81	10
23.10%		107	123	26	188	8	25	24	55	72	76	10
28.60%		104	135	24	183	7	27	23	53	67	71	9
33.33%		101	145	23	179	7	29	21	52	63	67	9
50.00%		91	180	17	164	6	35	17	48	50	53	8
60.00%		85	200	14	155	5	39	14	45	42	44	7
70.00%		79	221	10	146	4	43	11	42	34	35	6

Experimental values

Sample No	% temper	Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
t5 (n=3)	4.76%	111	82	29	184	7	17	26	60	91	89	9
t7 (n=2)	9.99%	109	94	27	188	6	19	25	60	85	84	13
t9 (n=3)	16.67%	104	117	24	177	6	22	22	55	73	75	8
t11 (n=2)	23.10%	99	134	21	172	5	28	20	54	65	60	8
t13 (n=2)	28.60%	98	147	19	171	5	30	19	51	58	65	8
t15 (n=2)	33.33%	94	159	18	165	5	30	18	51	55	56	8
t17 (n=2)	50.00%	97	159	18	160	5	30	19	50	56	58	8
t19 (n=2)	60.00%	90	181	14	156	5	34	14	47	47	45	6
t21 (n=2)	70.00%	84	200	11	151	4	35	13	46	42	38	6

Ratio E/T

		Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
t5	4.76%	0.94	0.96	0.91	0.90	0.70	0.94	0.87	1.00	1.06	0.97	0.75
t7	9.99%	0.95	0.98	0.87	0.94	0.67	0.95	0.89	1.03	1.04	0.97	1.18
t9	16.67%	0.94	1.06	0.86	0.91	0.75	1.00	0.85	0.98	0.95	0.93	0.80
t11	23.10%	0.93	1.09	0.81	0.91	0.63	1.12	0.83	0.98	0.90	0.79	0.80
t13	28.60%	0.94	1.09	0.79	0.93	0.71	1.11	0.83	0.96	0.87	0.92	0.89
t15	33.33%	0.93	1.10	0.78	0.92	0.71	1.03	0.86	0.98	0.87	0.84	0.89
t17	50.00%	1.07	0.88	1.06	0.98	0.83	0.86	1.12	1.04	1.12	1.09	1.00
t19	60.00%	1.06	0.91	1.00	1.01	1.00	0.87	1.00	1.04	1.12	1.02	0.86
t21	70.00%	1.06	0.90	1.10	1.03	1.00	0.81	1.18	1.10	1.24	1.09	1.00

Table 2.4. Data for the mixing of Andesite temper with the black clay.

A. major elements

		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	TOTAL
Clay (n=8)		74.11	0.54	15.40	6.54	0.03	0.82	0.56	0.19	1.78	0.03	100.00
Temper (n=2) t2		58.19	0.85	16.13	9.31	0.15	5.98	5.13	2.74	1.35	0.17	100.00
Ratio T/C		0.79	1.57	1.05	1.42	5.00	7.29	9.16	14.42	0.76	5.67	
Theoretical values												
% Temper												
4.76%		73.35	0.55	15.43	6.67	0.04	1.07	0.78	0.31	1.76	0.04	100.00
9.99%		72.52	0.57	15.47	6.82	0.04	1.34	1.02	0.44	1.74	0.04	100.00
16.67%		71.46	0.59	15.52	7.00	0.05	1.68	1.32	0.62	1.71	0.05	100.00
23.10%		70.43	0.61	15.57	7.18	0.06	2.01	1.62	0.78	1.68	0.06	100.00
28.60%		69.55	0.63	15.61	7.33	0.06	2.30	1.87	0.92	1.66	0.07	100.00
33.33%		68.81	0.64	15.64	7.46	0.07	2.54	2.08	1.04	1.64	0.08	100.00
Experimental values												
Sample No	% temper											
t4 (n=3)	4.76%	75.28	0.52	14.66	5.59	0.04	1.06	0.80	0.35	1.66	0.04	100.00
t6 (n=2)	9.99%	74.02	0.53	14.83	5.84	0.05	1.43	1.07	0.52	1.66	0.05	100.00
t8 (n=2)	16.67%	71.76	0.58	15.15	6.40	0.07	1.92	1.54	0.87	1.64	0.07	100.00
t10 (n=2)	23.10%	69.94	0.61	15.35	6.79	0.09	2.53	1.91	1.08	1.62	0.08	100.00
t12 (n=2)	28.60%	68.76	0.62	15.46	6.94	0.09	2.94	2.27	1.28	1.55	0.09	100.00
t14 (n=2)	33.33%	67.59	0.66	15.79	7.32	0.09	2.96	2.47	1.43	1.59	0.10	100.00
Ratio E/T												
t4	4.76%	1.03	0.95	0.95	0.84	1.00	0.99	1.03	1.13	0.94	1.00	
t6	9.99%	1.02	0.93	0.96	0.86	1.25	1.07	1.05	1.18	0.95	1.25	
t8	16.67%	1.00	0.98	0.98	0.91	1.40	1.14	1.17	1.40	0.96	1.40	
t10	23.10%	0.99	1.00	0.99	0.95	1.50	1.26	1.18	1.38	0.96	1.33	
t12	28.60%	0.99	0.98	0.99	0.95	1.50	1.28	1.21	1.39	0.93	1.29	
t14	33.33%	0.98	1.03	1.01	0.98	1.29	1.17	1.19	1.38	0.97	1.25	

Table 2.4 continued. Andesite temper

B. Trace elements.

		Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
Clay (n=8)		121	75	34	209	10	16	31	61	90	96	12
Temper (n=2)	t2	27	175	17	148	7	18	148	95	209	414	22
T/C		0.22	2.33	0.50	0.71	0.70	1.13	4.77	1.56	2.32	4.31	1.83
Theoretical values												
% Temper												
4.76%		117	80	33	206	10	16	37	63	96	111	12
9.99%		112	85	32	203	10	16	43	64	102	128	13
16.67%		105	92	31	199	9	16	51	67	110	149	14
23.10%		99	98	30	195	9	16	58	69	117	169	14
28.60%		94	104	29	192	9	17	64	71	124	187	15
33.33%		90	108	28	189	9	17	70	72	130	202	15
50.00%		74	125	26	179	9	17	90	78	150	255	17
60.00%		65	135	24	172	8	17	101	81	161	287	18
70.00%		55	145	22	166	8	17	113	85	173	319	19
Experimental values												
Sample No	% Temper											
t4 (n=3)	4.76%	102	72	28	187	6	12	33	62	100	113	11
t6 (n=2)	9.99%	100	77	27	182	7	14	38	63	108	134	12
t8 (n=2)	16.67%	92	90	27	180	6	13	51	67	119	168	11
t10 (n=2)	23.10%	87	100	26	182	7	15	61	71	129	192	15
t12 (n=2)	28.60%	82	105	25	176	7	16	68	73	137	208	15
t14 (n=2)	33.33%	81	112	24	177	6	15	75	75	144	235	15
t16 (n=2)	50.00%	82	113	26	183	7	17	72	76	144	222	15
t18 (n=2)	60.00%	73	122	23	174	7	17	86	77	155	255	16
t20 (n=2)	70.00%	65	132	22	168	7	17	96	81	167	280	16
Ratio E/T												
t4	4.76%	0.87	0.90	0.85	0.91	0.60	0.75	0.89	0.98	1.04	1.02	0.92
t6	9.99%	0.89	0.91	0.84	0.90	0.70	0.88	0.88	0.98	1.06	1.05	0.92
t8	16.67%	0.88	0.98	0.87	0.90	0.67	0.81	1.00	1.00	1.08	1.13	0.79
t10	23.10%	0.88	1.02	0.87	0.93	0.78	0.94	1.05	1.03	1.10	1.14	1.07
t12	28.60%	0.87	1.01	0.86	0.92	0.78	0.94	1.06	1.03	1.10	1.11	1.00
t14	33.33%	0.90	1.04	0.86	0.94	0.67	0.88	1.07	1.04	1.11	1.16	1.00
t16	50.00%	1.11	0.90	1.00	1.02	0.78	1.00	0.80	0.97	0.96	0.87	0.88
t18	60.00%	1.12	0.90	0.96	1.01	0.88	1.00	0.85	0.95	0.96	0.89	0.89
t20	70.00%	1.18	0.91	1.00	1.01	0.88	1.00	0.85	0.95	0.97	0.88	0.84

Table 2.5. Data for the mixing of quartz temper with the black clay.

A. Major elements	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	TOTAL
Clay (n=8)	74.11	0.54	15.40	6.54	0.03	0.82	0.56	0.19	1.78	0.03	100.00
Temper	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Ratio t/c	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Theoretical values											
% temper											
3.8%	75.10	0.52	14.81	6.29	0.03	0.79	0.54	0.18	1.71	0.03	100.00
13.3%	77.55	0.47	13.35	5.67	0.03	0.71	0.49	0.16	1.54	0.03	100.00
28.6%	81.50	0.39	11.00	4.67	0.02	0.59	0.40	0.14	1.27	0.02	100.00
42.9%	85.21	0.31	8.79	3.73	0.02	0.47	0.32	0.11	1.02	0.02	100.00
Experimental values											
TQ1 (3.8%)	75.54	0.50	14.57	6.16	0.02	0.70	0.52	0.18	1.69	0.12	100.00
TQ2 (13.3%)	77.70	0.46	13.22	5.75	0.02	0.61	0.47	0.15	1.50	0.12	100.00
TQ3 (28.6%)	81.74	0.37	10.79	4.75	0.01	0.50	0.39	0.10	1.23	0.12	100.00
TQ4 (42.9%)	85.61	0.28	8.44	3.81	0.02	0.38	0.32	0.06	0.96	0.12	100.00
Ratio e/t											
3.8%	1.01	0.96	0.98	0.98	0.67	0.89	0.96	1.00	0.99	4.00	
13.3%	1.00	0.98	0.99	1.01	0.67	0.86	0.96	0.94	0.97	4.00	
28.6%	1.00	0.95	0.98	1.02	0.50	0.85	0.98	0.71	0.97	6.00	
42.9%	1.00	0.90	0.96	1.02	1.00	0.81	1.00	0.55	0.94	6.00	

B. Trace elements	Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
Clay (n=8)	121	75	34	209	10	16	31	61	90	96	12
Temper	0	0	0	0	0	0	0	0	0	0	0
Theoretical values											
% temper											
3.8%	116	72	33	201	10	15	30	59	87	92	12
13.3%	105	65	29	181	9	14	27	53	78	83	10
28.65	86	54	24	149	7	11	22	44	64	69	9
42.9%	69	43	19	119	6	9	18	35	51	55	7
Experimental values											
TQ1	108	73	30	194	6	13	26	60	87	89	19
TQ2	98	67	29	176	4	12	24	55	77	82	19
TQ3	82	56	24	147	3	10	20	46	65	71	13
TQ4	63	43	16	116	0	8	16	37	50	42	10
Ratio e/t											
3.8%	0.93	1.01	0.91	0.97	0.60	0.87	0.87	1.02	1.00	0.97	1.58
13.3%	0.93	1.03	1.00	0.97	0.44	0.86	0.89	1.04	0.99	0.99	1.90
28.6%	0.95	1.04	1.00	0.99	0.43	0.91	0.91	1.05	1.02	1.03	1.44
42.9%	0.91	1.00	0.84	0.97	0.00	0.89	0.89	1.06	0.98	0.76	1.43

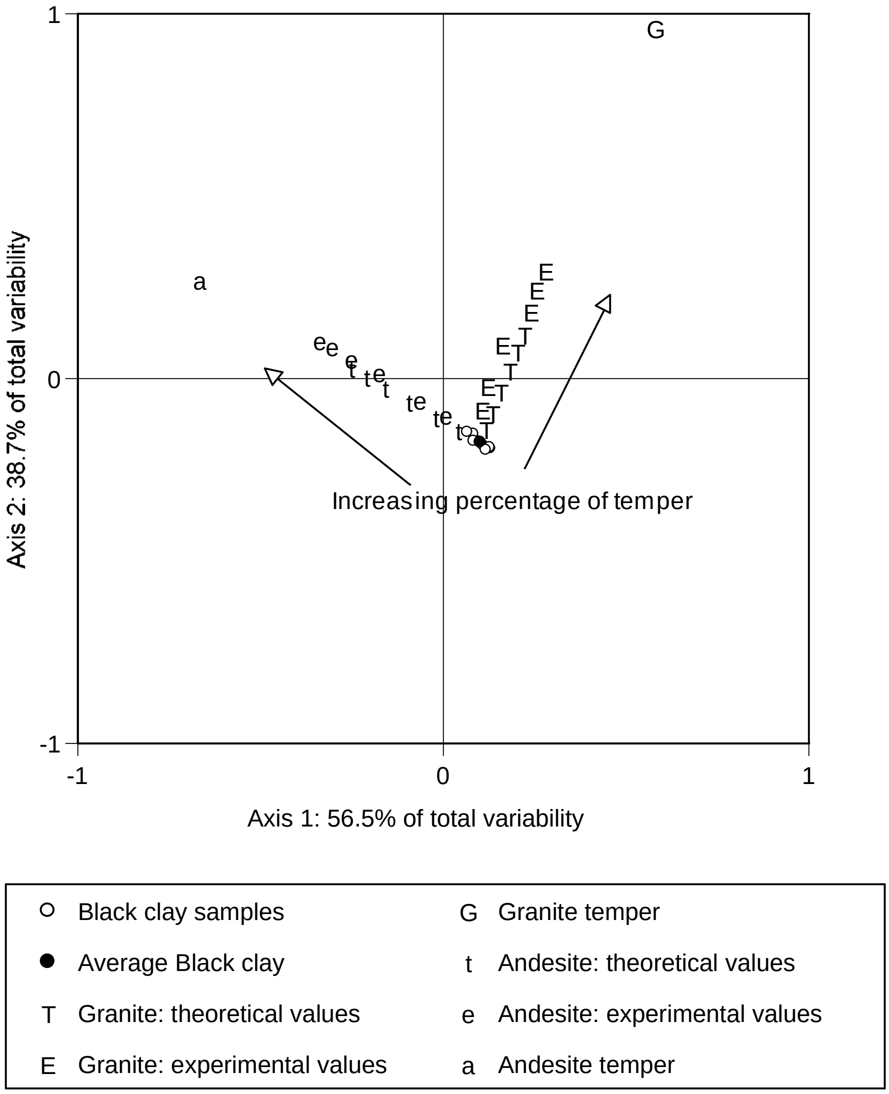


Figure 2.1. Correspondence analysis plot of andesite and granite tempers and clays. See text for further details.

estimates. For example, values for Ca (in human bone) range from 20.1 - 39.7% whilst that for P range from 9.2 - 18.0% depending upon whether or not fresh bone is analysed, the burial context of the bone (Hancock et al. 1989: Table 7) or the part of skeleton (Braetter et al. 1977). White & Hannus (1983) quote data for, presumably fresh, cow bones which range from 5.7 - 12.4% for P and 12.0-22.0% for Ca. Values for other elements (in human bone) have very wide ranges. For example, Na can range from 9700 ppm (Hancock et al. 1989: Table 7), to 5470 ppm (Kyle 1986: Table 1) or 3.35% (Edward & Benfer 1993: Table 4) but whether these values are normalised to 100% is not made clear. It also needs to be pointed out that the composition of bone can vary due to factors such as diet (Jones & Weeks 1985; Kyle 1986; Francalacci 1989; Baraybar & de la Rua 1997) as well as diagenesis (Lambert et al. 1985; Edward & Benfer 1993; Trueman et al. 2004), both of these factors acting upon each other in addition. There is thus likely to be some form of cross contamination between a fired clay matrix and any bone temper. In any case, if pottery is tempered with bone, the elements having the major effect on composition, depending upon their relative concentration, would be CaO and P_2O_5. From table 2.7 it is obvious that by the stage that 13.3% bone temper (sample T52b) had been added to the clay, the CaO and especially P_2O_5 levels are obviously high. Of the other elements, only Na_2O and Sr show a small increase indicating their presence in the bone in larger amounts than in the clay in this case.

The only localities known where bone is either known to be used or has been identified as temper is in the Kavango region of Northern Namibia and in Botswana at the Tsodilo Hills (Rudner, I. 1965; Woods 1984a). The few analysed sherds from the Kavango generally have low P_2O_5 values (Appendix A4.3.2) and have no visible bone temper but amongst the Tsodilo Hills samples are three sherds which stand out sharply with respect to their CaO and P_2O_5 values (Table 2.6). Sherds bz3, bz7 and bz10 contain visual traces of bone and have enriched values for these two elements ranging from 10 - 15% for the former and 7 - 11% for the latter. The compositional similarity between bz3 and bz10 could argue for them coming from the same vessel but all are obviously heavily bone tempered as described by Rudner (1965: Table 1). The bone is not always visible as it is embedded in the body of the sherd but compared to the data for CaO and P_2O_5 in Table 2.7, they could contain approximately 25% temper.

Table 2.6. Examples of pottery (from Botswana) characterised by bone and charcoal temper.

	bz3	bz7	bz10	bz6	bz12	bz4	bz5	bz9	bz11	bz28
SiO_2	47.14	60.18	45.65	51.17	51.10	57.15	57.69	35.26	73.45	51.24
TiO_2	0.56	0.54	0.54	0.71	0.70	0.60	0.59	0.40	0.18	0.70
Al_2O_3	11.87	12.14	11.18	15.15	14.41	14.28	14.73	11.50	3.28	15.12
Fe_2O_3	2.88	3.50	2.67	3.44	3.61	3.33	3.21	2.79	3.66	3.39
MnO	0.02	0.03	0.01	0.03	0.03	0.03	0.03	0.02	0.04	0.02
MgO	0.52	0.27	0.42	0.34	0.33	0.47	0.53	0.29	0.33	0.28
CaO	15.15	10.53	15.63	0.80	0.40	2.59	2.10	1.02	0.54	0.49
Na_2O	0.26	0.21	0.23	0.02	0.03	0.11	0.14	0.00	0.08	0.01
K_2O	1.46	0.84	1.05	1.02	0.93	1.35	1.61	0.95	0.33	0.94
P_2O_5	11.00	7.30	11.06	0.21	0.24	0.33	0.19	0.20	0.89	0.16
H_2O-	1.68	1.08	1.57	4.78	5.30	2.90	2.97	4.81	3.90	5.78
LOI	7.51	4.03	8.84	22.50	23.05	16.99	16.84	42.55	13.84	22.22
TOTAL	100.05	100.65	98.85	100.17	100.13	100.13	100.63	99.79	100.52	100.34
Rb	57	42	47	40	37	38	44	32	15	37
Sr	258	200	287	82	49	118	116	72	60	55
Y	19	19	18	18	17	13	12	3	1	19
Zr	149	198	150	198	209	123	120	66	57	198
Nb	12	10	11	7	8	7	6	0	0	7
Cu	16	14	12	6	5	14	12	16	0	5
Ni	15	19	16	19	18	21	20	17	20	18
Zn	72	54	67	47	33	32	30	30	22	37
V	91	103	91	186	196	175	176	194	101	189
Cr	51	72	50	106	109	89	87	96	87	104
Co	8	10	6	16	15	18	14	17	21	15

bz3	Tsodilo 9a: bone and ?charcoal tempered
bz7	Tsodilo 21: rim sherd, bone and ?charcoal tempered
bz10	Tsodilo 9a: bone and ?charcoal tempered
bz6	Tsodilo 9: thick coarse sherd, charcoal tempered: duplicate of bz12
bz12	Tsodilo 9: duplicate of bz6
bz4	Tsodilo 24.1: charcoal tempered
bz5	Tsodilo 24: charcoal tempered, vesicles
bz9	Tsodilo 12: cross hatched thick rim sherd, charcoal tempered
bz11	Tsodilo 14: charcoal and quartz tempered
bz28	Tsodilo 9c3: charcoal tempered

Table 2.7. Data for the bone temper mixed with black clay.

A. Major elements

		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	TOTAL
Clay (n=8)		74.11	0.54	15.40	6.54	0.03	0.82	0.56	0.19	1.78	0.03	100.00
Experimental values												
Sample No	% temper											
T50b	1.6%	73.62	0.56	15.17	6.28	0.02	0.83	1.10	0.23	1.73	0.46	100.00
T51b	3.8%	72.49	0.54	14.78	6.12	0.03	0.88	2.06	0.23	1.68	1.19	100.00
T52b	13.3%	67.78	0.46	13.62	5.76	0.02	0.85	5.67	0.28	1.57	3.99	100.00
T64b	23.5%	61.98	0.43	12.54	5.35	0.01	0.89	9.83	0.33	1.45	7.19	100.00

B. Trace elements

		Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
Clay (n=8)		121	75	34	209	10	16	31	61	90	96	12
Experimental values												
Sample No	% temper											
T50b	1.6%	117	79	33	211	11	14	27	60	90	86	11
T51b	3.8%	112	81	32	198	10	13	25	60	87	88	11
T52b	13.3%	103	96	29	178	10	12	26	64	76	84	11
T64b	23.5%	94	112	26	158	9	10	23	65	72	80	11

Table 2.8. Data for the mixing of charcoal temper with the black clay.

A. Major elements

		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	TOTAL
Clay (n=8)		74.11	0.54	15.40	6.54	0.03	0.82	0.56	0.19	1.78	0.03	100.00
Experimental values												
Sample No	% Temper											
T60c	1.64%	74.00	0.55	15.41	6.51	0.02	0.85	0.65	0.21	1.77	0.03	100.00
T61c	3.85%	74.12	0.55	15.20	6.49	0.03	0.84	0.79	0.18	1.77	0.03	100.00
T62c	13.33%	73.37	0.54	15.24	6.35	0.03	0.89	1.55	0.12	1.87	0.04	100.00
T63c	23.53%	71.98	0.54	15.09	6.59	0.03	0.99	2.72	0.06	1.96	0.04	100.00

B. Trace elements

		Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
Clay (n=8)		121	75	34	209	10	16	31	61	90	96	12
Experimental values												
Sample No	% Temper											
T60	1.64%	122	78	33	196	10	13	28	59	90	95	11
T61	3.85%	116	75	31	188	9	13	27	58	88	93	12
T62	13.33%	107	74	28	180	8	11	23	54	85	88	13

Charcoal temper has also been described from this region (Rudner, I. 1965; Woods 1984a) and amongst the Tsodilo sherds collected by Rudner (1965) were those with obvious charcoal temper, namely, bz6, 12, 4, 5, 9, 11, and 28 (Table 2.6). Charcoal is burnt wood. Wood can contain appreciable amounts of Ca and K to name but two elements. Compositional plant data presented in Connor and Shacklette (1975), although for North American species such as oak and hickory, show that up to approximately 34% Ca and 11% K can be found in certain trees (measured on plant ash). Obviously then, charcoal is not necessarily neutral in composition. Judging by the data in Table 2.8, the charcoal used in this experiment was enriched in CaO and perhaps with lesser amounts of K_2O. It is also obvious that charcoal and probably any other organic component including bone, results in a very high LOI, well into double figures (Table 2.6). This alone should alert one to the fact that tempering had taken place and that the data do not only represent values for a clay.

Temper can make sherds less than useful for provenancing unless they contain a unique marker element that is representative of a single region. For example, if bone and/or charcoal tempered pottery can be regarded as characteristic of northeastern Namibia and northwestern Botswana, this could provide a visual provenancing marker. If, then, such sherds are found in low frequencies elsewhere in the region, it may be assumed that they could have been traded or exchanged from that area. These unusual forms of tempering are also interesting in that they are behavioural indicators representing local adaptations to, presumably, poor quality clays or even less skilled imitations of better quality wares.

2.4 MIXED CLAYS AND MULTIPLE CLAY SOURCES

2.4.1 The use of several different clays at one site

It is possible that either a single or several potters in a community used a variety of clays with different chemical signatures over the course of time either as a result of a single source becoming exhausted, reasons of witchcraft or perhaps because they had different properties suitable for different types of pots (eg, cooking, storage, etc). The example of the potter from Nonnashoek who used two different though unmixed clays is instructive (see section 2.6 below). It has been noted in the Kavango, Namibia (A. Otto, pers. comm.) that women potters are generally very secretive about the location of their clay sources and that they use several over the course of time. These sources were shallow holes dug into a river terrace and which were changed either if the quality of the clay, in terms of their judgement, was not consistent as the hole was enlarged or else someone else got to know of the location. This latter reason apparently was linked to witchcraft and the fear of someone putting a spell on the clay, and hence the pot and food prepared therein, that might cause harm to the user. Such regular changes could, in a geochemically variable environment, introduce this variability to the homestead or village pot assemblage.

Such practices can therefore be problematical from an interpretive aspect. Only an understanding of the local geology and geochemistry can assist in sorting out local from any potential imported wares. Ideally, the full range of local clays should be sampled but this can be an expensive and time consuming matter and, more importantly, not always successful.

2.4.2 Mixed clays

Potters who mix clays from different sources present the same type of problem as that of temper which was discussed in the previous section. Depending upon the composition of each clay and the relative amount used, the most relevant concern is whether the mixing is consistent. Inconsistent mixing of two chemically variable clays could result in a compositionally variable vessel (i.e., different sherds from the same vessel could give different results) while different mixing ratios between batches will also result in a spurious variability. Clay mixing also presupposes that there are compositionally variable clays near a settlement. This kind of problem is more difficult to deal with without a detailed geochemical knowledge of the site. It also emphasises the need for a large suite of sherds for analysis.

If one makes the not unreasonable assumption that most pottery found on a site was locally made, then it is likely that two or three clusters of chemically similar sherds containing most of the suite are likely to be local.

2.5 DIAGENENSIS AND CONTAMINATION RESULTING FROM USAGE AND POST-DISCARD PROCESSES

The big question is whether a pot can have its composition changed either through use or as a result of being either buried or lying on the surface subsequent to being discarded. Residues from cooking or other food or beverage preparation techniques or storage could adhere to a pot and survive burial (Patrick et al. 1985; Copley et al. 2004) but as they would be organic in origin, it is doubtful whether these would influence the bulk composition. Precautions can be taken, however, to remove any visible residues by washing the sample before preparation.

Most publications dealing with the chemical analysis of pottery contain little or no discussion about the effects of burial on the composition of the ceramic although a number of studies have been carried out over the years. Water, for example, in the immediate environment of a potsherd could have a role to play in affecting its composition. This was suggested by Freeth (Freeth 1967) who had analysed a suite of sherds and who found that selective post-depositional changes in CaO and MnO content had taken place. Sherds from the same vessel but from below the water table were enriched in these two elements relative to sherds from above, in the case of CaO by up to three times as much. If one assumes that these sherds should have been similar in composition (as they could be joined thus indicating they came from a single vessel), then obviously the association with water must be responsible. In this case, the sherds were tempered with shell and it is hypothesised that water percolating down through the sediments would have dissolved the shell (CaO) out of those sherds above the water table and re-deposited it on sherds below the water table. The enriched MnO sherds would result from staining by MnO saturated water. Obviously, this is an interplay of very localised factors.

Schwedt et al. (2004) examined the difference between the surface of an eroded sherd and its core and found changes specifically in Ca but also in Cs, Rb, K and Na as well as a few Rare Earth Elements (REEs). They used Neutron Activation Analysis (NAA), a technique which only requires milligrams of sample for analysis. It would have been interesting to know if there was, in fact, any real difference between a normal and a corroded sherd if a typical bulk XRF analysis had been carried out.

Studies of kiln fired pottery have found that compositional alterations are influenced by firing temperatures. Cs (not analysed in this study) is adsorbed in low fired (<750°C) pottery whereas the alkali elements are leached in pots with extensive vitrification whilst very highly fired pots (>950°C) exhibit leaching of K and Rb but enrichment of Na (Buxeda i Garrigós et al. 2001, 2002). As South African pottery can best be categorised as low fired, these studies are of cautionary interest but not directly relevant.

Table 2.9. Summary statistics for P_2O_5 in pottery and sediments. See text for further details.

	Iron Age sherds	Cape Coastal sherds	Karoo sherds (1)	Karoo sherds (2)	Geological sediments	Archaeological sediments
Mean	0.42	0.16	0.46	0.27	0.10	0.88
Standard Deviation	0.87	0.12	0.61	0.18	0.08	1.39
Minimum	0.03	0.03	0.04	0.04	0.00	0.02
Maximum	12.51	0.87	2.85	0.87	0.40	5.95
CV %	207	75	133	67	80	158
N =	682	323	46	41	119	45

One certain contaminant is that of phosphorus. It has been demonstrated that phosphorus in the soil is readily adsorbed onto a variety of materials including potsherds and seeds (Freestone et al. 1985). Hence, it has no real interpretive provenance value and when recalculating the major elements to 100% (see section 1.2) for the purposes of statistical evaluation, it is omitted. Table 2.9 shows summary statistics for the P_2O_5 values in three groups of pottery and two groups of sediments. Figure 2.2 shows the distribution of the values in the form of bar charts. Cape Coastal (or Khoisan) sherds are usually found on open sites or else in shell middens with little ash for the most part hence their low average for P_2O_5. Iron Age sherds on the other hand are often excavated from ash middens which contain not just wood ash but bone and bone ash hence their higher average value. The Karoo LSA samples have the highest average of the three but one must note that the sample size is much smaller and thus not fully representative of that population. In fact, the sherds with the five highest values come from the excavation of the Roosfontein Shelter (Klatzow 1994) and range from 1.04% to 2.85% thus boosting the average (Appendix A2.1). If one removes the five Roosfontein samples, the average drops to 0.27% (Table 2.9: Karoo sherds(2)). These sherds must have become contaminated whilst buried.

Table 2.10. K2 split sherd analysis. VC36 is the encrusted piece, VC29 the cleaned piece.

	VC36	VC29	Ratio VC36/VC29
SiO_2	63.12	63.22	0.998
TiO_2	1.46	1.46	0.999
Al_2O_3	13.18	13.43	0.981
Fe_2O_3	8.24	8.41	0.980
MnO	0.12	0.13	0.922
MgO	5.37	5.33	1.008
CaO	3.83	3.34	1.148
Na_2O	1.54	1.64	0.942
K_2O	2.84	2.78	1.021
P_2O_5	0.30	0.26	1.127
TOTAL	100.00	100.00	
Rb	77	79	0.975
Sr	381	369	1.033
Y	25	25	1.000
Zr	285	299	0.953
Nb	16	16	1.000
Cu	51	51	1.000
Ni	248	250	0.992
Zn	85	89	0.955
V	134	137	0.978
Cr	354	384	0.922
Co	37	40	0.925

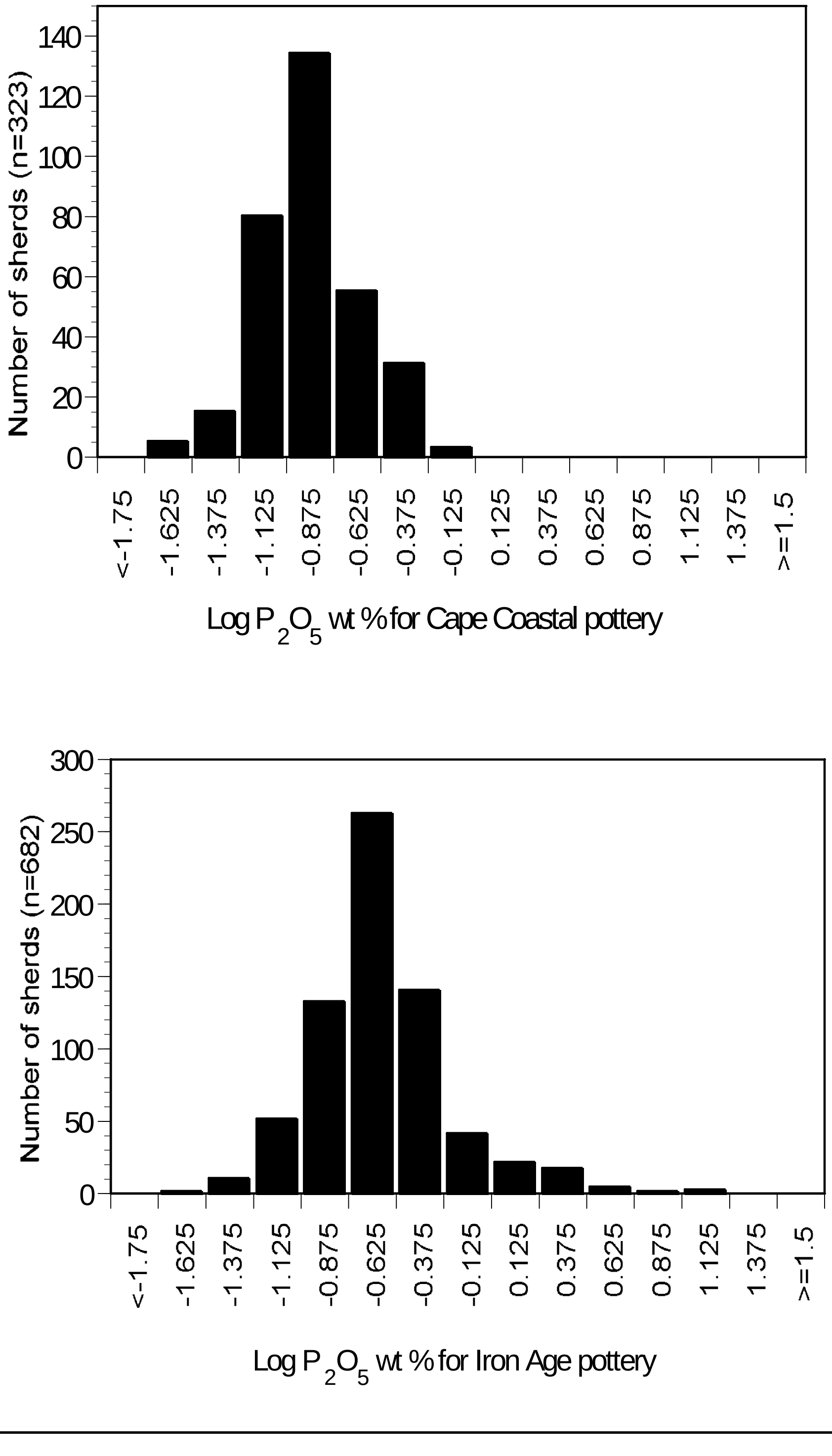


Figure 2.2. P_2O_5 values in pottery and sediments from a variety of sources.

A. Cape Coastal and Iron Age pottery.

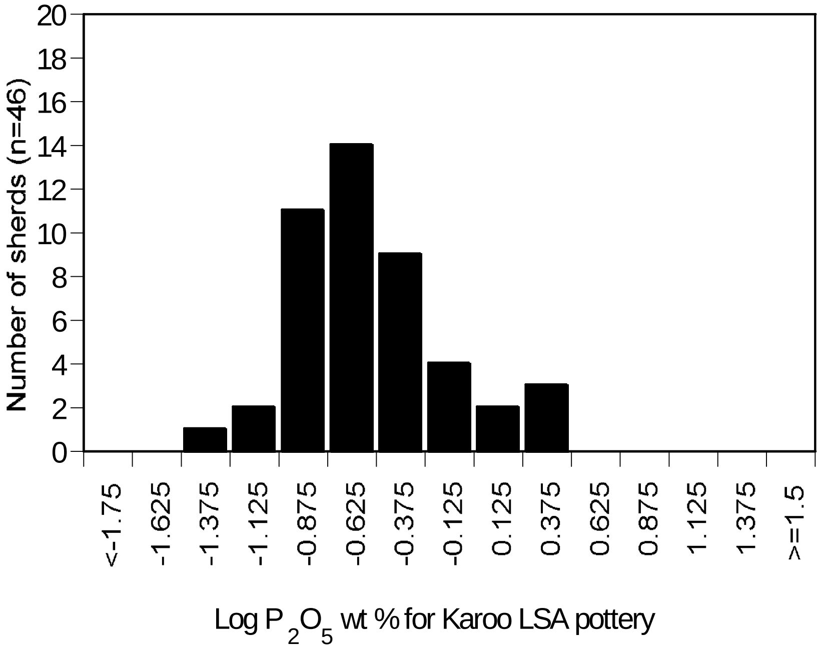


Figure 2.2 continued. B. Karoo Later Stone Age pottery.

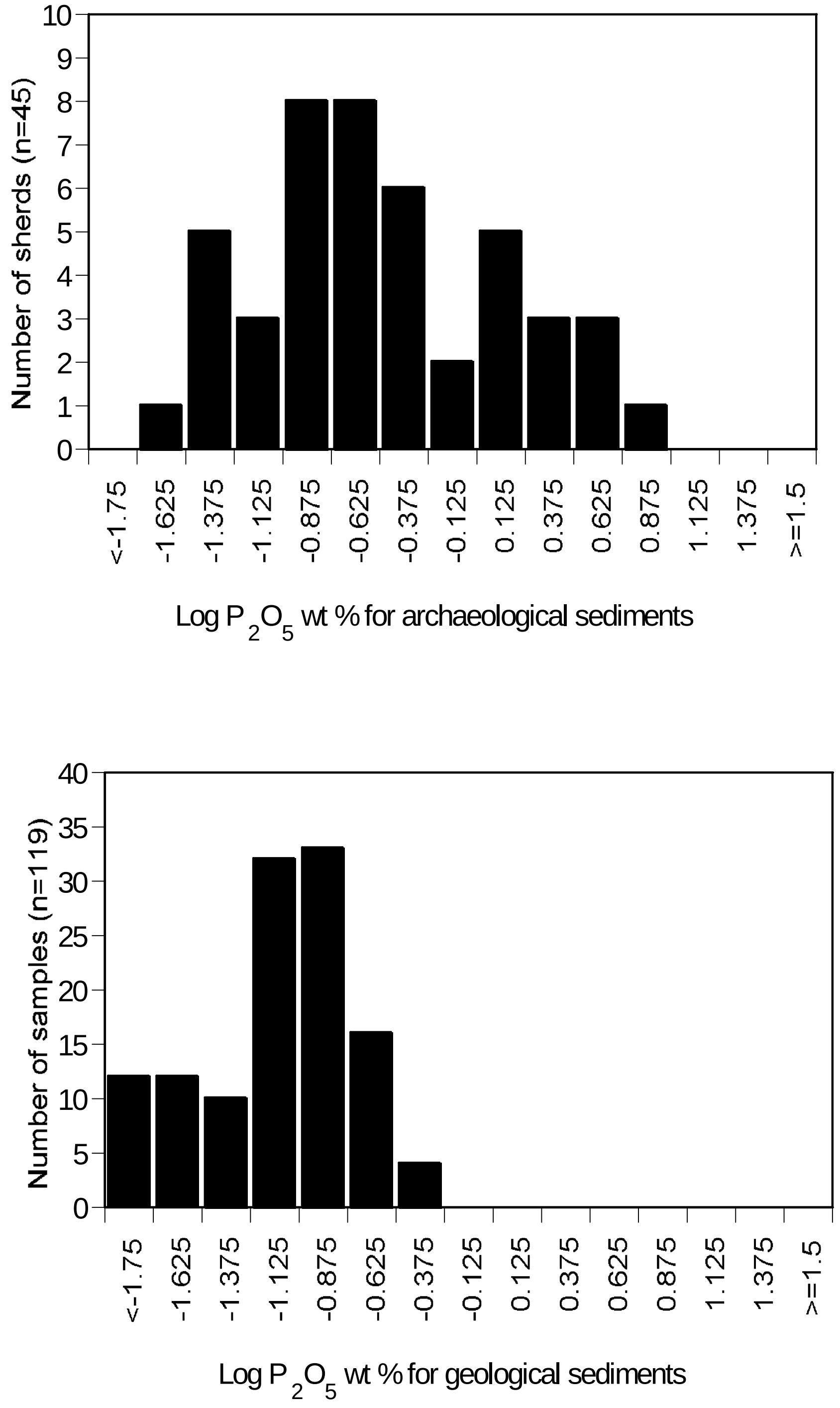
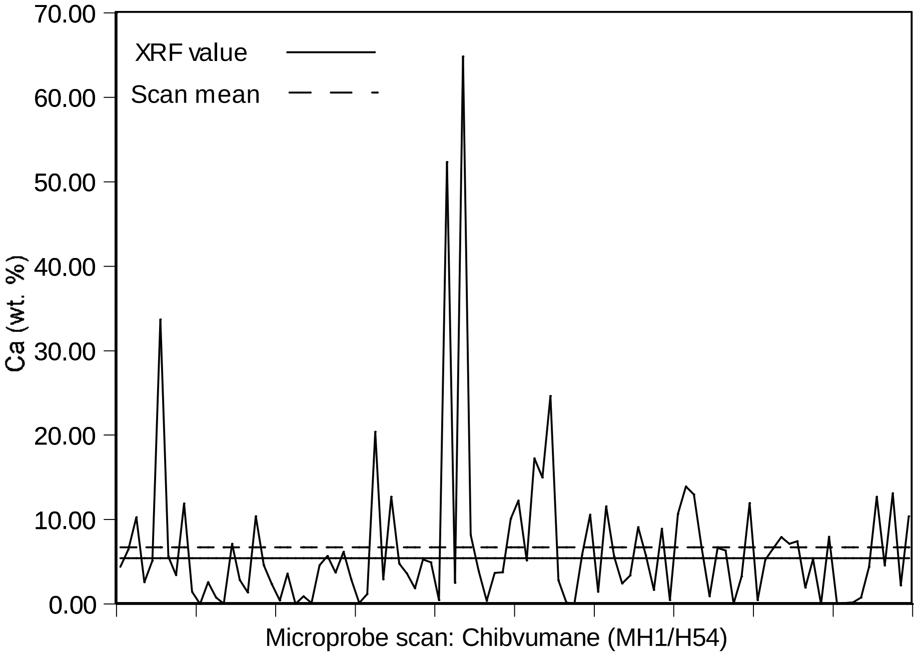


Figure 2.2 continued. C. Archaeological and geological sediments.



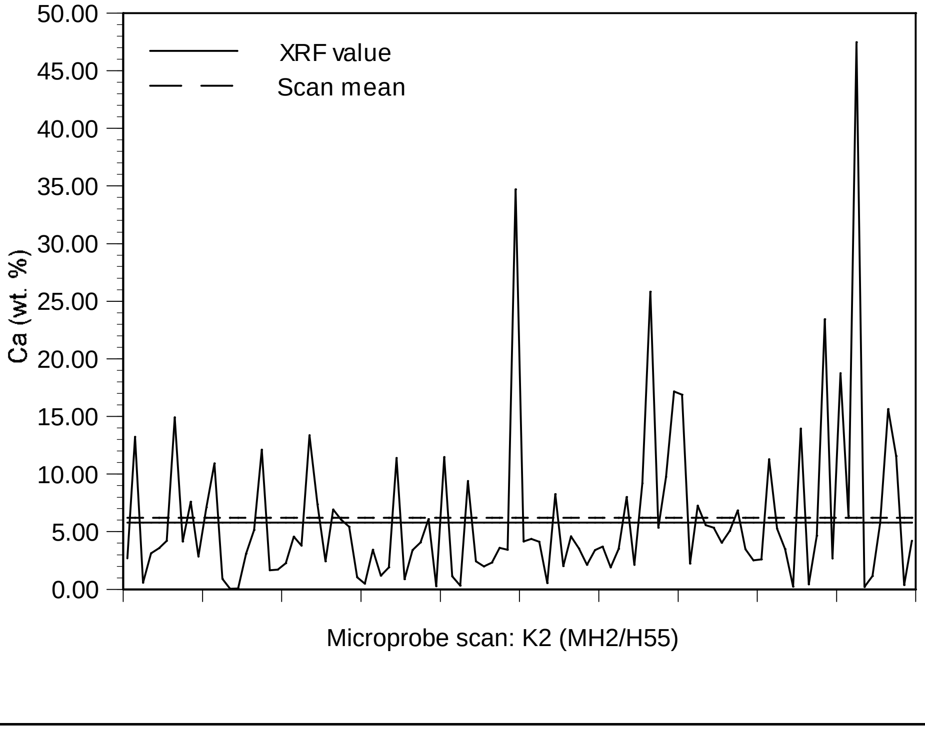
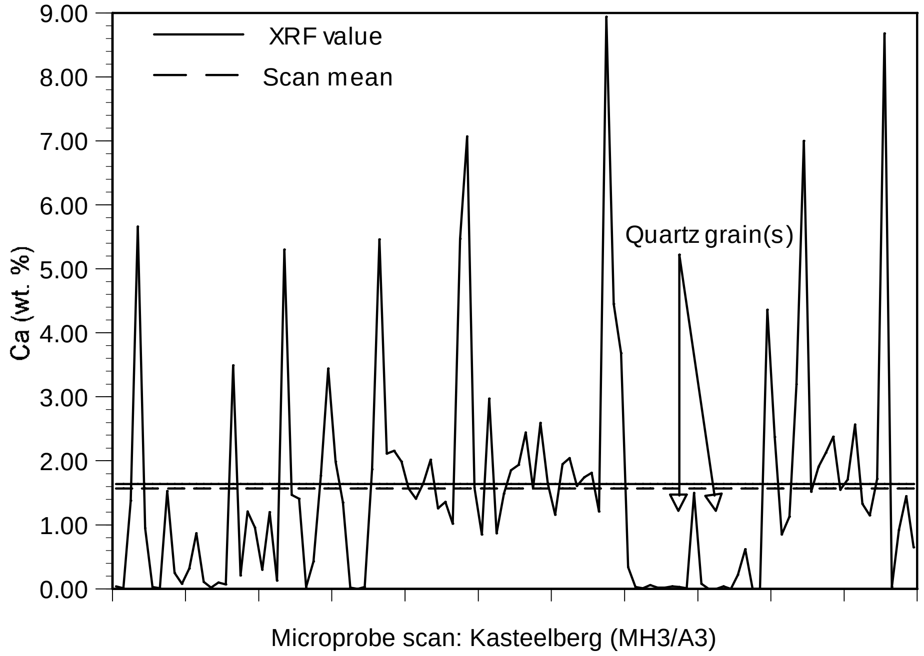


Figure 2.3. Microprobe scan showing the distribution of Ca across four sherds.



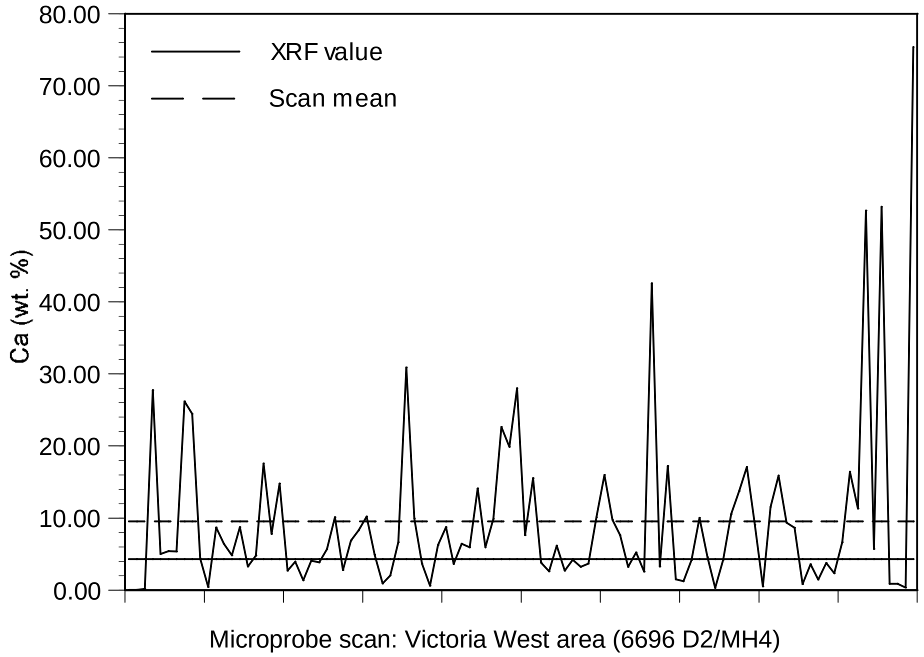
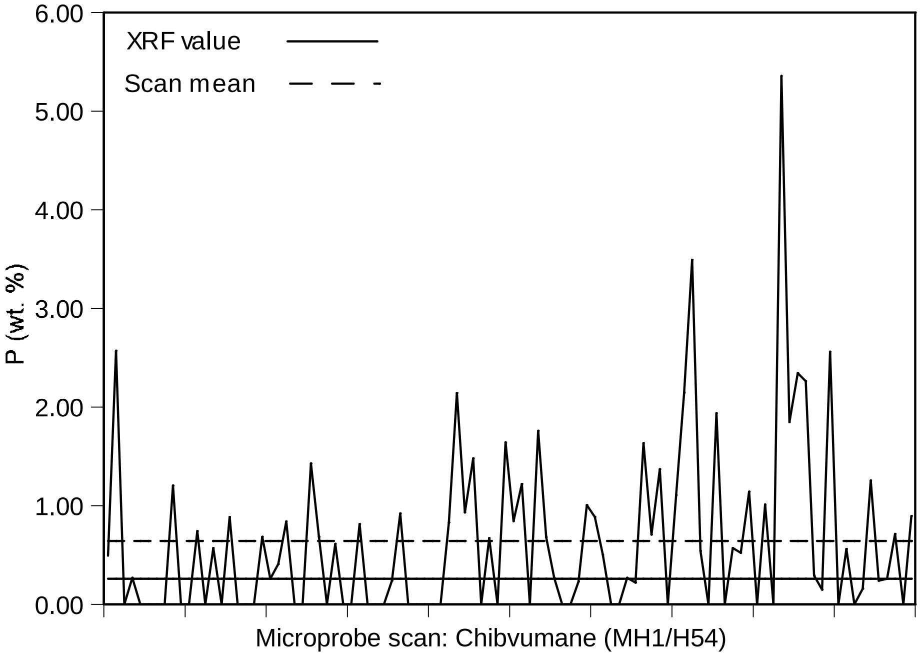


Figure 2.3 continued.



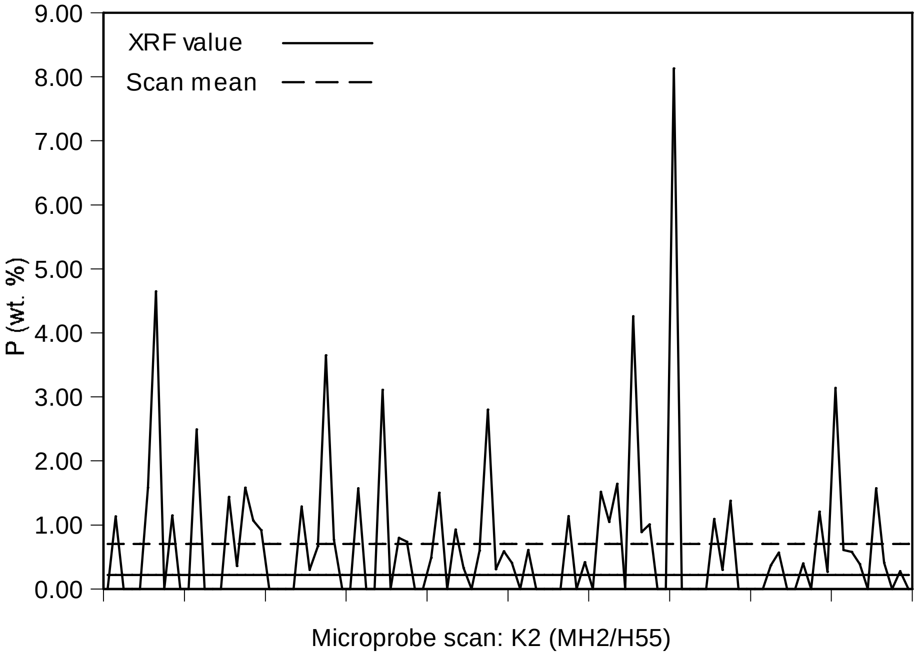
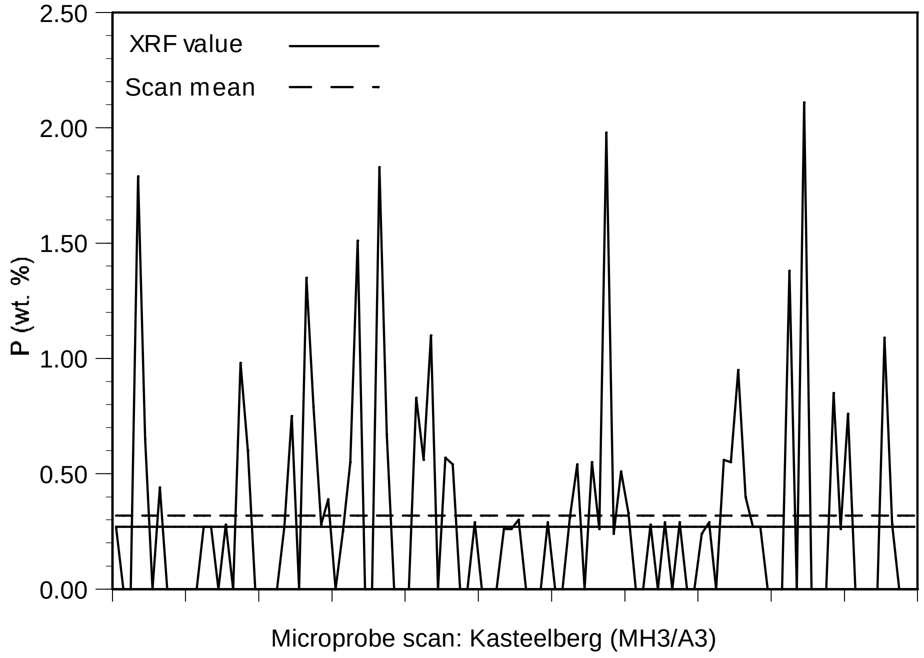


Figure 2.4. Microprobe scan showing the distribution of P across four sherds.



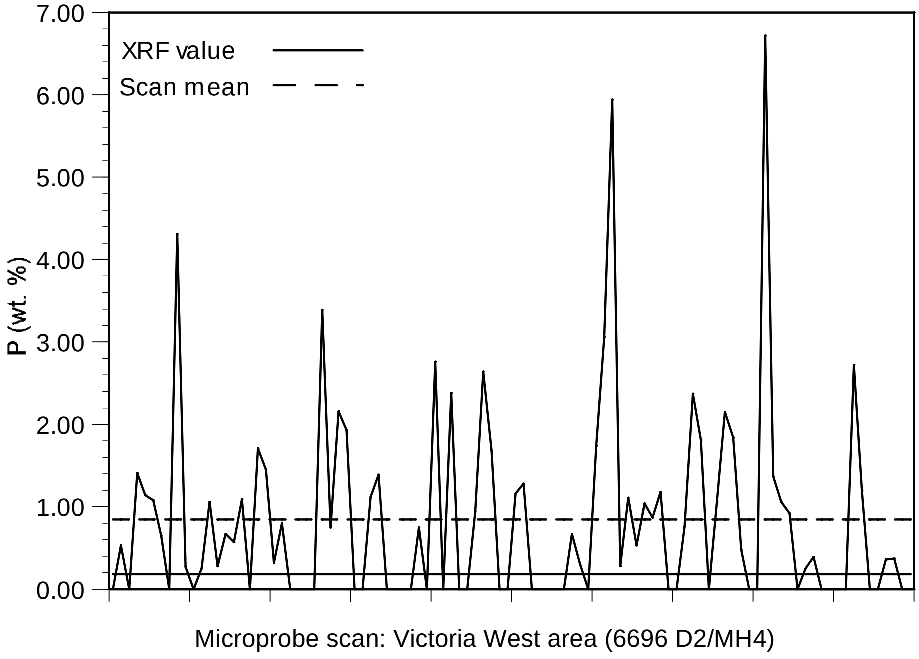


Figure 2.4 continued.

The contrast between the geological sediments and the archaeological sediments, which have been modified by anthropogenic additions such as wood and bone ash, once again demonstrates that P_2O_5 is in fact a marker of human activity. It needs to be borne in mind, however, that not all buried sherds become contaminated with phosphorus and that not all high phosphorus levels arise from contamination. As seen above in section 2.3, the latter condition can arise from bone temper added to the clay.

During the course of this project it had been the policy to only sample relatively fresh looking sherds. Any encrustations, sand or dust were removed by cloth or by washing either in water or a slightly acidic solution, this having no effect on the composition of the sherd (Schneider et al. 1991 quoted in Schwedt et al. 2004). When selecting sherds from K2 for analysis, however, a large sherd with a light grey coating over the surface was noticed and chosen for further study. This sherd was split: one half was analysed uncleaned (VC36) whilst the other half (VC29) was mechanically cleaned by having the coating scraped off with a plastic knife. The cleaned sherd was also analysed but unfortunately not enough of the coating was available for an analysis.

Table 2.10 shows the compositional data for these two sherds. It will be apparent that the biggest difference between the two is the reduction in the value of CaO and P_2O_5 by 14.8% and 12.7% respectively from the coated to the cleaned sherd. This difference may not be significant and could result from the variable distribution of these elements. However, the relatively enriched P_2O_5 levels in the sherd suggests that it had been lying in an ashy midden or kraal. As phosphorus is readily adsorbed onto buried objects such as pottery, it is therefore quite likely that this coating was formed from either wood or other ash in a midden or else ashed kraal manure which was deposited on the sherd when the deposit was moist possibly from rain or animal urine. Data demonstrating high levels of P_2O_5 in ashed kraal manure can be found in Jacobson et al. (2003a: Table 1). For further details on phosphorus contamination of sherds see Table 2.9 and the discussion above. Whether the coating was purely a surface phenomenon or whether it infiltrated the whole sherd (typical ceramics being porous) could not be determined. A visual examination of the sherd revealed no obvious evidence for this. There is also the possibility that the coating prevented the subsequent infiltration of soil solutions and any accompanying elemental contamination by sealing the pores in the body of the sherd.

Table 2.11. Summary data for the XRF and Microprobe analyses. Note: all data normalised to 100%. This list omits Cl and Cr in order to make it comparable with the XRF data.

MH1	Si	Ti	Al	Fe	Mn	Mg	Ca	Na	K	P
XRF	59.41	0.97	16.29	9.23	0.14	1.56	5.41	1.72	4.99	0.26
Probe mean (n=100)	48.14	1.30	16.81	19.17	0.26	1.35	6.69	1.91	3.72	0.64
Standard Deviation	22.12	4.22	8.95	16.78	0.40	1.34	9.34	3.39	5.25	0.88
Minimum	0.21	0.00	0.02	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	99.50	35.89	45.78	77.28	1.86	7.01	64.85	15.23	23.26	5.36
CV (%)	46	324	53	88	151	99	140	178	141	137
XRF/Probe	1.23	0.75	0.97	0.48	0.54	1.16	0.81	0.90	1.34	0.41

MH2	Si	Ti	Al	Fe	Mn	Mg	Ca	Na	K	P
XRF	56.22	1.64	14.68	9.77	0.14	5.00	5.79	2.03	4.52	0.22
Probe mean (n=100)	36.60	2.64	25.55	16.48	0.41	3.15	6.19	1.51	6.77	0.70
Standard Deviation	18.10	6.50	19.53	10.53	0.92	3.09	7.18	2.49	8.98	1.21
Minimum	0.00	0.01	0.89	0.21	0.00	0.00	0.03	0.00	0.03	0.00
Maximum	76.28	49.01	97.15	45.99	8.46	22.63	47.46	17.84	76.30	8.13
CV (%)	49	246	76	64	226	98	116	166	133	171
XRF/Probe	1.54	0.62	0.57	0.59	0.34	1.59	0.94	1.34	0.67	0.31

MH3	Si	Ti	Al	Fe	Mn	Mg	Ca	Na	K	P
XRF	65.48	0.53	15.73	6.67	0.03	0.94	1.64	1.57	7.13	0.27
Probe mean (n=110)	63.27	0.73	16.47	9.04	0.17	1.24	1.57	1.92	5.26	0.32
Standard Deviation	25.01	1.12	16.04	11.67	0.64	1.20	1.80	3.24	5.52	0.46
Minimum	1.53	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	99.69	7.75	97.53	78.79	6.53	4.38	8.94	15.79	26.29	2.11
CV (%)	40	154	97	129	369	97	115	169	105	146
XRF/Probe	1.03	0.73	0.96	0.74	0.18	0.76	1.04	0.82	1.36	0.84

MH1	Chibvumane, Zimbabwe
MH2	K2, Shashi-Limpopo Valley
MH3	Kasteelberg, Western Cape

Table 2.11 continued.

MH4	Si	Ti	Al	Fe	Mn	Mg	Ca	Na	K	P
XRF	57.29	1.13	17.00	11.36	0.16	3.20	4.32	1.72	3.63	0.18
Probe mean (n=100)	39.76	1.33	21.11	18.30	0.36	3.26	9.53	1.31	4.20	0.84
Standard Deviation	19.34	2.20	15.90	14.01	0.45	2.60	11.89	2.32	5.76	1.20
Minimum	0.25	0.00	0.19	0.80	0.00	0.00	0.02	0.00	0.00	0.00
Maximum	88.58	16.63	96.29	64.43	2.85	17.72	75.39	14.28	47.61	6.72
CV (%)	49	165	75	77	127	80	125	178	137	142
XRF/Probe	1.44	0.85	0.81	0.62	0.44	0.98	0.45	1.31	0.86	0.21

MH4 Victoria West Area

Freestone et al. (1985) provide data to show that contamination of sherds occurs at the inner and outer surfaces and that a microprobe analysis across a cross section would show a U-shaped distribution, i.e., enriched on the outer surfaces but depleted in the centre of the sherd. To assess this, thin sections were cut from four random sherds which had been collected from widely dispersed localities and from very different contexts, ie, Iron Age (mh1, Chibvumane, Zimbabwe and mh2, K2, Shashi-Limpopo Valley), Khoi pastoralist (mh3, Kasteelberg, Western Cape) and San hunter-gatherer (mh4, Victoria West area). In addition to the usual analysis by XRF, one hundred points were scanned across each section with 110 points on MH3.

It needs to be noted here that selected data (CaO and P_2O_5) for sherd mh2 had been published previously (Jacobson et al. 1995a). In this case, the average of every successive ten points was plotted. No U-shaped curve was noted although there seemed to be a trend of CaO enrichment towards the surface of the sherd.

The summary data for the current study is presented in Table 2.11 both for the probe and XRF analyses. Figures 2.3 and 2.4 illustrate the distribution for Ca and P respectively through the thin sections for each sample. For this current study, each point was plotted in sequence together with lines illustrating the mean value for the probe data and the value for the XRF bulk sample. Note that the vertical axes are not the same for each graph.

Table 2.12. Data for the five potsherds and two clays. Base, rim and body refer to the type of sherd analysed; these were collected from broken fragments found at the homestead. See text for further details.

	bc 8	base 0	rim 4	body 7	wc 9	base 5	body 6
SiO_2	67.00	76.27	74.74	73.39	76.81	81.04	80.62
TiO_2	0.44	0.54	0.58	0.58	0.67	0.71	0.72
Al_2O_3	13.78	13.78	14.37	14.96	10.99	11.23	11.68
Fe_2O_3	6.24	5.29	5.55	5.71	3.39	3.76	3.98
MnO	0.02	0.02	0.03	0.01	0.01	0.01	0.01
MgO	0.54	0.57	0.60	0.61	0.28	0.28	0.28
CaO	0.54	0.46	0.51	0.52	0.25	0.25	0.27
Na_2O	0.12	0.23	0.18	0.21	0.04	0.00	0.00
K_2O	1.51	1.82	1.86	1.86	1.40	1.52	1.54
P_2O_5	0.03	0.04	0.04	0.03	0.03	0.03	0.03
H_2O-	3.70	0.21	0.26	0.66	1.88	0.29	0.27
LOI	6.57	0.79	1.97	1.67	3.93	0.65	0.85
TOTAL	100.49	100.02	100.69	100.21	99.68	99.77	100.25
Rb	116	119	119	127	81	88	88
Sr	72	71	73	76	45	49	49
Y	32	36	37	38	26	30	31
Zr	195	243	253	261	358	381	390
Nb	7	10	10	11	11	13	13
Cu	17	15	16	17	6	9	9
Ni	30	25	25	26	13	12	13
Zn	62	55	55	60	32	33	33
V	91	85	85	89	96	88	87
Cr	91	74	79	81	70	65	66
Co	16	11	11	10	4	3	4

bc	Black clay
base 0	Base sherd
rim 4	Rim sherd
body 7	Body sherd
wc	White clay
base 5	Base sherd
body 6	Body sherd

Neither of the two elements show any U-shaped curve. P shows nothing in the way of a trend through the thin section for any of the sherds. For Ca, only sherds mh2 and mh4 show an apparent enrichment towards the right hand surface but the former is not too convincing as it does not quite reach the surface. Only the latter might qualify but it is not a continuous accumulating enrichment.

From all the above, it is quite obvious that conditions conducive for contamination or diagenesis are likely to be highly localised, even within one site or specific locality within one site. Dry burial is unlikely to have any effect but exposure to groundwater or moisture from any other source, depending upon intensity and duration of contact time could have a material affect. Further systematic research with specific reference to South African conditions still needs to be conducted in order to resolve some of these issues.

2.6 AN ETHNOGRAPHIC EXAMPLE

The samples

The samples for analysis were collected by J. Dreyer from Mrs Evelina Mokoena of the farm Nonnashoek in the Bethlehem District, who at the time was making pottery using traditional methods (Dreyer 1988). The potter used two types of clay, one a blackish clay from the nearby vlei, the other a whitish clay from a road cutting through a ridge near the house (referred to in Dreyer (1988) as "rooi klei" or red clay: when seen in situ this clay was yellow but subsequently dried white). A number of vessels, including a few broken fragments as well as clay samples, had been collected and it was from these that specimens were made available for analysis. Both types of clay were analysed as well as fragments from the broken but unused vessels. It was not known from which clay the sherds had been made.

A brief description of the manufacturing process is necessary as this could have a material effect on the original clay compositional profile. Once collected, the clay was processed by breaking up the lumps with a grindstone and ground into a fine powder from which all stones and grit were removed. Temper, in the form of finely ground potsherds, was added in order to give strength to the vessel and prevent it from exploding during the firing process. Water was then added and the clay thoroughly mixed and left for a while to “ripen”. The vessel was then formed in a cool place out of the wind and finally left to dry out thoroughly before firing which took place in a shallow hollow in the ground.

It is important to note that clay is not often found “clean”, i.e., without any stones or grit or other impurities. These may be removed by hand, but they will always form a small fraction of the total composition depending upon how thoroughly the cleaning is carried out during the preparation. These natural inclusions could have an influence on the chemical profile of the total vessel if their composition is widely divergent from the clay. In itself, this does not really matter as, being a natural component of the clay deposit, they form part of the clay’s chemical fingerprint. Where it could matter is if this material is not evenly distributed throughout a clay body or if different potters prepared the same raw clay on an individual basis with regards their own assessment of what was an acceptable amount of natural impurities in clay.

Results

Table 2.12 presents the results of the analysis. Note how the samples fall into two very clearly defined chemical groups, each consisting of a clay and two or three sherds (for the white and black clays respectively). The white clay is enriched in SiO_2, TiO_2 and Zr, whilst depleted relative to the black clay in most of the other elements although a few, eg, Nb and V, show little difference between the two groups. The origins of this difference must lie either in the source rocks from which these clays were developed or else mixing or winnowing or some other process such as inclusion of organic material (see below) during the formation of the deposits. The local area is underlain by sandstone, shale and basalt exposures from various Karoo Sequence formations any of which could contribute to the observed differences.

The compositional profile of the sherds follow the clay results closely enough for them to be assigned to one or the other. The only exceptions appear to be Cr and Co which are slightly enriched in the black clay relative to its sherds and Zr, which is enriched in the sherds relative to the black clay. The overall differences between the white and black clays and their sherds are obvious but more samples are needed before definite conclusions can be reached for some of the apparent differences between the clays and their sherds.

Conclusions

From this, there are two obvious conclusions. Firstly, the sherds closely resemble the clays from which they were made. Note, however, that the sherds had never been used or discarded and buried and thus two critical steps in the sequence from a raw clay to the archaeological sherd which could change or contaminate the original chemical signature (e.g., Freestone et al. 1985) are missing. Although some temper had been added to the clay, this had obviously had very little effect on the overall composition. This could be either due to the temper having the same composition as the clay or because not enough was added to materially alter the composition. Suffice it to say that it requires the addition of approximately 10 - 20% temper to make a significant difference to the compositional profile of a clay depending, most importantly, upon the relative values of the elements being measured (Neff et al. 1988, 1989), a temper with a profile similar to the clay having no effect (see also section 2.1.2 above). These results, however, also confirm that the firing temperature has no effect on the composition of fired clay (Cogswell et al. 1996).

The second point relates to interpretation. As demonstrated here, one needs to be cautious when interpreting the chemical variability of pottery from any one site in terms of trade or exchange before the geochemical variability of the local clays and substrate is understood. This is easier said than done as knowledge of clay sources near most archaeological sites is totally lacking particularly from a potter's perspective.

CHAPTER 3. SAMPLING

3.1 GEOCHEMICAL SAMPLING

Sampling is a generic term that can cover a variety of sins. It can vary from whether an analysed sample is representative of the whole vessel to whether the sherds being analysed from a site are representative of the full range of locally made pots and their clays. These are real concerns and will be dealt with below.

3.1.1 The sherd as representative of the whole vessel.

A basic requirement for any analysis is that the sherd being analysed is chemically representative of the whole vessel from which it came. As a 20-25 g sample (or larger) is usually prepared, it is felt that this adequately samples the fabric, even if coarse, and any inclusions which may be found therein. A geochemical rule of thumb, quoted by Schneider (1995), suggests a minimum sample of 500 g if inclusions have a maximum size of 1 mm. Clearly, such a sampling procedure would consume most of a vessel and obviously cannot be applied.

To test the sampling procedure, thirteen samples from an almost complete but broken lugged vessel collected from the vicinity of the Messum Mountains, Damaraland, Namibia were analysed (see Table 3.1 for the summary statistics and Table A3.1 for the complete data set). Although undated and without any archaeological context, this is a typical example of a late herder or Dama vessel (du Pisani & Jacobson 1985). This particular one was chosen as it was already broken though almost complete (the individual sherds could be refitted) and had a coarse fabric with a gritty temper. The sample sizes ranged from 10 g to 50 g with the majority in the range 20 g to 40 g. Samples were chosen that were representative of the rim, the body and the base of the vessel. The results indicate that there is little chemical variability within the vessel. Of the elements, P_2O_5, Cu and Co were the most variable (i.e., having a Coefficient of Variation (CV) greater than 10%) but they were also the elements occurring with the lowest concentrations.

For example, Cu has a CV of only 15.64% with a range of 8 - 13 ppm whilst the highest variability was shown by LOI with a CV of 21.07%. It would thus appear from this single vessel that variability is not necessarily a problem with respect to the sample size used for analysis.

A second vessel, however, produced a different result. Three sherds from a broken vessel found on the farm Erongo West 83, Omaruru District, Namibia were analysed. These comprised one small rim sherd, one large rim/body sherd and a thick pointed base (Table 3.2: samples ak 7-9). The results indicate that whereas the rim and body sherds were compositionally the same, the base was quite different being enriched in Al_2O_3, CaO, Na_2O, Sr and V and depleted in Fe_2O_3, MgO, Rb, Y, Zr, Ni and Cr. The base was very thick, 45 mm in part, and contained a number of large (>5 mm) inclusions. As this was a fairly large vessel, approximately 70 cm high, it is quite possible that the inclusions in the base were added to strengthen the vessel at this point and that their composition was sufficiently different from the clay thus producing a different result. Alternatively, the base could have been made from a different clay. Unfortunately, at the time no separate analysis was made of the temper.

A final example concerns the thick, very coarse sherd collected at the Tsodilo Hills in Botswana (Table 2.10) which has already been discussed (chapter 2.3). The fabric contained large (>5 mm) inclusions of charcoal and calcrete. This sherd was halved and the pieces analysed separately (samples bz6 and bz12). The two halves were compositionally alike for most elements except for CaO and Sr which were relatively enriched in sample bz6 compared to bz12, probably from the calcrete. The latter were clearly visible in the sherd. The uneven distribution of the temper in the vessel as a whole and which was manifest in the large sherd meant that separate coarsely tempered sherds, if not identified as coming from one vessel could mislead the analyst into accepting that they were from different vessels.

The conclusion to be drawn from this is to eschew choosing thick, very coarse tempered sherds as they could produce a result not necessarily representative of the total fabric of the vessel. If the samples above had been found as individual pieces and analysed, their composition would have indicated separate clays. Alternatively, it might be possible to remove the large inclusions and only analyse the fabric in order to obtain a result closer to the original clay.

Table 3.1. Summary statistics for the analysis of the Messum potsherds.

	n	Average	SD	CV%	Min	Max
SiO_2	13	61.21	0.70	1.1	59.97	62.58
TiO_2	13	0.68	0.01	0.9	0.67	0.69
Al_2O_3	13	18.12	0.15	0.8	17.9	18.36
Fe_2O_3	13	5.73	0.13	2.3	5.56	5.96
MnO	13	0.06	0.00	6.1	0.06	0.07
MgO	13	1.26	0.05	4.0	1.20	1.35
CaO	13	0.91	0.06	6.5	0.83	1.03
Na_2O	13	2.37	0.11	4.6	2.20	2.58
K_2O	13	4.55	0.24	5.3	4.35	4.99
P_2O_5	13	0.23	0.03	13.4	0.20	0.29
H_2O-	13	0.70	0.08	11.9	0.58	0.84
LOI	13	4.64	0.98	21.1	2.84	6.07
TOTAL	13	100.46				
Rb	13	261.9	3.7	1.4	257	270
Sr	13	80.9	5.8	7.2	75	93
Y	13	47.2	1.1	2.3	45	49
Zr	13	152.2	1.7	1.1	149	155
Nb	13	37.7	1.0	2.7	36	40
Cu	13	10.6	1.7	16.0	8	13
Ni	13	35.9	1.3	3.6	34	39
Zn	13	77.8	2.3	3.0	75	82
V	13	120.5	2.9	2.4	116	126
Cr	13	94.9	9.0	9.5	81	115
Co	13	12.6	1.7	13.5	10	16

Table 3.2. Data showing the variability of split sherds.

Sample	A3in	A3out	A3mid	A7	A7in	A7out	A7mid
SiO_2	63.89	63.32	62.89	61.48	61.81	61.14	60.33
TiO_2	0.91	0.89	0.88	1.09	1.11	1.13	1.09
Al_2O_3	16.55	16.42	16.85	19.59	20.06	19.72	19.25
Fe_2O_3	9.26	8.85	9.10	8.39	8.76	8.83	8.46
MnO	0.23	0.23	0.23	0.08	0.11	0.11	0.10
MgO	2.64	2.62	2.59	1.00	1.06	1.21	1.03
CaO	1.99	2.04	1.94	0.88	0.92	0.88	0.82
Na_2O	0.70	0.72	0.73	0.24	0.27	0.29	0.25
K_2O	2.74	2.80	2.71	1.29	1.28	1.45	1.25
P_2O_5	0.33	0.35	0.31	0.16	0.24	0.22	0.17
H_2O-	0.02	0.05	0.08	0.31	0.06	0.11	0.15
LOI	1.61	2.06	1.28	5.77	4.57	5.04	7.00
TOTAL	100.87	100.35	99.59	100.28	100.25	100.13	99.90
Rb	136	135	131	37	46	50	39
Sr	135	137	136	111	107	117	118
Y	30	29	31	29	23	23	26
Zr	223	215	223	250	255	250	265
Nb	13	13	15	10	8	9	11
Cu	48	51	52	59	60	62	64
Ni	72	68	68	32	35	35	34
Zn	106	106	104	70	70	73	71
V	172	169	179	212	185	204	217
Cr	212	207	214	192	180	179	218
Co	38	34	34	23	30	33	32

A3 in:	Driekopseiland; Type R; inner surface of sherd
A3 out:	Driekopseiland; Type R; outer surface of sherd
A3 mid:	Driekopseiland; Type R; centre of sherd
A7:	Omdraai; LIA or CLSA; whole sherd
A7 in:	Omdraai; LIA or CLSA; inner surface of sherd
A7 out:	Omdraai; LIA or CLSA; outer surface of sherd
A7 mid:	Omdraai; LIA or CLSA; centre of sherd

Table 3.2 continued.

Sample	ak7	ak8	ak9
SiO_2	66.76	68.31	63.04
TiO_2	0.33	0.33	0.21
Al_2O_3	17.60	17.94	20.73
Fe_2O_3	5.11	4.62	2.89
MnO	0.05	0.04	0.05
MgO	0.93	0.88	0.67
CaO	0.70	0.62	1.34
Na_2O	0.68	0.70	2.37
K_2O	4.15	4.16	4.79
P_2O_5	0.14	0.14	0.16
H_2O-	0.26	0.13	0.31
LOI	3.75	2.03	2.96
Total	100.46	99.90	99.52
Rb	330	340	171
Sr	69	67	211
Y	38	40	16
Zr	154	153	60
Nb	22	22	17
Cu	54	52	49
Ni	23	19	11
Zn	44	45	51
V	51	48	89
Cr	62	51	39
Co	4	2	4

ak7:	Farm Erongo West 83, Omaruru; small rim sherd
ak8:	Farm Erongo West 83, Omaruru; large rim and body sherd
ak9:	Farm Erongo West 83, Omaruru; thick base sherd

During the course of this study it was the practice to halve particularly large sherds on a random basis where possible and carry out analyses on both pieces as a control with reference to any potential variability which may be present. These duplicate analyses, when present, are noted in the tables. No other specimens with variable results were noted. The two examples quoted above were obviously extreme examples.

3.1.2 Within-sherd variability

Two large sherds were analysed to test specifically for any compositional variability through the wall of the sherd, ie, from outer to inner surface, which may have arisen from contamination or other causes (Table 3.2). Two large sherds (A3 and A7) were split longitudinally such that individual analyses could be undertaken on samples of the outer, the inner and the centre of the sherds. In addition, A7 was large enough for a complete sample to be analysed as well. Examination of the data in Table 3.2 shows that there is little difference between the results from any one sherd. Whilst it is obvious that a sample of two does not prove or disprove anything, nevertheless, it does show in this instance that contamination from use or burial had not in any way altered the composition through the body of that sherd. Any potential variability such as this is not really an issue in view of the sample size taken.

As will be shown in section 3.3, there is a great deal of variability in composition at the micro level when analysing samples by microprobe but this constitutes a special case and is not relevant to the main thrust of this work.

3.2 ARCHAEOLOGICAL SAMPLING

A major issue relating to the archaeological sample relates to the actual sherds chosen for analysis. Are they representative of all the pots (which in turn represent all clay sources) found on a site? When one has broken sherds similar in colour and texture, it can be very difficult indeed to decide whether they represent one vessel or several vessels. Furthermore, certain settlements such as Iron Age villages have well defined, spatially bounded activity and domestic areas. These can influence the type of ceramics found. For example, where would imported vessels most likely be found: at the chief's homestead, at his court where people from the region might gather for meetings or to have cases adjudicated, or at ordinary homesteads? Middens or pits in which domestic rubbish, including ash, bone and potsherds, were disposed of might result from communal or individual cleaning activities. Archaeological excavations are often of limited extent and do not necessarily sample the entire range of domestic and public space. The definition of space will also vary between Khoisan and Iron Age sites. Indeed, there seems to be little written about the former (nothing in any archaeological site report that I can find) whilst knowledge about the latter is more readily available (Huffman 1993, 1996, 1997).

For the Iron Age, much will also depend upon whether the site represents a straightforward homestead or a local or regional capital. All these factors influence the representivity of the sample. Another no less important factor is whether the archaeologist will allow sherds to be used for destructive analysis although in this case most Iron Age sherds are generally large enough to be sampled.

Table 3.3. Quality rating developed for analysis of Khoisan sherds.

Quality	Context
Q7	sherd from known site or horizon, dated: distinctive style or texture
Q6	sherd from known site or horizon, dated: no decoration
Q5	sherd from known site or horizon, undated: distinctive style or texture
Q4	sherd from known site or horizon, undated: no decoration
Q3	sherd with distinctive style or texture: vague locality
Q2	plain sherd or non-distinctive decoration: vague locality
Q1	sherd with distinctive style or texture: no locality
Q0	plain sherd or non-distinctive decoration: no locality

In Tables 3.3 and 3.4 I have listed a hierarchical evaluation of sherd "quality" or suitability for analysis. The higher the quality, the greater the interpretive value of the sherd. I have drawn up separate tables for rating Khoisan (Table 3.3) and Iron Age (Table 3.4) sherds. There are a number of reasons for this. As already pointed out, Khoisan pottery, except perhaps for the western Cape (Sadr & Smith 1991), is not necessarily as regionally or chronologically distinctive as Iron Age wares although there is a textural characteristic that stands out. This is the grass tempered sherd which appears to be restricted to the interior and has not yet been found on the coast. This means that unless a site is dated by ^{14}C or some other method, the interpretive value is greatly lessened. The implication is that most of the Khoisan coastal pottery analysed will fall into the Q4 category and only Kasteelberg as Q6. (Note here that although the Kasteelberg sherds come from a well defined stylistic horizon, the actual sherds analysed were undecorated hence can only be classified as Q6).

Iron Age sites, on the other hand, can be broadly dated by any competent archaeologist on the basis of the stylistic pattern on a small sample of sherds or even on a single sherd.

Table 3.4. Quality rating developed for analysis of Iron Age sherds.

Quality	Context
Q7	sherd associated with specific feature on site: decorated
Q6	sherd associated with specific feature on site: no decoration
Q5	sherd from known site or horizon: decorated
Q4	sherd from known site or horizon: no decoration
Q3	sherd decorated in distinctive style: vague locality
Q2	plain sherd or non-distinctive decoration: vague locality
Q1	sherd decorated in distinctive style: no locality
Q0	plain sherd or non-distinctive decoration: no locality

The most interesting type of sherd to analyse and which will yield the most information is Type Q7. Unfortunately, there is only one site, Mutokolwe, in this project which has such data. Nevertheless, ratings from Q4 upwards will provide enough suitable archaeological information to integrate with a chemical analysis. They also provide the necessary background information for defining a regional geochemical space.

At the very bottom of the scale are the totally isolated sherds (Q0, Q1) about which no or little information is available at all. These are included for the sake of completeness and as they may have some forensic value some day (Ruffell & McKinley 2005).

Sherds analysed from any particular site will thus reflect varying degrees of representivity, ie, a random grab sample or deliberate sampling from various features. For the purpose of this thesis I had to accept whatever samples were available but future work should pay attention to the quality of the excavated material.

3.3 A CASE STUDY OF A SAMPLING PROBLEM

This critique of a published provenance study will demonstrate the problems associated with the application of an inappropriate sampling strategy to a provenance problem.

Grant et al. (2000) thin sectioned six Khoisan sherds from Rose Cottage Cave near Ladybrand in the eastern Free State and analysed them by SEM and EDX. The excavated pottery was of two types, grass tempered and grit tempered: the former are similar to Smithfield pots made by the San and which could have been exchanged from the Orange River Valley to the south west whilst the latter are either of Sotho or Khoi origin (Thorp 1997). Provenancing the sherds could establish whether they were locally made or imported. This is of some interest as there is other evidence at the site to support direct contact with the east coast (a cowrie shell and rock art images of mormyrid fish native to KwaZulu-Natal). These comments will be limited to the analysis of the grit tempered sherds only. Other problematical issues with this work can be found in Ambrose (2001a, b) and Jacobson et al. (2002a, c) with responses by Grant & Wadley (2001, 2002).

Two (sherd 3) or three analyses were made on each grit tempered sherd. All three sherds yielded one analysis with very high Ti (41-49%) and Fe (47-52%) and which, based on Ti/Fe ratios, was shown to be ilmenite. Grant et al. (2000) then state:
"*Sherd 2 [Table 2 (f)] has a Ti content in the range 48-52% expected for KwaZulu-Natal beach deposits, and this, together with the rounded sand grains, is evidence that sherd 2, at least, was manufactured there*." (Grant et al. 2000: page 447).

They most certainly did identify ilmenite but they misunderstood that the Ti value was that of a *grain* of ilmenite and not representative of the composition of the whole vessel. If the area of the beam is smaller than that of a grain of ilmenite, and the beam focussed on that grain, then all that will be recorded is the composition of the ilmenite. They had used a point analysis method when a bulk analysis was needed (Jacobson et al. 2002a). This then led them to assume that the pot was made from a KwaZulu-Natal dune sand which has a very high ilmenite content. Their response to this comment (and others) showed that they had difficulty in grasping this point (Grant & Wadley 2002).

Table 3.4 gives the summary data for the XRF and the Microprobe results. It is obvious from both the standard deviation (sd) and coefficient of variation (CV) that there is a great deal of variability from one scan point to another. By way of illustration, figure 3.1 shows the distribution of values across a scan for Ti for each of the four sherds.

It is also noticeable that there is a difference between results from the bulk analysis by XRF and the average of the scans. The body of a pot at the microscopic level is not a smooth, even texture with an evenly distributed chemical composition. There are irregularities, voids, fragments of organic material, minerals and grains of various sizes and other granular and lumpy inclusions. Thus, even a hundred point scan might not be fully representative and give an accurate estimation of the true average composition of the vessel. From a theoretical level, one can see that a bulk sample of a suitable minimum size that will include all these diverse components in 2002c). This factor adds to the debunking of the claim made with respect to the origins of the sherds.

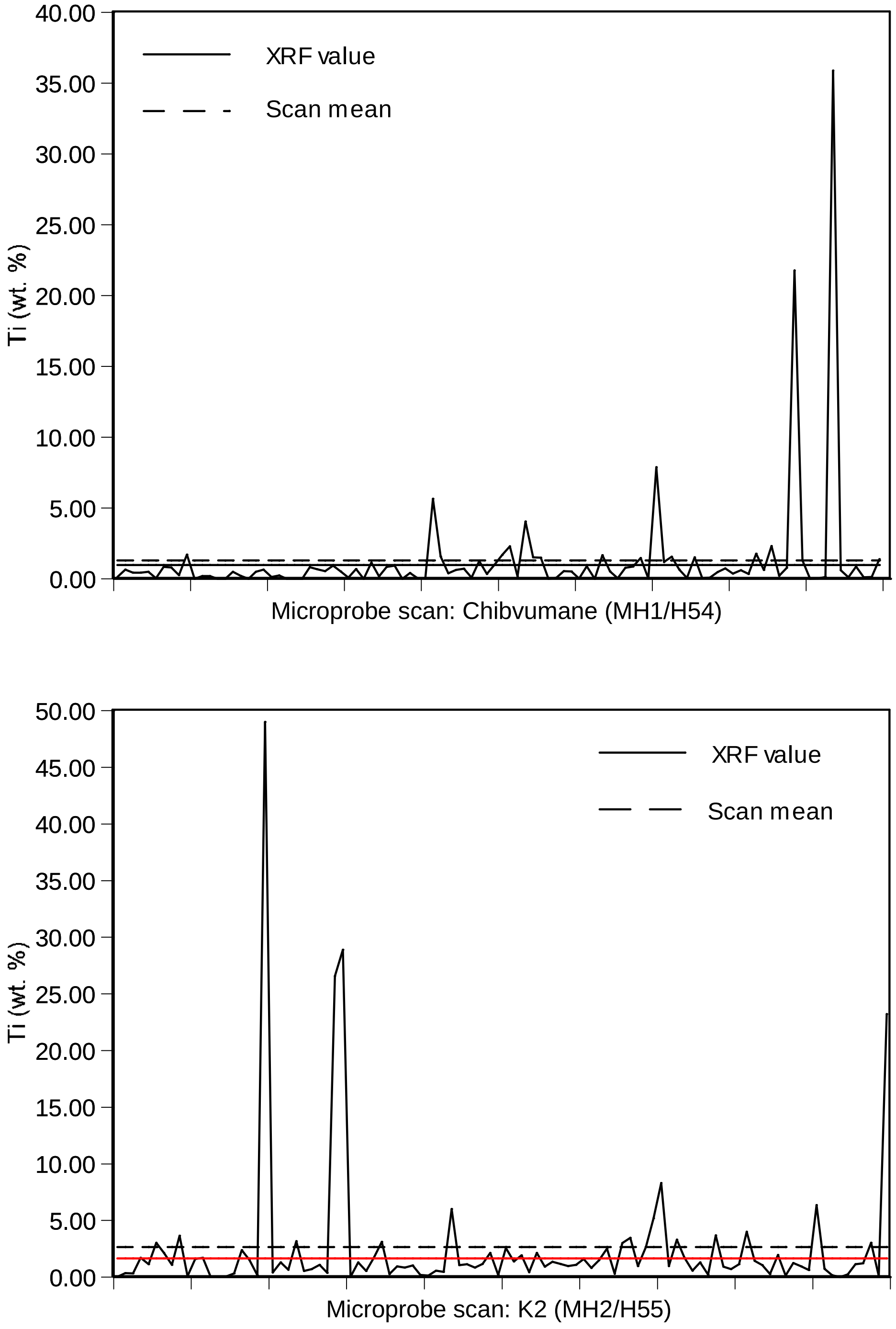
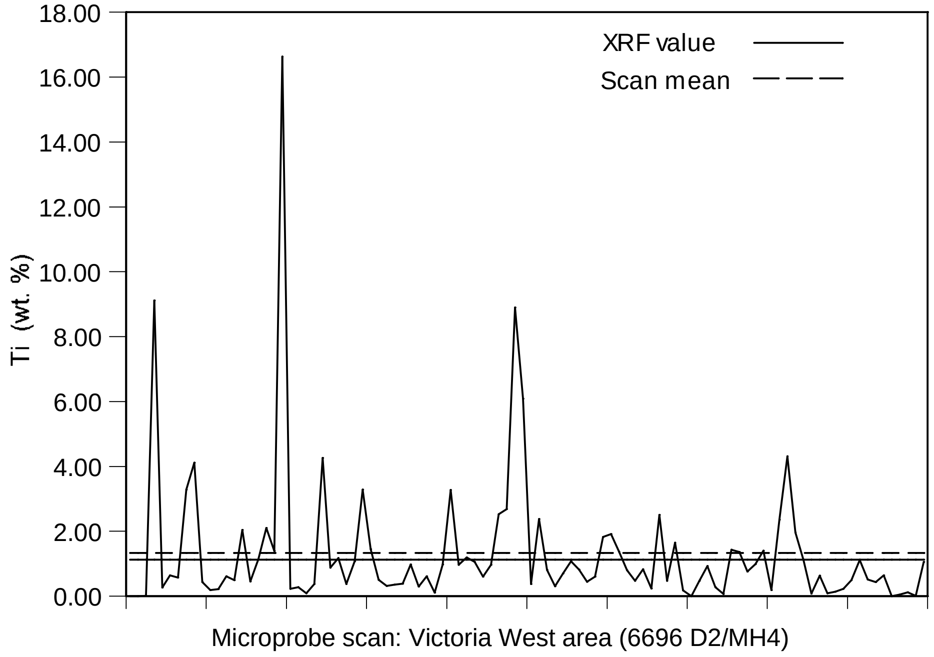


Figure 3.1. Microprobe scan showing the distribution of Ti across four sherds.



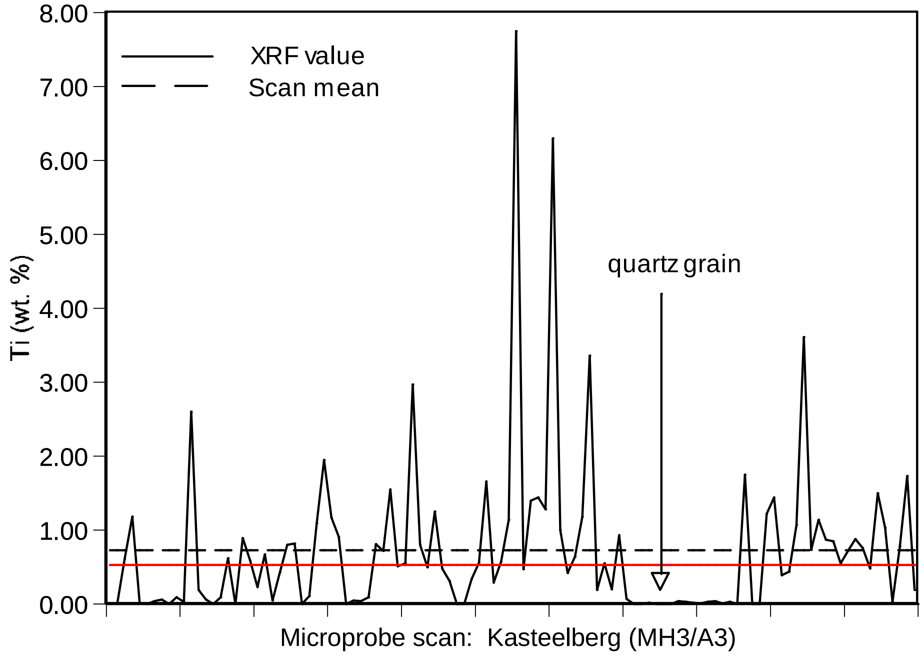


Figure 3.1 continued.

CHAPTER 4. CASE STUDIES

4.1 INTRODUCTION

Bearing in mind the recommendations and warnings discussed in the previous three chapters, this chapter will deal with a number of case studies from a variety of geographical locations. Each of these locations will be dealt with separately. In most cases they are centred around at least one site with an adequate sample size together with other sites with varying sample sizes.

It needs to be emphasised that neither the age nor the stylistic tradition of the samples analysed is of any real importance for the initial geochemical analysis. Style and age only come into play when the archaeological interpretation is made. In essence, I am looking at the combined chemical variability of a group of sherds either from a single site or a closely related (in spatial terms) group of sites from the same geological substrate in order to define a local or a regional geochemical signature (see section 1.3.1). Assuming a few outliers are found, and in the absence of known clays to define the group, comparison with a neighbouring geochemical region or regionss acts as a control for deciding whether any statistical "outlier" is in fact an imported item or not. The big question is, "how different would a group have to be before it could be confidently classified as nonlocal?"(Steponaitis et al. 1996).

Evers' 1974 review of Iron Age trade in Mpumalanga (the former eastern Transvaal) lists gold, copper and iron which were mined in the region. Of these, the former two were probably involved in trade networks to the coast whilst iron would have been in demand regionally for a range of utilitarian household objects. Tin, mined at Rooiberg to the west, would have passed through on the way to the coast. Salt, which is a necessity in the human diet, was actively processed at hot springs such as Eiland on the Letaba River. Glass beads, obtained in exchange, are further indicators of external trade. After reviewing the historical evidence for direct contact between the interior and the coast, Evers concludes by saying that "these suggest great mobility in Iron Age society prior to the Difiquane (sic)" (Evers 1974: 36).

De Vaal (1984, 1985) showed that the first Voortrekkers in the region did not travel randomly but followed old established trade routes. His map lists the most important ones which included routes from Inhambane to the Soutpansberg, from the Zimbabwe ruins to the Musina copper mines and the Rooiberg tin mines, amongst others.

Whilst much of this intense activity was no doubt stimulated by European contacts, nevertheless internal trade in metals such as copper and iron as well as salt, would have been present since the first Iron Age settlement.

4.2 KHOISAN POTTERY FROM COASTAL AND INLAND AREAS

4.2.1 Archaeological Background

There are a number of interrelated problems to be faced with any provenance study of Khoisan ceramics. Firstly, it must be noted that a distinction between herder (i.e., Khoi) and hunter-gatherer (i.e., San, Soaqua) sites of the last 2000 years is often problematical especially when discussing pottery. There is a current debate as to whether there is in fact a cultural difference between these two groups and what this may or may not entail (e.g., Sealy & van der Merwe 1992; Mitchell 2002; Sadr 2003; Smith, B.W. & Ouzman 2004) but obviously the pros and cons of this issue cannot be debated here. My own preferred model is simply that there may be socio-political differences between groups (not necessarily a simple hunter/herder dichotomy) but that boundaries may have been flexible enough for people to move easily across them. The big question is: if there was a difference in culture or economic status or social or political identity between Khoisan communities, did they use material culture to signal these differences and if so, was pottery one of the items used and how was it used?

As far as style is concerned, I have already mentioned (Section 2.3) the suggestion by Rudner that technology was the defining attribute, i.e., that fibre tempered pottery was made by hunter-gatherers and quartz tempered wares were made by Khoi herders (Rudner 1968, 1979). An attempt was made to delineate fibre tempered ware stylistic boundaries for the Seacow River Valley (Sampson 1988; Ridings & Sampson 1990) but these still need to be put into a much broader context, that is, relative to all fibre tempered wares throughout the region where they are found (the Karoo and Bushmanland) before they can be regarded as definitive. Bollong (1993, 1997b) subsequently raised the issue over whether fibre tempered pottery was a stylistic type (i.e., hunter-gatherer pottery) or a functional type better suited for cooking and used as such by both groups (Section 1.1). Fibre tempered pottery by itself could be a marker for inland pottery. As far as I am aware none have been found on coastal sites. Although no other definitive regional stylistic differentiation is known, there are limited stylistic chronological sequences (Sadr & Smith 1991; Bollong & Sampson 1996; Sadr & Sampson 1999) which have been described but this is not really relevant to a provenance study when spatial differentiation is necessary when trying to identify the movement of pots based on style.

There are of course the few decorated potsherds but there is no pattern to their distribution probably because the vessels of which they were once part had moved around the landscape so that any assemblage is “spatially” mixed. The potential could exist for few locally made pots to be found on any site.

The first problem, therefore, is that of an imperfect understanding of the difference between style and function, should there be one, and a lack of a distinctive and unique regional typology of ceramic decoration such as there is for the Iron Age. Although there were distinctive Khoisan communities defined by language differences (Westphal 1963; Traill 1995) and so-called “tribes” amongst the Cape Khoi (Elphick 1977; Barnard 1992) whether these groups can be unequivocally linked to pottery stylistic types is uncertain. There is some evidence from Early Herder sites such as Geduld, Die Kelders and Spoegrivier for spatially discrete styles (Sadr 1998, 2003), however, this needs confirmation from more sites. Certainly, the lack of a distinctive regional style in later wares could be a function either of a lack or research or a function of the political system. Khoisan communities were mobile and lacked a centralised, settled, hierarchical political structure such as that of Iron Age communities. Bands joined and split usually on a seasonal basis. This could result in a lack of any strong need to signal band membership. Alternatively the signalling was carried out via another medium which has not survived in the archaeological record. Another point to remember is that hunters and herders were not necessarily geographically distinct entities but shared the landscape (Sampson 1985) except perhaps for mountainous areas where domestic stock could not be kept. This obviously will have implications when it comes to an archaeological interpretation of the geochemical results of the analysis. One might be able to define imported sherds geochemically but a finer analysis integrating style in terms of the model presented in figure 1.2 may not be possible. It also means that one cannot stylistically define a reference group of local sherds or target obvious imported sherds for analysis.

A second problem is the paucity of suitable samples. Excavated, dated sites are few and sherds from the few excavations are generally too few in number to sacrifice for destructive analysis quite yet. A large number of surface collections exist but these are undated thus any archaeological interpretation will be limited. Most of them come from coastal shell middens (Rudner 1968). They can, however, provide samples suitable for defining a regional geochemical signature assuming that they have not been too "mixed" as a result of the mobility of their owners. But of these only a few samples are suitable for analysis as Khoisan pottery is characterised by a high degree of fragmentation such that not many samples are large enough for an XRF analysis.

To summarise, the "Khoisan" constituted a number of communities characterised by differences in language, economy, political association and with a degree of independence from each other. The archaeology of the Khoisan over the last 2000 years (since the appearance of pottery) has revealed a rather complex picture of herders making their seasonal rounds in search of grazing (Smith 1984; Balasse et al. 2002), bands of hunter-gatherers on their own seasonal rounds which may have included movements between the coast and the interior (Parkington 1972, 2001) as well as so-called "strandlopers" living on the coast (Wilson 1993) whether permanently, although commuting up and down the coast (Jacobson & Noli 1987), or seasonally (Sealy & van der Merwe 1986). In addition, I have already drawn attention to *hxaro* gift giving whilst there was also some documented trade in copper, iron and dagga with neighbouring Iron Age societies (Elphick 1977). As they all had pottery but little style, geochemical provenancing offers the only hope of trying to establish where the pottery originated, whether it did move, how far it may have moved and between whom.

4.2.2 Geological setting

Most of the samples in this section are from coastal sites stretching from Swakopmund, Namibia (site 1: figure 4.2.1) to Kleinmond on the south Cape coast some 130 km east of Port Elizabeth (site 147: figure 4.2.3). Unfortunately, most of the coastline is underlain by the same geological formation which parallels the coast, the Cape Supergroup. It stretches from approximately Lamberts Bay (site 18: figure 4.2.1) to approximately Kleinmond and stretches from the coast to between 120 - 180 km inland. It consists mainly of sandstones, quartzites and shales. The Cape Granite Suite is found in a belt stretching from Saldanha Bay to the Cape Peninsula whilst the Malmesbury Group can be found in a similar area. Inland of Lamberts Bay around Vanrhynsdorp are the Gariep Supergroup and Vanrhynsdorp Group whilst to the north stretching inland to Namaqualand is the Namaqua Metamorphic Province. Inland of the folded belt is the Karoo Supergroup consisting of sandstones, shales and dolerite. The southern boundary of the Supergroup follows and east -west trend eventually reaching the coast approximately to the east of Kleinmond (site 147). The southern Namibian coastline and interior is generally buried by the aeolian sands of the Namib Desert. The interior is underlain by a variety of metamorphic and other rocks (Martin 1965).

All these rock types will influence the geochemical composition of local clays. As little geochemical data is available for the sedimentary rocks, it is difficult to predict whether they will differ from each other. The Cape and Karoo Supergroup sedimentary rocks are likely to have a more felsic profile although the presence of dolerite in the Karoo could also add more mafic elements in that area. The Namaqua Metamorphic Province could be generally enriched in metals such as Cu and Zn.

The main point here is that there are broad swathes of very similar geology in the western and southern Cape and the Karoo interior and it is therefore unlikely that there will be very much variability in the background geochemistry within these areas.

4.2.3 Previous work and current aims

There has been little systematic provenance or other analytical studies on Khoisan ceramics. An early example of a visual analysis is that of Parkington (1977) who noted the presence of shale fragments in pottery from de Hangen, situated in the Cape Folded belt near Clanwilliam. He interpreted this as evidence for a source in the Karoo. Miller (1991) cites several student undergraduate projects using a variety of techniques, i.e., XRD and thin sectioning, but these were of limited scope and reached no firm conclusions although some studies indicated a variety of clay sources may have been used in the manufacture of pottery from one site. Organic residue analysis has been carried out but this is aimed at determining the use of the vessel (Patrick et al. 1985; Copley et al. 2004). A paper by Bollong et al. (1997a) analysed a suite of ceramics from the Karoo using PIXE but this paper was focussed on methods of statistical analysis and the identification of outliers rather than provenance per se. The data was obtained in the form of counts and therefore can not be used for any comparative work.

Provenancing enables a number of archaeological questions to be posed. For example, given that there was a degree of residential mobility based on the search for resources and probably manifesting itself in seasonal aggregation and dispersal patterns, were pots made opportunistically on the move when needed or was there a period when a larger number were made at the same time? Opportunistic manufacture could result in greater compositional variability through the use of a wider range of clays whereas the latter case could result in less variability. Would non-locally made pots be found more frequently at larger sites or smaller sites or even perhaps at specific types of sites such as shell middens? If the movement of pottery did take place, did it match the movement of other material objects, for example, marine shells found inland (Parkington & Poggenpoel 1971)?

Whether these questions can be answered will depend on whether sources can be defined. The problem with defining clay sources in a rather bland and uniform geological environment is the first issue to be dealt with. A few sediment samples, not all of them clays, were taken to try to characterise different areas as a lack of time and money prohibited a detailed search for clays. Thus the pottery itself will be used to define a regional compositional signature although this is further complicated in the case of Khoisan ceramics as a result of the probable movement of pottery across the landscape in mobile households. The samples, however, cover a very wide territory and it is expected that some regional clustering will occur. This work, then, is primarily exploratory in purpose. The definition of local or regional compositional reference groups is the first aim: is there a clear geochemical separation between the coast, the Cape Folded Belt and the Karoo interior? Are there any geochemical differences along the coast? If satisfactory answers to these questions can be obtained then the future prospects of contributing archaeological interpretations to some of the above questions will be possible.

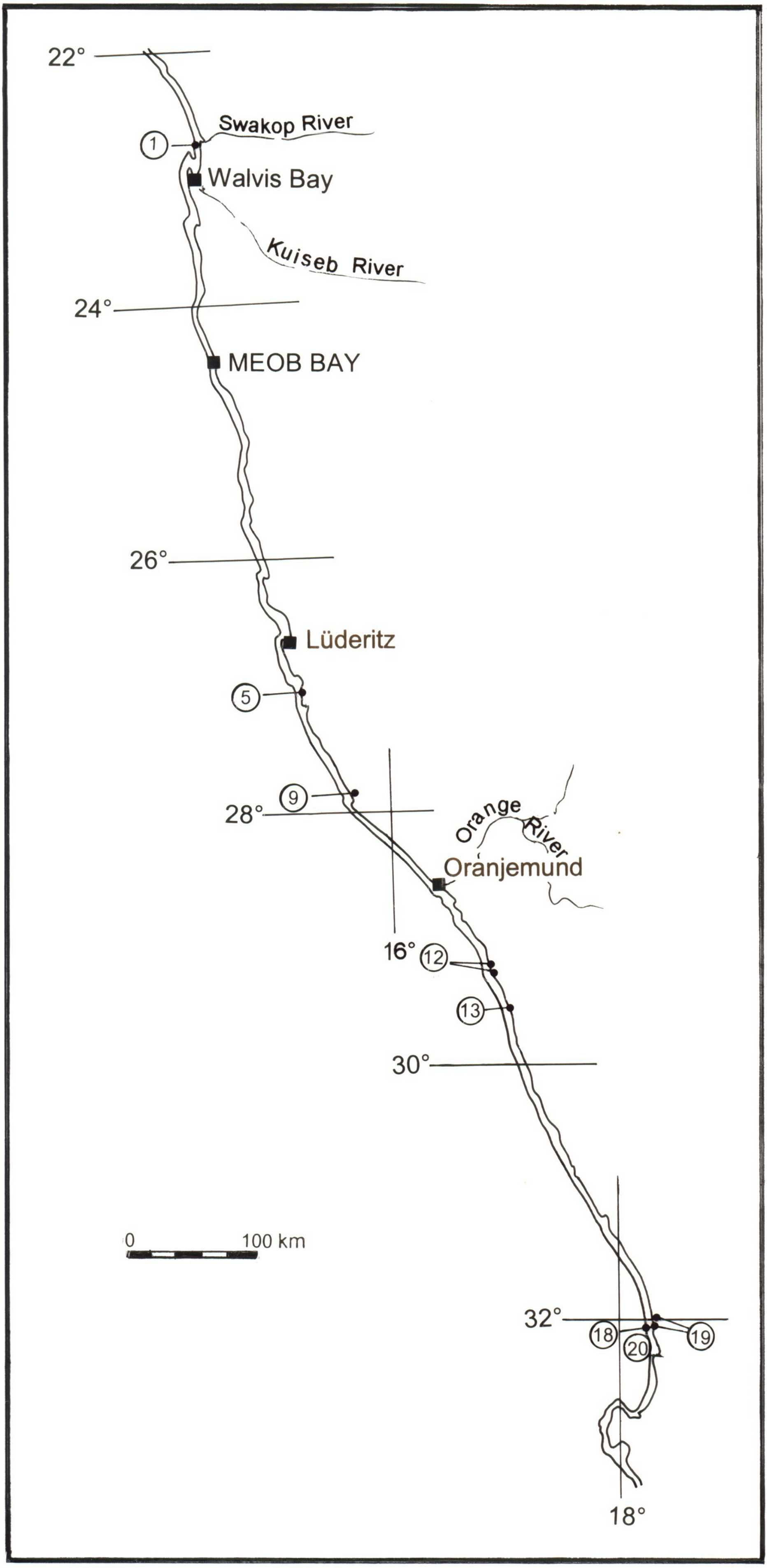
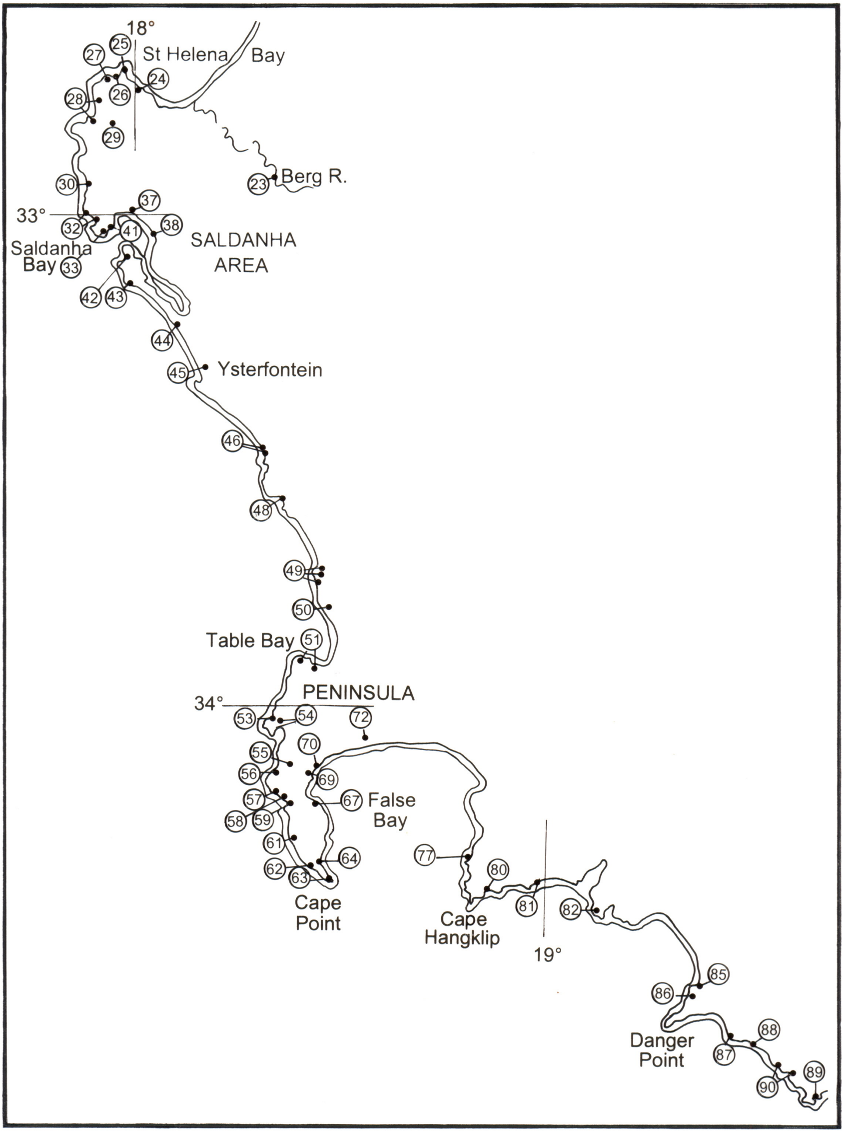

22°
Swakop River
①
Walvis Bay
Kuiseb River
24°
MEOB BAY
26°
Lüderitz
⑤
⑨
28°
Orange River
Oranjemund
16°
⑫
⑬
30°
0
100 km
32°
⑱
⑲
⑳
18°

Figure 4.2.1. Map of the West Coast. See Table 4.2.1 for explanation of site numbers.


18°
St Helena Bay
Berg R.
33°
Saldanha Bay
SALDANHA AREA
Ysterfontein
Table Bay
34°
PENINSULA
False Bay
Cape Point
Cape Hangklip
19°
Danger Point
23
24
25
26
27
28
29
30
32
33
37
38
41
42
43
44
45
46
48
49
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57
58
59
61
62
63
64
67
69
70
72
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80
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82
85
86
87
88
89
90

Figure 4.2.2. Location of sites from Saldanha Bay to Danger Point. See Table 4.2.1 for explanation of site numbers.

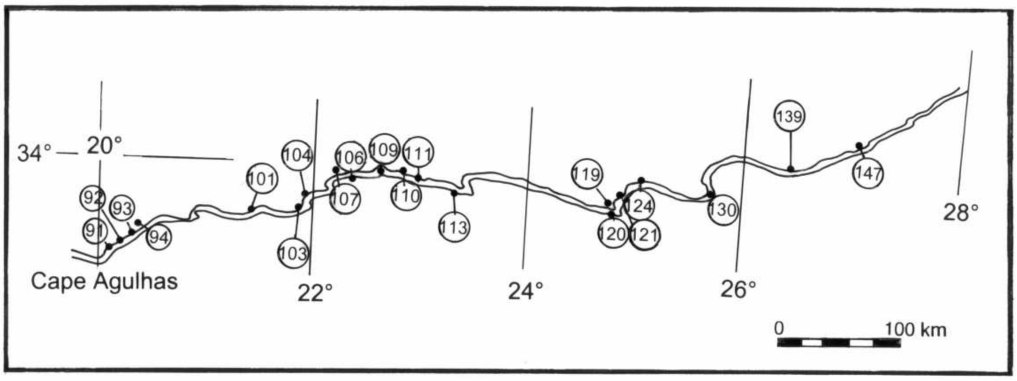


Figure 4.2.3. Map of the south coast. See Table 4.2.1 for explanation of site numbers.

4.2.4 The samples

A total of 377 potsherd specimens were analysed. These consisted of 16 specimens from Namibian coastal sites, 321 from South African coastal sites and 40 specimens from a variety of inland sites with localities ranging from the Cape Folded belt through to the Karoo and Namaqualand. The vast majority of these, particularly those from the coastal sites, were collected by J. and I. Rudner from the 1950's onwards and whilst there is information about their location and context, mainly coastal shell middens (Rudner 1968), there is little if any information about dating, artefactual associations, etc, (Rudner & Rudner 1954, 1955, 1956; Rudner & Grattan-Bellew 1964; Rudner 1968). The maps, figures 4.2.1, 4.2.2 and 4.2.3 with the associated tables 4.2.1 and 4.2.2 indicate the locations and names of the coastal sites and are redrawn from Rudner's (1968) monograph. Additional material came from older collections in the S.A. Museum, Cape Town as did the Rudner samples.

Only one site has been properly excavated, dated and published, Kasteelberg (Sadr et al. 2003. Even here, of the five samples analysed, two are from Rudner's surface collection (locality 29:

Table 4.2.1 South African coastal sites according to Rudner's (1968) listing where relevant together with the number of samples analysed from each site. See maps for locations.

Rudner	Site	No of samples
1	Swakopmund	1
–	Walvis Bay	4
–	Meob Bay	9
5	Claratal	1
9	Chameis Bay	1
12	Port Nolloth	9
12	McDougall Bay	1
13	Kleinsee	1
18	Lamberts Bay	1
19	Van Puttens Vlei	3
20	Elands Bay	3
23	Berg River	1
24	St Helena Bay, Sandy Point	1
25	Stompneus Bay	8
26	Britannia Point	2
26	Britannia Bay	2
27	St Martins Point	1
28	Paternoster salt pan	1
29	Kasteelberg	5
30	West Bay	1
32	Danger Bay	5
32	Danger Point	1
32	Morrison's Point	1
33	Noordbaaikop Cave	2
37	Saldanha Bay	3
37	Saldanha Cave	1
38	Lynch Point	1
41	Saldanha Peninsula	11
42	Jut Bay	1
43	Vondelingbaai	4
44	Abrahamskraal	1
45	Yzerfontein	26
46	Modderrivier	14
48	Bokbaai	13
49	Melkbos	2
50	Blouberg	6
51	Milnerton	1
53	Sandy Bay	2
54	Hout Bay	9
55	Noordhoek	4
56	Kommetjie	5
57	Witsands	3
58	Witsands Cave	2
59	Schusters Bay	3
61	Olifantsbos	1
62	Platboom	1
63	Cape Point	1
64	Buffels Bay	13
67	Simonstown	1
67	Millers Point	1
69	Fish Hoek	3
69	Clovelly	1
70	Lakeside	1
72	Cape Flats	1
77	Rooiels	1
80	Cape Hangklip	26
81	Palmiet River	1
82	Hawston	13
85	Die Kelders	1
86	Gansbaai	1
87	Sandy Bay	3
88	Pearly Beach	12
89	Quoin Point	3
89	Die Dam	1
90	Die Lagoon	3
91	Cape Agulhas	1
92	Arniston	1
93	Ryspunt, Arniston	1
93	Rysbaai	1
94	Skipskop	2
101	Still Bay	1
103	Fish Bay	8
104	Flesh Bay	3
106	Klein Brak	1
107	Groot Brak River	4
109	Oakhurst	3
110	Sedgefield	3
111	Goukamma River	2
113	Robberg cave	1
119	Goedgeloof	2
120	Kromme Bay	15
121	Jeffrey's Bay	5
124	Gamtoos River mouth	1
130	The Willows, PE	1
139	Perdekloof	2
147	Kleinmond	2

Table 4.2.2. Additional samples not fully provenanced. Note that of these samples, a number were not available for statistical analysis as they were only partially analysed (i.e., only major elements) due to inadequate specimen size. See text for further details and data appendix sheets for further details about localities. For example, the Karoo samples cover the area from Carnavon to Oudtshoorn.

van Rhynsdorp area	2
Hopefield	2
Cape Agulhas area	2
Holbaai, Vredenburg	1
Vermont, Hawston	1
Die Grys, Bredasdorp	1
Arniston area	1
Cape Peninsula unprovenanced	1
Phomong, Lesotho	1
Clanwilliam area (Folded Belt)	5
Aspoort	3
??Doornriver	4
Matjiesriver shelter	1
?Karoo	2
Karoo region	14
Ceres (Folded Belt)	3
Namaqualand region	8

figure 4.2.1). As no decorated sherds were analysed, the majority of coastal sherds have a quality rating of Q4 whilst the interior specimens are of Q2 status. Decorated sherds are present on a number of sites but it was decided not to use them in this exploratory analysis and certainly not until they had been studied in the context of new information obtained since their original publication by Rudner.

A problem encountered in the selection of sherds for analysis was the small, fragmented size of the specimens. Enough powder for preparing both a glass bead for the analysis of major elements and a briquette for traces was not always available and a number of specimens could only be analysed for the former.

Although superficially it appears that there is a large sample size, it will be seen from tables 4.2.1 and 4.2.2 that these samples come from 96 coastal and interior sites. Only 14 sites provided more than seven specimens per site whilst 10 or more specimens were only found on 9 sites. The majority of the other sites are represented by only 1 or 2 specimens, occasionally more. Attention was focussed on the larger sites to assess the variability at such a site with the smaller sites filling in the gaps, so to speak.

In addition, 39 sediment samples were collected in order to get an understanding of the background geochemistry in selected areas. This is obviously not a sufficient number but as a detailed search for and collection of clays was not possible due to the constraints of time, finances and sheer logistics and the geology generally uniform, i.e., quarzites and shales for the most part, when taken together with the limited published information particularly on the Cape Granites and the Karoo dolerites, it does provide a small starting point.

4.2.5 The statistical analysis

The complete data is presented in tables A4.2.1 to A4.2.4 in the appendix. In view of the large sample size and the wide distribution of sites, I divided the coastal localities into a number of discrete areas and analysed adjacent areas with each other as well as with the interior sites. First, however, I carried out an analysis of all specimens together with the 13 analyses made on the sherds from the Messum vessel reported in section 3.1.1 of Chapter 3. One problem with choosing specimens for analysis is that one can never be sure whether they all come from one vessel or not in spite of differences in colour and texture. On the other hand, specimens which appear to be chemically alike do not necessarily come from one vessel but could be made from the same clay. Specimens from a number of sites which are similar in composition could be assumed to come from a series of clays which are similar and do not necessarily imply the movement of pottery. The Messum specimens are a good indicator of the range of variability to be expected in a single pot. Therefore, it was of interest to see how it compared to the Khoisan sherds.

Figure 4.2.4 shows the first two axes of the CA plot for five different regional groups. The important point to notice is the space occupied by the three coastal clusters relative to the

Messum specimens. The Western Cape and the Cape Peninsula have very tight central clusters surrounded by sub-clusters. This could be taken to mean either that many pots were being made from a few clays or else that the clays are very similar. The Southern Cape cluster tends to be more diffuse. It will also be obvious at this stage that there is no unique regional reference group that stands out amongst the coastal potsherds. Each of these regional groups will be dealt with in more detail below.

The first group to be analysed individually are the Namibian coastal specimens together with those from Port Nolloth to Elands Bay. Only four specimens from Namaqualand were considered for the analysis. They came from vague localities: one each from Augrabies, Bushmanland, Rooidam (?) and Gordonia. The other four examples were omitted as two were enriched in CaO and Sr whilst the other two had extremely high Zr and V values which made them extreme outliers. The CaO could result from calcrete inclusions whilst the Zr enrichment could result from sand temper. The focus of the analysis was on the Port Nolloth and Kleinsee sherds, their variability and any link they may have with the interior specimens. The other localities were added for comparative purposes. Figures 4.2.5 and 4.2.6 plot the first three axes of the correspondence analysis. Nine of the Port Nolloth sherds stand out from the Namaqualand, Kleinsee, Lamberts Bay and Elands Bay sherds. The sherds are highly variable and although there appears to be an overlap with those from the Namibian coast, they in fact separate from each other when the 3rd axis is taken into account (figure 4.2.6). This cluster loads heavily on the more felsic elements probably indicating a granitic source (figure 4.2.7) but the Port Nolloth specimens are enriched in Y and this separates them on the 3rd axis (figure 4.2.8). The Y probably originates from a pegmatite source. Only one Port Nolloth sherd has a possible link to the other S.A. sherds which are grouped to the right of the plot. Although this is suggestive of a reference group, there are as yet too few analyses available for a definitive statement. The Meob Bay group breaks down into five sub-clusters of which one shows a close link to the Claratal specimen. Chamois Bay is distinguished by enriched Cu. The small sample sizes, however, preclude any further interpretation.

The next analysis included all sites from Port Nolloth south to Saldanha Bay (sites 12-44: figure 4.2.2). In addition to the coastal sites three categories of interior sites are included. These are the four Namaqualand sherds (table A4.2.3), eight sherds from sites I have labelled Folded Belt and 23 sherds from locations in the Karoo (table A4.2.2). The former are situated in the mountainous areas underlain by rocks of the Cape Supergroup whilst the Karoo sites are from the Karoo Supergroup. The Saldanha Bay group consists of 53 sherds from that area (sites 24-44) whilst there is a single sherd from Vlakmyn in the Vanrhynsdorp area. A second sherd from Komkans in the same area was omitted from the statistical analysis because of the highly enriched Zr (1174 ppm) which made it an extreme outlier in preliminary runs. The point of this analysis was to compare the Port Nolloth sherds with those from Saldanha Bay, an area with granite exposures as well as pegmatites which are probably the cause of the high Y enrichment in some of the sherds from Port Nolloth.

Figure 4.2.9 shows the first two significant axes of the analysis whilst figure 4.2.10 shows the elements upon which they significantly load. The first point to note is that three Port Nolloth sherds with a high loading on Y stand out as definite outliers from the other specimens. A further three sherds overlap with what could be outliers from the Saldanha Bay group. There is a strong clustering of the majority of the Saldanha Bay sherds: associated with this cluster is the Berg River sherd, two Port Nolloth sherds, a single Karoo sherd and three Folded belt sherds and possibly a Namaqualand sherd. A further two sherds could be associated with a Folded Belt and the Vanrhynsdorp sherd. It is important to reiterate at this time that these overlaps do not imply any movement of pottery between these sites but simply that there is a similarity in the clays from which they were made, however, the pattern is provocative and further more detailed work such as locating clays to assess the local variability could establish for certain whether the pottery represent long distance contacts.

The next analysis was carried out to establish the nature of the clusters and sub-clusters from further south. Sites from Elands Bay to the Cape Peninsula were analysed. Figure 4.2.11 plots of those sherds from sites between the Saldanha Bay area and the Cape Peninsula. Note the tight overlapping cluster into which sherds from all sites fall. Two linear clusters are also present but there is no well defined break between them. Figure 4.2.12 omits the Cape peninsula sherds but adds those from the interior. Embedded in the tight cluster is a Karoo sherd, whilst other Karoo sherds show a linear pattern. Reference to figure 4.2.13 shows that the Karoo sherds load strongly on Cu and that the value for this element decreases as one moves to the left of the plot. The central position with both Karoo and Folded Belt sherds as well as two Lamberts Bay and a number of Saldanha Bay sherds represents an intermediate loading on this element. A similar pattern is seen clearly in figure 4.2.14 for the Cape Peninsula sherds. I will come back to this point below.

Finally, the pattern for the Southern Cape sites. All sites from the Cape Peninsula to Kleinmond are plotted in figure 4.2.15. The basic pattern is the same but with two differences. Firstly, there are a greater number of sherds clustering below the basic top left cluster. This group tends to load more heavily on Zr which implies a greater addition of sand probably as temper to the basic clay. The second point is most interesting in that a single sherd from the Kromme Bay series clusters very tightly with the Cu-enriched Karoo sherds.

Before proceeding, I would like to deal with the question of Cu enrichment in the Karoo sherds. Tables 4.2.3 and 4.2.4 present data on rock and soil samples from the literature and from my own sampling. It will immediately be seen that relative to the Cape granites and Supergroup, the rocks and sediments of the Karoo Supergroup are enriched in Cu. Figure 4.2.16 presents the Cu data for the sherds graphically. It could very well be the case that the amount of Cu in a sherd relates to its provenance. A cut-off value of 18-20 ppm seems indicated: lower than this could indicate a provenance in the Cape, whilst higher than this could indicate a Karoo origin. Obviously, this needs to be tested in a far more detailed and thorough manner.

The Kromme Bay sherd can thus be seen as a potential imported ware. This is not improbable given what is known of social mobility and gift giving outlined above but it does need to be further tested. The fact that it is a single specimen of all those from the area does make a stronger case. If it came from a local clay source there would surely have been a strong chance of finding other sherds with this chemical profile.

On the other hand, the single Karoo sherd (from Smithfield) has a profile typical of Cape sherds. Once again, this could be an imported sherd from the coastal areas.

Table 4.2.3. Copper values from the literature (Low & Bristow 1983; Zawada 1984; Duncan et al. 1984; Marchant & Moore 1978).

Cape Town soil samples (Low & Bristow 1983)	Cu ppm
Granite	8
Shale	5
Sandstone	2
Non-calcareous sandstone	2
Calcareous sandstone	2
Malmesbury Shale (mean)	-
Pre-Cape Granite	-
Table Mountain Sandstone	-
Karoo (Zawada 1984):	
Ecca mudrock	52
Ecca/Beaufort transition zone	34
Beaufort mudrock	27
Karoo (Duncan et al. 1984):	
Central Karoo dolerite	75
Cape Peninsula (Marchant & Moore 1978):	
Average SA shale	28
Chapmans Peak shale	16
Cape Granite	5-10

Table 4.2.4. Data for Cu (in ppm) from various sampled sources. See text for discussion.

No	Location	Cu ppm
AC60	Soil (Malmesbury System): Durbanville	12
AC60B	Soil (Malmesbury System): Durbanville	10
AC200	Malmesbury System: clay, UCT	16
AC201	Malmesbury System: clay, UCT	14
AC56	Hout Bay beginning of Chapman's Peak Drive	18
AC57	Camps Bay Rd at Kloof Nek, TMS soil	8
AC58	Castle rocks, TMS soil	3
AC35	Chapman's Peak granite soil	9
AC36	St Helena Bay Granite soil	4
AC53	Calvinia soil	35
AC62	South of Laingsburg	13
AC41	Laingsburg River	16
AC54	Soil north of Van Rhynsdorp	6
AC39	River terrace sediment east of van Rhyns Dorp	20
AC38	River sediment North of Van Rhyns Dorp	21
AC33	River sediment east of Van Rhyns Dorp	27
AC12	Sediment: T'Goep River, Pofadder	42
AC13	Sediment: T'Goep River, Pofadder	31
AC30	Stream sediment east of Port Nolloth	29
AC29	Stream sediment east of Port Nolloth	24
AC16	Port Nolloth area	25
AC15	Rietkloof gate stream sediment Port Nolloth Rd, below escarpment	13
AC8	Rietkloof gate stream sediment Port Nolloth Rd, below escarpment	18
AC26	Stream sediment near Goegap Nature Reserve, Springbok	110
AC21	Stream sediment north of Springbok	529
AC27	Soil, Goegap Nature Reserve Springbok	22
AC17	Green River terrace, Springbok	12
AC20	River sediment between Vioolsdrif and Springbok	31
AC18	Orange River terrace sediment, Vioolsdrif	52
AC24	Sediment from southern tributary of Orange River near Vioolsdrif	53

4.2.6 Conclusions

It is obviously going to be extremely difficult to provenance Khoisan pottery from the Cape alone and possibly the same applies to the Karoo both of which systems have their own individual widespread geologically similar formations. There may be other elements or even isotopes which I have not considered which may differentiate different formations of either system. Whilst the bulk geochemistry might be similar, it is possible that rare earths or isotopes can differentiate sandstones and shales based on their provenance and hence any clays derived from them.

Thin section analysis carried out on a localised basis might also be successful in identifying inclusions which can be locally provenanced. Overall, however, only broad long distance provenancing may be possible for the time being.

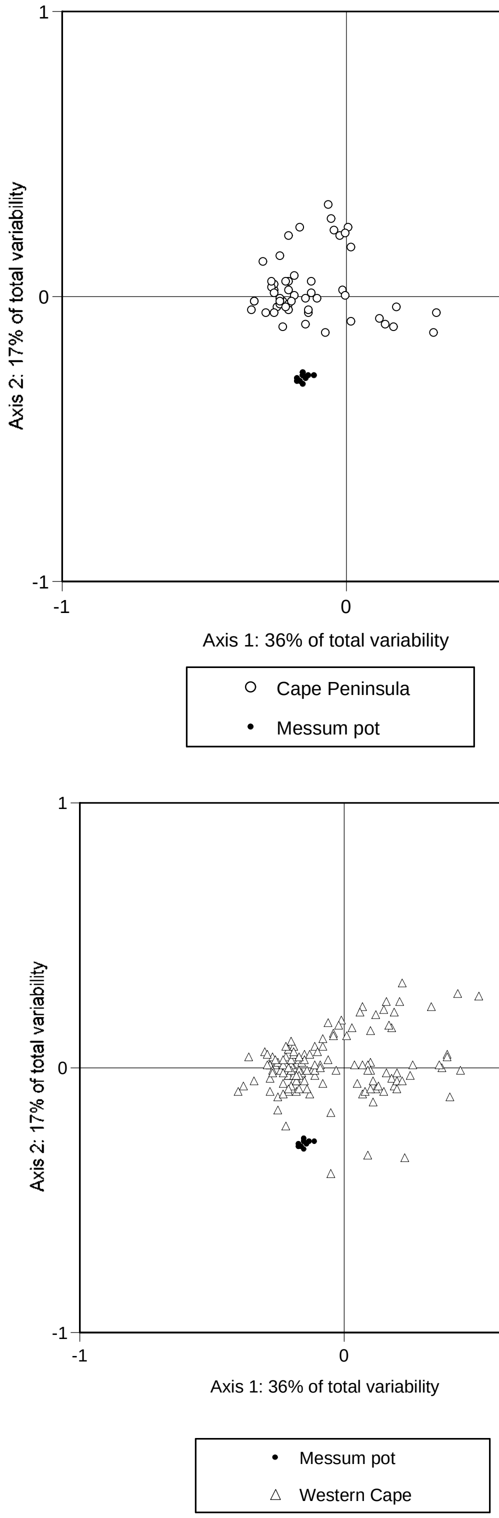
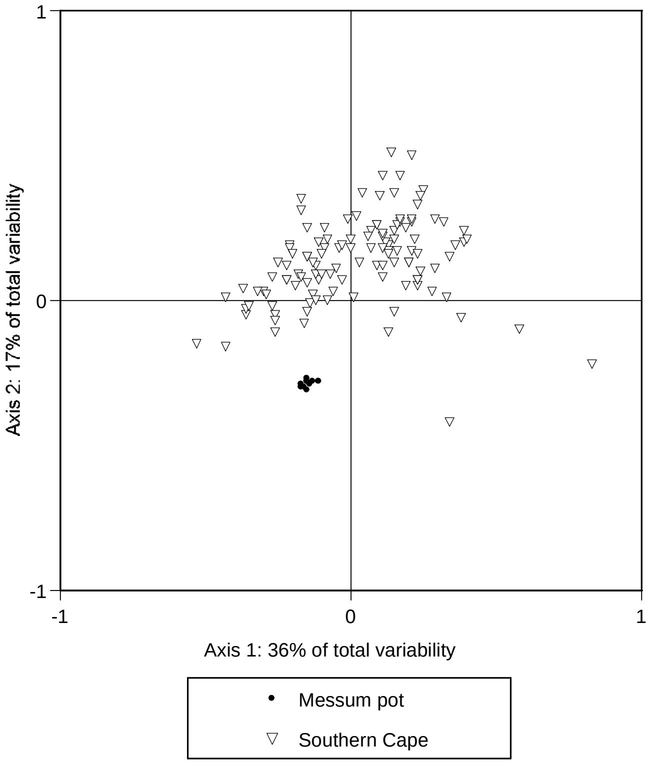


Figure 4.2.4. CA plot of the first two axes for the comparison between all the Khoisan sherd samples and the variability of a single whole vessel (from the Messum, Namibia) represented by analyses of thirteen individual specimens from the same whole vessel (see Ch. 3.1.1).



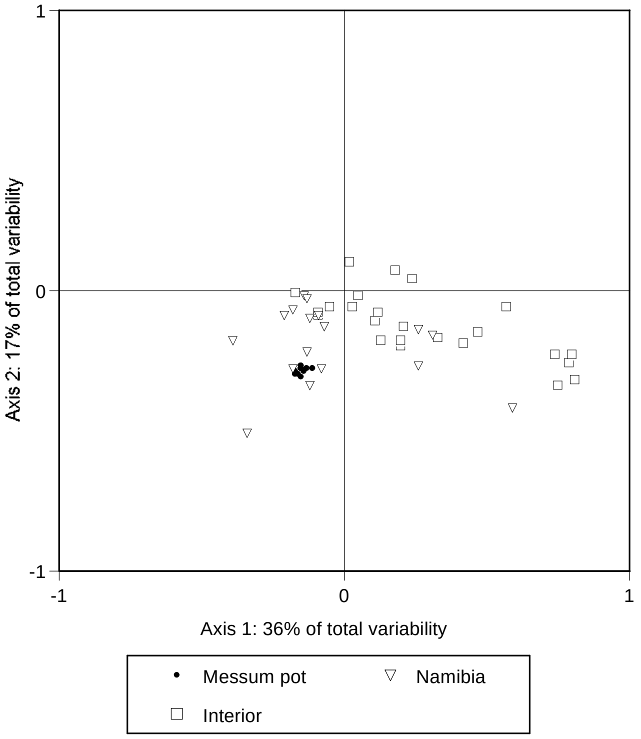


Figure 4.2.4 continued.

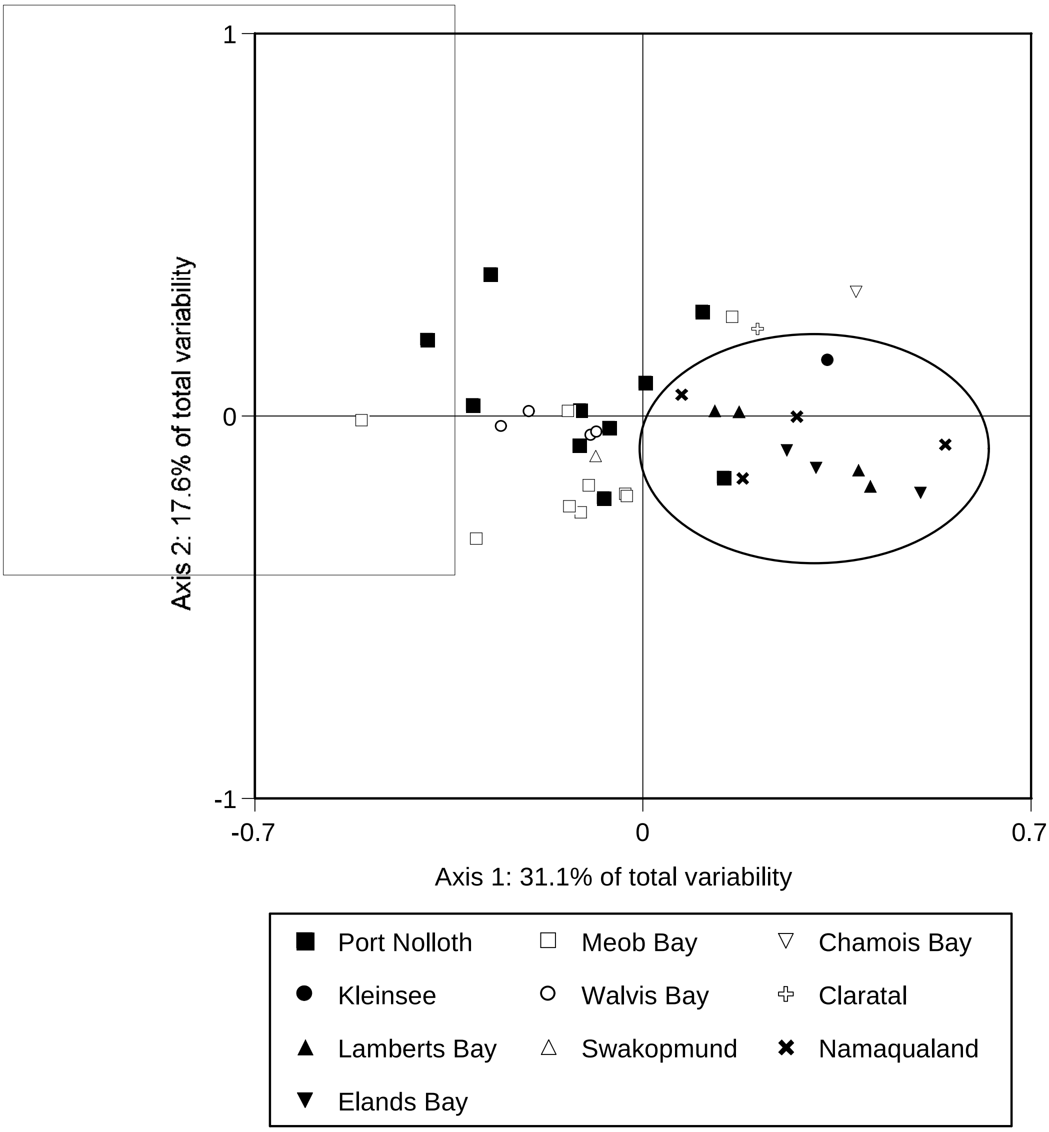


Figure 4.2.5. CA plot of first two axes for coastal sites from Namibia to Elands Bay.

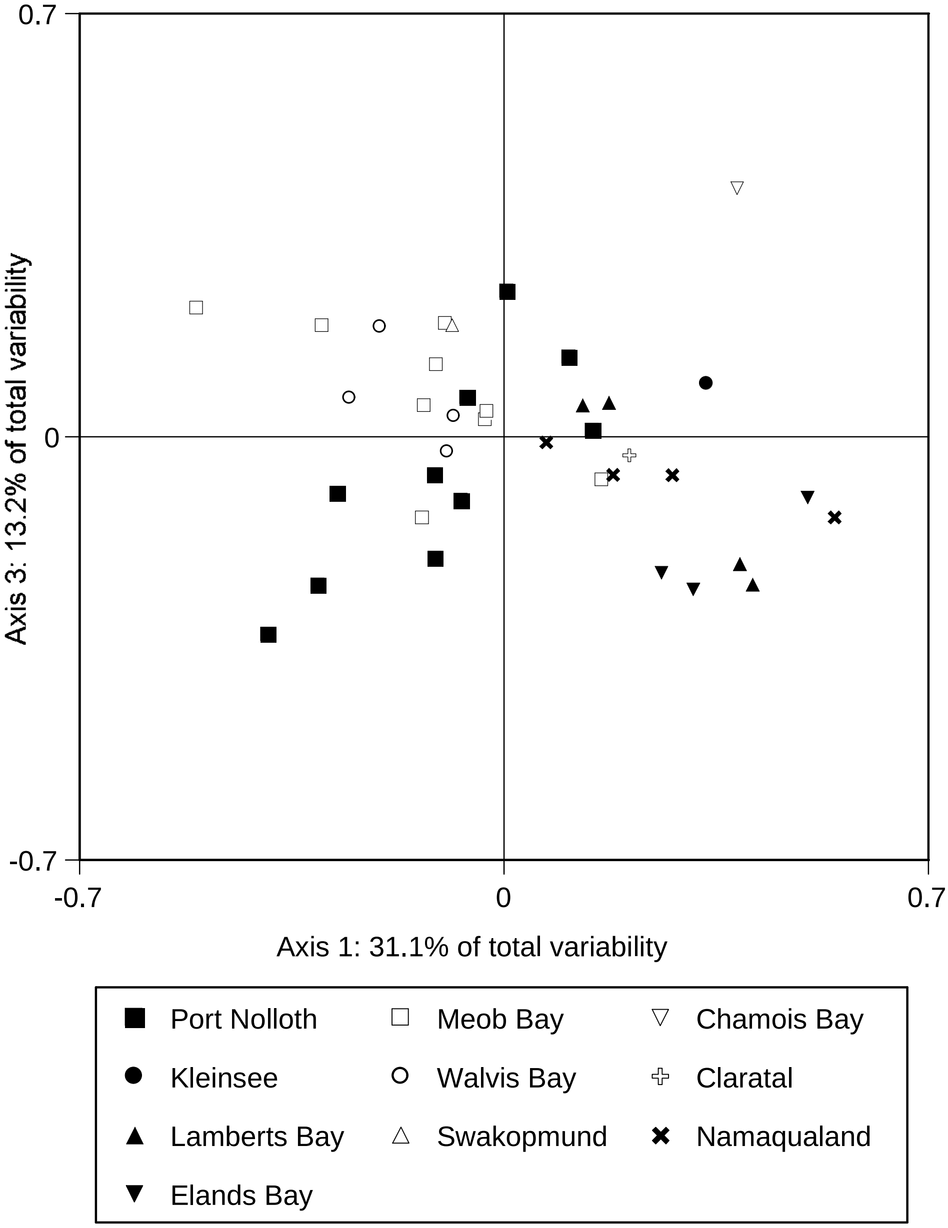


Figure 4.2.6. CA plot of the first and third axes for coastal sites from Namibia to Elands Bay.

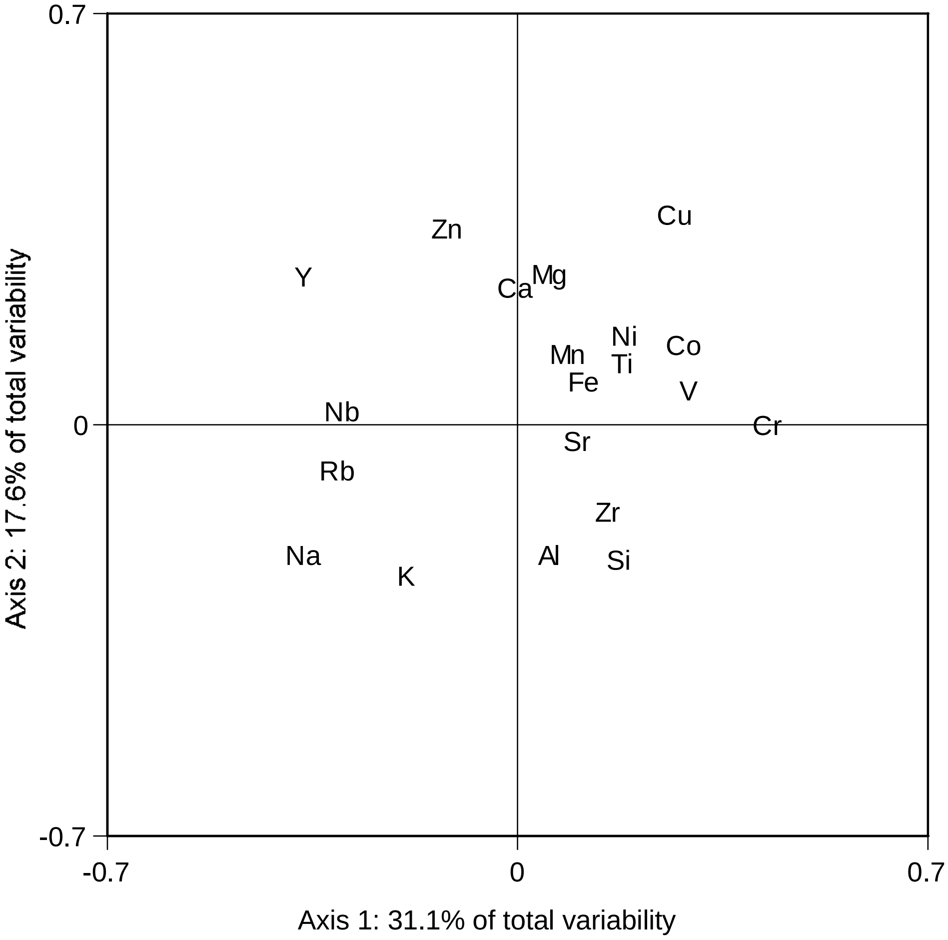


Figure 4.2.7. CA plot showing the distribution of elements upon which the sherds load.

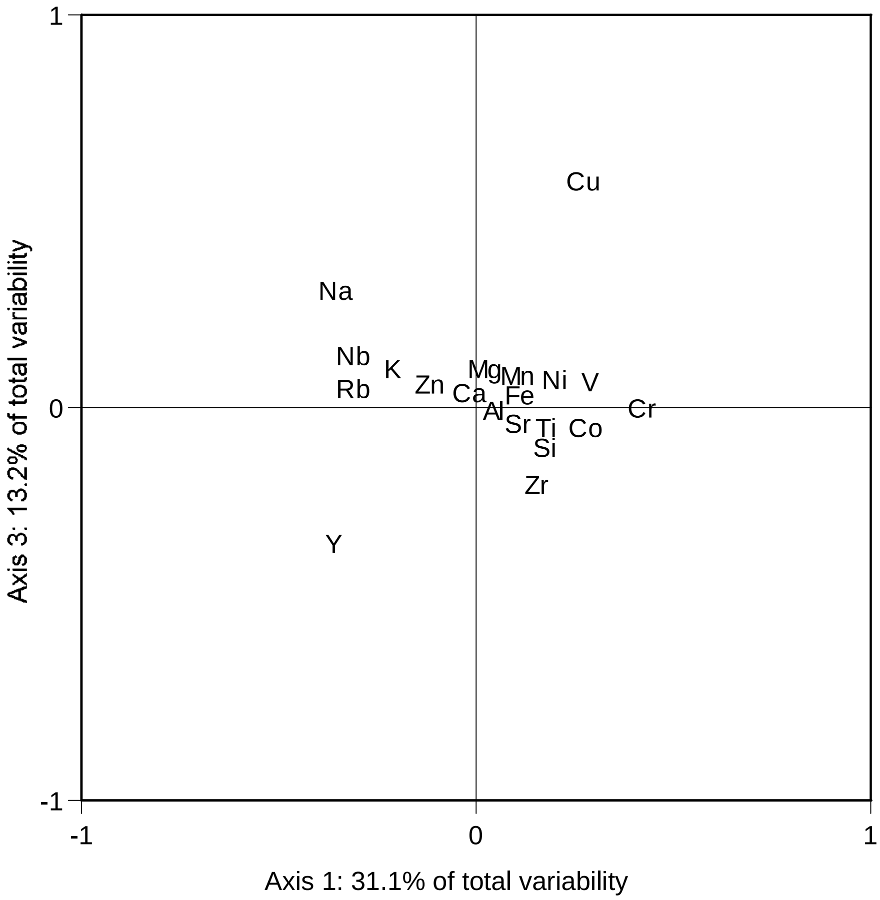


Figure 4.2.8. CA plot of axes 1 and 3 of the elements upon which the sherds load.

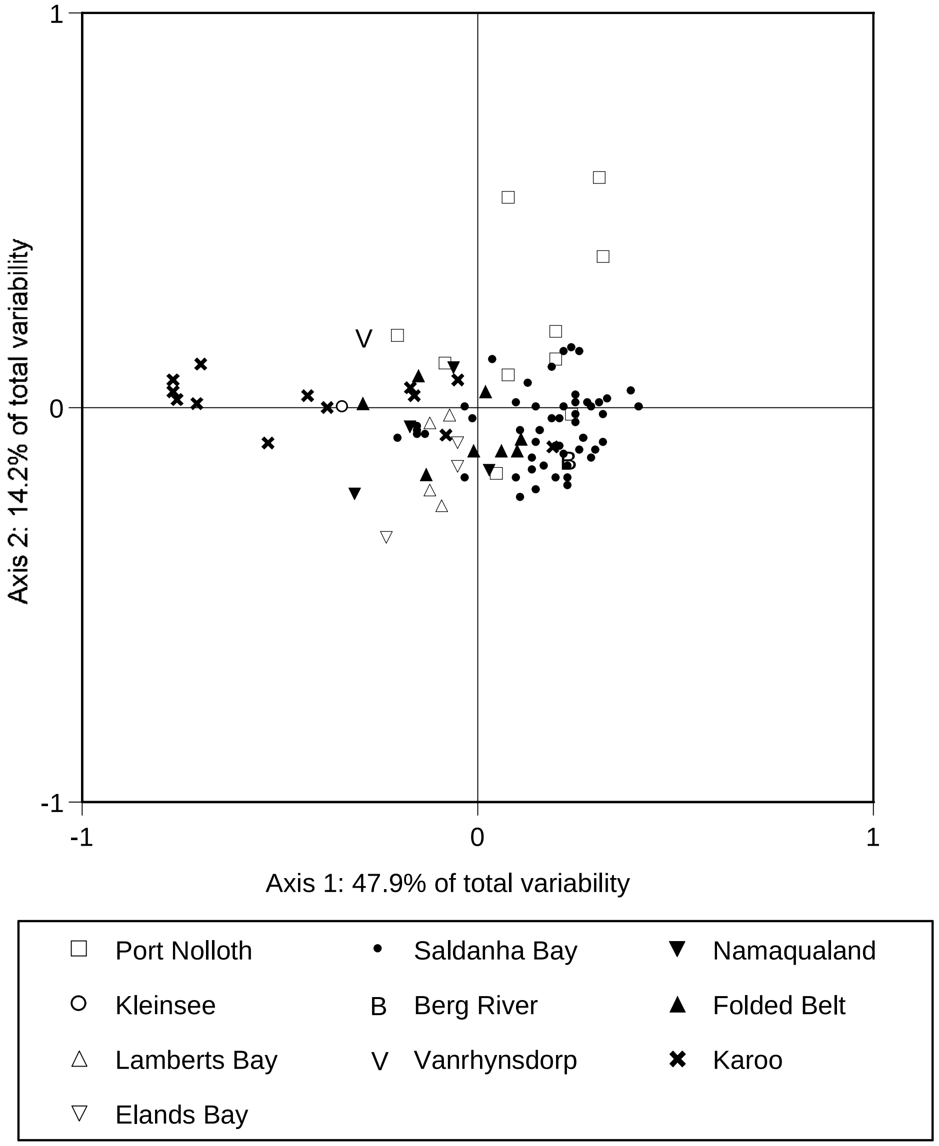


Figure 4.2.9. CA plot of the first two axes of the Port Nolloth to Elands Bay sites.

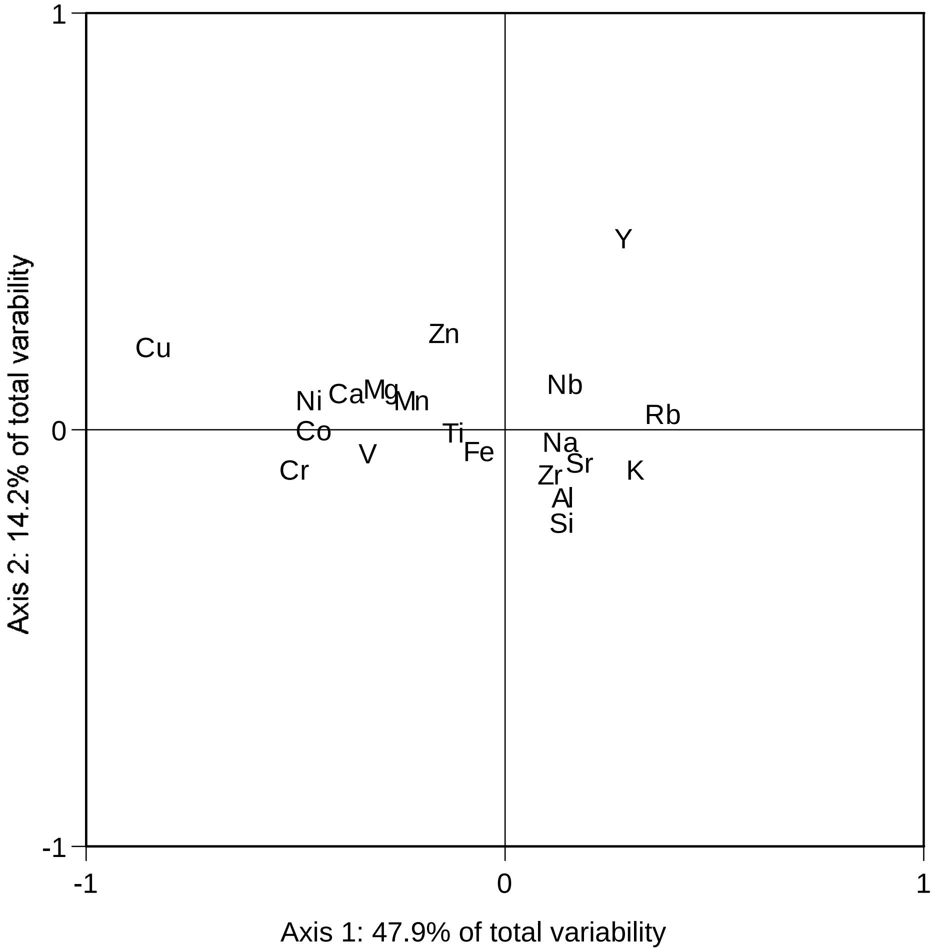


Figure 4.2.10. CA plot showing element loadings for the Port Nolloth to Elands Bay sites.

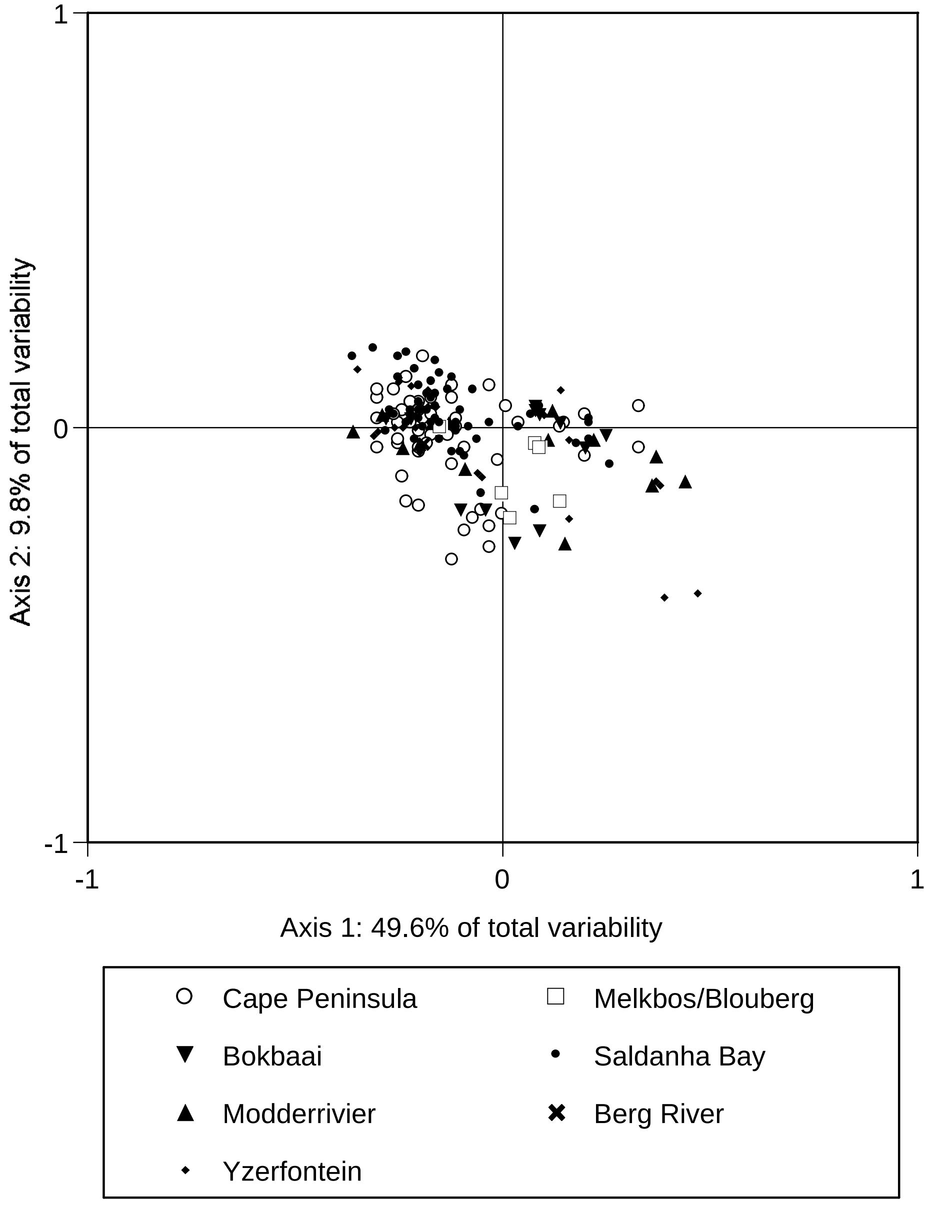


Figure 4.2.11. CA plot for the first two axes of the Elands Bay to Cape Peninsula analysis. Note the Elands Bay, Lamberts Bay and interior specimens have not been drawn on this plot.

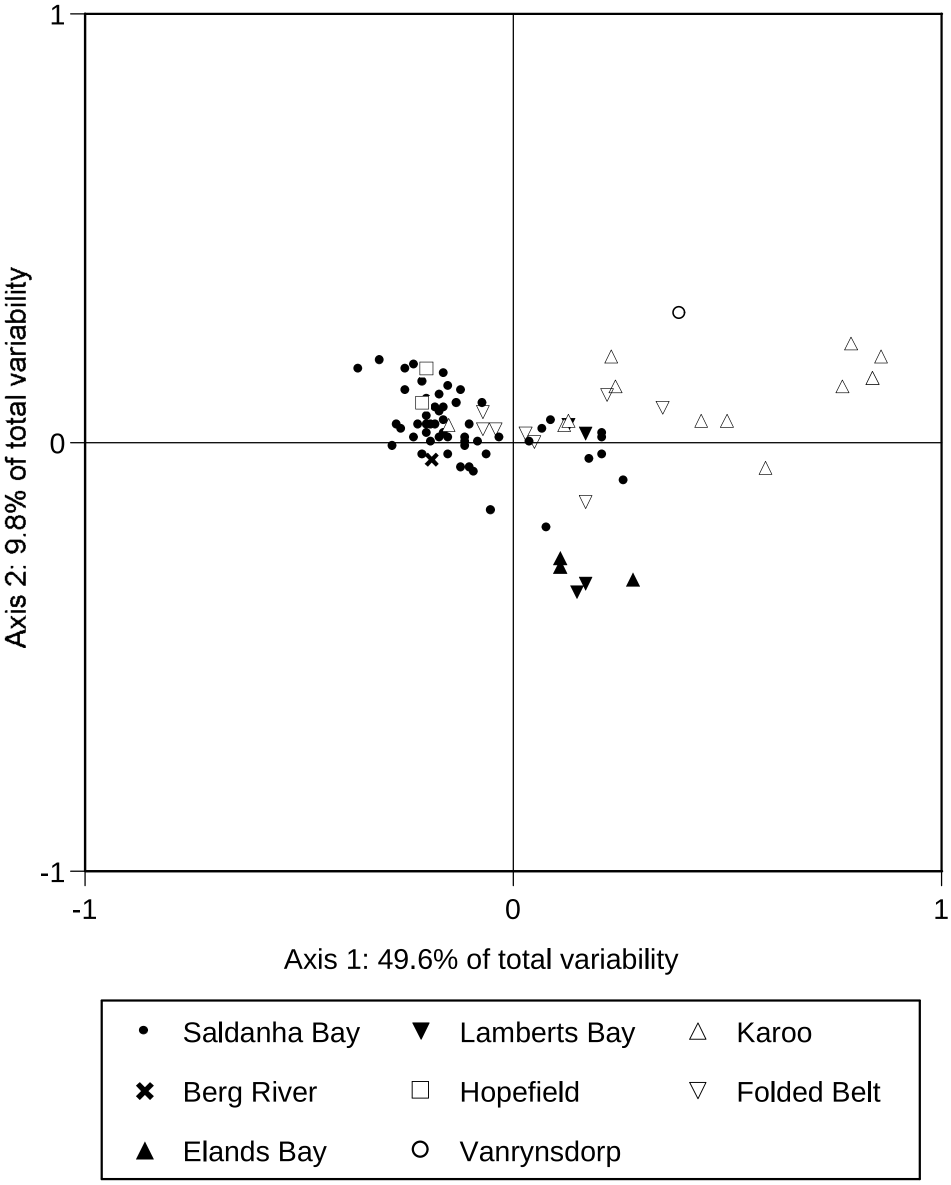


Figure 4.2.12. CA plot of the first two axes of the Elands Bay to Cape Peninsula analysis showing the relationship of Saldanha Bay to other selected locations.

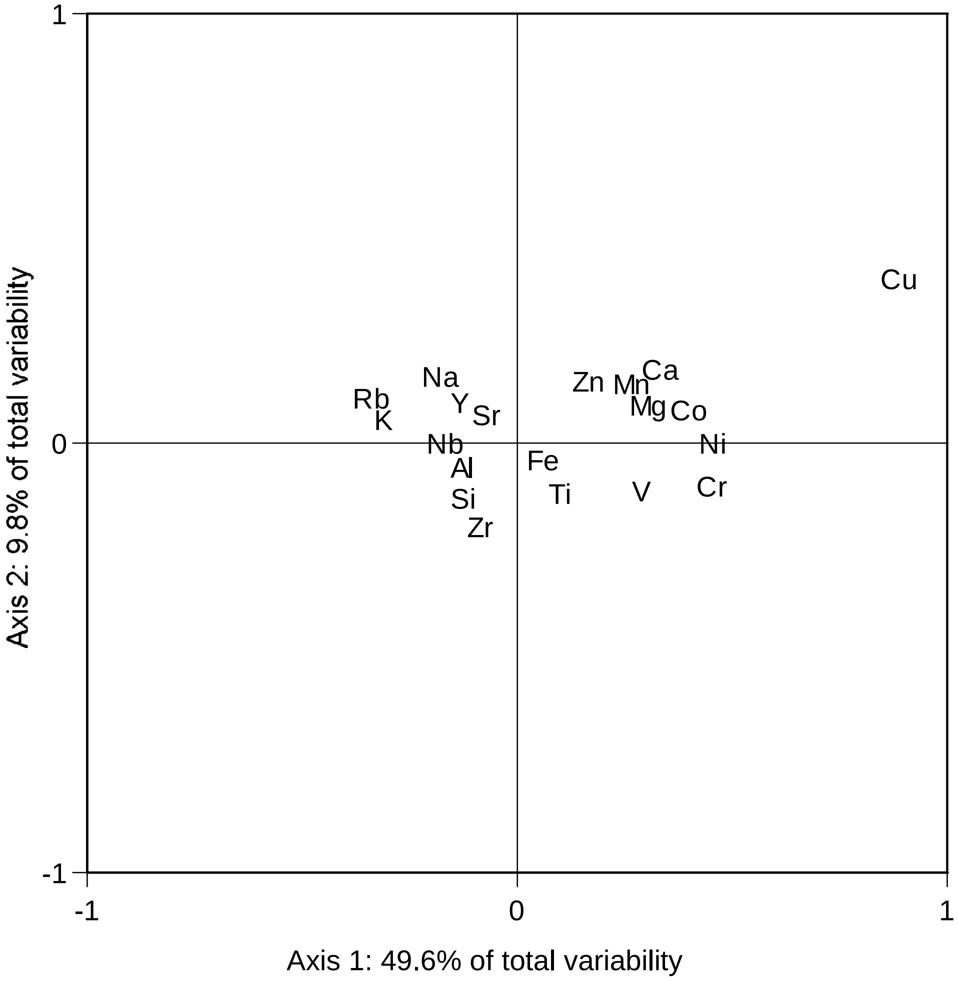


Figure 4.2.13. CA plot of element loadings for the Elands Bay to Cape Peninsula analysis.

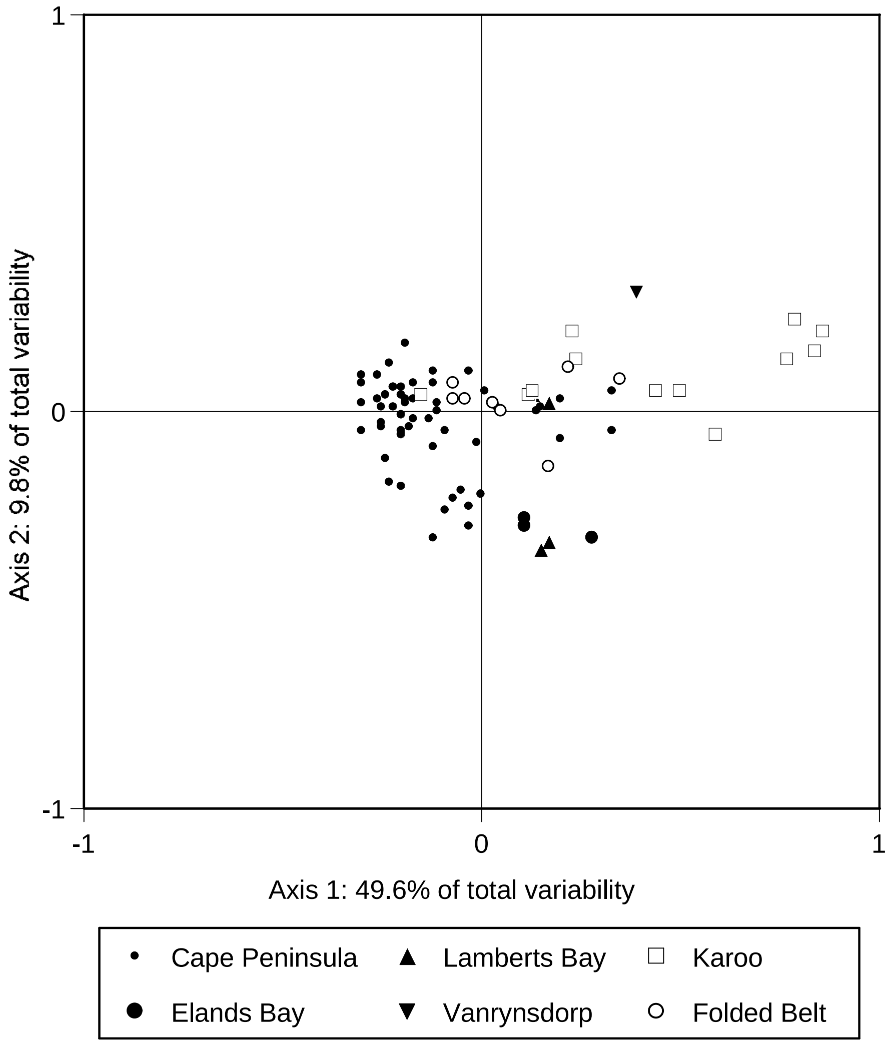


Figure 4.2.14. CA plot showing the relationship of Cape Peninsula sites to selected other sites.

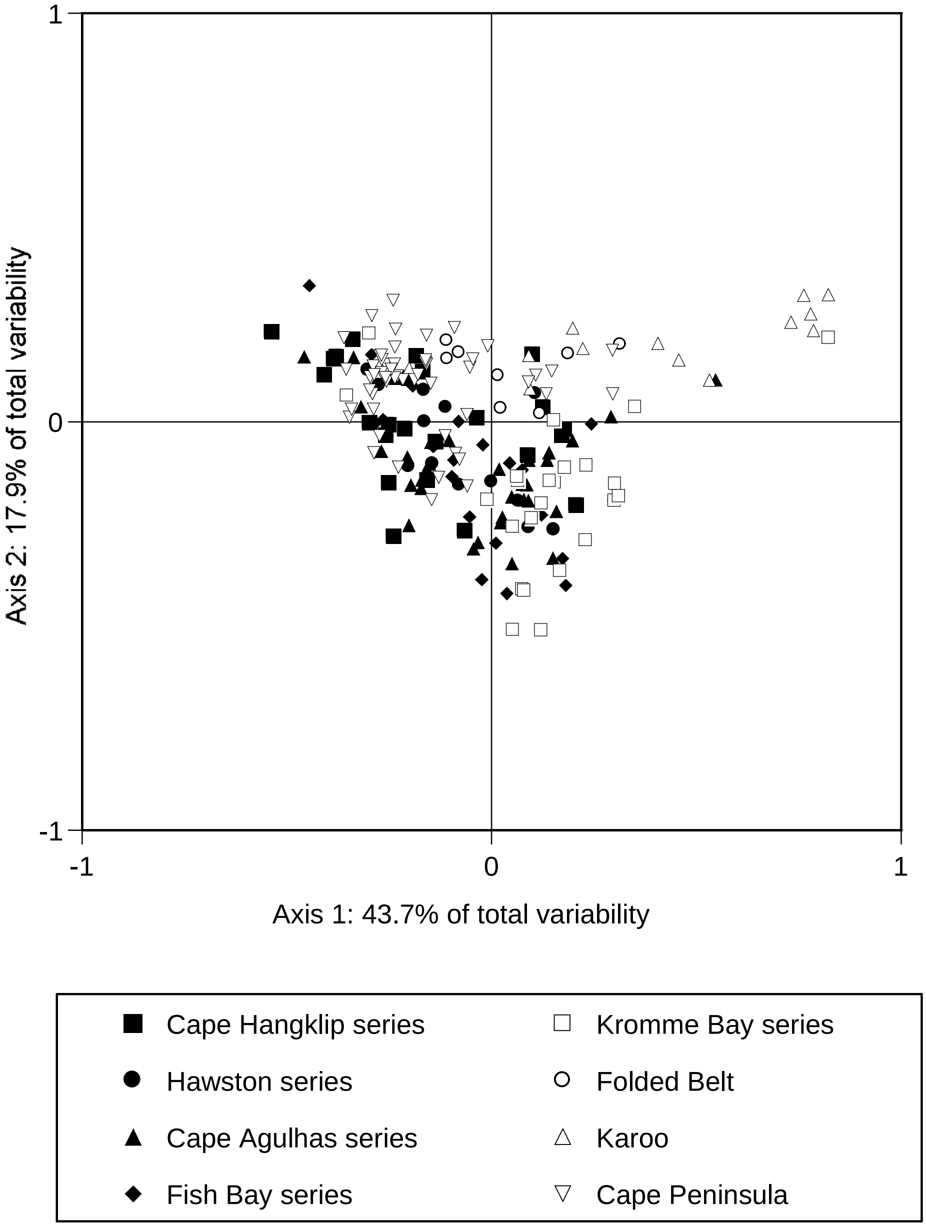


Figure 4.2.15. CA plot of the Cape Peninsula and southern Cape sites.

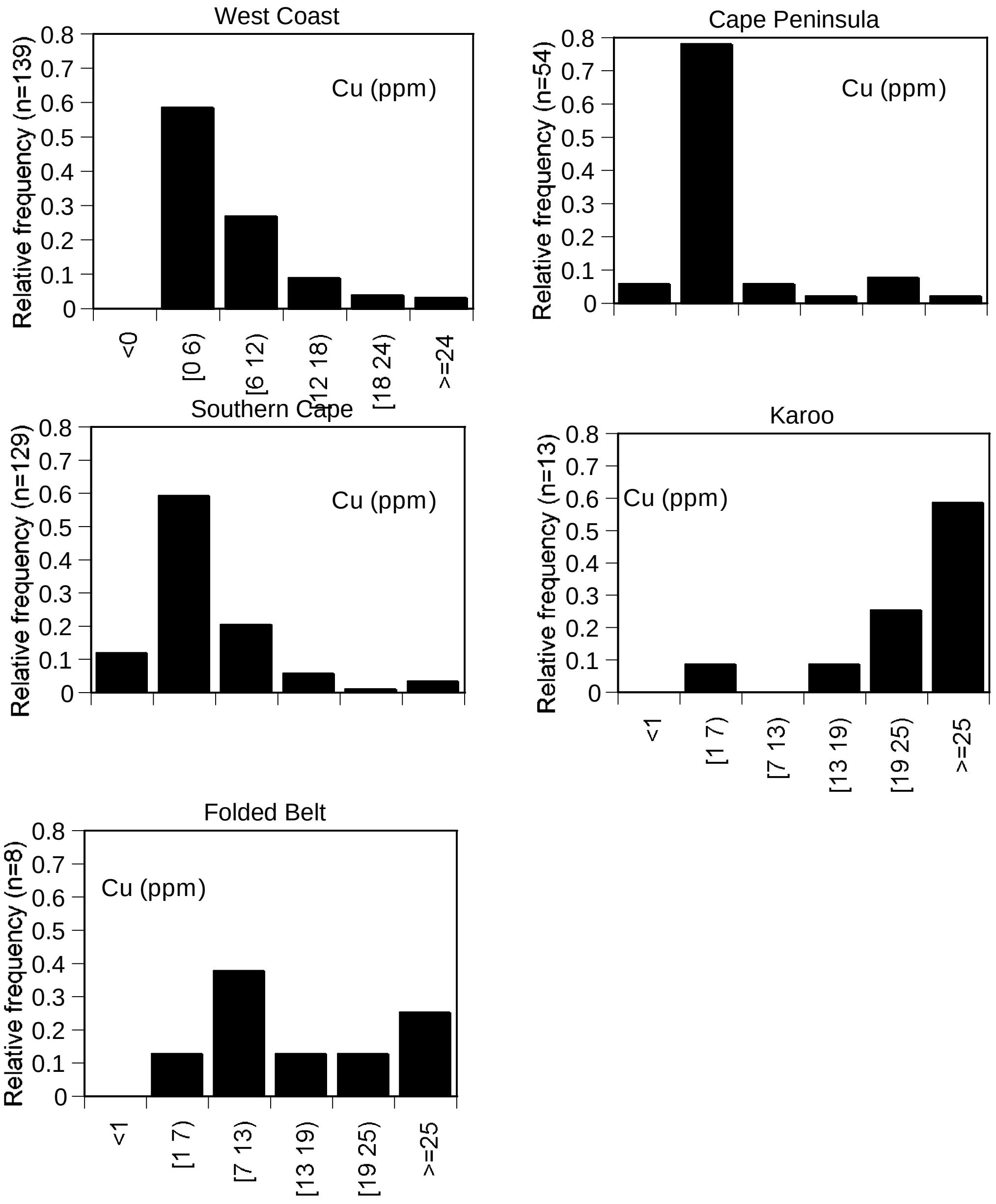


Figure 4.2.16. The distribution of Cu in sherds from different geographical locations.

4.3 BOTSWANA AND NORTHEASTERN NAMIBIA.

4.3.1 Archaeological Background

This section will deal with defining provenance issues relating to Botswana, in particular the north, but as there are close cultural as well as geological links to northeastern Namibia (the Kavango and Caprivi) these areas will also be dealt with as a whole.

Northern Botswana is one of the more fascinating areas from both an anthropological and archaeological point of view not, however, as a result of spectacular finds (of which there are) but rather for the theoretical implications for southern African archaeology. It is believed both on archaeological (Cooke 1965; Huffman 1994) and linguistic evidence (Westphal 1963; Elphick 1977) that this area was the entry point for the introduction of the first domesticated stock, pottery and perhaps metal-working into southern Africa and hence the first contacts between hunter-gatherers and these new economies and material objects.

The contact between a highly mobile hunting and gathering way of life and a community (whether herders or Iron Age farmers) who owned domestic stock and practised new technologies would have had important and far reaching social implications for each other. This has provoked an acrimonious debate amongst anthropologists over the history and current status of present day surviving !Kung (or San) communities: had they remained independent hunter-gatherers since the arrival of these first herders and farmers or are they to be seen as an underclass economically dependent on them (Denbow & Wilmsen 1983, 1986; Wilmsen 1983, 1993, 1995, 1996; Lee & Guenther 1991)? Provenance studies could be of some relevance to this debate by determining whether one item of material culture, namely pots, were locally made or imported.

For example, if pottery found on hunter-gatherer sites outside the sphere of settlement of early farmer or herder sites can be provenanced to the latter areas, it would provide evidence for trade or exchange since the earliest contact. If there is evidence for a trend over time that pottery was increasingly being made locally, this could indicate that a certain social distance was being kept.

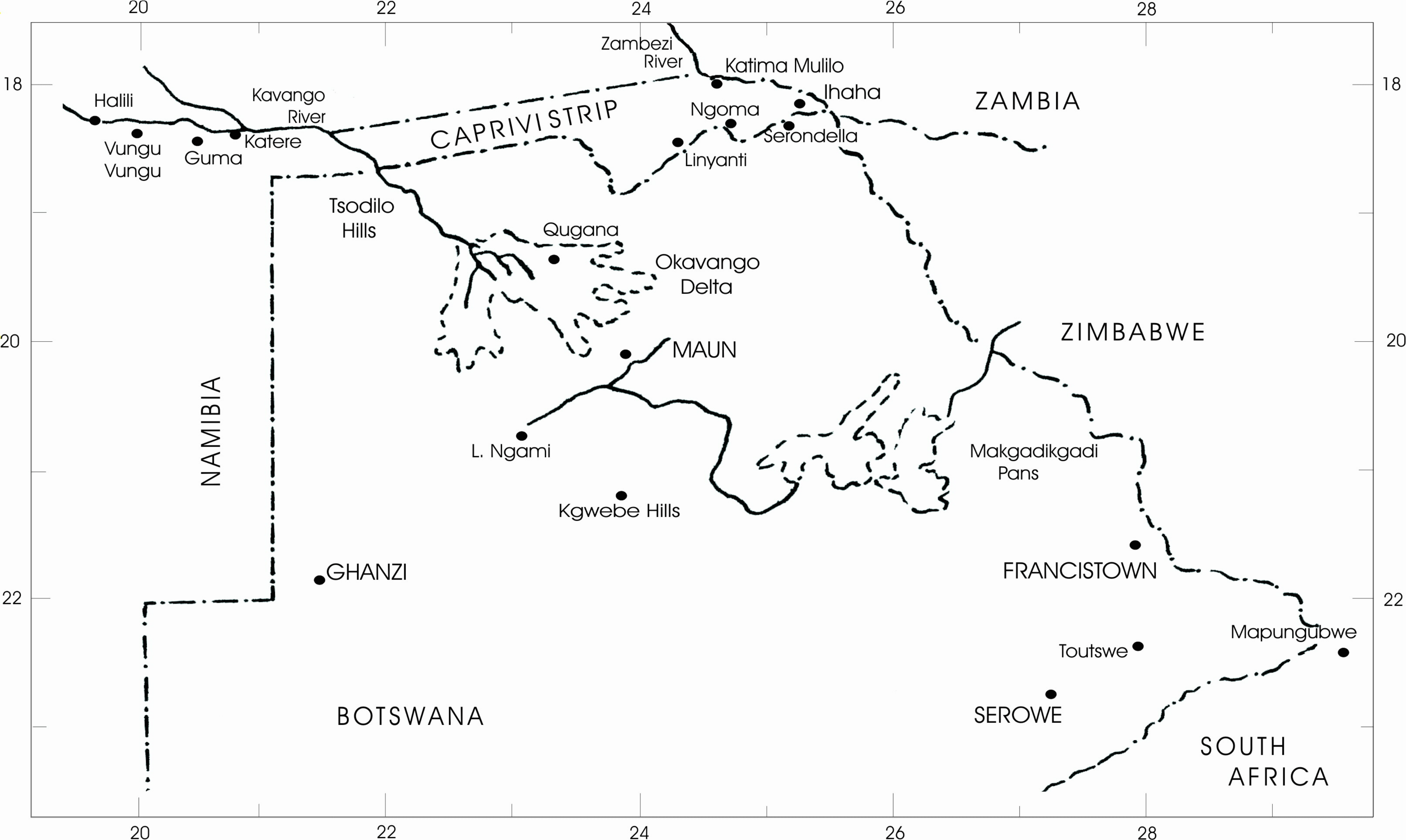

20
22
24
26
28
18
20
22
Zambezi River
Katima Mulilo
Ihaha
ZAMBIA
Halili
Kavango River
CAPRIVI STRIP
Ngoma
Serondella
Linyanti
Vungu Vungu
Guma
Katere
Tsodilo Hills
Qugana
Okavango Delta
ZIMBABWE
MAUN
NAMIBIA
L. Ngami
Makgadikgadi Pans
Kgwebe Hills
FRANCISTOWN
GHANZI
Mapungubwe
Toutswe
SEROWE
BOTSWANA
SOUTH AFRICA

Figure 4.3.1. Northern Botswana and northeastern Namibia showing main sites mentioned.

Various scenarios depending upon one's theoretical inclination are of course possible assuming enough sites of the appropriate age are found and excavated. What is definitely known is that groups of San hunter-gatherers from the Kalahari regularly visited Iron Age farmers living along the Kavango River and traded for various commodities. Ostrich eggshell beads, game and skins were traded for clay pots, metal artefacts and grain. Such interactions have been described by Wilhelm (1954) whilst Mbukushu potsherds have been excavated from the site of Cho/ana some 100 km south of the Kavango River (Smith & Lee 1997). In addition, I have examined a typical Kavango style pot, accessioned in the collections of the Völkekunde Museum, Berlin as a !Kung pot, which had been collected in the central Kalahari from a !Kung band by an interested German Schütztruppe during the course of a patrol sometime after 1900 and subsequently donated to the Museum. This was obviously a trade item.

The Early Iron Age sites of N!oma and Divuyu as well as other sites such as Depression Cave and various specularite mines in the hills have also produced evidence for extensive two way trade links (Denbow 1990; Robbins et al. 1993, 1998; Miller 1996; Wilmsen 1996; Reid & Segobye 2000) with both the east and the northwest. Iron, copper, cowrie shells and glass beads came in whilst haematite or specularite, salt, fish, and game went out. No imported decorative pottery typologies have yet been reported (site reports are still lacking) but clues to these trade or exchange links could yet lie in the geochemistry of the sherds found at those sites. Naturally enough, the archaeological interpretation of the geochemical data will depend upon the particular theoretical position taken.

4.3.2 Geological setting

The surface geology of this northern region consists of the Kalahari Group which comprises a flat landscape characterised by dunes, pans, gravel and clays which have been transported, laid down and reworked by water and wind, substantial alluvial deposits laid down by the Kavango River as well as a few outcrops (such as the Tsodilo and Kgwebe Hills) of much older rocks (Key & Ayres 2000; Modie 2000). The geochemistry of these sediments will be influenced by the catchment of the rivers flowing into the region and depositing sediments, for example, the Kavango, the Kuito and the Kwando flowing south and southeastwards out of Angola and which are sourced to anorthosites (Furon 1963). There could thus be patches of variability depending upon which river was dominant at any point in time. The only study currently available indicates a fairly uniform compositional profile with perhaps isolated areas of variability (Chatupa & Direng 2000).

Approximately 250 km to the southeast of the Tsodilo Hills lies the Kwgebe Hills formed from various volcanic rocks (Kampunzu et al. 1998). Modie (2000) reports that Cu mineralisation is known from the area. This fact, together with the presence of a more mafic geology, could result in a geochemical signature characteristic for this area.

The other sites to be considered, Toutswe and BPT2, are located in the southeast. Toutswe is situated on an inselberg of presumably Archaean rocks (Key & Ayres 2000) in the eastern hardveld and BPT2 is some 29 km to the east. It is presumed that the underlying geology would influence the composition of the surface sediments (either through re-mobilisation by water or termite activity) and that this area can be distinguished from other areas.

4.3.3 Previous work and current aims

The only previous provenance research was carried out by Gihwala et al. (1985b) who analysed a small suite of potsherds and clay samples from sites along the Kavango River and in the Caprivi using PIXE. The results were inconclusive in that there was no clear geographical separation between clay sources. Whether this was a function of the method of analysis or small number of samples is now difficult to say. As samples were still available, it was decided to re-analyse them together with the Botswana samples.

Reference has also made (Chapter 1.1 and figure 1.1) to the existence of pottery traders in Ovamboland (Jacobson et al. 1985). How far their wares were traded is unknown but one can only assume they must have been fulfilling a need for ceramic vessels in areas where they were not being made or which lacked suitable clays for their manufacture. Trade items should therefore not be too scarce in some areas but whether they can be identified is the challenge. There is also the challenge of finding whether there are any imports at other sites in the region.

The total sample size of the combined samples from Kavango and Botswana is small thus making any provenance study unrealistic at this stage. The aim of the analysis is, rather, to empirically test my initial hypothesis based on what is known of the geology, that the compositional profile of the northern Botswana-Kavango-Caprivi area will be different to that of the Kgwebe Hills and both to Toutswe and BPT2. The empirical data can then be used for developing revised hypotheses to be tested in more detail in the future.

Table 4.3.1. Clays from northeastern Namibia. All clays collected from potters.

Sample(s)	Locality	Comments
D9	Guma, Kavango	Prepared mixture of clay and temper (a crushed sherd)
D10, D30	Guma, Kavango	Rejected clay
D13	Halili, Kavango	Raw clay
D14	Kapako, Kavango	Raw clay
D15	Kapako, Kavango	Prepared mixture of clay and temper (a crushed sherd)
D16, D29	Katere, Kavango	Rejected clay
D18, D22	Katima Mulilo, Caprivi	Raw clay
D17, D26, D27, D42	Linyanti, Caprivi	Raw clay
D19, D24	Ngoma, Caprivi	Raw clay
D23, D28	Oshombo, Oshakati	Raw clay

4.3.4 The samples

Kavango and Caprivi

Eighteen clay samples from eight different localities and fourteen potsherds from seven localities were analysed. Where possible, more than one specimen for analysis was taken from each sample. The clays represent those that were collected by the potters themselves although the potters had rejected a number for various reasons, such as being too "gritty" (Table 4.1).

The sherds had not been systematically excavated but were surface samples collected at random by various people. They probably represent a variety of ages, cultural affinities and manufacturing techniques from the region (Sandelowsky 1973; Otto 1978; Woods 1984a, b; Kinahan 1986; Jacobson 1987). The site locations are shown in figure 4.3.1.

Tsodilo Hills

The three hills of quartzitic schist which break the monotony of the Kalahari gives the area its name. The Hills and surrounding area are well known for the amount of research they have received from archaeologists: long and short sequences of Late Stone Age (and earlier) settlements in caves and shelters (Robbins & Campbell 1988; Robbins 1990) as well as surface scatters (Rudner, I. 1965), important Early Iron Age (EIA) settlements (Denbow & Wilmsen 1983; Denbow 1990), schist and hematite mines (Robbins et al. 1993) and rock art (Rudner, I. 1965; Robbins et al. 1993; Campbell et al. 1994) have all been excavated, studied and recorded from this area. Incidentally, a previous visitor had been the well known Laurens van der Post (1958) who thought the Hills were inhabited by spirits and for whom he left a message in a lime juice bottle!

Potsherds had been collected from a number of localities including overhangs, clefts and between boulders during a rock art survey by Rudner (1965) and it was from this collection that most of the Tsodilo sherds were taken for analysis. Two sherds (b12 and bp2) have only been provenanced to the broad Tsodilo area and were obtained from a tourist who had visited in the 1950's and had collected them out of interest. Based on the illustrations in Rudner (1965) the pottery can be stylistically referred to Early Iron Age Divuyu (eg, Rudner 1965, figure 6: 14.2, 14.7, 15A.3, 25.2) and N!oma (Rudner 1965, figure 6: 14.6) or modern Hambukushu wares (Rudner 1965, figure 6: 9B.1, 9B.3, 16.1; Huffman pers. comm.). Hambukushu settlements are found in the general area of the Okavango River from the swamps northwards into Namibia. Little is known of their history but they are supposed to have entered Botswana about 1700 AD (Campbell pers. comm.). Although the Tsodilo pottery may have been made by them, they did not necessarily leave it at these particular sites. Firstly, the rock art with which the pottery is usually associated is regarded as being of hunter-gatherer origin and secondly there is ample evidence for trade between hunter-gatherers and the Bantu-speaking farmers of the area (Wilhelm 1954). This scenario is equally applicable to account for the presence of the Early Iron Age wares in the Hills.

In addition to the above samples, a number of other sherds from specific sites in and around the Hills were analysed. These are:

Depression Cave: This is a cave located in the Hills and containing a long sequence of Late Stone Age occupation horizons (Denbow & Wilmsen 1983; Robbins 1990; Robbins & Campbell 1988). The upper levels contain pottery and are dated between 100 and 1650 A.D. Three plain sherds were analysed. It is possible that these sherds were not made by the hunter-gatherer occupants of the site but originate from herder or Iron Age settlements nearby.

Divuyu: This major EIA site is located close to the Hills (Denbow 1990, 1999; Wilmsen 1996). It is dated to the period 550-730 AD. Of interest is the presence of many iron and copper artefacts and ornaments. These must have been traded into the area as no local sources for these metals are known (Miller 1996). There are also subsistence items such as fish, mammals and shells which originate from the Kavango/Kunene river systems. The pottery style has no parallel with anything known in South Africa or Zimbabwe and could extend into Angola. Both charcoal and calcrete tempered sherds are recorded from this site.

N!oma: This is the second major EIA site in the immediate area (Denbow 1990, 1999; Wilmsen 1996). Radiocarbon dates place its initial period of occupation between AD 850-1090. Much metal work was found similar to Divuyu (Miller 1996). Not only does the pottery differ stylistically from Divuyu (although linked to Angola and Zambia) but the economy seems to have been more dependant upon cattle than Divuyu. Trade in salt is inferred as well as wider links across the Kalahari from the swamps eastwards reaching as far as the Indian Ocean from the evidence of glass beads and cowrie shells. Pottery here is mainly charcoal tempered but includes Gokomere and Dambwa types which are found from Limpopo Province (SA) to southern Zambia. Analysis of the copper artefacts by Miller (Miller 1996) revealed a few with very high phosphorus content similar to known artefacts from Zaire and copper ore from Phalaborwa. All the evidence for this site as well as Divuyu thus indicates extensive trade links whether direct or indirect. Four sherds were available for analysis.

Xaro: This site is situated near Tsodilo close to the Okavango river. The ceramics belong to the same tradition as those from Divuyu and Nqoma although the site is somewhat later, i.e., the 16th century A.D. (Denbow 1990, Denbow & Wilmsen 1986).

Sites from further afield but within the Kalahari are:

Qugana: An island site in the eastern delta of the Kavango swamps and dated to the eighth century A.D. The ceramics are of the Gokomere tradition of northeastern Botswana (Denbow & Wilmsen 1986). This could be a hunting site and not the usual living site.

Serondela: Similar to Qugana with respect to age and ceramics but situated on the Chobe river (Denbow & Wilmsen 1983).

Kgwebe Hills: Both Khoi and Tswana ceramics have been found here together with iron and copper artifacts, slag and glass beads (Denbow & Wilmsen 1983). There is also evidence for "ancient" workings in the hills (D.P. Piper, Geological Survey of Botswana, pers.comm.) which may be connected to the Cu mineralization mentioned above.

Toutswe: A major Early Iron Age site with glass beads and cowrie shells indicating extensive trade links to the East Coast and dated to 960 AD (Lepionka 1979; Denbow & Wilmsen 1983, 1986; Denbow 1999). Toutswe style sherds have also been found at sites further to the east such as K2 in the Limpopo Valley. A few have been analysed and will be discussed under these sites.

Break Pressure Tank 2: A Toutswe period site 29 km to the east of Toutswe (Reid & Segobye 2000). The analysed sherds included Toutswe and Mapungubwe types (Reid pers comm).

Lobatse: A duplicate sample from a modern pot made at Lobatse was also analysed. This is very far south of the areas currently being surveyed but it was included out of interest as a comparative sample. There is a record, in addition, that modern pots from this area are tempered with asbestos (Grant, L.H. 1968) so the results could be of further interest.

Xaro, Depression Cave, Divuyu, Nqoma and the Tsodilo Hills surface sites are located very close to each other and can be regarded as a single broad locality. If indeed no clays are found in the vicinity of the sites (see below) then either clays for potting were carried in or vessels were made elsewhere and brought in. There is thus the expectation for a lot of variability in the chemical data for the vessels from this area.

4.3.5 The temper problem

A. Campbell (pers. comm.) who knows the area well has indicated that there are no clays in the immediate Tsodilo area and that the nearest sources are probably the Xaudum River 20km to the south or the Ncamaseri River 10 km to the north. This could account for the use of charcoal and other tempers in the pottery. If it was necessary for clay to have been carried in for some distance, it is therefore possible that temper was added to the imported clay to make it go further. However, as charcoal and (occasionally) bone tempered wares appear to be found throughout northern Botswana and into northeastern Namibia (Woods 1984a, b; Denbow & Wilmsen 1986), alternative explanations are also possible. Such temper might have been necessary as an additive for clays difficult to work or fire or simply, as has been noted previously, to produce lighter vessels (Skibo et al. 1989). Ione Rudner, the writer of the Tsodilo paper who together with her husband Jalmar has had considerable experience in collecting and handling pottery from most of southern Africa (Rudner, J. 1968, n.d.), noted in this context "This pottery is surprisingly light in weight" (Rudner, I. 1965). Alternatively, these vessels could have been traded far afield. Perhaps, in the end, a combination of these circumstances is responsible.

As much of the pottery from this area is tempered to a greater or lesser extent with either charcoal, bone or grit, careful examination of the sherds prior to choosing suitable samples for analysis was made but at the same time, given the experimental work on temper described earlier, tempered samples were also chosen. As has been noted, a tempered sherd might not necessarily give an accurate locality provenance but it could identify a potter or group of potters to a broader geographical region.

4.3.6 Statistical analysis

Kavango and Caprivi

Table A4.3.1 presents the data for the clays. It can be seen that individual samples from the same site give very similar results (these are not duplicated samples) except for perhaps Katere (D16 and D29). The potsherds, Table A4.3.2, offer no surprises. The only evidence for a possible (lightly) bone tempered sherd, given its prevalence in the region, might be pc5 with somewhat enriched CaO and P_2O_5 values although the latter could be the result of contamination.

In order to visually present the relationships between the clays and the sherds, a CA plot is presented in figure 4.3.2. Three sherds are omitted from this run, namely, D11 (depleted in Y), bz14 (depleted in Al_2O_3, CaO and V) and bz23 (enriched in CaO and Sr). These three sherds because of their extreme differences with respect to these elements compared to the other examples, plot as extreme outliers. This is not to interpret them as imports, rather they represent the outer limits to the variability of the sherds for this region. For the rest, note how the clays from the Kavango tend to cluster together. The two Katere samples show some distance from each other but the Katere sherd plots right on the upper clay. The Ngoma sherd also plots close to the Ngoma clays which in turn are close to the Katima Mulilo clays and the Ihaha sherds. The Linyanti sherds are quite variable and bear little resemblance to the Linyanti clays. Although the small sample size does limit interpretation there nevertheless does seem to be a differentiation between Kavango, Ovambo and Caprivi clays. Whether this will be maintained once samples from additional new localities are obtained remains open at present.

Botswana

Table A4.3.3 presents the full set of analytical results for Botswana. The two Lobatse samples stand out dramatically with their highly enriched MgO, Ni and Cr values. RB01 (Site BPT2) is also enriched, relative to all other samples, in Ni and especially Cr and indicates a mafic background but probably a source with a higher Cr content than the local basalts contain. I shall return to this interesting sample in a later section. Otherwise, a perusal of the composition of sherds from the same site indicates a great deal of variability, for example, b1 and b2 from

Divuyu where, amongst others, Y ranges from 0 to 73 ppm respectively. The group of sherds with a consistent pattern of elemental enrichment relative to others in the suite, i.e., Zn and MnO in particular as well as Cu and Ni, are those from the Kgwebe Hills. On the basis of their geochemistry, these samples can definitely be related to clays formed from the Kgwebe basic volcanics (Kampunzu et al. 1998).

These and other differences will be better examined with a CA plot, but first, however, I wish to draw attention to five samples, bz3, bx7, bz10, bz6 and bz12. The first three have exceptionally high CaO and P_2O_5 values clearly indicating the presence of bone temper. Based on the figures in Table 2.6 (page 33), better than 24% of the sherd body must consist of bone temper. These three samples were omitted from the correspondence analysis but a visual comparison of the values for the other elements between these three samples and other Tsodilo samples indicate fairly similar broad compositional profiles.

Samples bz6 and bz12 were originally a single large coarsely tempered sherd which was split and separately analysed (see section 3.1.1). The difference between the halves lies in the CaO and Sr values which for bz12 are approximately half those for bz6. This indicates the presence of more calcrete or charcoal temper in the latter. Both halves were kept for the correspondence analysis.

Another pointer to the presence of charcoal as temper appears to be the high LOI values (>10%) found in many sherds from the Tsodilo Hills. The heavy and obvious tempering of sherds with charcoal and/or bone could be a distinctive provenance marker for this area as the charcoal and bone temper that Woods describes in thin section (Woods 1984a, b; Gihwala et al. 1985b) and that I have seen from the Kavango and Caprivi are not visually obvious and can generally only be seen under the microscope or with the aid of a strong magnifier. Certainly, they do not occur as “lumps” or large fragments.

Figure 4.3.3 is a CA plot of all the Namibian and Botswana sherds and clays apart from the bone tempered sherds mentioned above and RB01. When such a highly variable group of samples is used, the Kavango clays cluster into a single tight group. At this scale it means that the individual clay sources from the Kavango River can not be differentiated assuming the differentiation was originally realistic. The apparent grouping of all the clays is disproved by the plot of the 1st and 3rd axes in figure 4.3.4. The three regions move away from each whilst the separation of Ngoma and Linyanti clays is still maintained. There is also a strong separation between the Kalahari group on the one hand, the eastern Botswana group and the Kgwebe Hills.

The apparent overlap between the two Serondella samples and the Kavango sample with the eastern group of Toutswe and BPT2 in figure 4.3.3 is resolved in figure 4.3.4 when those samples move in opposite directions on the 3rd axis which represents 14.2% of total variability, a significant amount. This particular attempt to link the clays to the sherds will not be taken further as the few clays are definitely not representative enough for a final definitive statement. What is needed are clay samples away from the major northern rivers in order to assess the region's overall variability.

Figure 4.3.5 is a similar plot but excluding the clays. Notice the relationship of the split sherds to each other. Although the 3rd axis, figure 4.3.6, separates them somewhat, in the light of the overall variability for the Tsodilo Hills area they do not show any significant differences once all the elements have been taken into consideration in a multivariate analysis. The 3rd axis once again separates out the three samples (Kavango and Serondella) with the apparent overlap. Of these three, the Kavango sherd is definitely the most different to the Toutswe/BPT2 group but it must be borne in mind that it is an assumption that these sherds are locally made. The two Serondella sherds could, in fact, originate from an area not considered in this work as no samples are available. It is also just possible that the long elongated cluster of the Kalahari sherds represents two sub-clusters, the lower one localised at the Hills and the upper cluster imports from an as yet unknown locality.

Figure 4.3.7 maps the generalised relationship between the sherds and their chemistry for axes 1 and 2. If figure 4.3.5 is compared to this, axis 1 separates out the northern sherds from the eastern sherds on the basis that the former load higher in general on more felsic elements whilst the latter load higher on mafic elements. The 2nd axis separates the Kgwebe sherds from the eastern sherds on the basis of their Zn and MnO content whilst the northern sherds are strung out on a continuum emphasising Sr and K (amongst others) at one end and Y and Nb at the other.

Figure 4.3.8 is a map of the northern sherds only plotted according to their location. Even with small numbers note the wide dispersion of the samples in the group indicating highly variable clay sources though whether local or from afar is not yet possible to say.

Finally, figure 4.3.9 shows the distribution of Tsodilo Hills sherds plotted depending upon whether they have high (>10%) and low (<10%) values for LOI. Once again, there is no pattern to the distribution. If I am correct that high LOI (i.e. >10%) indicates that pottery with high levels of charcoal temper are only found in the Tsodilo Hills area and, further, if Alec Campbell is correct that there are no local clays, then clays must have been brought in from a variety of sources to be made locally. Alternatively, the potters themselves could have travelled to the clay deposit, made their vessels there and carried them back, the temper serving to lighten the vessels for their transportation.

4.3.7 Discussion and Conclusions

Northern Botswana, and northeastern Namibia with which it forms a geographical whole, is a large area covered mainly by Kalahari Group sediments. The evidence presented above shows that in spite of only a few pottery samples being analysed, there is a lot of geochemical variability present probably as a result of the sediments and clays having different origins resulting from drainage patterns changing over time. Nevertheless, the region stands in contrast to the samples from eastern Botswana and the Kgwebe Hills, a more localised area within the Kalahari, and can be said to have a regional signature which can be defined in multivariate “space”. This makes it suitable for provenancing with respect to regional issues but might be problematic for more localised issues such as contact between Tsodilo and the Kavango, for example.

However, bearing in mind the low numbers of pots tested especially those from the sites of Divuyu and N!oma, the following models are presented as competing working hypotheses for future testing:

1. Local clays used (highly variable in composition) - temper added to improve firing success;

2. No suitable local clays - clays brought in from other sources and pots made locally; temper added to improve firing success or to maximise use of clay;
3. No suitable local clays - potters travel to distant clay sources, make vessels there and carry them back (?charcoal tempered to lighten vessels for transport);
4. No suitable local clays - pots specifically imported.
5. Pots arrive from outside as an adjunct to trade in other items or through social factors (marriage, tribute, attendance at court, etc).

Testing the above scenarios will require the collecting and analysing of many more clay samples as well as the analysis of a wide range of sherds including different decorative styles principally from the two Early Iron Age sites of Divuyu and N!oma before the final word on this issue can be realised. Models 2 and 3 could mean that sherds tempered with large charcoal fragments are unique to the Tsodilo area therefore providing a provenancing key should similar vessels be found in low frequencies elsewhere. Separating model 2 from 3 might only be possible if caches of raw clay (with a nonlocal compositional profile) are found. Separating models 3 and 4 might be even more difficult and might only be possible if imported vessels are stylistically different or, in terms of composition, are more variable than would be the case if people were exploiting one clay source. The final picture, however, could probably be a mix of locally made (or near locally made) vessels and those imported either deliberately or secondary to other trade items or social factors. It will be up to archaeologists to suggest the more plausible explanation by integrating compositional profiles and style with other lines of evidence such as the exact features where pots are found on a site. Further comparisons between the eastern Botswana sites of BPT2 and Toutswe will be discussed in the section on the Limpopo Valley to which they are culturally and geographically linked.

Clearly, there is much to do in the Kalahari. Extensive trade has been documented both archaeologically and historically and the results presented above show the potential that a detailed survey can realise.

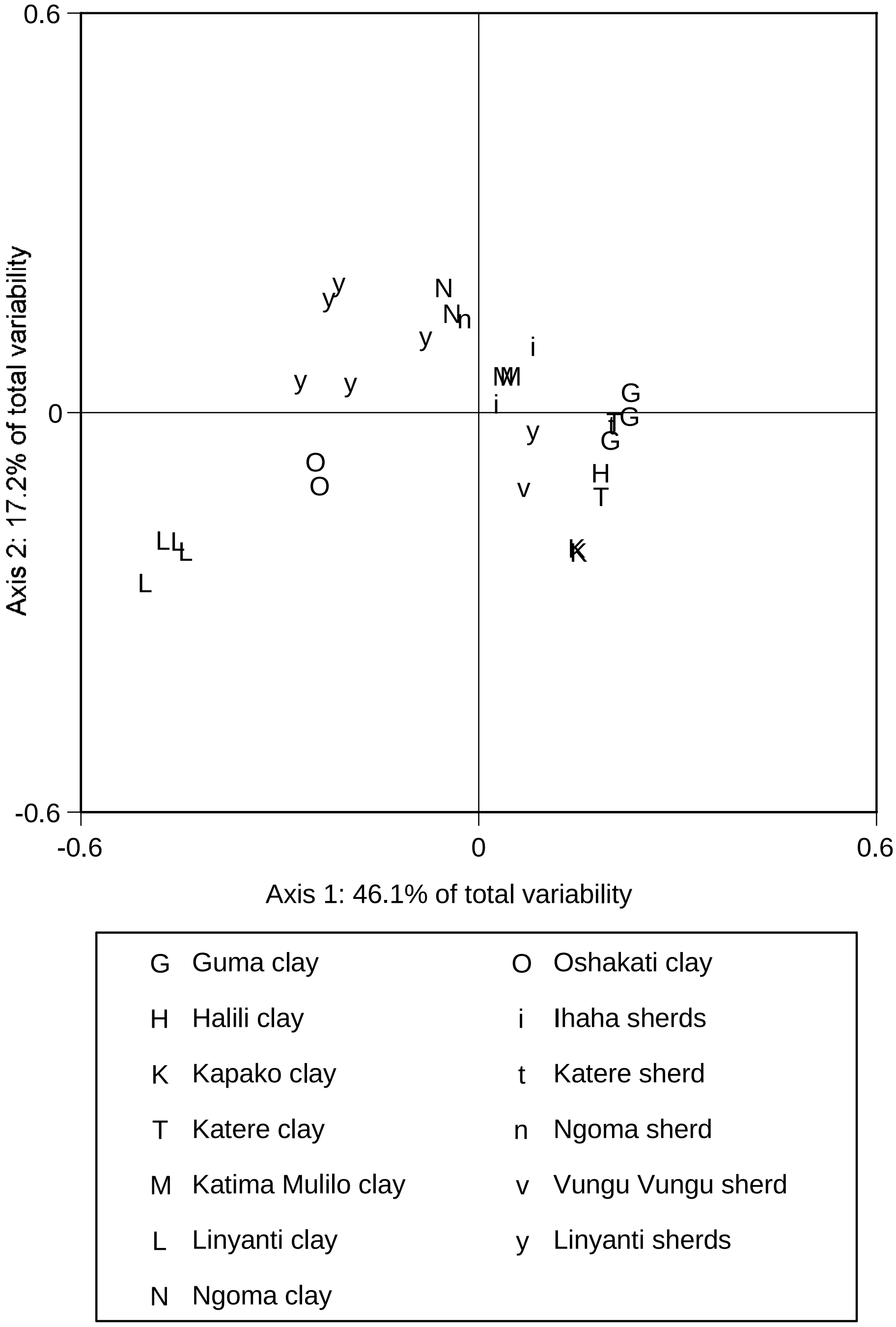


Figure 4.3.2. Plot of the analysis of Kavango/Caprivi sherds and clays.

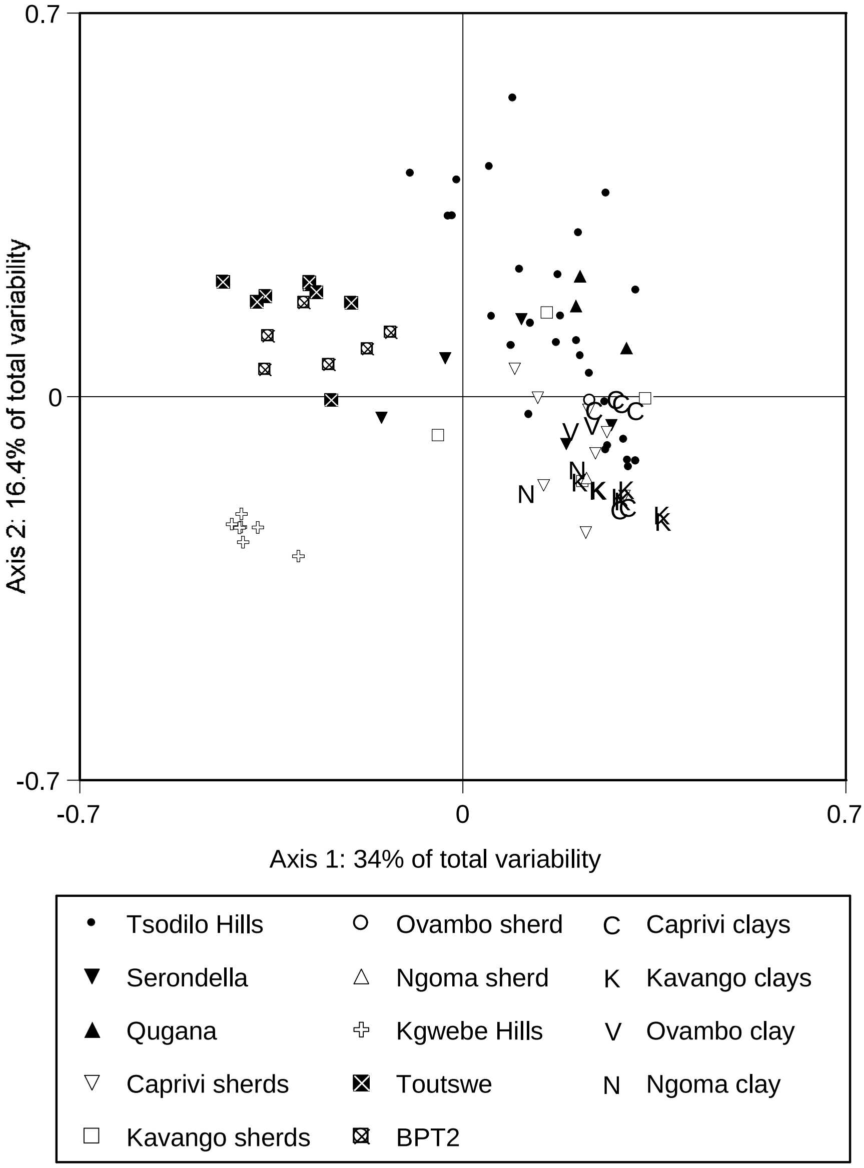


Fig 4.3.3. Plot of the complete data set for the first two axes.

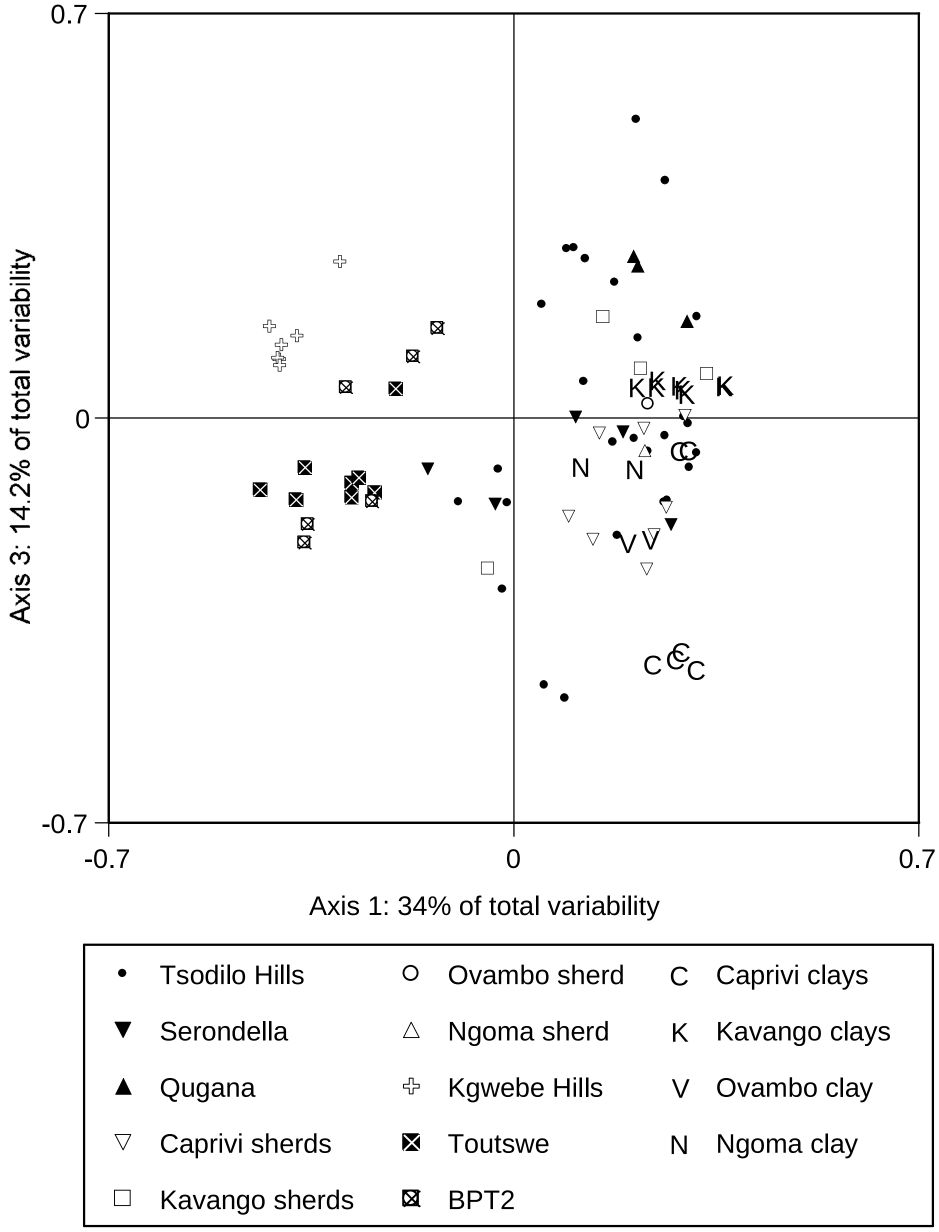


Figure 4.3.4. Plot of the complete data set for the first and third axes.

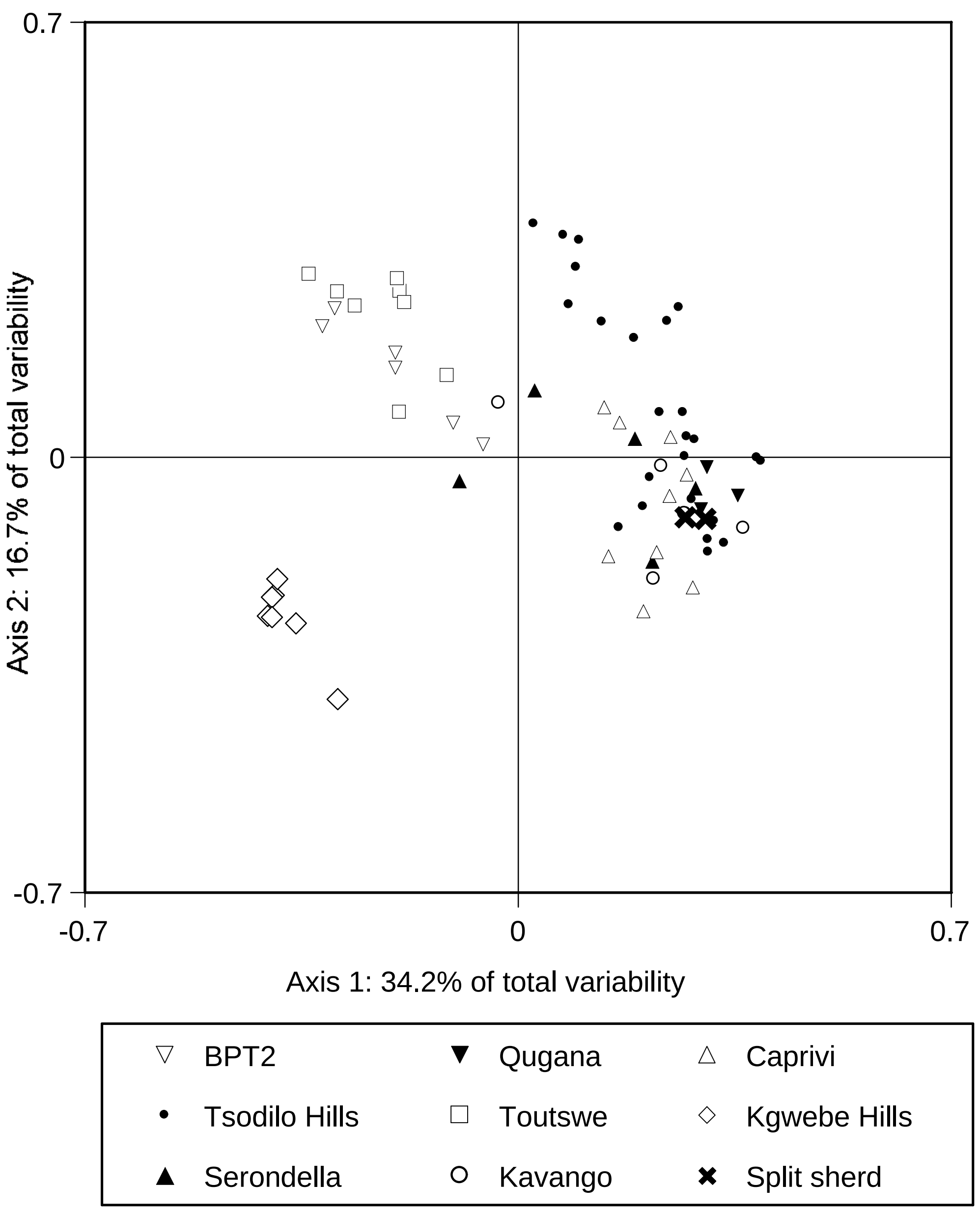


Figure 4.3.5. Plot of the first two axes of the Botswana, Kavango and Caprivi sherds.

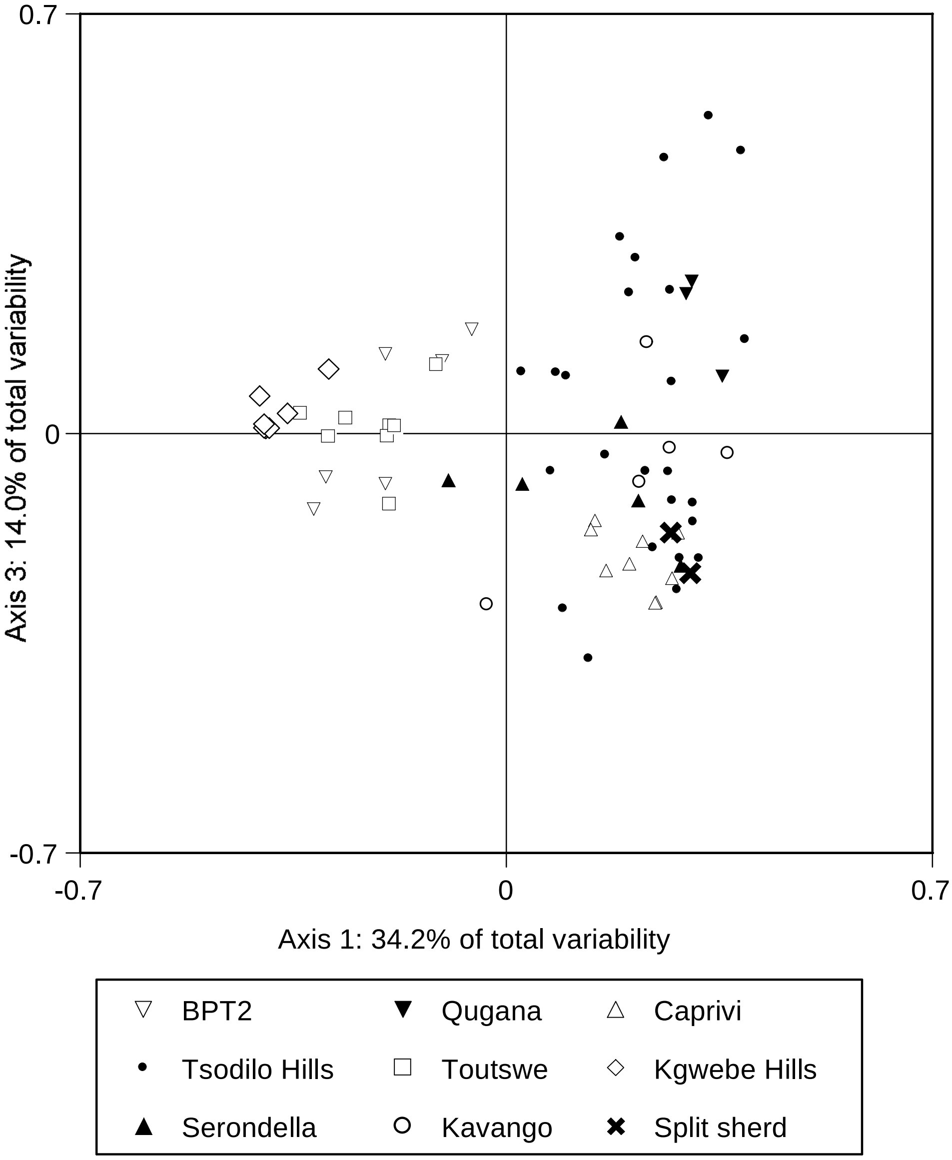


Figure 4.3.6. Plot of the first and third axes of the Botswana, Kavango and Caprivi sherds.

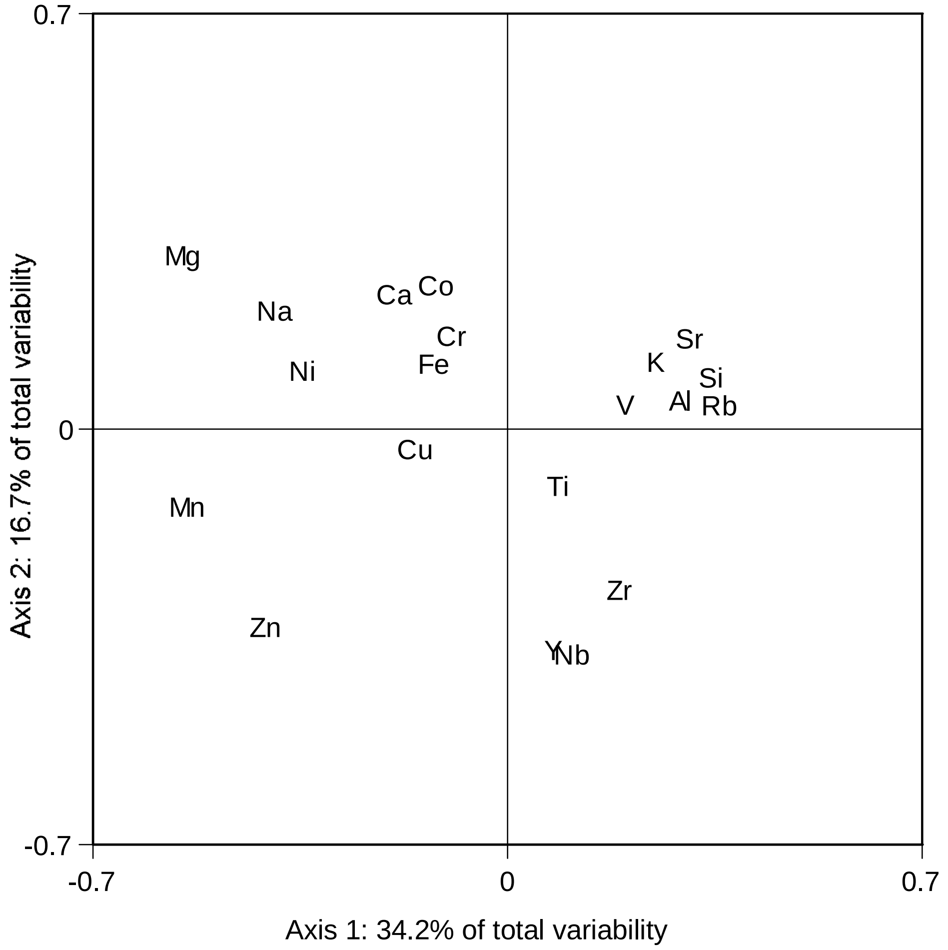


Figure 4.3.7. Plot of the first two axes of the element loadings.

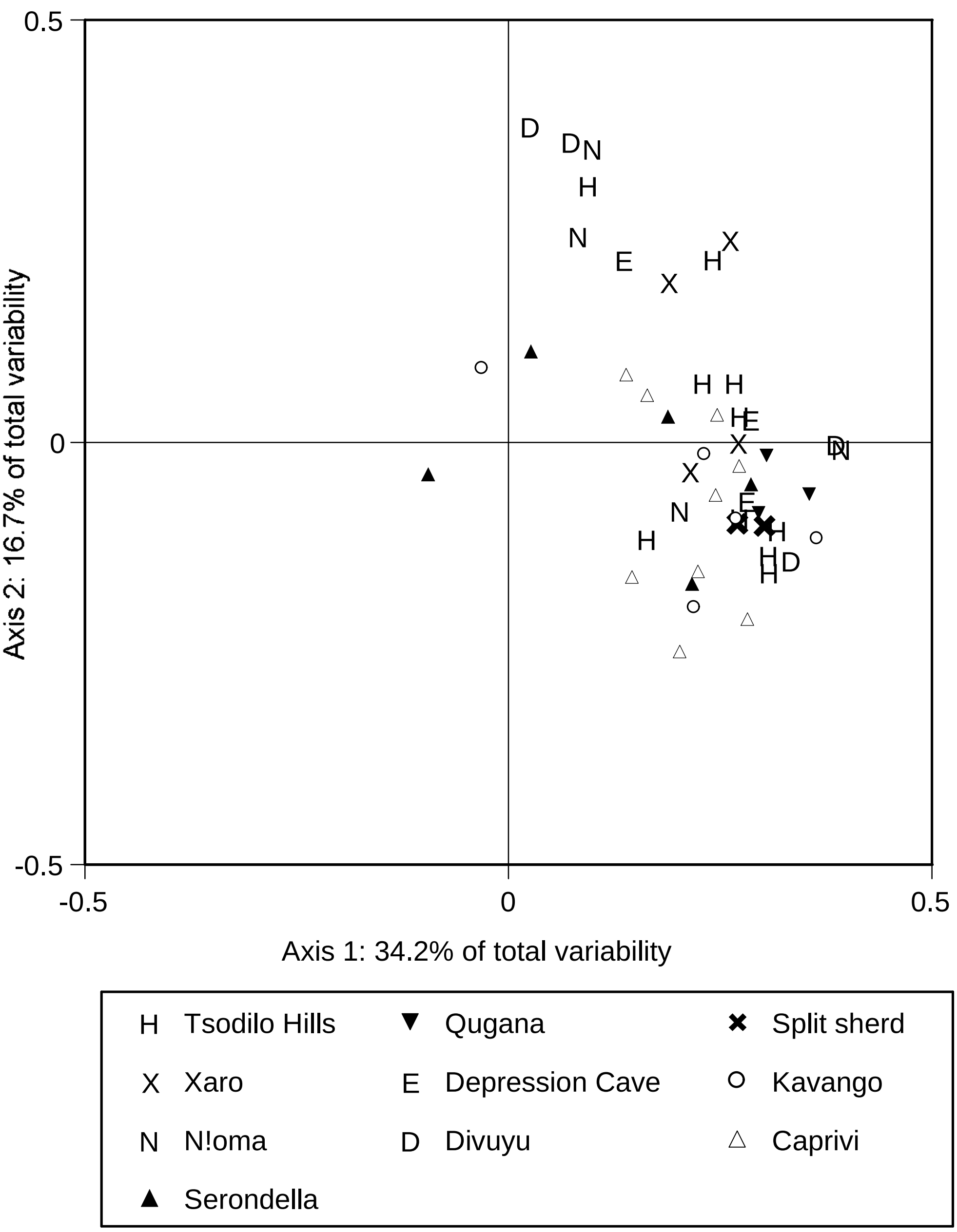


Figure 4.3.8. Plot of northern sherds only.

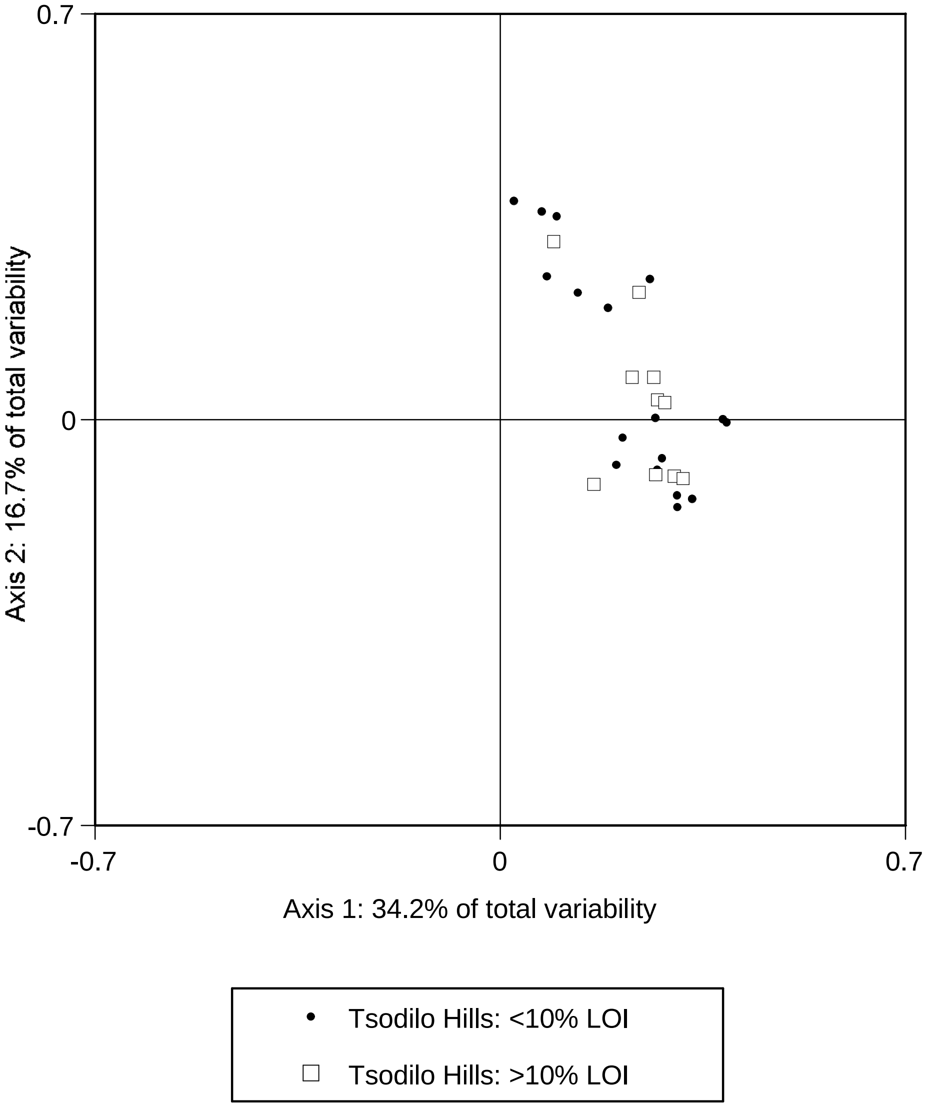


Figure 4.3.9. Tsodilo sherds plotted according to whether they have high (>10%) or low (<10%) LOI values.

4.4 THE SHASHE-LIMPOPO RIVER CONFLUENCE.

4.4.1 Archaeological background

The area at the confluence of the Limpopo and Shashe Rivers is the location of three important Iron Age sites which document increasing trade relations between the interior and the East coast as well as important social transformations that resulted from the control of this trade.

The first of these, Schroda was settled by Zhizo peoples in the early 10th century AD. It was the largest and most important site in the area (36 Zhizo settlements are known) and it is estimated that some 500 people lived there. Evidence for trade includes glass beads and cowrie shells which were imported and ivory which was exported (Hanisch 1981; Huffman 1996, 2002a; van Schalkwyk, J.A. & Hanisch 2002). In addition, any iron artefacts would have had to be imported as the area is deficient in natural sources of the metal. As it was the capital, it would also have been the centre where religious and ritual ceremonies were held. It is therefore of interest that a large number of clay figurines were found. These would most likely have been used in initiation ceremonies.

About AD 1020 Schroda was abandoned. At the same time Leopard's Kopje pottery suddenly appeared in the region (Huffman 1978, 1996) and rapidly displaced the local Zhizo although pockets remained in the west (Calabrese 2000a). By AD 1030 K2 was established and lasted until AD 1220 when it too was abandoned. During this time, K2 took over control of the east coast trade which had become intensified and developed its own particular pottery style. It, too, was the capital of a large area which included a number of subordinate sites and it is estimated that the population grew to about 2000 people (Voigt 1981a; Huffman 1996, 2000; Meyer 1998, 2000; Calabrese 2000b).

K2 was abandoned in AD 1220 when people moved to the foot of a hill, Mapungubwe, about one kilometre away (Fouche 1937; van Riet Lowe 1955; Gardner 1963; Voigt 1981a, b, 1983; Huffman 1996, 2000; Meyer 1997, 1998). The population grew to approximately 5000 people and the importance of the site grew accordingly. It is estimated that it controlled an area of some 30 000 sq km (Huffman 2000). Trade intensified and gold was added to the exports. By now, social stratification was taking place and this site saw the origin of sacred leadership develop when the Chief and his family isolated themselves from the rest of the people by moving to the top of the hill (Huffman 2000).

The Shashe-Limpopo Valley itself has few mineralogical resources so any metal, whether gold, copper or iron, would have originated elsewhere although they could have been reworked locally. Ivory, which was another important trade item, indeed, probably the original trade item from Schroda times, would originally have been obtained locally but, as agriculture expanded and local elephants hunted out, would have been accessed elsewhere, perhaps Botswana. The same applies to hides and fur of other animals (Voigt 1981b, 1983). Trade and traders would therefore have passed through each of these capitals. They may even have settled there in their own compounds. Sourcing pottery might be the only way of measuring the direction and intensity of trade and other social exchange and interaction. To this end, potsherds from all three sites were analysed as well as specimens from a number of other smaller sites in the area. Figurine fragments from Schroda, probably used in ritual ceremonies, were also analysed.

4.4.2 Geological setting

All the sites mentioned here are located on Karoo Supergroup sediments (Bordy & Catuneanu 2001, 2002) associated with localised outcrops of dolerite. To the north, across the Limpopo River is a massive outcrop of Karoo basalts (Haughton 1969). The Karoo rocks are surrounded by the Limpopo Belt and other early formations consisting of Archaean granites, gneisses and other metamorphic rocks (Haughton 1969; Holzer et al. 1999). It is expected that clays developed on Karoo rocks will be quite different to those of the surrounding formations. In particular many of the latter are mineralised and are enriched in Cu, Cr, Ni and V among others.

4.4.3 Previous work and current aims

The only previous work was carried out on a smaller sample of sherds by Jacobson et al. (1995a). A number of outliers were identified but only five trace elements were used in the analysis. Since then, those samples as well as additional ones have been fully analysed.

Given the wide ranging trade networks mentioned above as well as the fact that the larger sites were capitals and were the location of courts, it is no surprise that stylistically non-local sherds were recovered (see below). As no clay sources are known, once again the question of local versus imported revolves around defining a geochemical reference group against which outliers can be compared.

Table 4.4.1. The Shashe-Limpopo River Valley. The sites, their phases, dates and the number of sherds analysed. Dates from Vogel (2000).

Site	Phase	Date AD	No of sherds	
Schroda	Zhizo	970-1025	30	
Schroda Figurines	Zhizo	970-1025	10	(figurine fragments)
Leokwe Hill	Zhizo	1160-1210	60	
Baobab	Zhizo	1020	22	
K2	K2	1030-1210	60	
Den Staat	K2	-	12	
Mapungubwe	Mapungubwe	1210-1280	66	
Edmondsburg	Mapungubwe	1240	6	
AD15	Mapungubwe	-	7	

Another topic relates to the production of pottery. The large populations inhabiting K2 and Mapungubwe raises the question as whether each family unit produced its own pottery or whether specialised potters made an appearance. The firing of ceramics requires a lot of fuel. As wood in the close vicinity of the towns might have been soon exhausted due to consumption as firewood and for building, it might have been necessary to travel a distance to accumulate enough for a firing. Under the circumstances, there is the possibility that potters living away from the main centre may have produced pottery specifically for sale or exchange in the town. The identification of such a practice may not be easy and will depend upon the variability of local clays and the ability to pin point these sources. A small number of sources could indicate fewer potters at work.

A further interesting point relates to the growth of population at each of these three centres but particularly Mapungubwe with its estimated 5000 people. Did this growth arise through natural increase or through immigration from outlying areas? As the capital of a trading state were there specific locations for the domicile of traders and other merchants? Can provenancing pottery assist in the answering of these questions? This will ultimately depend upon linking non-local styles, proven imports and other material objects to specific features or domestic units of the settlement.

4.4.4 The samples

Table 4.4.1 lists the sites and the number of sherds analysed. Both decorated and undecorated sherds were analysed. The identifications were made by the archaeologists who provided the sherds. Table 4.4.2 lists those with non-local decoration. Unfortunately, the specific feature from which the sherds were taken is unknown. They therefore qualify as type Q4 or Q5 sherds (Table 3.4). This does limit the interpretation of the results.

4.4.5 The statistical analysis

Apart from those sherds with incomplete data, the entire suite of sherds, 263 in all, from the sites listed above were analysed together. The full data set can be found in Tables A4.4.1 to A4.4.5 in the Appendix.

Table 4.4.2. Limpopo Valley. Sherds with non-local style.

EDMONDSBURG	
LM625	K2
LEOKWE HILL	
LM203	LK
LM229	K2
LM230	?Woolandale
LM231	K2
LM232	K2
LM236	Happy Rest
LM237	Happy Rest
LM244	K2
SCHRODA	
LM410	Late Matakoma
LM411	Atypical ?Klingbeil
LM412	Atypical ?Klingbeil
LM414	Atypical ?Klingbeil
LM415	Atypical
AD15	
LM630	Thin black sherd: ?shallow bowl *ex* Mapungubwe?
LM631	K2
BAOBAB	
LM601	Blouberg
LM602	Blouberg
LM603	K2
LM604	K2
LM605	K2
LM606	Klingbeil
K2	
LM136A	Toutswe
t17	Toutswe
t18	Toutswe
t255	Toutswe
t8	Toutswe
MAPUNGUBWE	
LM102	Eiland
LM103	Eiland
LM105	?Woolandale
mxj1	Eiland
mxj2	Eiland
hp3	?Khami

One sherd, hp1 from Mapungubwe, was analysed as a supplementary point as its very high loading on MgO, Ni and Cr makes it an obvious outlier whilst these high values would also compress the rest of the points and make their interpretation less obvious. Figure 4.4.1 is the first plot of all samples and illustrates the position of hp1. This plot also shows the dense clustering of the majority of the sherds together with a smaller number of outliers. Figure 4.4.2 omits hp1 and plots the sherds identified to their individual sites. The obvious outliers have been cordoned off. It can be plainly seen that there is no obvious clustering separating the sites on the large central cluster from each other. The samples overlap and the best explanation for this at present is that the whole cluster represents a geochemical reference group for those sites situated on the Karoo Supergroup rocks. It is therefore important to note here that in terms of this definition, until local clay sources on the Karoo rocks can be uniquely differentiated, “local” in terms of physical provenance will refer to this entire area, i.e., the approximately 65 km wide and up to

20 km deep area of Karoo sediments (Bordy & Catuneanu 2002: figure 2).

The outliers (listed in Table 4.4.3) are very different in composition as I shall further demonstrate. The small cluster to the lower right of the group is either an extension of the main cluster's variability or else a separate cluster of sherds made elsewhere. Figure 4.4.3 shows the distributional pattern of the elements on which the sherds load.

The trend marked in figure 4.4.2 shows a steadily increasing amount of the mafic elements MgO, Ni and Cr in the overall composition. This can either result from potters adding temper in varying amounts derived from the local dolerite or basalt or else it reflects naturally formed clay sources with varying amounts of these elements depending upon their locality. A thin section analysis might resolve this problem. The small cluster or sub-cluster at lower right loads heavily on felsic elements such as K_2O and Rb which are typical of granites and sedimentary rocks derived from them and could either represent some form of local variability or be imports.

I mentioned earlier that I would provide further evidence for showing the outliers to be different. Figure 4.4.4 is a plot of the same number of specimens including this time sherd hp1 but omitting the mafic elements MgO, Ni and Cr from the analysis. Note how, with the exception of the outliers, the large cluster seen in figure 4.4.2 collapses into a smaller more compact group. This proves the point about the mafic elements being a linear additive whether artificially or naturally. Refer to figure 2.1 for an illustration of such a linear trend. Note also the position of hp1. It does not disappear into the central cluster as the rest of its compostion is clearly different and it remains a true outlier. In any case, its very high Ni (633 ppm) and Cr (1429 ppm) values are far higher that those found in basalt or dolerite for the area.

There are still a small number of specimens surrounding the main cluster. These are either those sherds at the outer limits of variability or else outliers. I will now test this. Figure 4.4.5 is a plot of the first and third axes. Under normal circumstances I do not take into account an axis with a variability of less than 10% but this axis at 9.6% is close enough and can add to the interpretation. Whilst there is a fair amount of movement on the third axis a number of sherds not previously taken into account stand out. These I have arrowed and where applicable labelled them appropriately when their decoration (when known) is of a non-local style. Thus, of two arrowed Mapungubwe sherds which potentially appear to be non-local, one has been decorated in the Eiland style. See Table 4.4.3 for a complete list. I have also ringed cluster A which are four sherds loading high on K_2O and Rb (Table 4.4.3). Once again, I must invoke caution. More work needs to be done on local clay geochemistry before a definitive answer can be made.

I will now examine each site individually and plot the sherds in terms of the non-local decorative style where known (see Table 4.4.2) but note that not all analysed sherds were decorated. This will entail unpacking figure 4.4.2. It needs to be borne in mind that each site forms part of the large central cluster. The question arises: why not omit the mafic elements altogether? The answer is that this will result in a loss of detail: the different sub-clusters or trends that the sherd compositions display could reflect either the tempering practices of individual potters or group of potters or else the individual clay sources that were being exploited.

Schroda.

Figure 4.4.6 plots the Schroda sherds together with the figurine fragments. The apparent clusters, except perhaps for that on the extreme lower right, are probably part of a trend. Of note is that two of the non-local styles are definitely outliers whilst the rest are definitely local.

The figurines are also of interest. Hanisch and Maumela (2002) had originally classified the figurines into coarse and fine clay sizes but this difference is not supported by the data (Table 4.4.1). Although they were not fired and possibly not made to the same standards as a fired ceramic, nevertheless their composition does overlap with the sherds with two possible exceptions. Firstly, there is sample SF09 which can be seen in figure 4.4.2 to be an outlier. In a previous publication dealing with these figurines (Jacobson & van der Westhuizen 2002a), I had opted for a more conservative interpretation at that time having no geochemical data from the full suite of Limpopo Valley sherds and not performing a multivariate analysis. Now, I am prepared to accept its non-local status. The Ni and Cr values for this figurine are far higher than those for the local (Tuli) basalts that I have been able to find in the literature (see Table 4.4.4) whilst its V content is also enriched relative to basalts and other sherds from the central cluster. Adding basalt temper cannot enrich a local clay (assuming it to be similar to the majority of sherds analysed) to these levels as the basalt is not as enriched in these elements as the figurine. It is depleted in Cu relative to the basalt data which suggests it may have had a provenance beyond the area of Karoo Supergroup exposures. I have also suggested SF03 as a provisional non-local figurine. This fragment is enriched in CaO, Sr and TiO but once again more local geochemical data is needed to confirm this.

Leokwe Hill

Eight non-local styles were part of the suite of sherds analysed. Figure 4.4.7 shows that two definitive outliers are present on the first two axes of the plot of which one is in a non-local style, Happy Rest, whilst figure 4.4.5 shows a potential further two and a possible Happy Rest sherd as part of cluster A.

Baobab

There are six non-local styles in this group but all sherds appear to be of local clays (figure 4.4.8).

K2

There are five Toutswe style sherds in this group. Figure 4.4.9 is an interesting plot. Similar to a number of the previous sites, there appear to be well defined clusters which might be interpreted as local or non-local if the site had been analysed in isolation. In particular, the five Toutswe-style sherds might tempt one into labelling them as non-local. However, when the complete picture is seen as in figure 4.4.2, these sherds are simply part of the larger group. Only one potential non-local sherd was identified from axis 3.

Mapungubwe

This site has the highest number of geochemical non-local sherds: six identified from the first two axes (figure 4.4.10) and a further two when the third axis is taken into account. Of these, three have non-local styles: hp3, the Khami sherd is the most obvious example with its enriched Ni and Cr values. Two of the Eiland sherds are also included. A third Eiland sherd is one of the two identified from axis three as a potential import.

Table 4.4.3. Limpopo valley. Potential imports recognised on the basis of geochemistry.

a. Potential non-local sherds identified from axes 1 and 2.

LEOKWE HILL
LM233
LM237: Happy Rest

SCHRODA
LM410: Late Matakoma
LM415: Atypical
SF09

MAPUNGUBWE
H419
H420
hp3: Khami
hp1
LM103: Eiland
mxj1: Eiland

DEN STAAT
SH152

b. Potential non-local sherds identified from axes 1 and 3.

EDMONDSBURG
LM625: K2

LEOKWE HILL
LM204
LM241

SCHRODA
LM408
SF03

K2
LM127

MAPUNGUBWE
m206
mxj2: Eiland

c. Potential non-local sherds identified from sub-cluster A (figure 4.4.5).

DEN STAAT
SH159

SCHRODA
LM423
LM406

LEOKWE HILL
LM236: Happy Rest

Den Staat

No stylistically non-local sherds were analysed. Only one sherd is plotted as an outlier in figure 4.4.2.

Toutswe and Break Pressure Tank

I now turn to comparisons with sites outside of the Shashe-Limpopo Valley. Two Botswana sites overlapping in age with K2 and Mapungubwe are Toutswe (Denbow 1982, 1984, 1986, 1999) and Break Pressure Tank (Reid & Segobye 2000). Toutswe is located 200 km to the west of

Table 4.4.4. Chemical data for Zimbabwe basalt from Duncan et al. (1984).

	Bas 28	Bas 29
SiO_2	49.97	51.79
TiO_2	2.94	3.01
Al_2O_3	14.84	12.77
Fe_2O_3	14.06	13.47
MnO	0.15	0.17
MgO	4.63	6.05
CaO	9.20	9.11
Na_2O	2.76	2.34
K_2O	1.45	1.29
TOTAL	100.00	100.00
Rb	104	27
Sr	721	711
Y	36	38
Zr	321	343
Nb	34	17
Cu	205	149
Ni	75	112
Zn	107	107
V	279	257
Cr	98	199
Co	49	55

bas28	SRBF, Tuli
bas29	Basalt, Zimbabwe

Mapungubwe/K2, had its own distinctive pottery style (Toutswe), and, as the largest site of this phase, was a local capital. Break Pressure Tank (BPT) is a small commoner site located 29 km the east of Toutswe and is dated to between AD 1025 and 1115 and is likely to have been a small impermanent site devoted to herding (Reid 1996).

Figures 4.4.12 and 4.4.13 illustrate the first three axes of the analysis. All the Limpopo Valley sherds were used. Note that seven of the Toutswe sherds are quite distinct from the Limpopo Valley group, show a fair degree of variability forming four clusters although the small sample size invites caution. The eighth specimen is situated on the edge of the outermost Limpopo Valley sherds and this could indicate a similar type clay albeit from anywhere.

The BPT sherds are more interesting. The sherds split up into five clusters, six if the third axis is included. Even allowing for single sherds in a “cluster” their compositions are quite divergent. Either the location of the site was close to a variety of compositionally very different clay sources or else the impermanent nature of the site, probably with repeated occupations, resulted in pottery arriving from a variety of destinations.

Note the two outliers at the extreme left of the plot. Both of these were plotted as supplementary points. The lower is Mapungubwe hp1 whilst the upper is a BPT sherd with a Toutswe style decoration. A second sherd is closely linked to a Toutswe sherd on both plots (i.e., axes 1/2 and 1/3). Two sherds form a group in the upper left whilst three sherds overlap with the Limpopo Valley sherds, one at the outer edge and two embedded within. On the third axis one of the latter two disassociates itself and moves away. The one that is left remains embedded and obviously has a similar composition.

Figure 4.4.14 unpacks the stylistic details of the BPT sherds plotted against only K2 and Mapungubwe sherds for clarity. The extreme outliers have also been omitted. Note that the embedded sherd has a Mapungubwe style. Once again, a note of caution: this does not mean that it comes from Mapungubwe itself. Table A4.3.4 lists the data for a series of daga and other sediments from BPT. Note that there is no real correspondence between these and the data for the pottery. It must be acknowledged that it is problematic to compare sediments with a ceramic as grain size does influence chemical composition (Zhang et al. 2002) as well as the potential effects on a pot of temper, use and diagenesis. Nevertheless, if these sediments are typical of the local area, these pots might all have been brought in from elsewhere particularly if it was a temporary herding camp. As Reid (1996) found little in the way of structures, it may very well have been a male only camp and pot making may not have been carried out there.

4.4.6 Conclusions

The Limpopo Valley is a major location for the study of economic ties of the southern African interior with the Indian Ocean trade. Sourcing everyday utilitarian pottery can also play a part in defining interior links either resulting from economic ties or social and political relationships. The presence of non-local wares defined either stylistically or by provenancing on any of the sites above needs to be properly interpreted. Obviously no community lives in isolation. Social, political, economic and legal relationships between communities exist at various levels. The presence, however, of sherds from quite different traditions such as Eiland at Mapungubwe must mean that major ethnic interaction was taking place across linguistic boundaries.

The work above has produced definite evidence for the presence of non-local pottery as well as the local manufacture of vessels with non-local styles. More work is needed to define clay sources in the valley itself in order to assess whether these sources can be uniquely defined thus allowing observations on the production of pottery to be made as well as more locally based inter-site relationships. This, however can be a mammoth undertaking as would be the necessary characterisation of clays from further afield.

Of interest is the identification of one and possibly two Schroda figurines that are not local. This could result from initiation or other rituals being held at the capital and drawing people in from surrounding areas. Alternatively, Wood (2002) reports comments by a traditional Lemba doctor who describes how a married woman will take her clay doll or figurine, received during her initiation, with her to her husband’s home. Further work on the figurines will definitely be of interest particularly when they can be linked to specific features on the site.

A further need is the analysis of more decorated pottery associated with specific features on a site. Are imported vessels being found in public or private spaces, in commoner or the chief’s domestic unit? These questions cannot be answered as yet. Larger samples are also needed. A site such as Mapungubwe produced tons of pottery. It makes more statistical sense to analyse a small carefully chosen and provenanced sample from a restricted area than a grab sample from the whole site which is what has been done here.

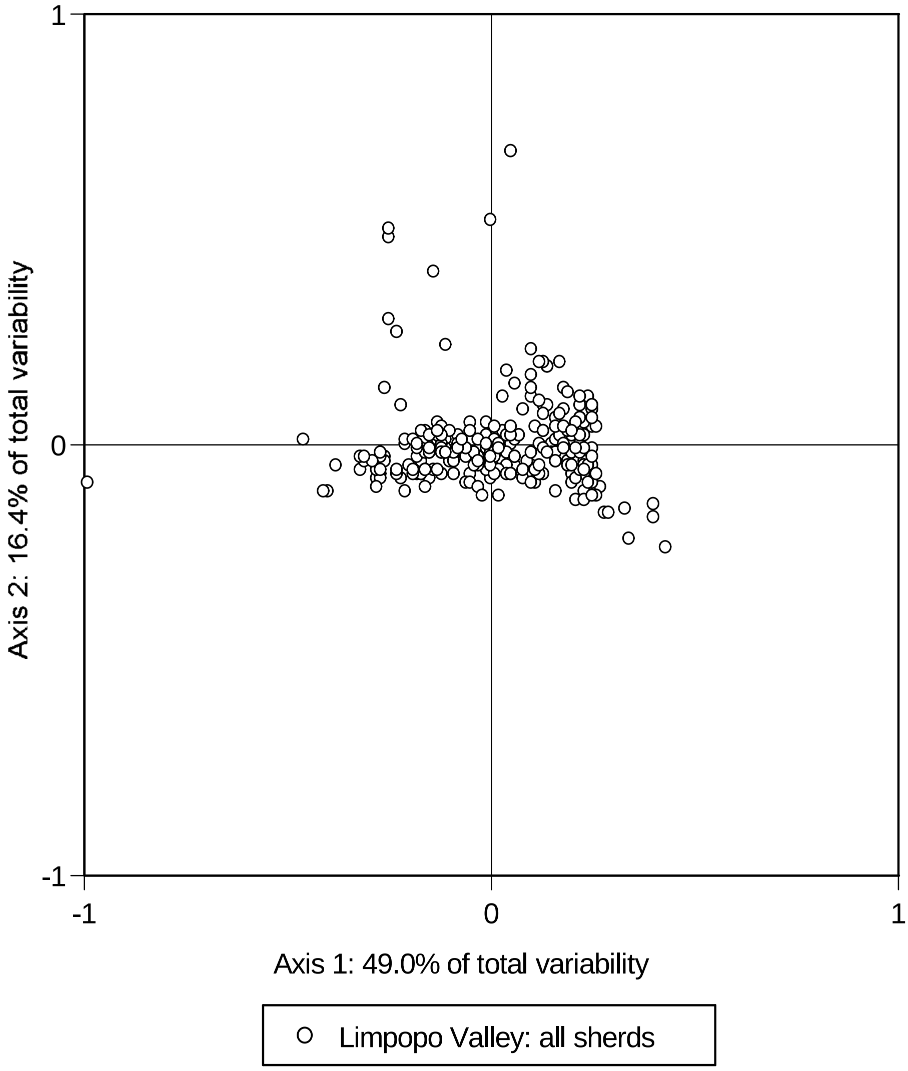


Figure 4.4.1. CA plot of the first two axes of the entire data set of sherds from the Limpopo Valley sites. Note the extreme outlier to the left of the plot.

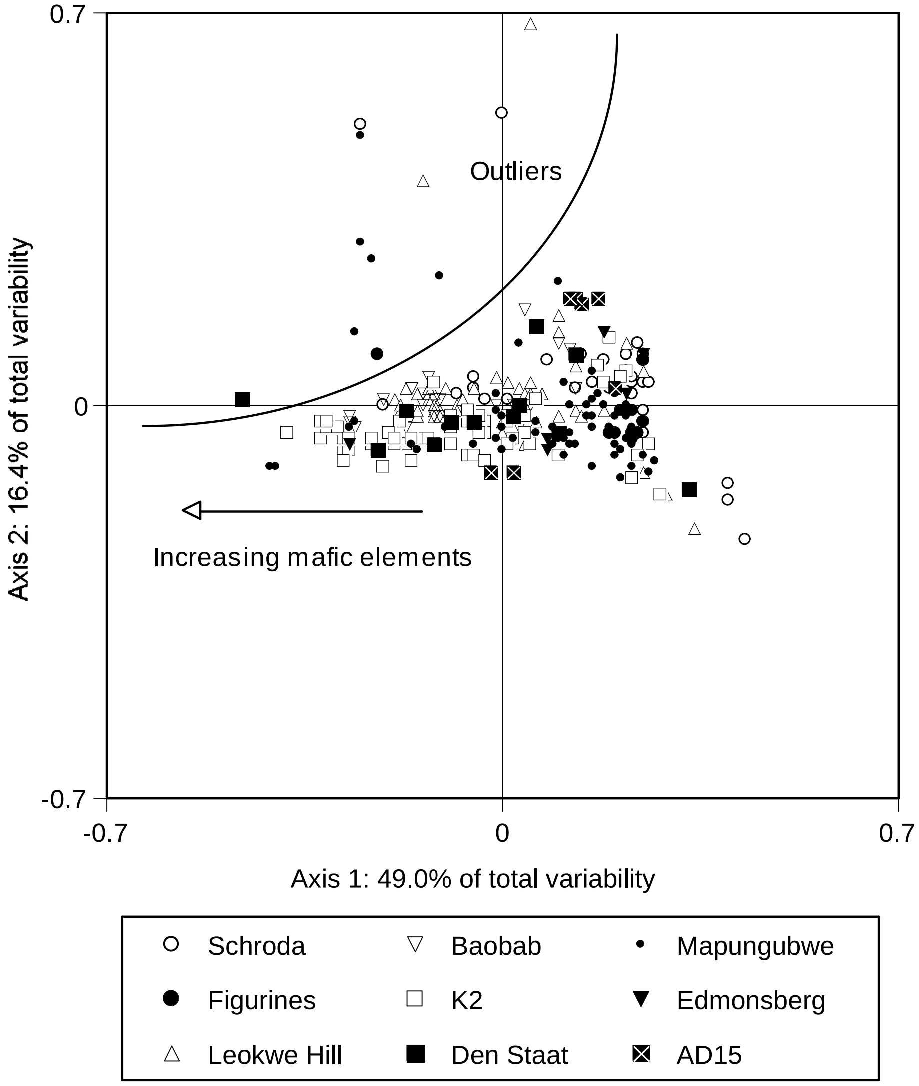


Figure 4.4.2. Plot of the first two axes of the data set omitting the extreme outlier. The sherds are plotted according to their site. Outliers are indicated. The arrow points in the direction of the increase in mafic elements. This linear trend, which is more pronounced when individual sites are plotted singly, is similar to the trend seen in the temper experiment.

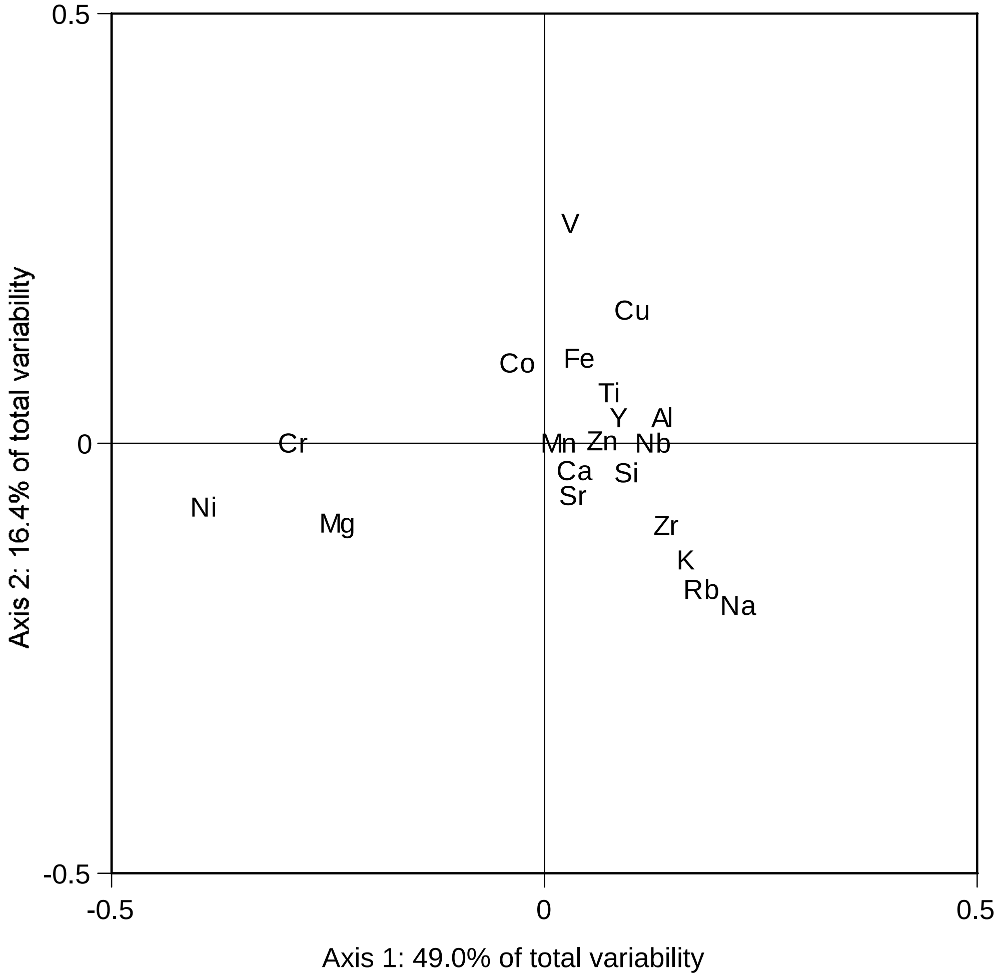


Figure 4.4.3. Plot of the elements to illustrate how the sherds in the previous plot load. The strong mafic trend to the left can be seen.

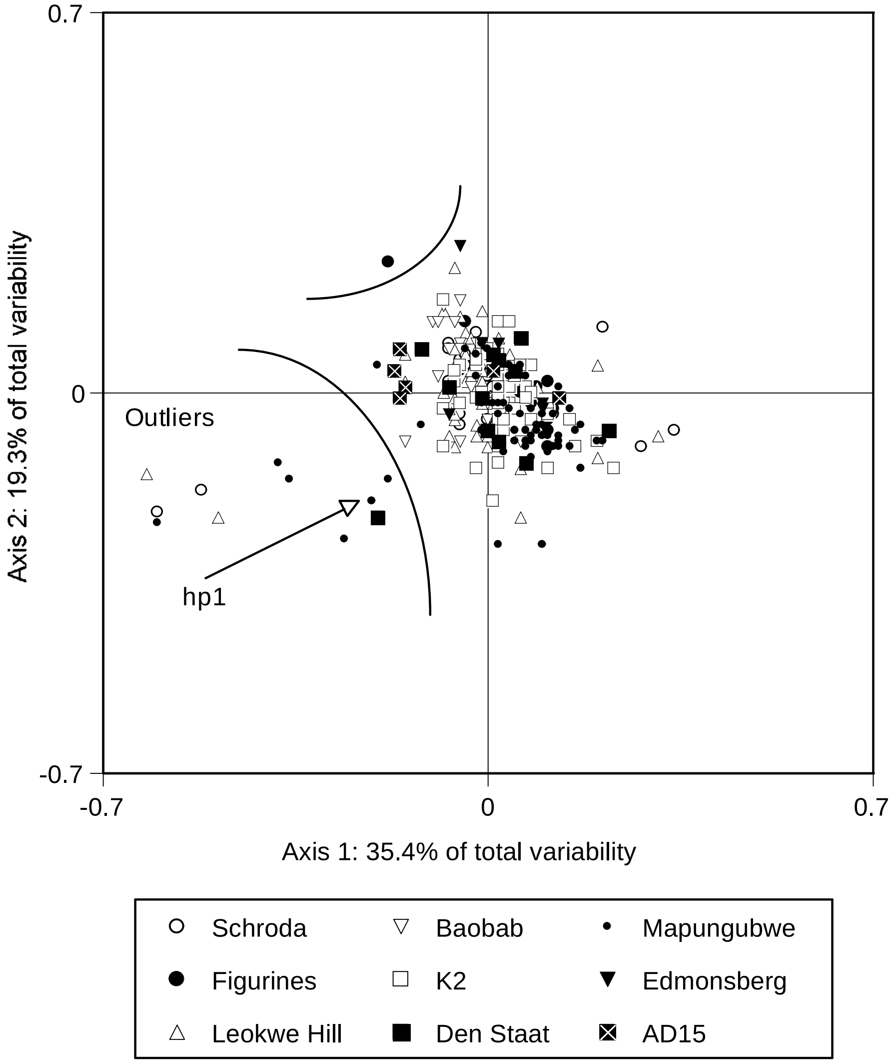


Figure 4.4.4. Plot of the first two axes of the analysis omitting the mafic elements MgO, Ni and Cr. The same outliers are demarcated as in the previous plot. Note the position of hp1. Whereas all the other sherds on the mafic trend collapsed into a single cluster, hp1 remained out thus proving that its overall composition was different.

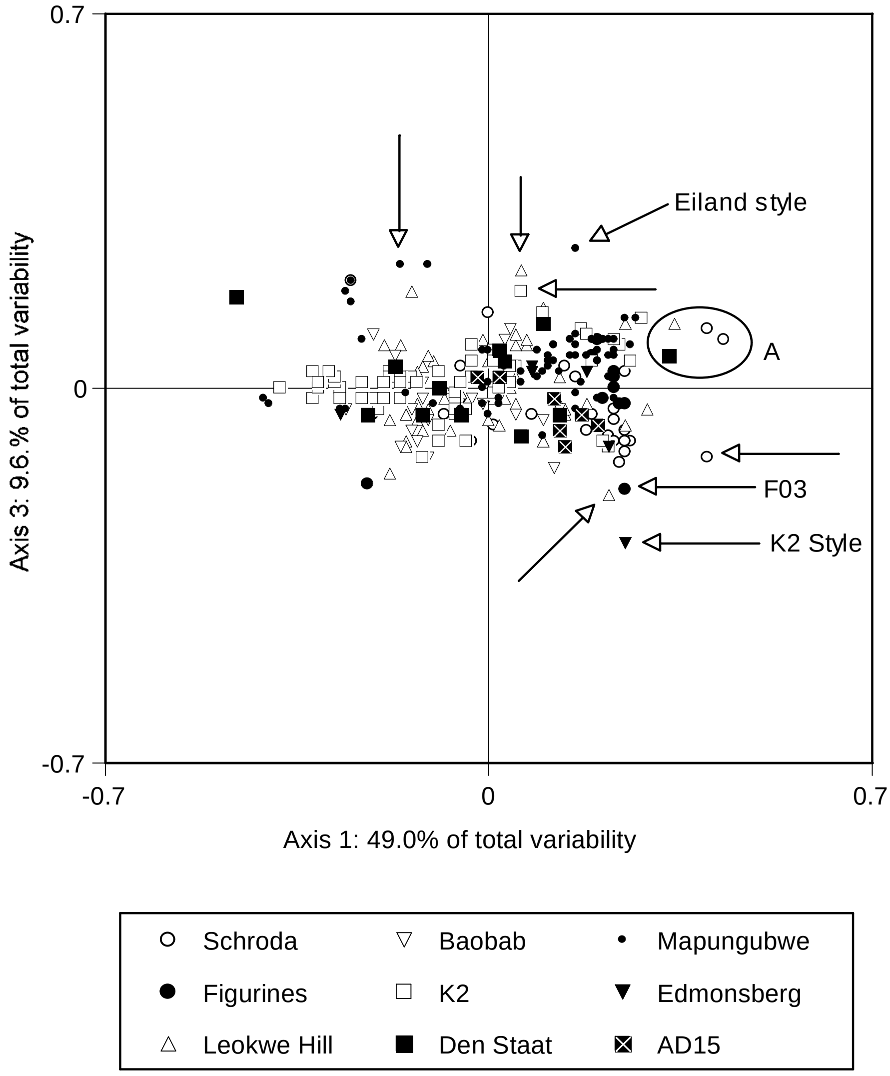


Figure 4.4.5. Plot of the first and third axes (using all elements) showing the exposure of additional potential outliers. These are identified by the arrows and their style if non-local.

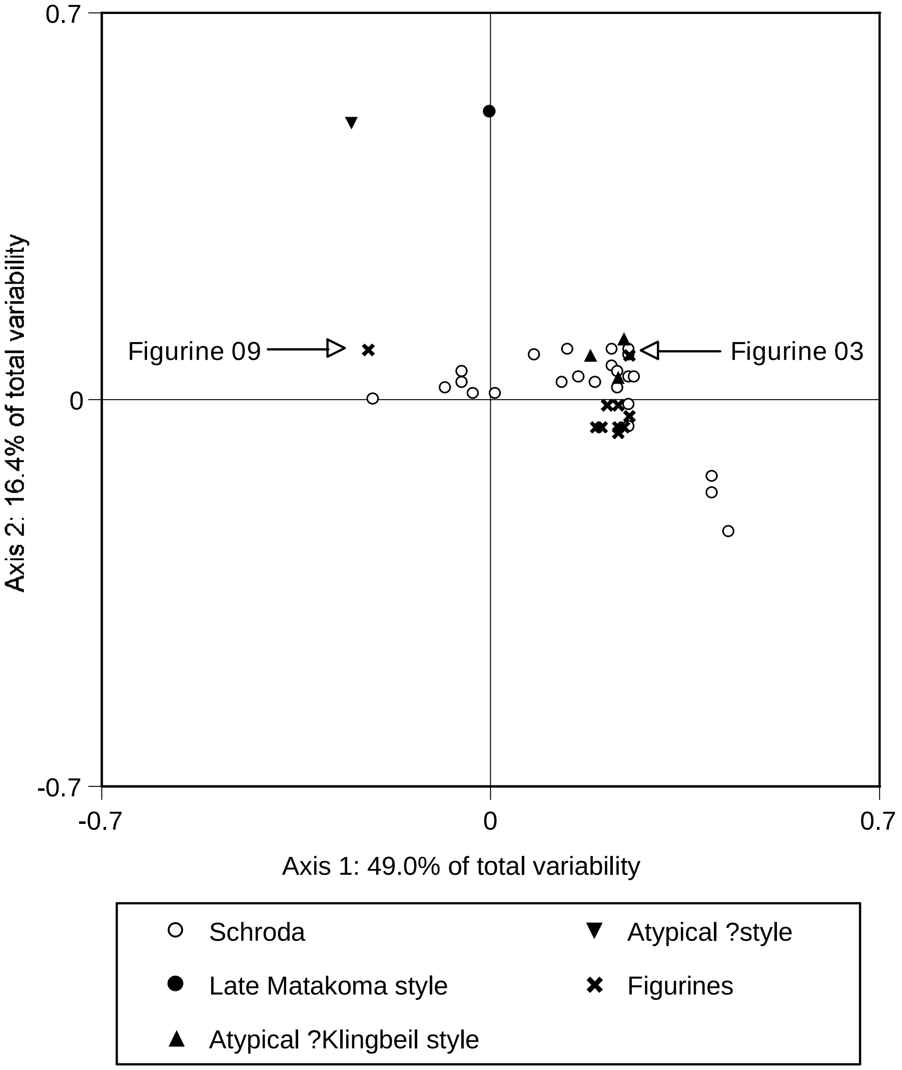


Figure 4.4.6. Plot of the first two axes for the Schroda sherds and figurines. Non-local styles are identified where known as are the two figurine outliers. Figurine 03 is only apparent as an outlier from axis three as shown in the previous figure.

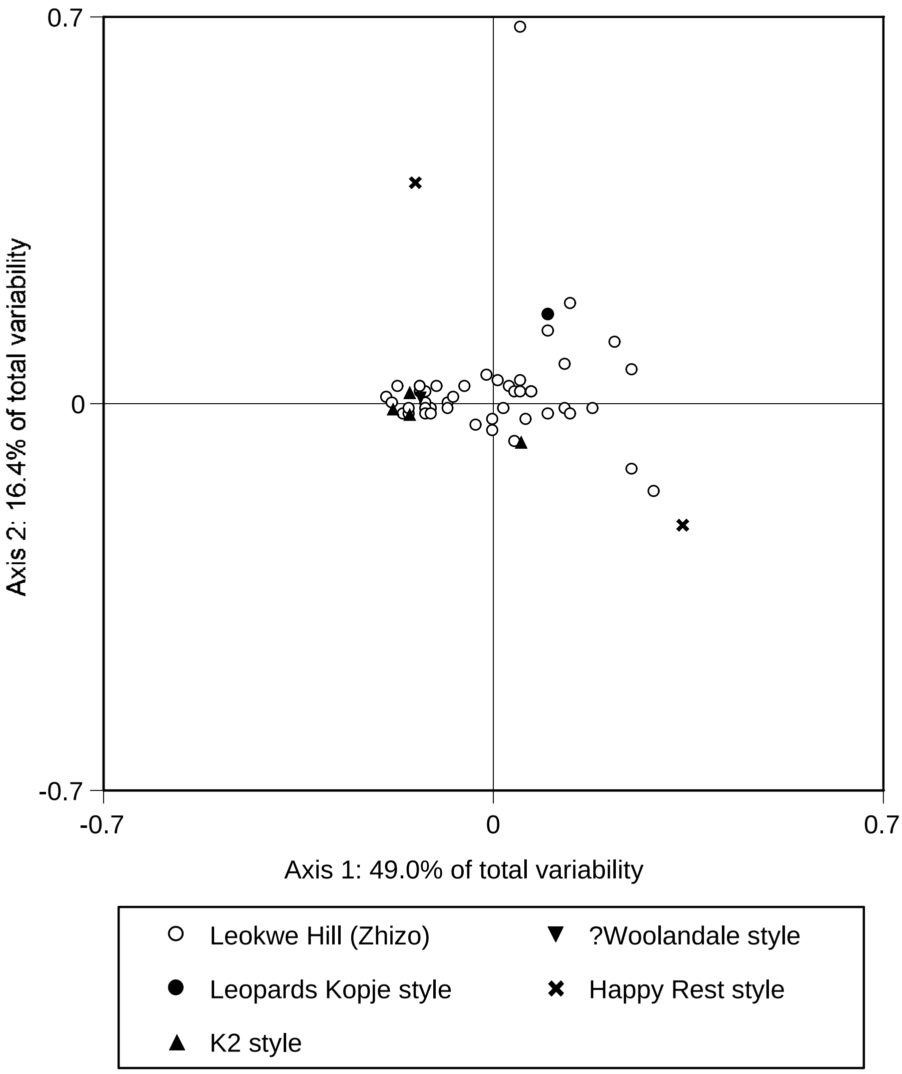


Figure 4.4.7. Plot of the first two axes for the Leokwe Hill sherds. Non-local styles are identified where known.

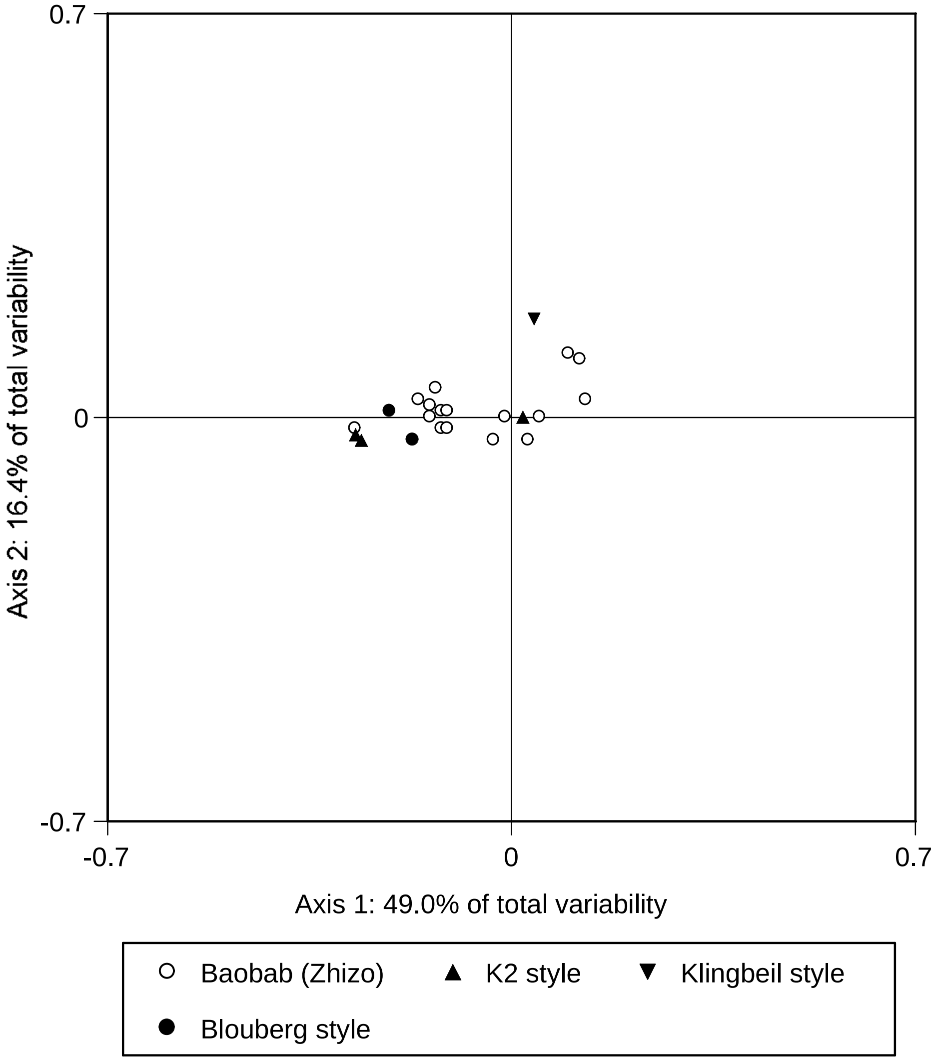


Figure 4.4.8. Plot of the first two axes for the Baobab sherds. Non-local styles are identified where known.

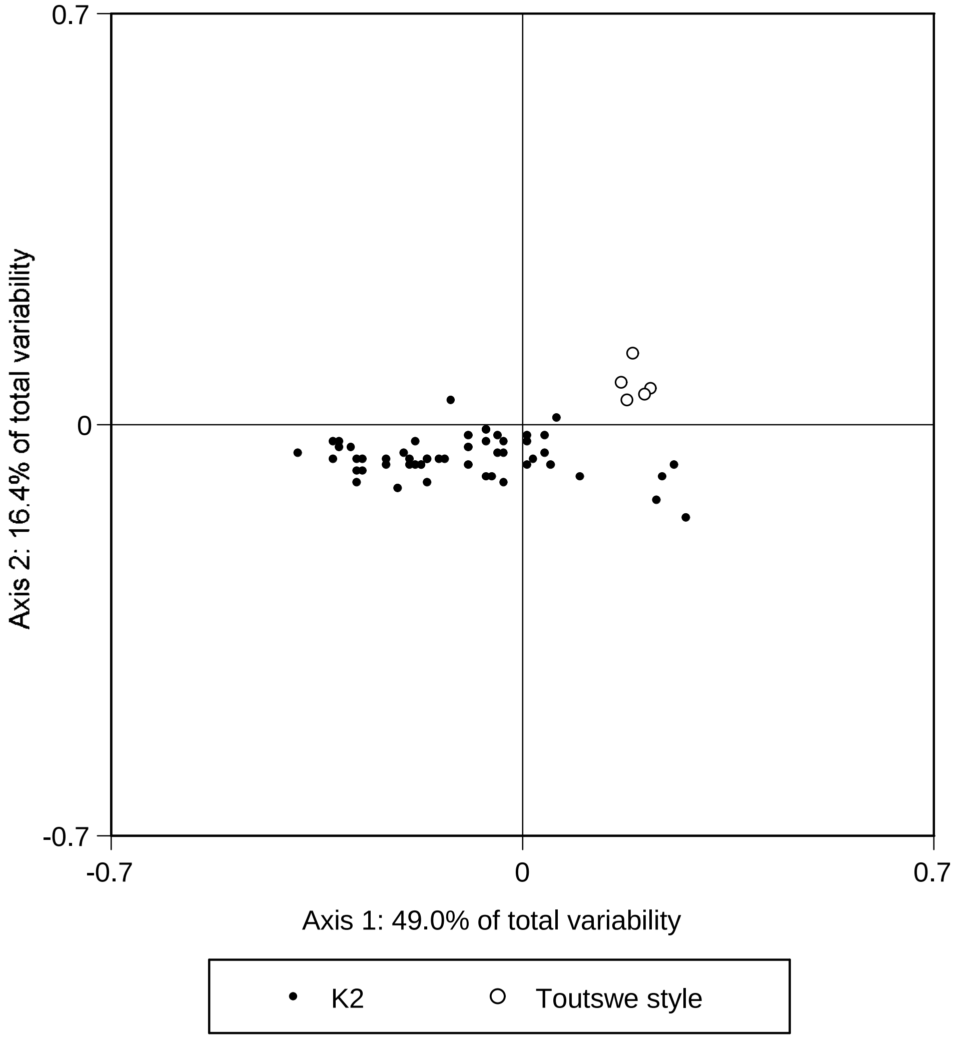


Figure 4.4.9. Plot of the first two axes for the K2 sherds. Non-local styles are identified where known.

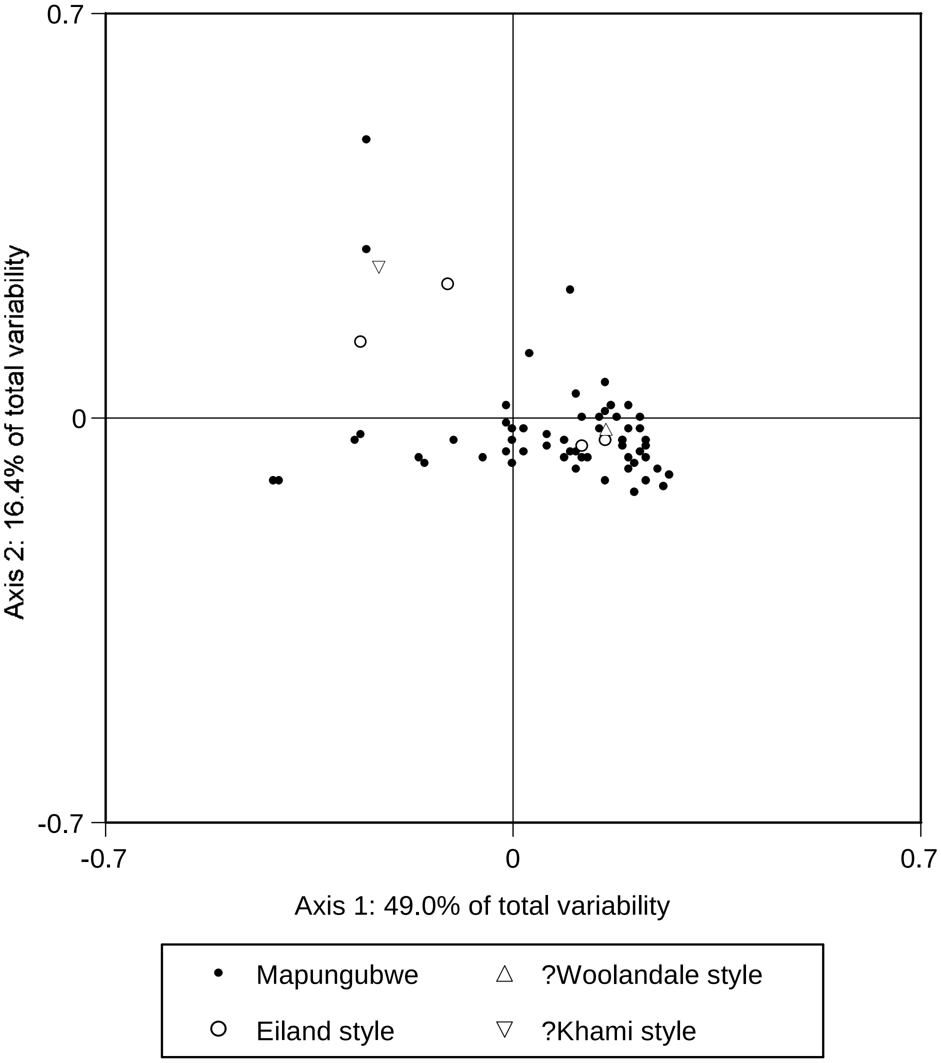


Figure 4.4.10. Plot of the first two axes for the Mapungubwe sherds. Non-local styles are identified where known.

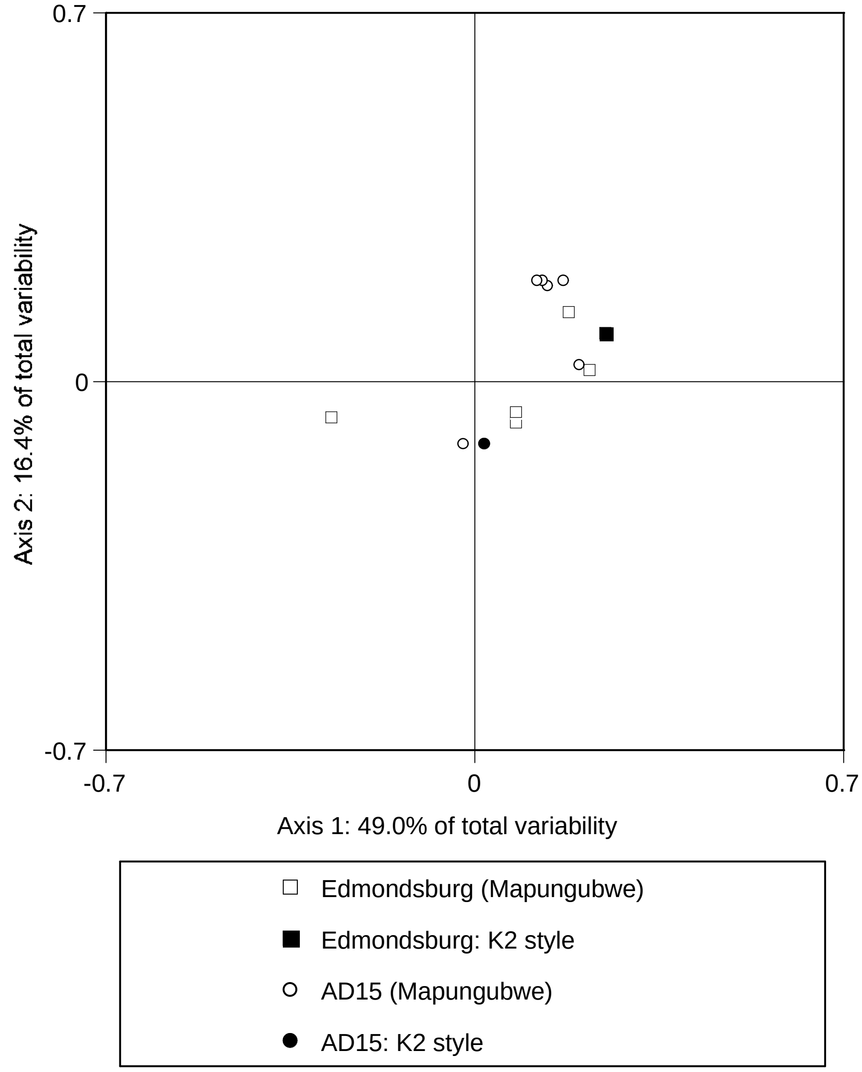


Figure 4.4.11. Plot of the first two axes for the Edmondsburg and Site AD15 sherds. Non-local styles are identified where known.

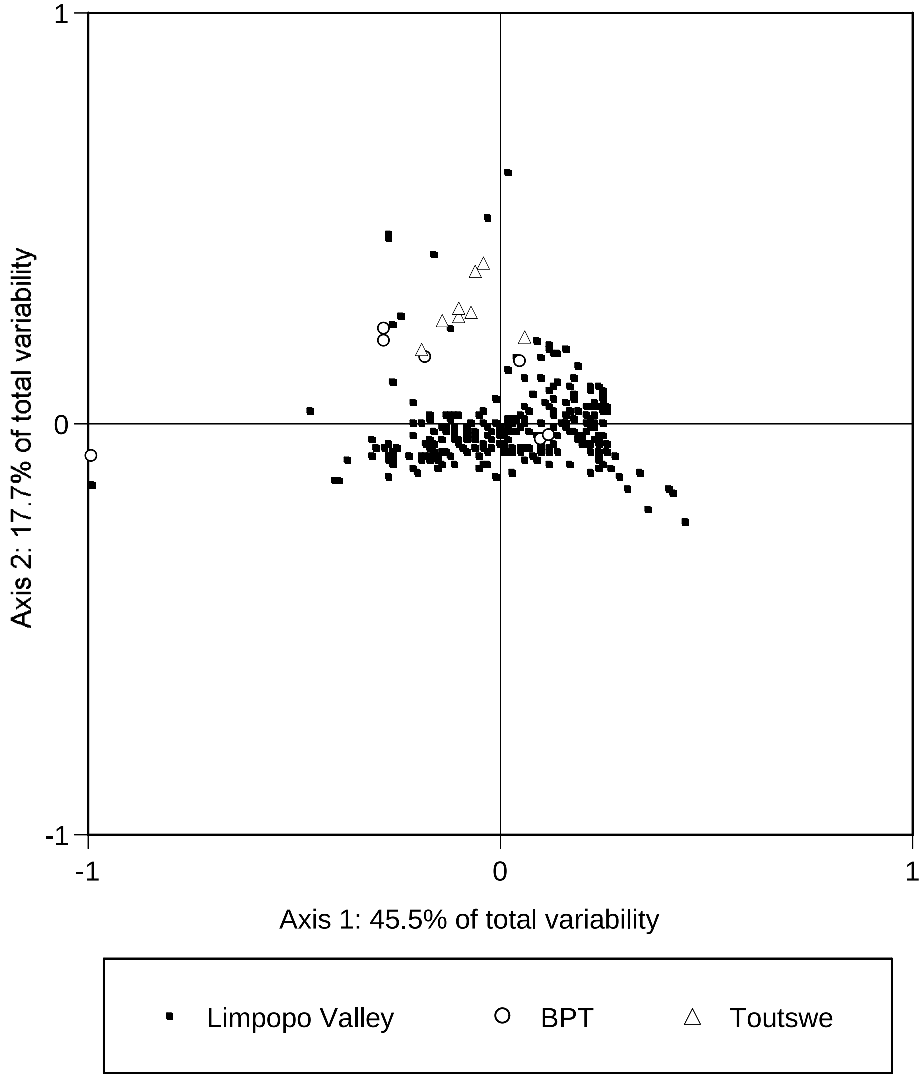


Figure 4.4.12. Plot of the first two axes for the combined Limpopo Valley, Break Pressure Tank (BPT) and Toutswe sherds.

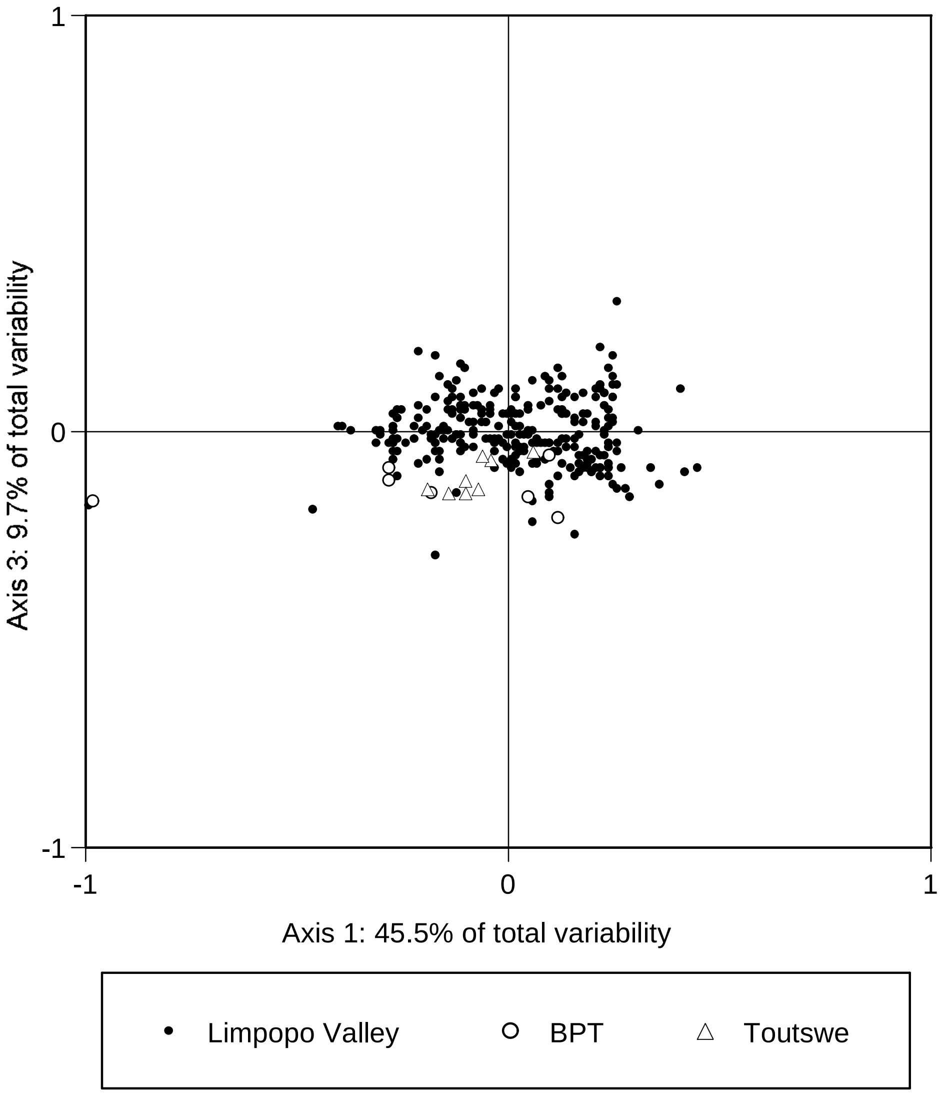


Figure 4.4.13. Plot of the first and third axes for the combined Limpopo Valley, Break Pressure Tank (BPT) and Toutswe sherds.

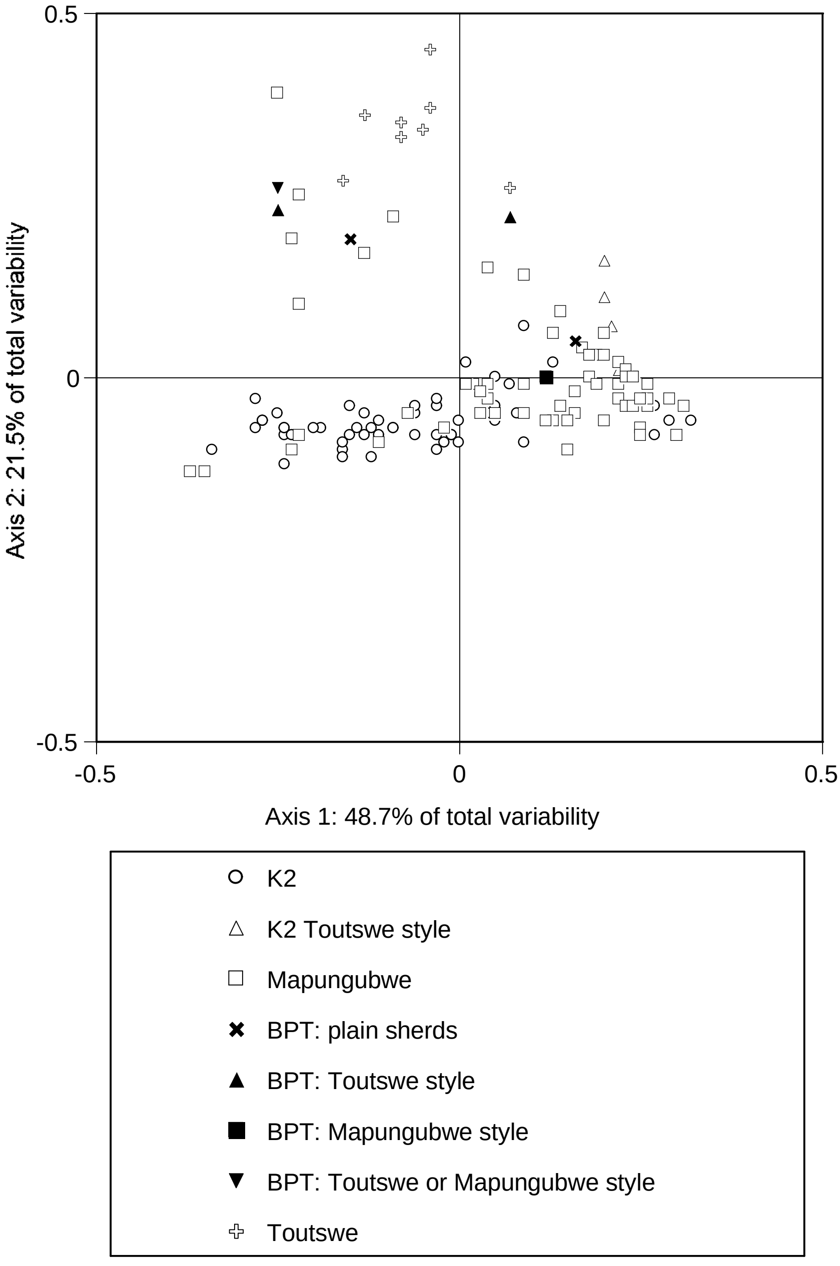


Figure 4.4.14. Plot of the first two axes for the K2, Mapungubwe, Break Pressure Tank (BPT) and Toutswe sherds. K2 and BPT are plotted against their styles.

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4.5 THE SOUTPANSBERG AND RELATED SITES

4.5.1 Archaeological background

Mutokolwe A and B are level 4 Khami period dry-stone walled ruins (Fish 2001) in the Soutpansberg, a 180 km long series of east-west oriented mountain range (Fig. 4.5.1). This region is inhabited by Venda speakers and is wedged between the Shona linguistic cluster in present-day Zimbabwe and the predominantly Sotho-speaking area to the south. The political and social history of the Venda people is complex and can only be understood by studying the archaeology of pre-Venda sites such as these. Basically, both language and culture is the result of interaction between Shona and Sotho communities and which is documented in the evolution of pottery styles from the region (Loubser 1991). The detailed excavations by Fish (Fish 2001) and the quality of its data merits a more detailed discussion of its archaeological background. The sites are close to each other and must have been occupied one after the other but which came first is not known at present.

Khami

For decades archaeologists and ethnographers noticed the similarity between coursed-wall ruins in northern South Africa and Great Zimbabwe (Fouche 1937; De Vaal 1943; Stayt 1968). They also suggested affinities between Venda pottery and adjacent Shona and Sotho pottery styles (Schofield 1937), but, as independent dates were not then available, these similarities were mostly ignored (Loubser 1991). Since the 1950's much work has been undertaken at Zimbabwe Culture sites, and the advent of radiocarbon dating has made possible the establishment of a detailed chronology. Great Zimbabwe which had its fluorescence between about AD 1290 and 1450 was the capital of an empire that encompassed most of present-day Zimbabwe as well as parts of Botswana, northern South Africa and Mozambique. Numerous smaller regional centres were built within the empire. Even if these centres were not all part of the same empire, they were at least all part of the same culture area (Huffman 1996). Its economy was largely based on trade (Summers 1969).

By about AD 1450 Great Zimbabwe had ceased to function as a capital for a variety of reasons including over-utilization of natural resources, diminishing trade, as well as internecine strife. By the time the Portuguese established trading stations on the coast in the sixteenth century, it had been abandoned for about fifty years, and there were at least two rival kingdoms: the Mutapa dynasty (also known as the Monomotapa, or Mwene Mutapa) in the northeast and the Torwa dynasty in the southwest (Beach 1980; Huffman 1986b, c). The archaeological site of Khami, some 20 km west of Bulawayo in present-day Zimbabwe, can be identified with some certainty as the Torwa capital (Beach 1980). Subsequently this kingdom had an influence on developments in southern Africa due to the southern migration of chiefs in their search for new sources of ivory, gold and copper for their trading activities.

Construction at Khami began some time after AD 1410 and it was abandoned at about AD 1640 (Beach 1980). Khami settlements and its influence extended across eastern Botswana, Zimbabwe and northern South Africa (Huffman 1986a; van Waarden 1989). Long-distance trade, as practised at Great Zimbabwe, continued at Khami. The Khami period in Zimbabwe was strife-filled, with many civil wars and migrations (Beach 1980), some of which ended in, or just north of the area now inhabited by the Venda (Loubser 1991). Thus, some of the Zimbabwe Culture ruins in present-day Venda date to this time.

Moloko

Pre-Venda Late Iron Age activity is also found south of the Soutpansberg and is assocaited with Sotho speaking people who contributed to the beginnings of Venda ethnicity. This period began with the appearance of Moloko ceramics at the beginning of the fourteenth century. Moloko ceramics were made on the southern highveld until historic times among various Sotho-Tswana groups (Maggs 1976; Evers 1984; Mason 1986), and one of its most recent expressions can be seen in Pedi ceramics (Collett 1982). There is thus little doubt that Sotho-Tswana people made Moloko assemblages and lived in Moloko settlements.

Fourteenth century Moloko assemblages, belonging to the Icon facies (Huffman 2000), have been excavated at a number of sites north and south of the Soutpansberg (Hanisch 1979; Loubser 1991; Fish 1999). Moloko assemblages are generally associated with Central Cattle Pattern settlements. The focus of all Sotho-Tswana settlements was a central cattle byre, or series of byres, and an associated court. This was an area dominated by males, where decisions were made on bridewealth and other significant matters. Important people - usually males - were also buried here. An outer arc of huts and grain bins was associated with women (Evers 1984; Huffman 1986a, b, c; Loubser 1991).

Interaction and Venda origins

Khami and Moloko pots have been excavated from the same contexts in some Soutpansberg sites (Fish 2001; Loubser 1991). The different traditions, however, were not uniformly represented. Moloko vessels were more common at Central Cattle Pattern settlements on both sides of the Soutpansberg, whilst Khami ceramics were predominant at the latest elite Zimbabwe Pattern settlements in and north of the Soutpansberg. This reflects interaction between Sotho speakers and Shona speakers.

This interaction led to the appearance of a ceramic style that Loubser (1991) called "Tavhatshena", characterized by Khami (single bands of either chevrons or herringbone) and Moloko (parallel bands) motifs on the same vessel. This ceramic style is unique to the Soutpansberg and was in existence by the late AD 1400's and early 1500's. By AD 1600 it had evolved into the Letaba ceramic facies, which Venda-speakers still make today. Loubser (1991) argues that this probably also reflects the emergence of a new language, and these two factors signal the creation of Venda ethnicity.

Mutokolwe, then, is a Khami site that would have been involved in trade relations with the north and south. Although most of the ceramics at the site are Khami, there were also Moloko and Tavhatshena examples. In addition, Fish's excavations (Fish 2001) recorded specific features and structures on the site as well as their associated artefacts such as pottery. By knowing the typical layout of a site, these could be interpreted according to their functions.

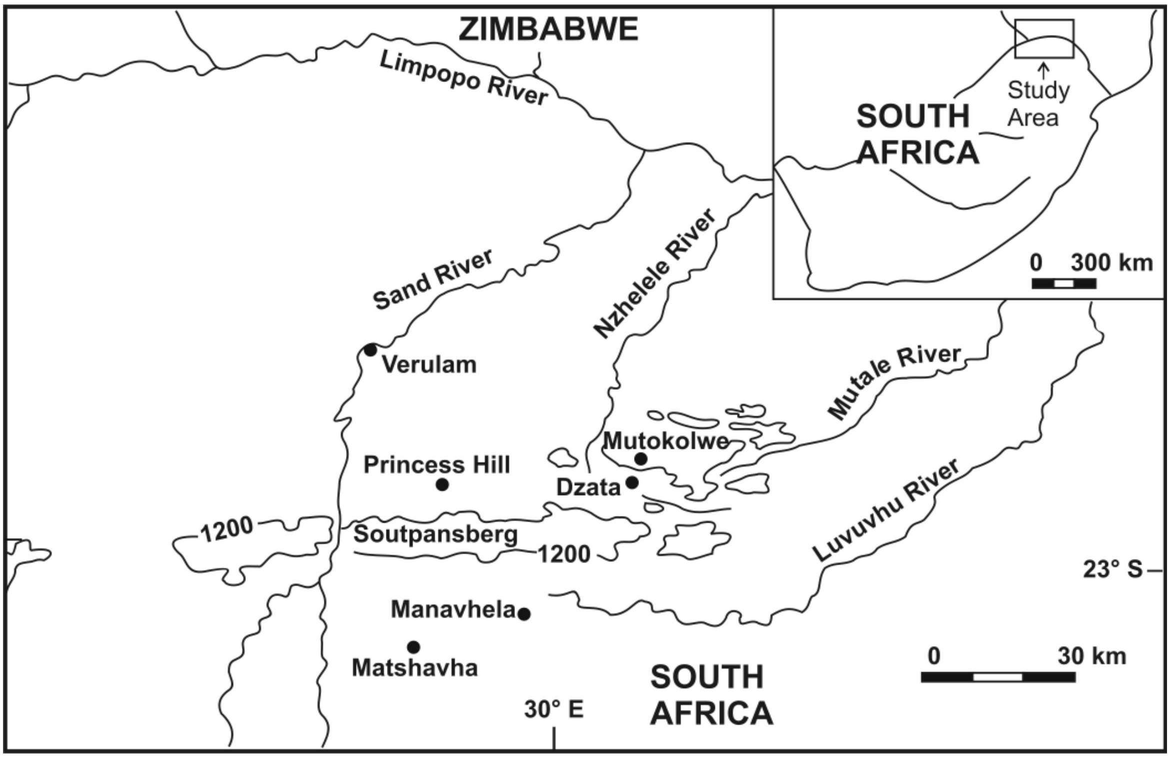

Figure 4.5.1. Map of Soutpansberg sites.

4.5.2 Geological setting

The Soutpansberg forms three roughly parallel mountain ranges running some 180 km from east to west. The southern mountains where Mutokolwe is located consists mainly of basalts of the Sibasa Formation with predominantly sediment formations to the north. This is known as the Soutpansberg Group. Approximately 30-35 km to the north is an east-west trending zone of Karoo sediments similarly followed by Karoo volcanics. A variety of rocks surround these formations to the north including Archaean granite-gneiss and amphibolites. To the south of the mountain is an undifferentiated mass of gneissic material with a granitic composition. This also contain rafts of mafic gneiss and amphibolite (Wilson 1989; Jacobson et al. 1991). Of specific interest, however, is the results of a geochemical soil sampling survey of Venda. Although only economically important elements were analysed, a number of these provide enough information to assist in the evaluation of the ceramic data (Wilson 1989). These elements include Cu, Cr, Nb and Zr.

One problem relating to the geology of the area concerns the east-west strike of the Soutpansberg and Karoo Formations. This results in the geochemical discontinuities between the different formations close to Mutokolwe following a north-south direction. This has implications for provenancing in that clays following the strike either to the east or west of the same formations could likely to be similar to each other.

Of the other sites, Matshavha is associated with granite terrain, Manavhela with amphibolite, Princess Hill and Verulam with sandstone and Dzata with gneisses. These diverse backgrounds should serve to differentiate them from Mutokolwe.

4.5.3 Previous work and current aims

A previous project on Soutpansberg ceramics (using PIXE) had established that a small number of vessels had moved from south of the mountain to the north but, more significantly, three vessels found in the north of northern style (Khami, Mapungubwe) were in fact made in the south (Jacobson et al. 1991; Peisach et al. 1991b). In addition, two specimens found and made in the south imitated northern wares (Jacobson et al. 1991: Table 3). These results not only suggest that women carried their stylistic templates with them to the north, the most preferred direction of marriage alliances (Van Warmelo & Phophi 1967), but that the south emulated northern pottery styles either as a matter of prestige or by virtue of their political links. These models are summarized in Peisach et al. (1991: Table 2). Parts of this work were published previously (Jacobson et al. 2002d).

The basic research question posed was to determine which sherds were local and which were imported. The chemistry of any imported sherds would also provide evidence of the direction from which the sherds may have travelled and whether they may have followed other trade networks. For example, metals would have moved northwards from the Soutpansberg. Some metals such as copper may also have originated some 300 km to the south east and passed through the area on their way northwards. Cotton was most likely imported from the north as were glass beads (Loubser 1991).

As single Tavhatshena and Moloko sherds were also available for analysis, their chemical relationship to the Khami sherds was also important. As this was a Khami site, evidence that the Moloko sherd was locally made would reinforce ethnographic and historical research that Sotho women married into the Khami ruling class but continued making their own pottery at their new residence.

Finally, a number of sherds were provenanced to specific activity areas at Mutokolwe B. The question of interest here is whether there was any spatial pattern to the distribution of recognizable non-local wares.

4.5.4 The samples

Twenty seven potsherds and six spindle whorls from Mutokolwe B were analysed. In addition, one duplicate spindle whorl and five duplicate potsherd samples were also analyzed to control for compositional variability. These were fragments of larger pieces and were chosen from a number of activity areas. Five sherds from Mutokolwe A were also analysed (Table A4.5.1).

In addition, data from a further thirty four sherds (Tables A4.5.2 and A4.5.3) from five other sites were used in the statistical analysis in order to put Mutokolwe into a more regional geochemical context. These are Matshavha, Manavhela, Dzata, Princess Hill and Verulam (Loubser 1991). The location of these sites, some of them of different ages and representing different ceramic phases, are shown in figure 4.5.1. Their interest resides, for the purpose of this thesis, solely in their comparative chemical profiles and no detailed interpretation of their results will be undertaken here. Princess Hill and Verulam, both Mapungubwe sites, will also be compared to the data from the Limpopo Valley in view of their stylistic relationship.

The quality rating of the Mutokolwe sherds is high, Q6-7 whilst the other sherds is Q4-5.

4.5.5 Results

One sample, FW55, from Mutokolwe was omitted from the analysis. This was a spindle whorl that was highly enriched in CaO, some 9.13% (when normalised to 100% with volatiles removed). Consequently, this sample would show up as an extreme outlier in the CA plot. This enrichment makes geochemical sense if the whorl originated in the vicinity of calc-silicates well to the north (Jacobson et al. 1991).

Figure 4.5.2 shows the first two axes of the correspondence analysis whist figure 4.5.3 shows the influence of the third axis. For the first two axes, the major compositional trend influencing the clustering of the sherds is the mafic elements pulling to the left, Cu to the top of the plot and K_2O and Rb, the felsic elements typical of granites, towards the bottom right. Figure 4.5.4 illustrates this clearly.

Mutokolwe samples cluster in three groups with a number of individual outliers. These clusters are quite distinct from the other samples. The Princess Hill sherds cluster together with the three specimens from Verulam in the centre of the plot with the exception of two outliers one of which (pm115) overlaps with the Mutokolwe sherds. This sherd is differentiated from other Princess Hill sherds by its enriched Cu. The second sherd (pm167) is characterised by depleted MgO but more especially CaO. Whereas all the other sherds measure above 2% CaO, this one has a content of only 0.53%. When the third axis is considered (figure 4.5.3), the Princess Hill group separates out with the exception of these two outliers. Figure 4.5.5 demonstrates this nicely. Once again, this does not mean that pm115 was made at Mutokolwe, rather it was made of a similar clay.

The sherds from the other three sites show mixed results. The four Matshava sherds show a great deal of variability. It is situated at the foot of a granite hill but surprisingly, however, only a single Matshavha sherd is granite-like (i.e., low mafic values but high K_2O and Rb). Manavhela is found on an amphibolite outcrop (Loubser 1991) and the sherds have a mafic compositional profile which one would expect from its locality.

Dzata is situated just to the south of Mutokolwe yet its four sherds are also quite diverse in composition. The samples from the above three sites are, however, too few for any definite conclusions to be offered.

Figure 4.5.6 is a replot of figure 4.5.2 but with only the Mutokolwe sherds and spindle whorls plotted according to their location within the site or by stylistic type. A single sherd, FW28 from the cooking hut, was also omitted as it loads extremely highly on MgO, Ni and Cr; it plotted on the extreme left in Figure 4.5.2. It stands out by itself but its origin is difficult to decided on at present although it may originate from ultramafic rocks 30-50 km to the south or, perhaps, one can speculate for an origin in the Bushveld Igneous Complex even further to the south.

The rest of the pottery and spindle whorls cluster into three groups with a number of outliers. Either these represent vessels made from local, highly variable clays or some are imports. Cluster I loads high on Cu and probably represents pottery made in the vicinity of the site. The Sibasa Formation basalts of the area are reported by Wilson (1989) to have higher Cu values that other soils in the region. Included in this cluster is sample FW06, a large Khami style water pot. The size of this vessel makes it unlikely that it was imported from any distance. Under these circumstances, these sherds must represent locally made pots. This cluster has examples from all features except the messenger's hut and also excludes the Tavatshena sherd. Note also that the Moloko sherd fits this cluster and was therefore made locally.

Cluster II to the mid right tends to load on Nb and Zr with lower Cu (see Figure 4.5.4). Wilson (1989:87) reports that the former two elements are comparatively enriched and the latter depleted in Karoo soils compared to Soutpansberg soils. It is therefore likely that this cluster represents pots made from Karoo clays some 30-40 km to the north. The dominant samples here are those from the messenger's hut although there are representative samples from other features. Note that the plot of the samples from the messenger's hut overlaps with and obscures the symbol for a Khami sherd. The two specimens located outside this cluster, the spindle whorl (FW47) and the

Khami pot from the cooking hut (FW03), do not form part of this group as they split off from it when axis 3 is taken into account (Figure 4.5.6). They actually load high on both K_2O/Rb and Cu and therefore are intermediate between clusters I and III. It is possible that these two samples either represent a mixed clay (whether natural or artificial) or else come from the Gumbu Formation area to the north of the Karoo sediments and volcanics. This area to the south of the Limpopo River contains high Cu values as well as granite intrusives.

Cluster III contains five samples with some variability mainly relating to Na_2O. All samples load high on K_2O and Rb and this indicates a provenance in the granitic gneisses some 30 km to the south. I have labelled this as a cluster in spite of the variability as the samples move upwards together on the third axis following the K_2O, Rb and Na_2O (Figure 4.5.7).

Of the second outlier with a very high Cr (sherd FW43 from Mutokolwe A), its likely origin is the ultramafic rocks some 30-50 km to the south. The Tavatshena sherd cannot be assigned a source area except to say that the relatively high K_2O, Rb and Ni values and low CaO does suggest a southerly origin.

As Princess Hill and Verulam are stylistically linked to Mapungubwe I compared the data between them and the Limpopo Valley group. Figure 4.5.8 is a plot of the first two axes showing a somewhat tantalising overlap between a number of Princess Hill sherds and the fringes of the main Limpopo Valley cluster. Of special interest is a single Princess Hill sherd embedded in the centre of the cluster. In order to clarify the this, I re-plotted the figure using only the Mapungubwe data (figure 4.5.9). It can be seen that the outlier (pm116) is firmly associated with the Mapungubwe group. If the third axis is taken into account (figure 4.5.10) it will be seen to retain this association. I once again make no claim to this sherd coming from Mapungubwe itself or even from the Limpopo area but rather that it was made from a very similar clay to those in the Limpopo Valley. The reason for this caution is simple. There are Karoo rocks north of the Soutpansberg and at present I have no information about the geochemistry of these rocks and whether they can be differentiated from those of the Limpopo Valley.

4.5.6 Discussion and Conclusions

If Cluster I is accepted as representative of locally made sherds and the others as imports, then, even though only a small number of samples were analyzed, nearly half of the sherds from Mutokolwe A and B originate elsewhere. This confirms the high degree of socio-economic interaction with outlying communities which was known from other sources. The other sites, although sample sizes are really minimal, display the same pattern. However, the Princess Hill sherd which fell into Cluster I should not be regarded as originating at Mutokolwe B itself: rather, until more is known of the chemical profiles of other clays derived from the Simbasa Formation, it should simply be provenanced to this general area.

A differentiation must be made between imported pottery (, pottery made elsewhere and found on the site) and imported decorative motifs on pots made locally. Imported pottery is unlikely to have resulted from the marketing of such wares as no markets are known. Pottery production took place in the household. It is therefore likely that such wares reflect pots that may have been food containers used by individuals visiting for a variety of reasons, including attending the chief’s court, paying tribute or brought in as utilitarian items by traders or even by families resettling at the site. In this regard, the fact that two spindle whorls were also imports is of interest and could reflect the latter.

Locally made pots with external decorative styles such as the Moloko sherd suggest marriage alliances or the settlement of outsiders who continued with their own stylistic traditions although on a smaller scale. In the former case, Sotho women marrying into a local Shona family may have continued making a limited number of typical Sotho (i.e. Moloko) vessels for their own private use. Alternatively, Sotho speaking outsiders who settled at Mutokolwe may have adopted the local Khami styles whilst retaining a few personal pots in the Moloko tradition. It is known historically that people in the region have changed their ethnic affiliation in order to identify with a dominant group for economic advantages (Loubser 1991).

The spatial provenance of the imported vessels is also interesting although samples are small and present problems of interpretation. The imported sherds are distributed in low numbers among all the other activity areas which is to be expected. The messenger's hut, however, had no locally made sherds which could reflect tribute or gifts brought to the chief from outside.

The Soutpansberg is a powerful laboratory for testing models of exchange patterns (e.g., Peisach 1991: Table 3): a reasonably differentiated geology with a detailed geochemical soil survey; archaeological sites from a range of hierarchies and cultures, oral histories and other written records. Future provenance work should also concentrate on sites from different settlement hierarchies. At the moment there is no evidence that pots were actively traded into the site; rather, they probably arrived in association with the trade in other materials (e.g. as containers). If that is the case, larger sites should show a greater variety of sources, and from further afield, than smaller sites lower on the hierarchical scale. More information is still needed, as well, on the chemical composition of the clays in particular to obtain more likely sources for the outliers in Figure 4.5.2. The main problem with this proposal is the size of the area which needs to be sampled. The alternative, or rather, a program which can be carried out simultaneously is to take a pottery sample from sites within a radius of 100 km around Mutokolwe in order to assess their variability and their compositional overlap, if any, with Mutokolwe.

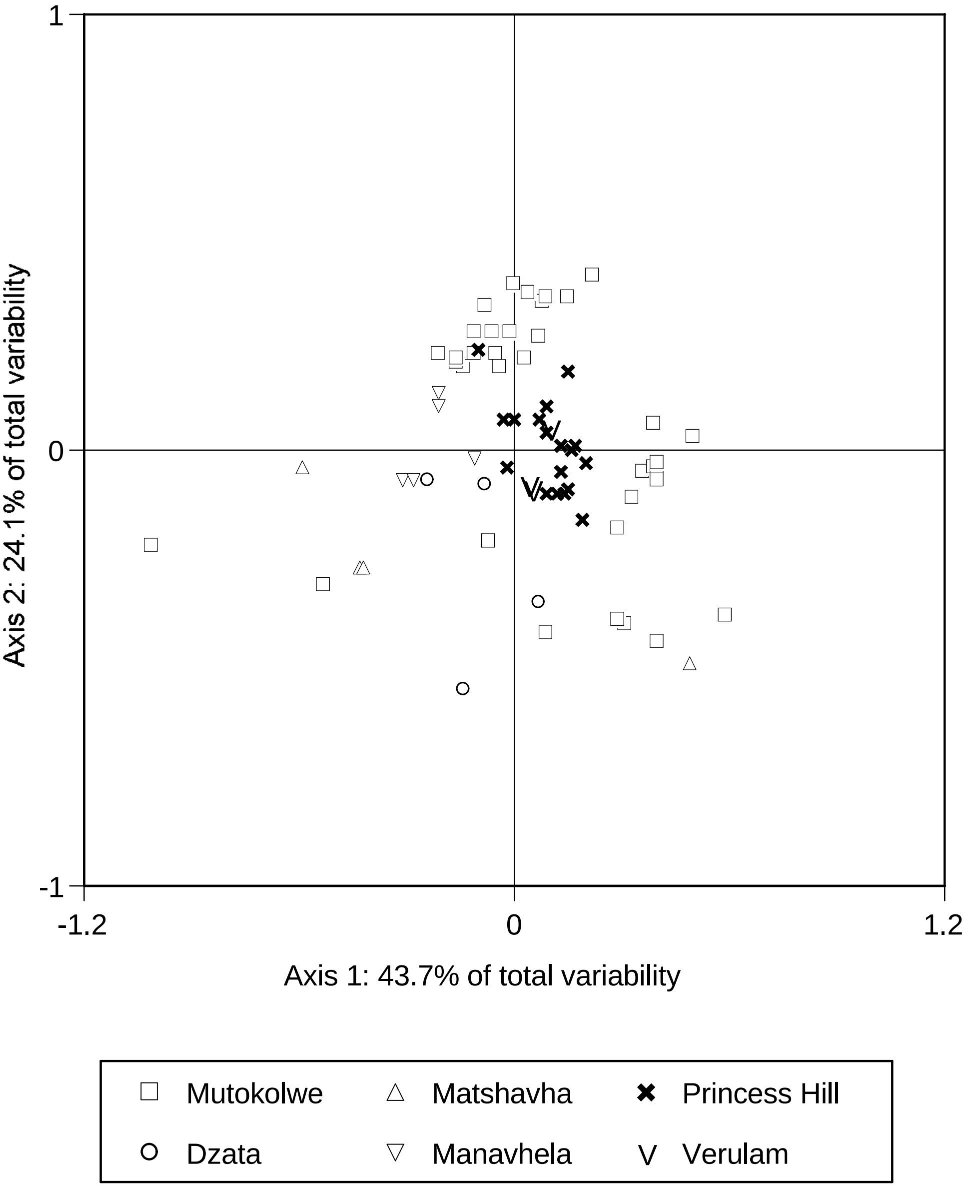

Figure 4.5.2. Plot of the first two axes for the complete data set.

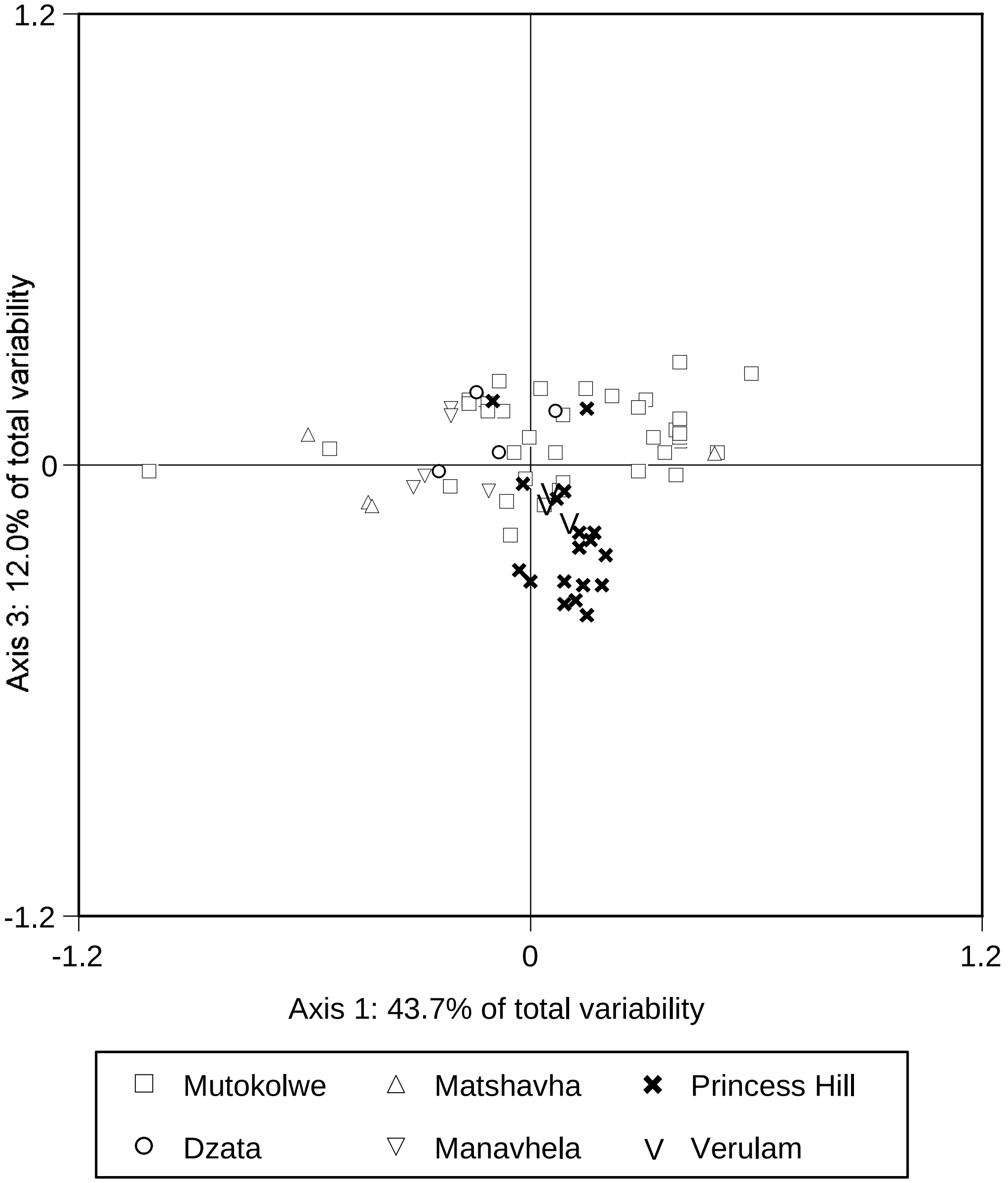

Figure 4.5.3. Plot of the first and third axes for the complete data set.

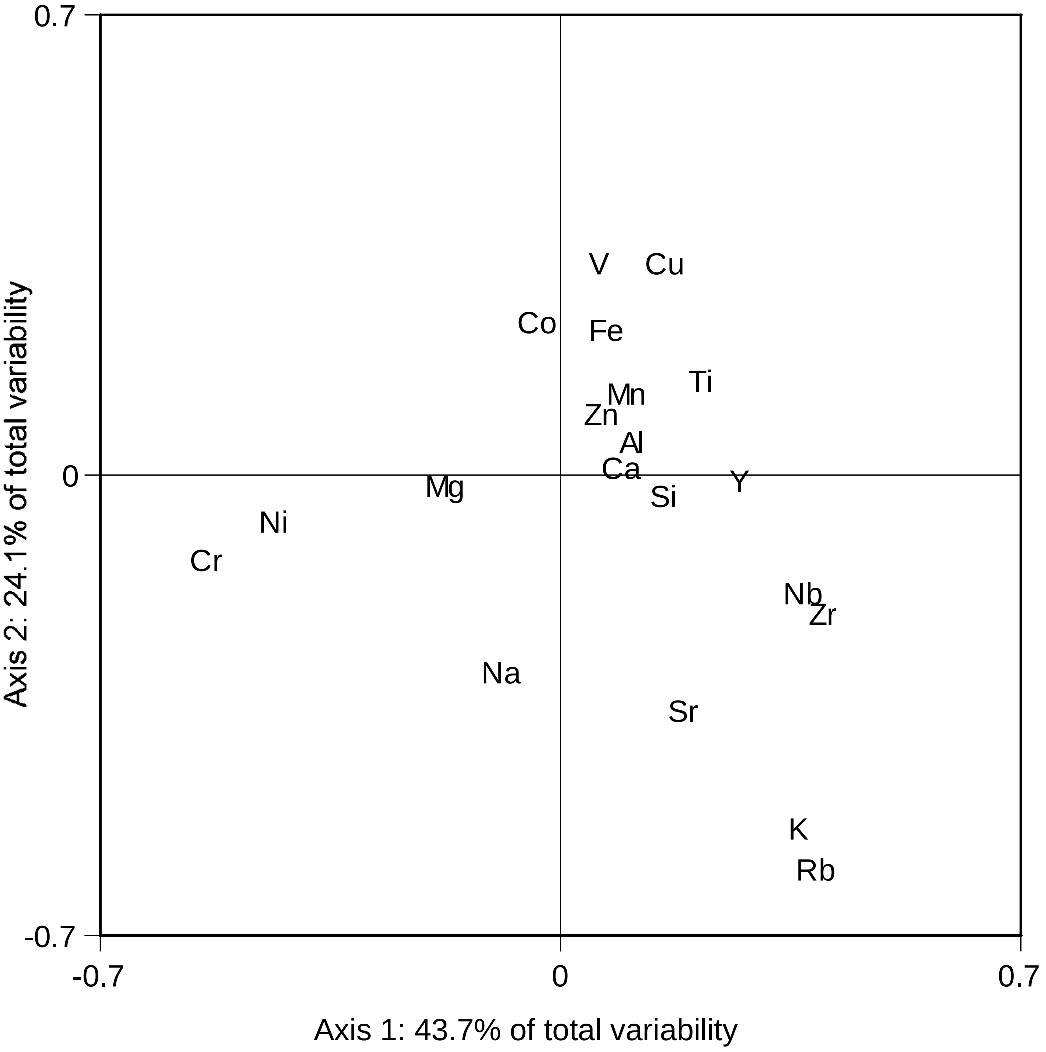

Figure 4.5.4. Plot of the first two axes of the element loading.

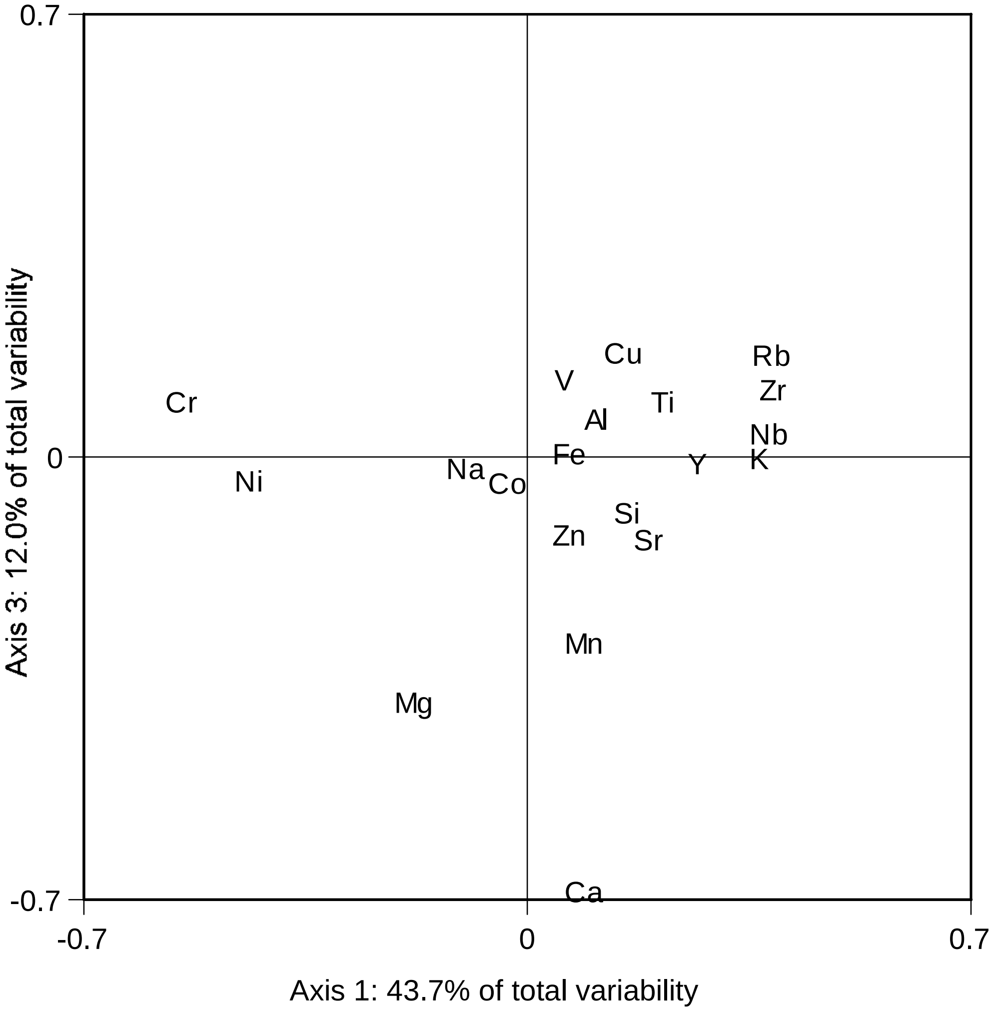

Figure 4.5.5. Plot of the first and third axes of the element loading.

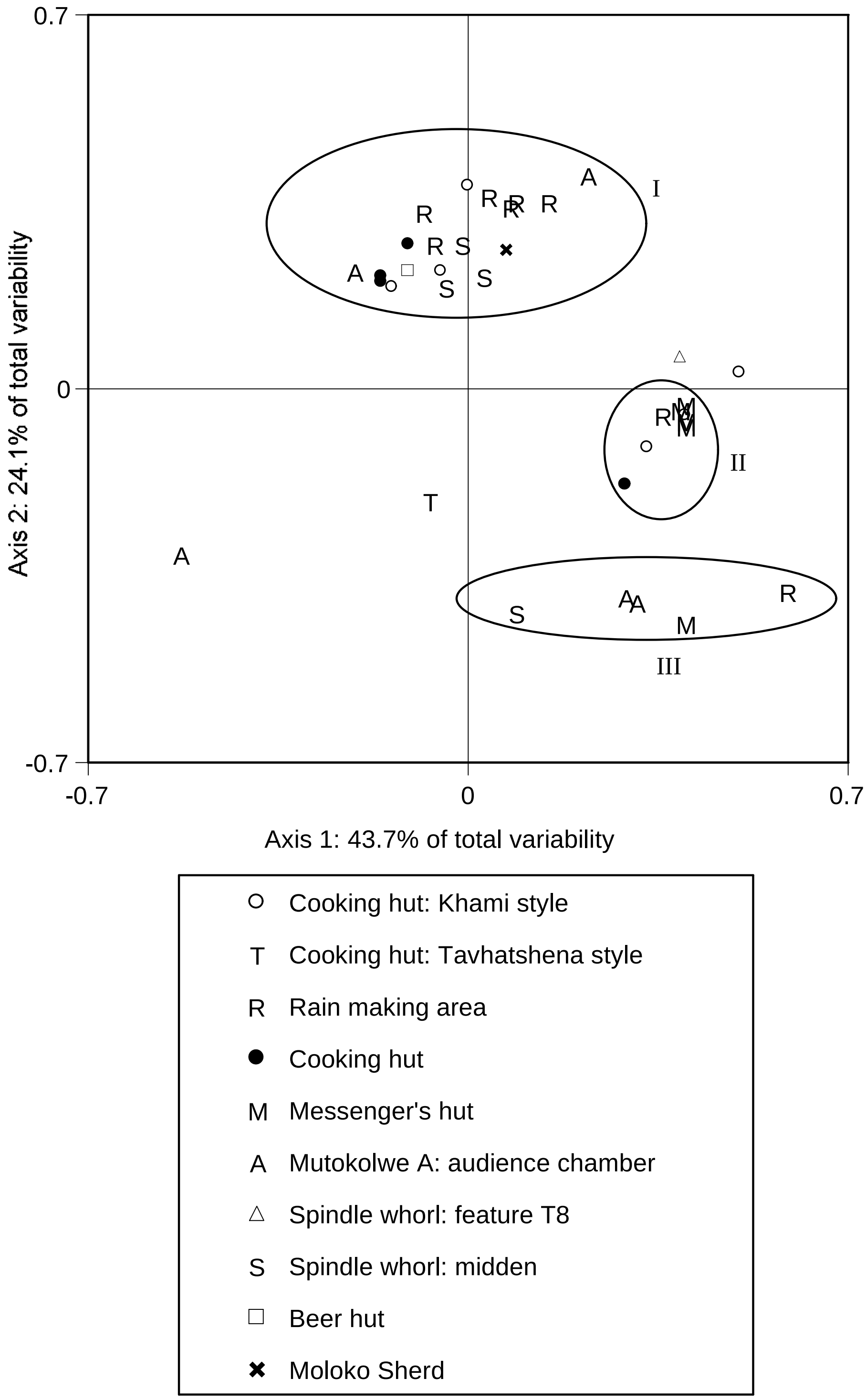

Figure 4.5.6. Plot of the first two axes of the sherds and spindle whorls from Mutokolwe only marked according to location and style.

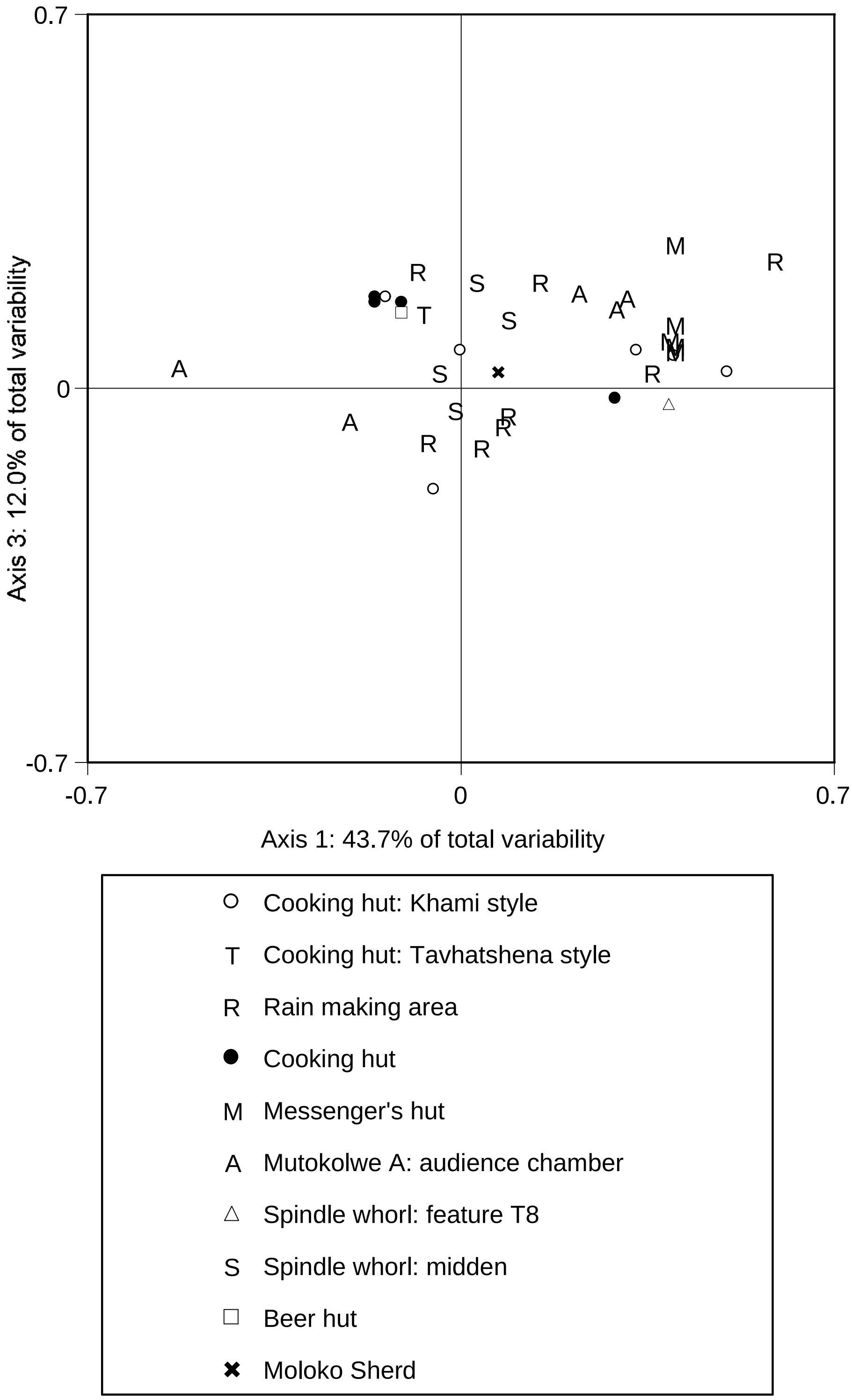

Figure 4.5.7. Plot of the first and third axes of the sherds and spindle whorls from Mutokolwe only marked according to location and style.

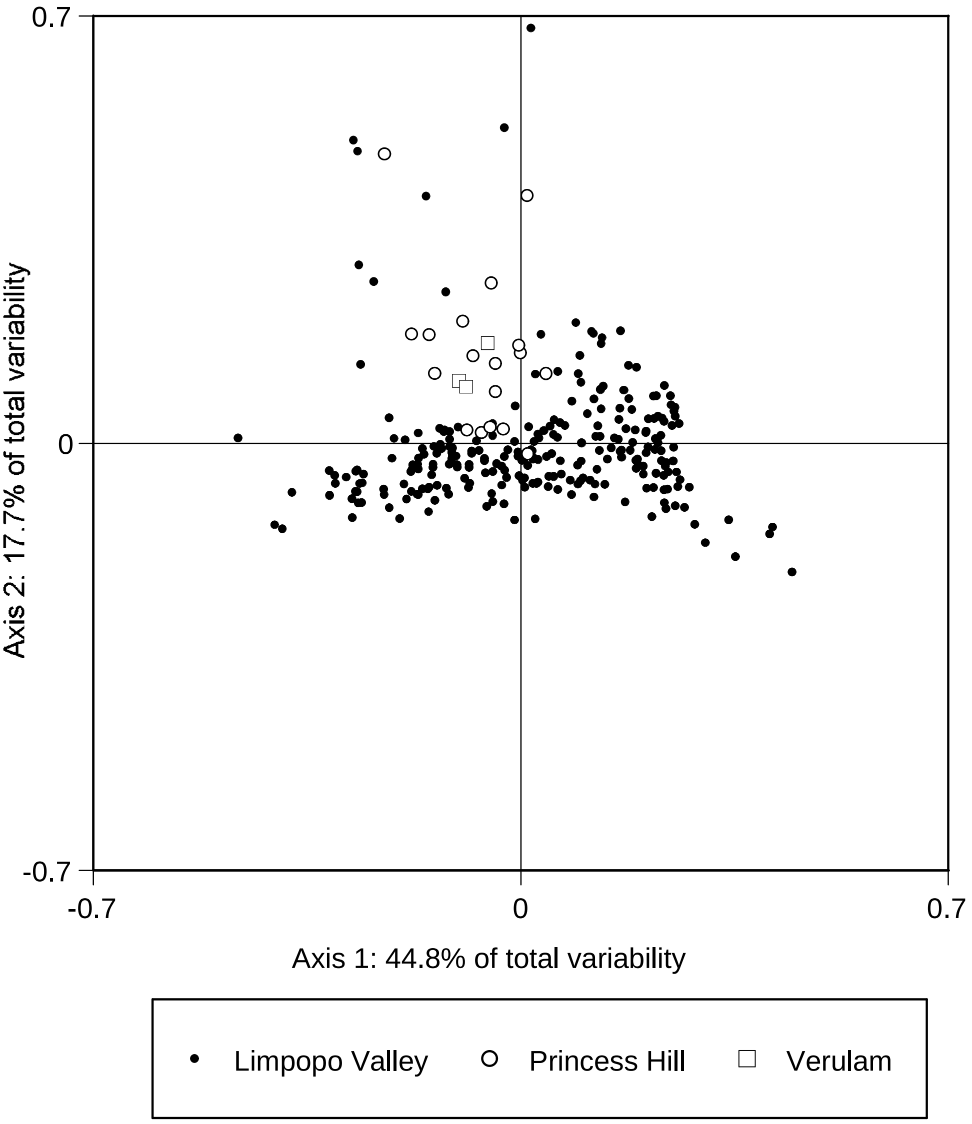

Figure 4.5.8. Plot of the first two axes for the Limpopo Valley/Princess Hill analysis.

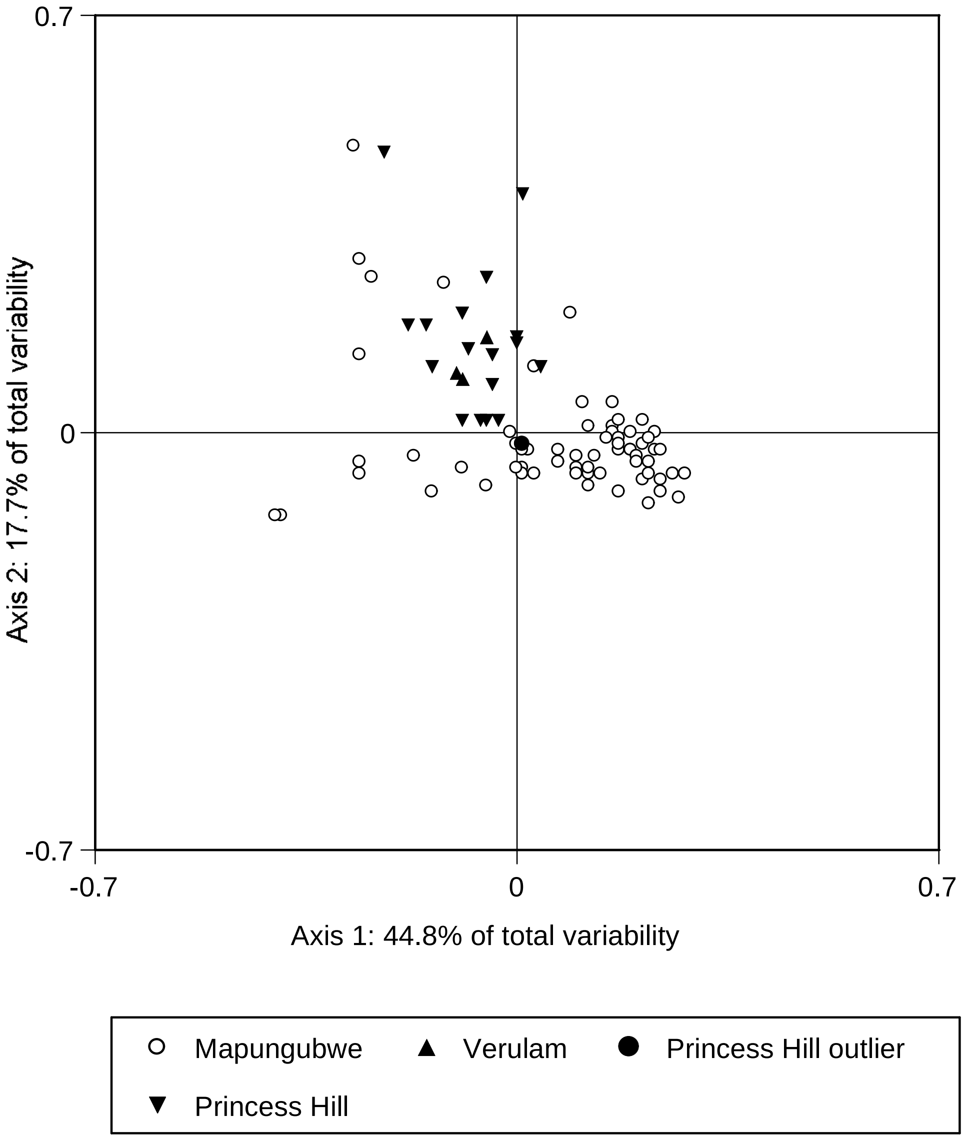

Figure 4.5.9. Plot of the first two axes for the Princess Hill/Mapungubwe analysis.

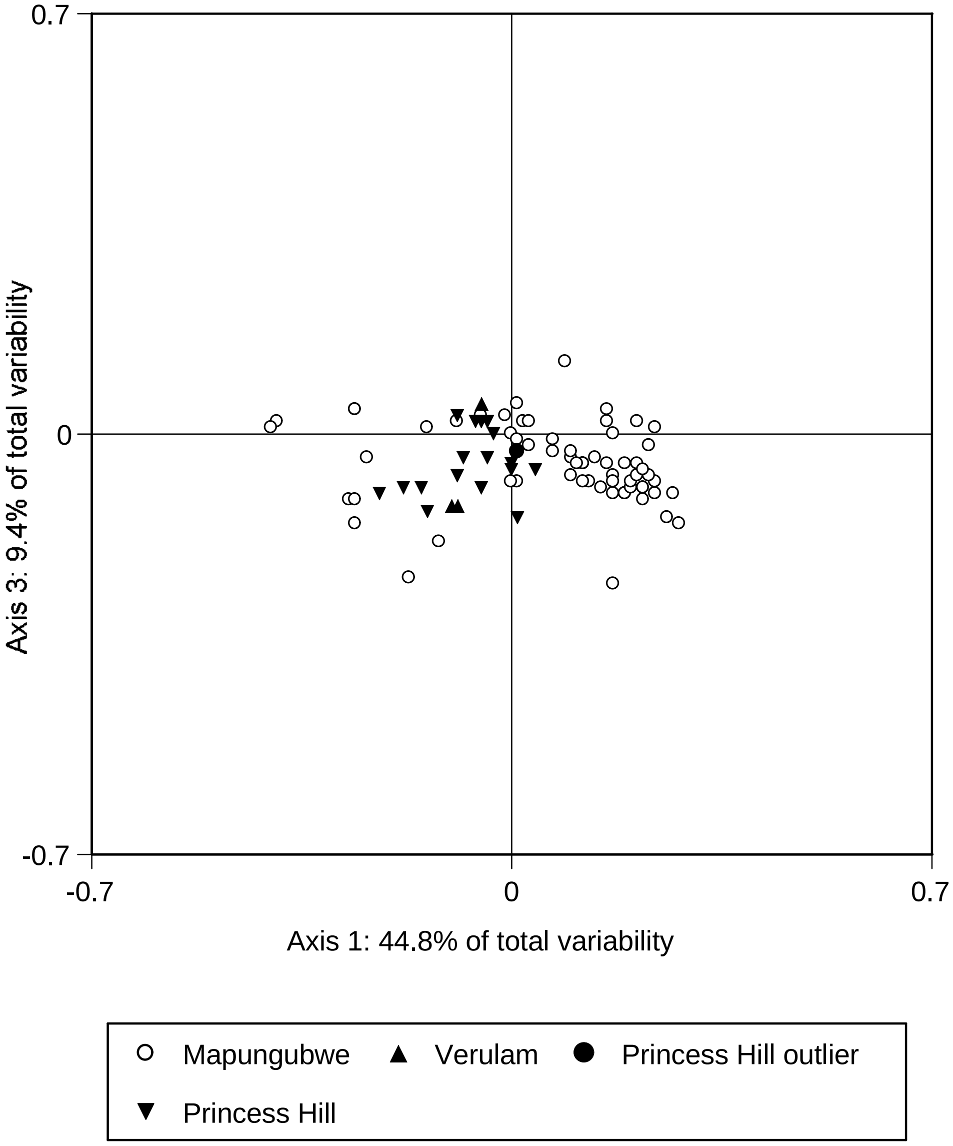

Figure 4.5.10. Plot of the first and third axes for the Princess Hill/Mapungubwe analysis.

4.6 LYDENBURG AND OTHER SITES

4.6.1 Archaeological Background

The area formerly known as the Eastern Transvaal is particularly rich in Iron Age remains dating from amongst the earliest known sites at about the 3rd Century AD until the contact period (van der Merwe & Scully 1971; Evers & Van den Berg 1974; Klapwijk 1974; Evers 1975, 1980, 1981, 1982a, b, 1988; Evers & Vogel 1980; Voigt 1982; Klapwijk & Huffman 1996; Whitelaw 1996). In addition, it is also the location of the famous Lydenburg Heads (Inskeep & Maggs 1975), ceramic masks that were probably used in ritual ceremonies. Mining of iron and copper was carried out (Evers 1974; Evers & Van den Berg 1974; Van der Merwe & Killick 1979; Gordon & van der Merwe 1984; Klapwijk 1986a, b) as was the recovery of salt at a number of naturally occurring hot brines (Kent 1942; Evers 1979, 1981): all these economic activities formed an important part of the extensive trade links which developed in the region (De Vaal 1984, 1985).

4.6.2 Geological setting

I have little information on the specific geology with which the sites and hence their clay sources may be associated. In general, though, the Lydenburg sites are situated on rocks of the Transvaal Supergroup, mainly shales and volcanic rocks (Haughton 1969). The Eiland Salt Works is situated on granite/gneisses (Kent 1942) as is the Silver Leaves and Phalaborwa sites whilst the Mokopane (previously named Potgietersrus) sites are either on the Bushveld Igneous Complex or the Transvaal Supergroup (Haughton, 1969). These different substrates will all effect the chemistry of any clays in very different ways. Certain areas of the Bushveld Igneous Complex are highly enriched in V and Cr which are currently mined whilst other areas have elevated Cu levels. All these should serve to make for geochemically distinctive clays.

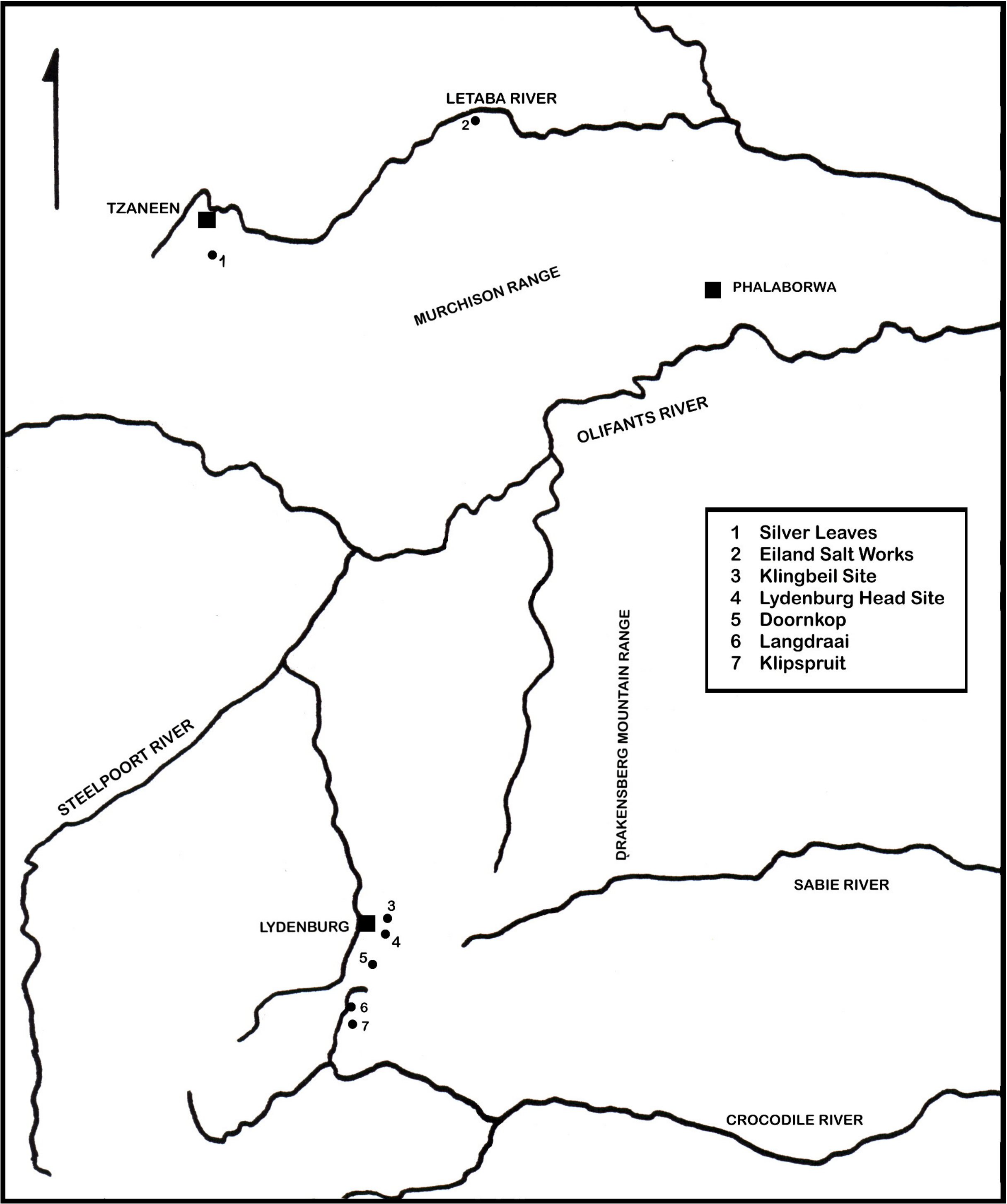
LETABA RIVER
2
TZANEEN
1
MURCHISON RANGE
PHALABORWA
OLIFANTS RIVER
1 Silver Leaves
2 Eiland Salt Works
3 Klingbeil Site
4 Lydenburg Head Site
5 Doornkop
6 Langdraai
7 Klipspruit
DRAKENSBERG MOUNTAIN RANGE
STEELPOORT RIVER
SABIE RIVER
3
LYDENBURG
4
5
6
7
CROCODILE RIVER

Figure 4.6.1. Location of sites mentioned in text.

4.6.3 Previous work and current aims

There has been no previous provenancing of pottery in this eastern part of the country. Van der Merwe & Killick (1979) had carried out an experiment to source iron ore found on smelting sites in the Phalaborwa area but no other work has taken place.

Although evidence for trade in the region has been documented (Evers 1974; De Vaal 1984, 1985), none of the sherds analysed shows a non-local style at any site. The emphasis in this section will be on exploring the potential for provenancing rather than addressing any specific archaeological question. It will be of interest, however, to see whether the composition of the pottery from the Lydenburg sites, which are Early Iron Age, shows a greater or lesser variability than Later Iron Age sites already investigated above, depending upon local clay source variability of course.

Eiland Salt Works situated in the Hans Merensky Reserve is a special case. The evidence at the site indicates a long occupation, since the Matola Phase (4th century AD) until recent times (Evers 1981). Whether people were permanently settled there or whether it was only occupied for the business of salt making is not known but probably the latter. This raises the question of whether people made their pottery elsewhere and brought it to the site or made it locally. This investigation then is purely exploratory.

4.6.4 The samples

This study was carried out principally on a range of sherds excavated from sites in the vicinity of Lydenburg as well as smaller collections of sherds from further afield for comparative purposes (figure 4.6.1). These include a number from the Eiland Salt Works, and a few sherds each from sites in the region of Mokopane (not shown on the map: collection of sherds was made about 80 years ago), Tzaneen (Silver Leaves), Phalaborwa and Nelspruit. These last three sites contributed only a couple or three sherds each. All the aforementioned were probably surface collections. In addition, the data for thirteen sherds from the three Venda sites of Dzata, Manavhela and Matshavha were also used in the statistical analysis. Apart from the sherds from

Eiland, all the others were plain sherds. Full details of the sherds and the sites will be found in Tables A4.6.1 to A4.6.4. The Eiland Salt Works sherds come from three different phases (as well as some plain sherds). These appear to come from the salt workings and not any domestic areas.

In terms of the potential interpretive quality of the samples, they fall into a Q4/5 rating for Lydenburg, Eiland and Silver Leaves but only Q2 for the others. No sediments or clays were available for analysis.

4.6.5 Statistical analysis

Two of the Mokopane (previously named Mokopane) sherds were omitted from the analysis: one because of insufficient data and the second, vm13, because of highly enriched CaO and Sr values which made it a remote outlier. All the data is listed in Tables A4.6.1 to 4.

Figure 4.6.1 plots all the data on the first two axes whilst figure 4.6.2 brings the third axis into account. The Lydenburg sherds are distributed along a continuum from the lower left of the plot towards the upper centre. Based upon the element loadings in figures 4.6.7 and 4.6.8 their composition varies from a high loading on the mafic elements to one with high metals such as Cu, V, Zn. The Mokopane sherds, on the other hand, occupy a continuum from the felsic elements (K_2O and Rb which are indicative of granites or sedimentary rocks derived from them) at lower right to a similar loading on the same metals. The Mokopane cluster at lower right follows its relationship with K_2O and Rb and separates from the Salt Works sherds when the third axis is taken into consideration. This cluster consists of the Holmsleigh and Mozoto sherds (see figures 4.6.9 and 4.6.10) which obviously must come from a different substrate to the other Mokopane sherds. The single Matshavha sherd follows them closely which indicates its own granitic background.

The Lydenburg sherds are unpacked in figures 4.6.3 and 4.6.4. Klipspruit is the most variable with the two sherds at extreme left being highly enriched in Cr (SL154 and SL155 containing 2749 and 3091 ppm respectively). Several other values both from this site and the Lydenburg

Heads site have levels of Cr exceeding 1000 ppm but this is not surprising given the basic geology of the region. There are too few Klipspruit sherds to indicate whether these are sub clusters or are part of a continuum from the mafic elements to the metals at the centre of the plot. The Lydenburg Heads sherds follow a similar pattern as does the few Doornkop sherds. Langdraai and Klingbeil lack this dominant Cr component although values do not fall below 300 ppm.

The Salt Works sherds show a broader range of variability (figures 4.6.5 and 4.6.6). Although situated in a gneissic granite environment there are outcrops of dolerite and especially amphibolite which could account for the high mafic content of the two sherds to the left of the plot (Kent 1942). The central cluster which moves down relative to the other sherds on the third axis reflects an enriched CaO content. Overall, however, the total pattern of variability could simply reflect the local clays.

The other sherds hold no surprises. The Venda sherds have already shown their high variability whilst the Phalaborwa and Nelspruit sherds reflect their own granitic backgrounds although they are quite different from each other.

One final point concerns the P_2O_5 levels in the sherds from the Lydenburg area. They are highly enriched having a mean (normalised to 100% volatile free) of 1.05% compared to the average for the Salt Works sherds of 0.08%, Mokopane sherds of 0.58% and for all Iron Age sherds of 0.42% (Table 2.8). Whether this is a result of diagenesis, local clays that are naturally enriched or result from the manufacturing process (i.e., addition of temper) is of interest but cannot be determined at present.

4.6.6 Conclusions

None of the analyses carried out above shows any definitive evidence for the movement of pottery although a marked degree of variability is present. This, however, could result from

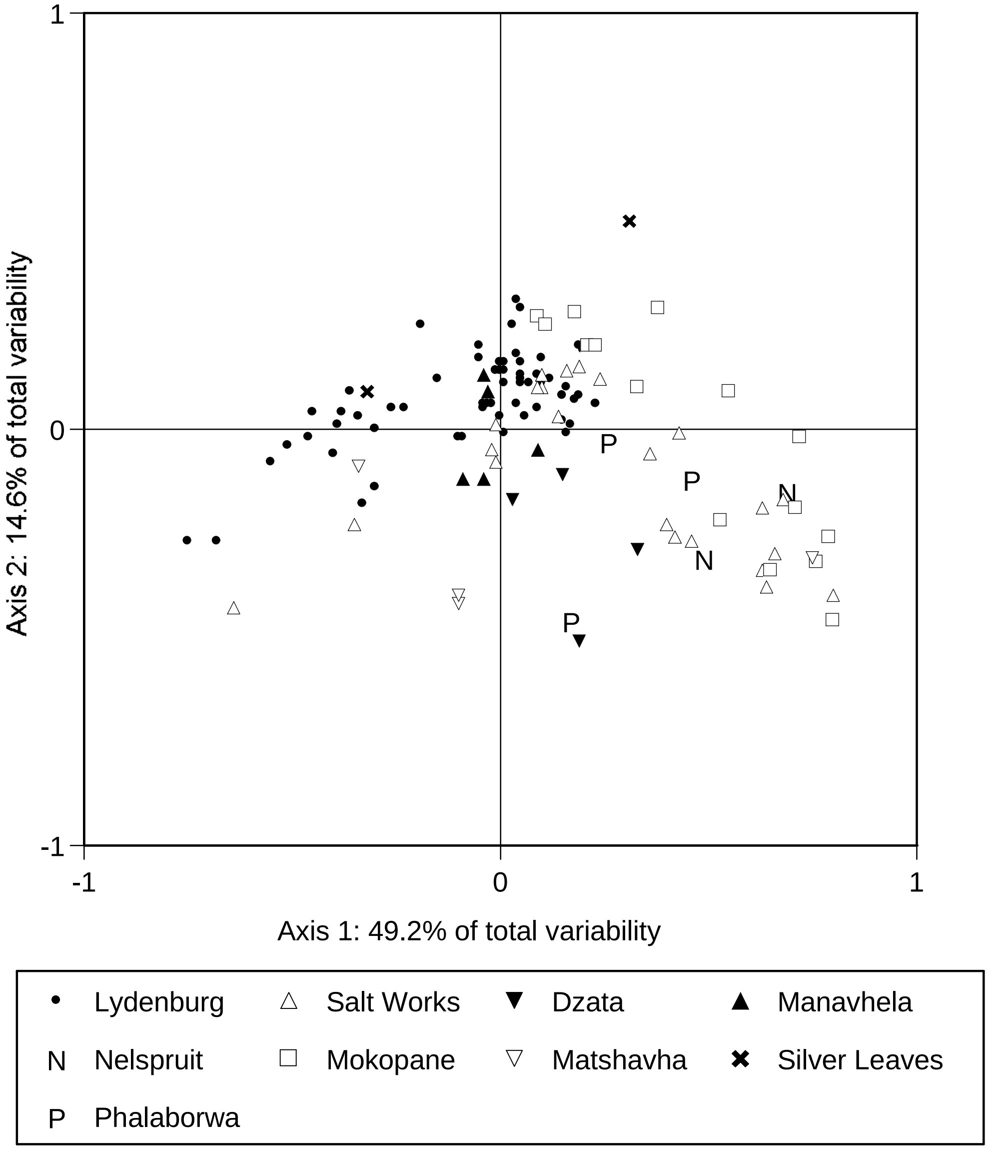

Figure 4.6.2. Plot of the full data set for the first two axes.

variability in local clays. What is of particular interest is the pattern exhibited by the Lydenburg sites. Langdraai and Klipspruit, which are quite close to each other show quite different compositional patterns whereas Klingbeil and Langdraai are more similar in spite of being further apart, allowing for the small sample size of course. Overall, it does show that for this broad region it will be possible to differentiate sherds geochemically. The boundaries between these geochemical reference areas still need to be determined though.

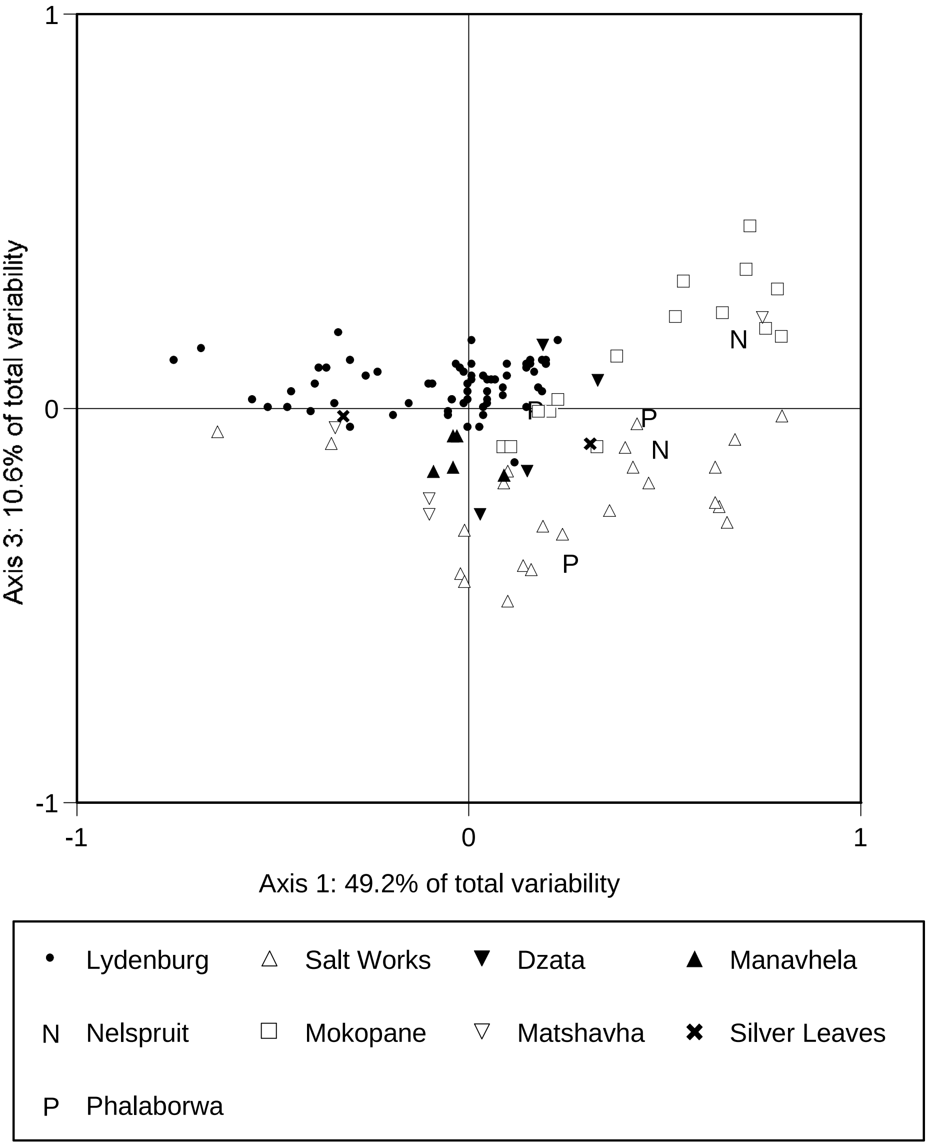

Figure 4.6.3. Plot of the full data set for the first and third axes.

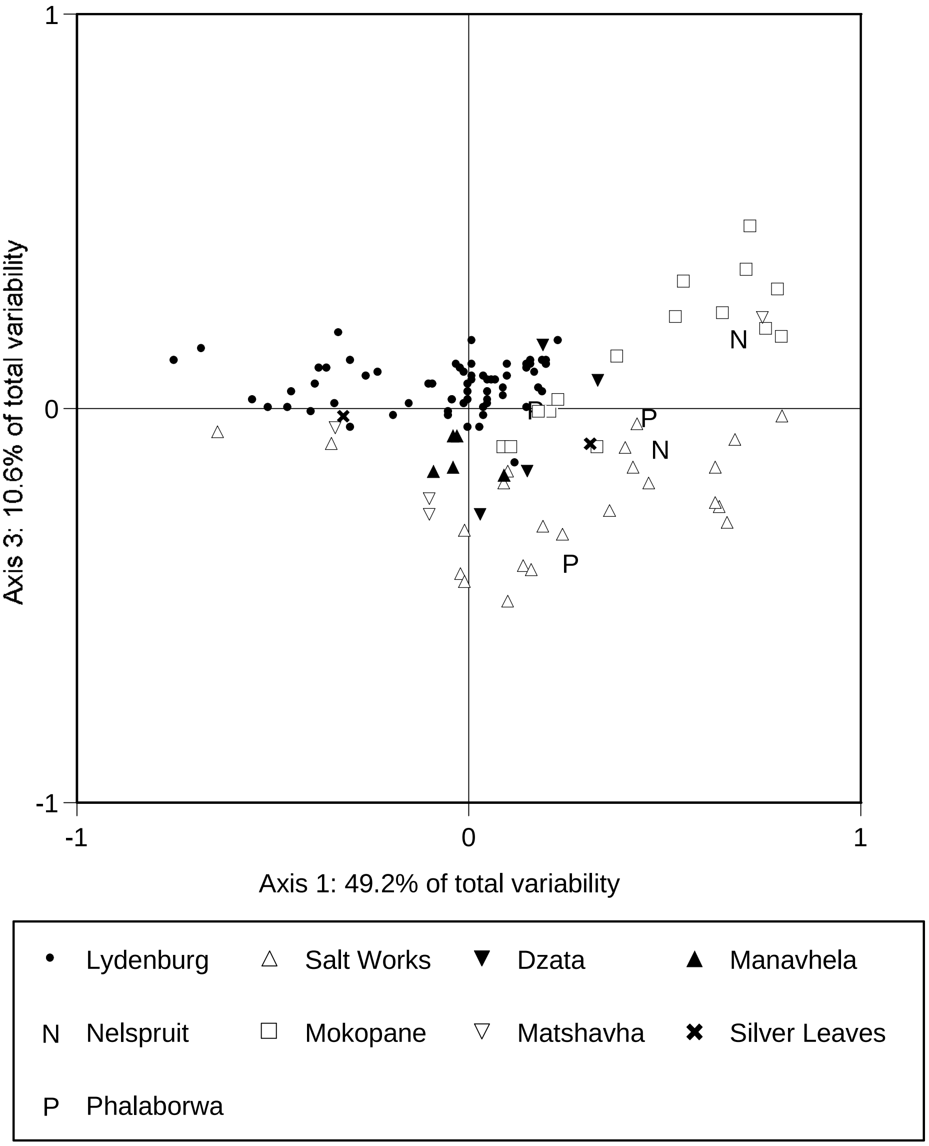

Figure 4.6.4. Plot of the first two axes for the Lydenburg sites.

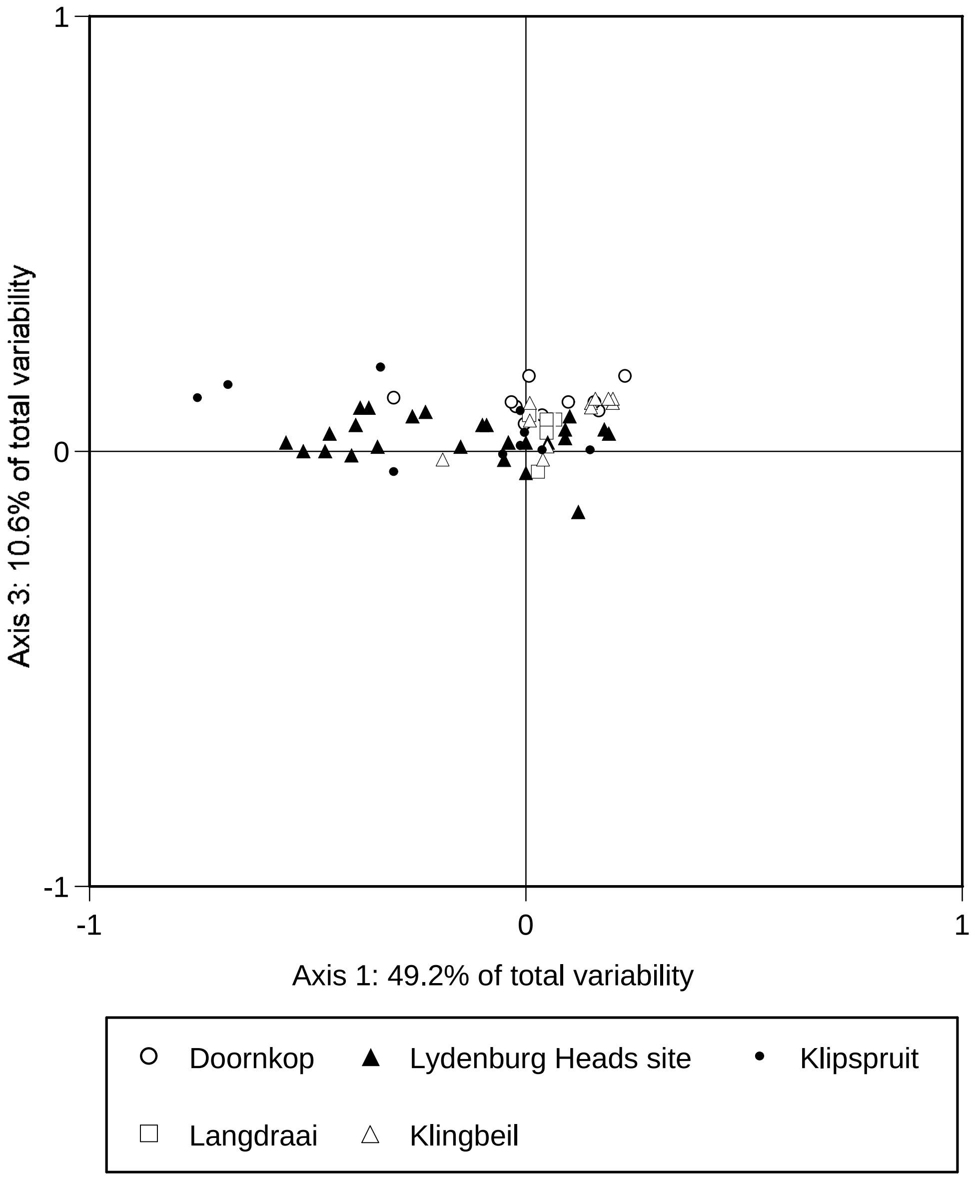

Figure 4.6.5. Plot of the first and third axes for the Lydenburg sites.

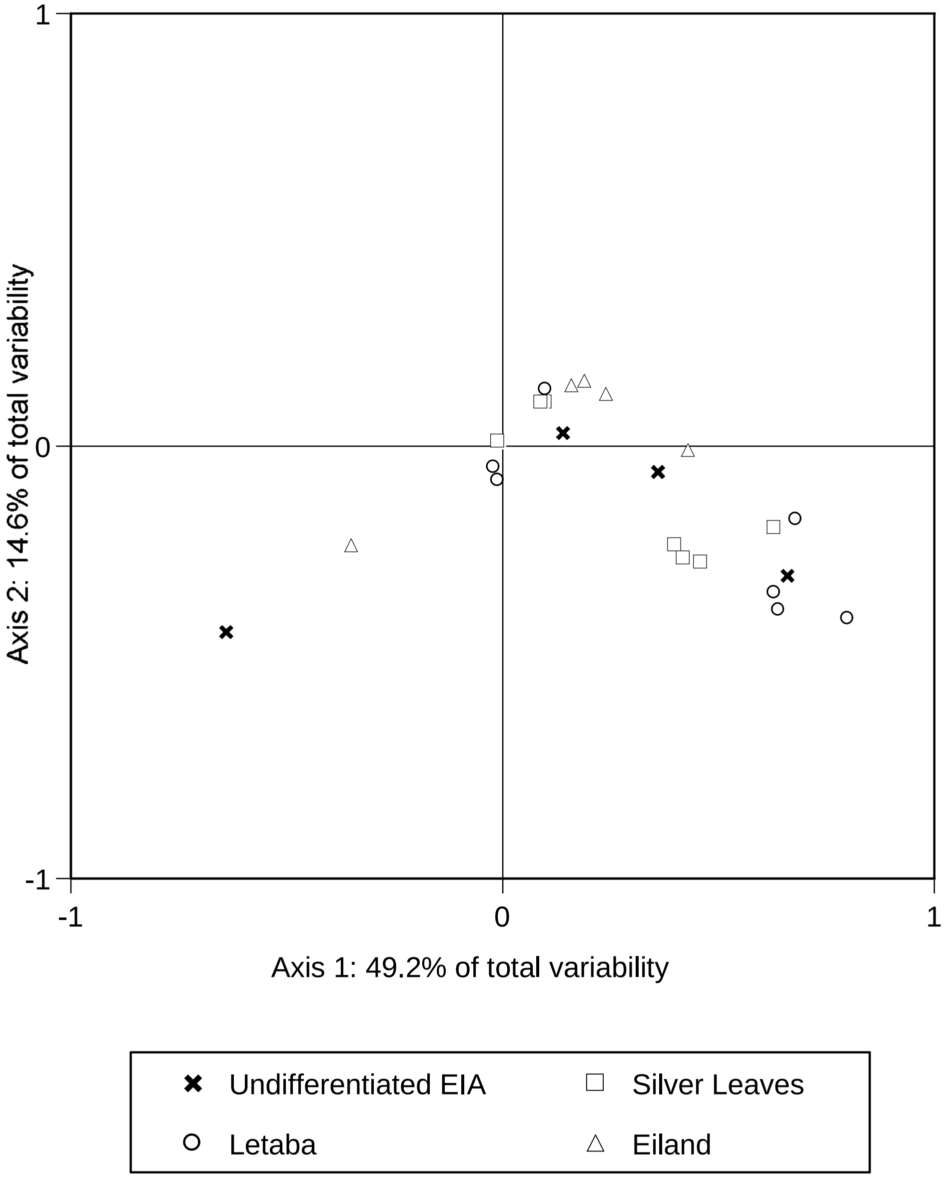

Figure 4.6.6. Plot of the first two axes for the Eiland Salt Works sherds identified according to stylistic phase where known.

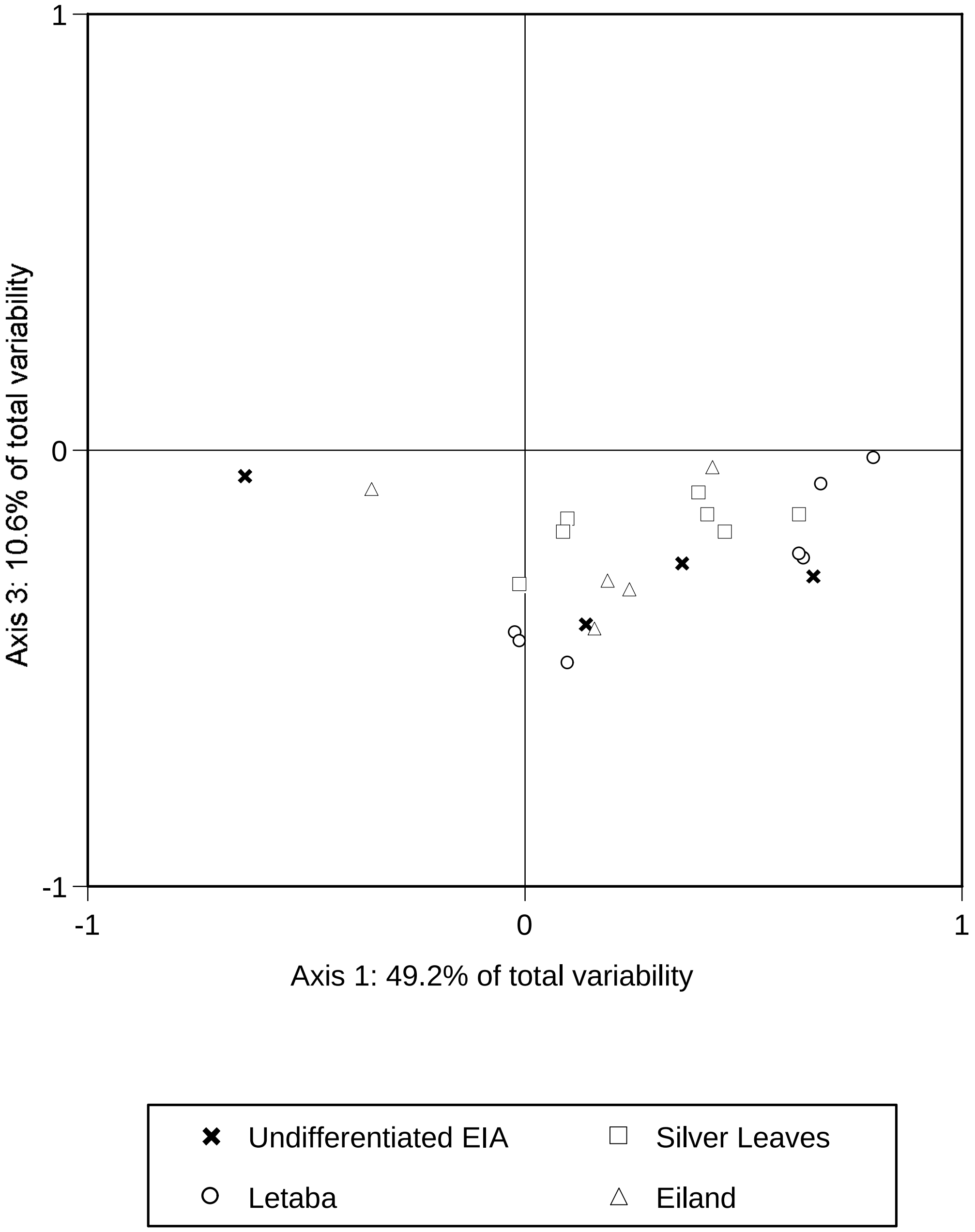

Figure 4.6.7. Plot of the first and third axes for the Eiland Salt Works sherds.

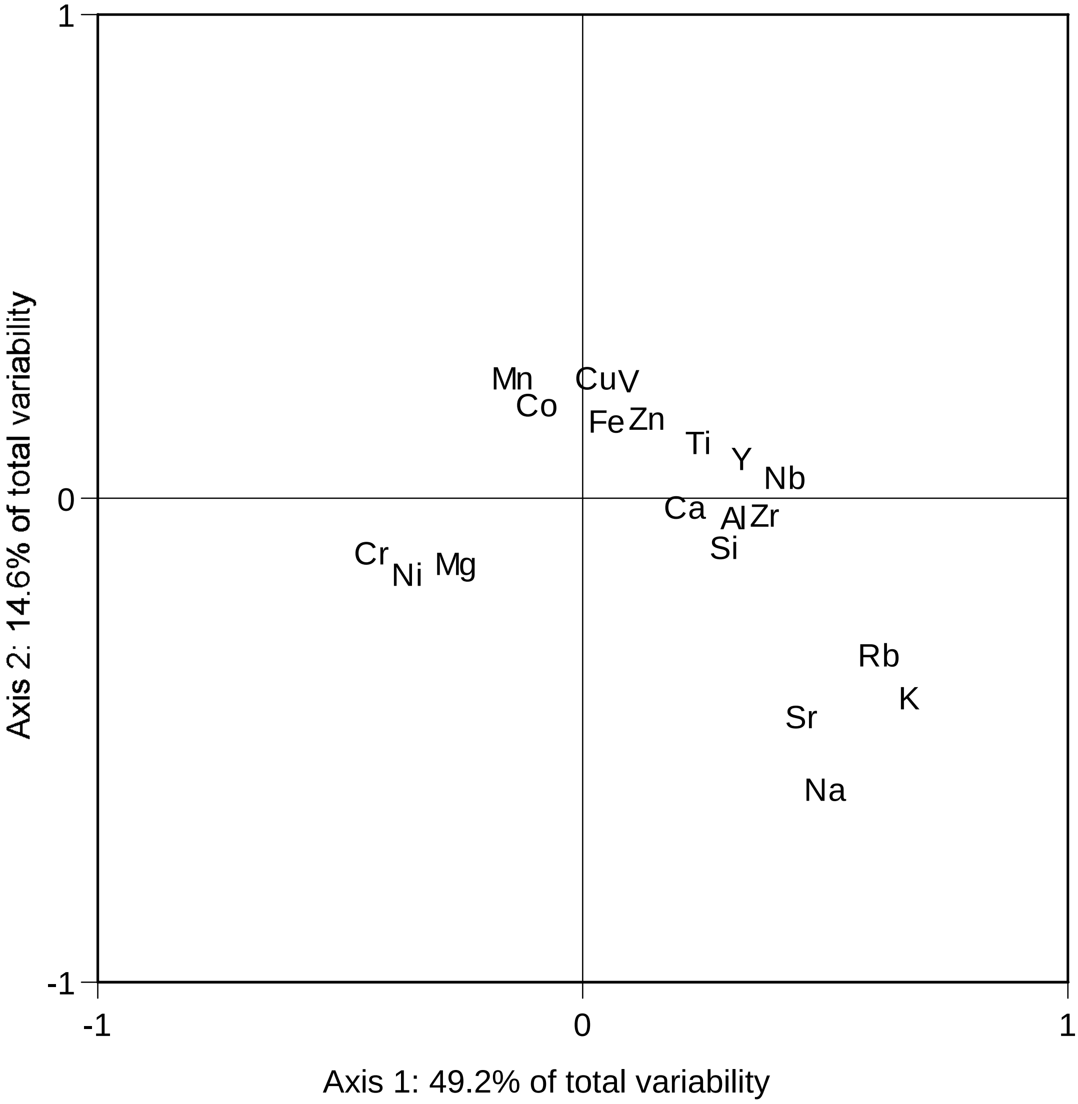

Figure 4.6.8. Plot of the first two axes showing the element loading.

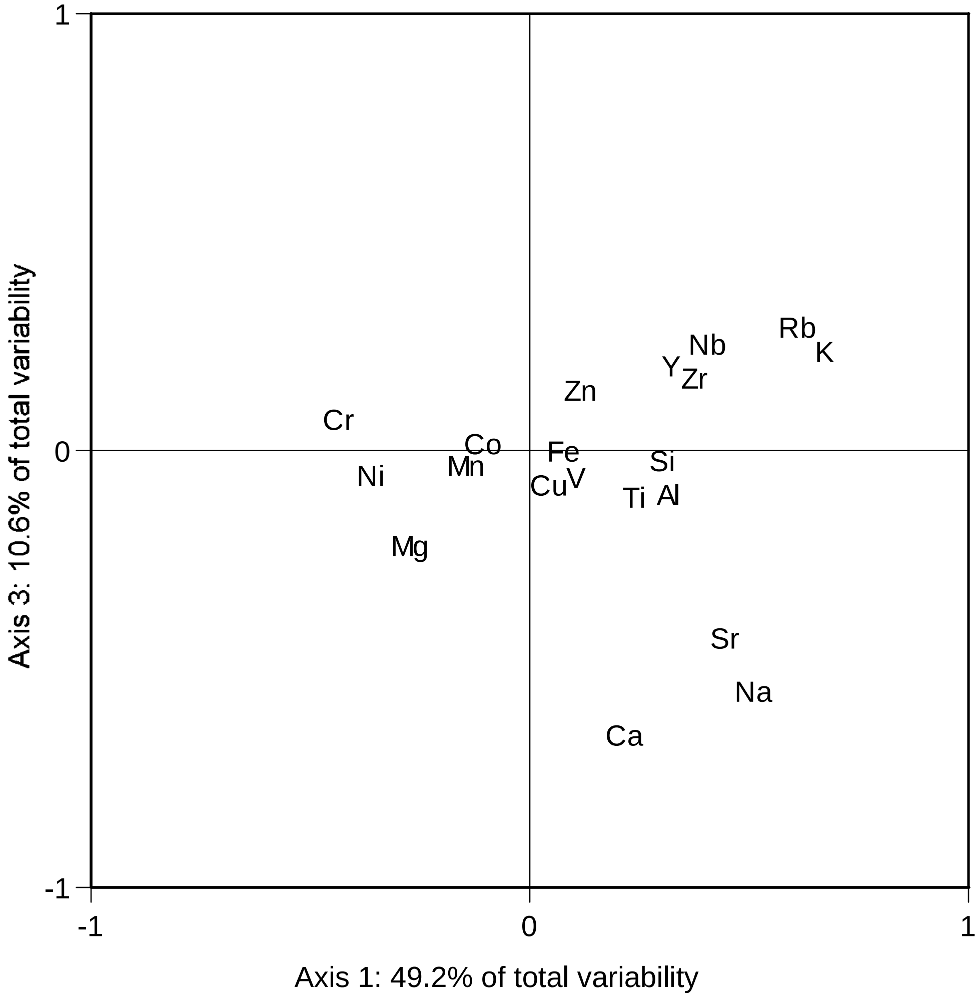

Figure 4.6.9. Plot of the first and third axes showing the element loading.

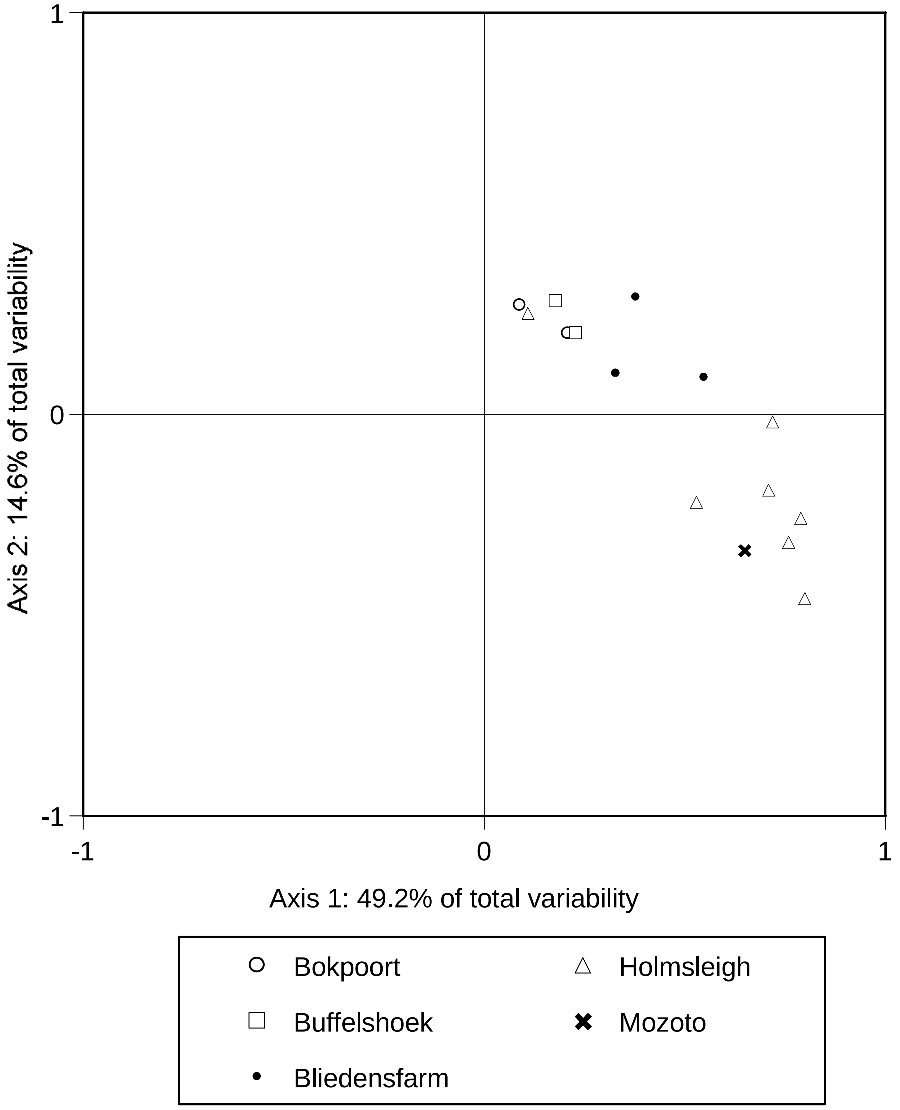

Figure 4.6.10. Plot of the full data set for the first two axes of the Mokopane sherds.

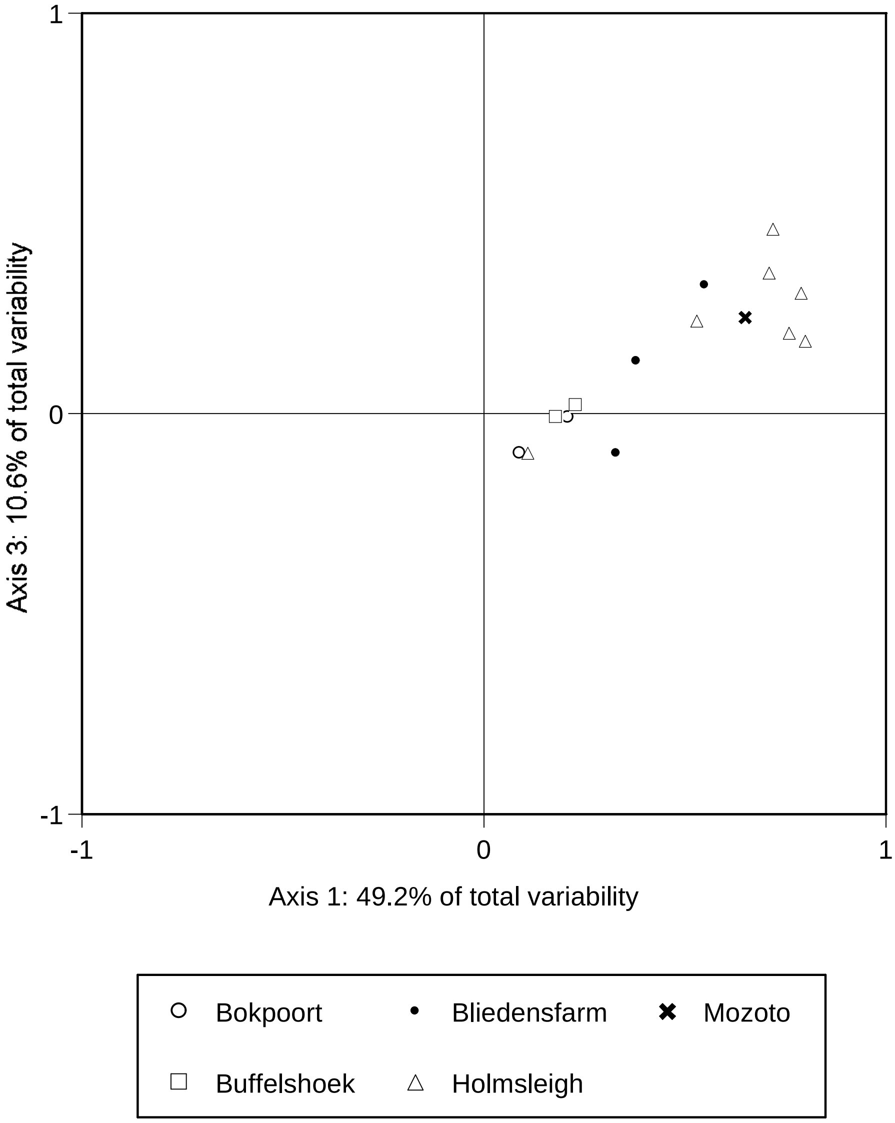

Figure 4.6.11. Plot of the full data set for the first and third axes of the Mokopane sherds.

4.7 NORTHERN CAPE AND THE TYPE R SITES

4.7.1 Archaeological Background

Along the lower reaches of the Riet River for some 130 km are extensive remains of settlements built of stone walling. Associated with them are numerous graves often containing grave goods such as copper earings, glass beads and marine shell. These settlements are characterised by a consistent pattern, viz, a large stone walled enclosure around which are smaller enclosures some linked by secondary walling. The former were probably large stock enclosures while the latter could have been used either for domestic activities or as small stock pens. Other remains are stone artefacts, pottery, metal and faunal remains. These distinctive sites and pottery are referred to as Type R. It would appear that they flourished for some three hundred years from the 16th century, or slightly earlier, until the early 19th century. The inhabitants were supposedly Bushmen hunter-gatherers who obtained stock and flourished in the area until early 19th century cattle raiding and other social upheavals impoverished and scattered them (Humphreys 1970, 1973; Humphreys & Maggs 1970; Maggs 1971, 1976).

In addition, the Type R sites are surrounded by other archaeological remains representative of Khoisan herder and hunter-gatherers the latter often referred to as Ceramic Later Stone Age (Rudner, I. 1953; Thackeray et al. 1983; Beaumont & Vogel 1984; Beaumont & Morris 1990; Morris & Beaumont 1991; Beaumont et al. 1995; Smith, A.B. 1995a, b; Rudner, J. n.d.).

4.7.2 Geological setting

The area in which the Type R settlements are found is composed of sediments of the Karoo Supergroup specifically Dwyka tillites. To the south and east are Ecca and Beaufort shales and sandstones. To the north are andesitic lavas of the Ventersdorp Supergroup while to the west are various metamorphic, rocks, dolomites, banded ironstones and volcanics of the Griqualand and Olifantshoek sequences and the Zoetlief group (Haughton 1969; Jacobson et al. 2002f). This

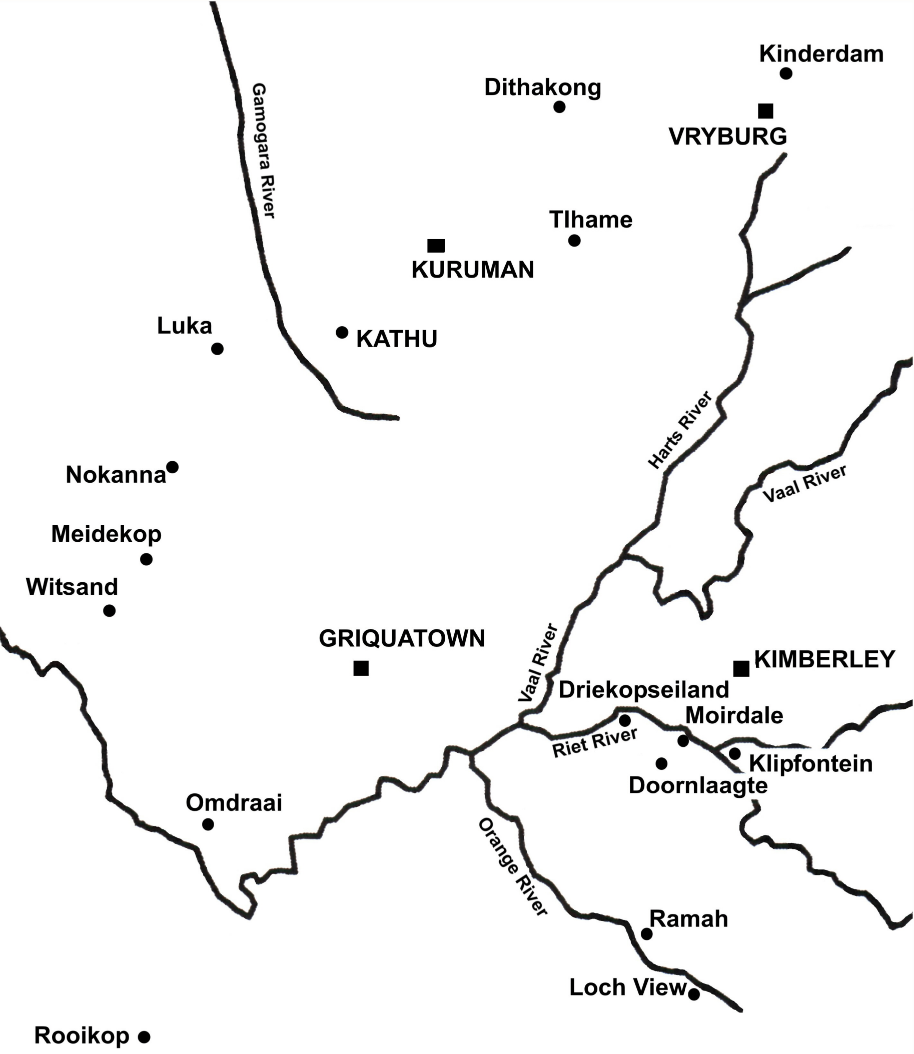
Kinderdam
Dithakong
VRYBURG
Gamogara River
Tlhame
KURUMAN
Luka
KATHU
Harts River
Nokanna
Vaal River
Meidekop
Witsand
GRIQUATOWN
Vaal River
KIMBERLEY
Driekopseiland
Moirdale
Riet River
Klipfontein
Doornlaagte
Omdraai
Orange River
Ramah
Loch View
Rooikop

Figure 4.7 1. Map showing location of sites mentioned in text.

diverse background should combine to make for distinctive clay sources.

4.7.3 Previous work and current aims

A previous study by PIXE analysis found that one out of three analysed decorated sherds found in the Riet River area was an import (Jacobson et al. 1994c). As decorated vessels are atypical, the fact that they were both imported and made locally albeit on a small scale is of some interest as there had been much speculation as to where the Type R communities had obtained their livestock. This study was undertaken in order to extend the previous work and was run on a different set of sherds.

The current aim for the small suite of samples is simply whether the sites they come from can be geochemically differentiated. Once the presence of provenanced sherds is reliably established, this will give an indication of the direction of any trade or exchange relationships which the earlier PIXE study could not conclusively answer. Future research can then debate the question of where they obtained their livestock - north from Iron Age farmers or elsewhere from Khoi pastoralists? An earlier version of this work has already been published (Jacobson et al. 2002f).

4.7.4 The samples

Forty three samples from a range of sites were analysed. These included hunter-gatherer, pastoralist, Iron Age and Type R from a variety of geological substrates. The samples have been grouped according to the broader geological setting upon which they were found in order to develop a regional compositional signature. A major problem in achieving this could be the small number of samples as well as the diversity of the region. The samples and their geological substrate are set out in table 4.7.1.

A number of sediments associated with a number of the sites were also analysed in order to provide background geochemistry to which the sherds could be related. None were clays which is problematical as grain size plays a role in determining the concentrations of many traces in a sediment (Zhang et al. 2002). The data is presented in table A4.7.2. This data is problematical and it does not always relate to the chemistry of the sherds. For example, the data for the Nokanna sherd is quite at odds with the data for a sediment sampled near the site. It does demonstrate that caution is necessary when collecting non-clay sediments.

Table 4.7.1. List of sites from which sherds were obtained and the relevant geological substrate.

Nokanna	Olifantshoek Sequence
Kinderdam	Ventersdorp Supergroup andesite
Tlhame	Griqualand Sequence
Loch View	Karoo Supergroup: Ecca
Luka Jantjie Stad	Olifantshoek Sequence
Rooikop	Karoo Supergroup: Beaufort
Doornlaagte	Karoo Supergroup: Dwyka
Driekopseiland	Karoo Supergroup: Dwyka
Ramah	Karoo Supergroup: Ecca
Moirdale	Karoo Supergroup: Dwyka
Klipfontein	Karoo Supergroup: Dwyka
Witsand	Olifantshoek Sequence
Meidekop	Olifantshoek Sequence
Kathu Nature Reserve	Griqualand Sequence
Dithakong	? Volcanic
Omdraai	Griqualand Sequence

4.7.5 Statistical analysis

In addition to the forty three samples, seven inland Khoisan sherds previously dealt with in chapter 4.2 (three from Gordonia and four from the Karoo) were also used in the statistical analysis. These are labelled “Gordonia” and “Other Karoo” in figures 4.7.2 and 4.7.3, the plots of the first two and first and third axes of the statistical analysis. Twelve sherds were analysed as supplementary points. These were AK51 (Kinderdam: highly enriched in Cr), AK54-56 (Luka Jantjie: AK54 enriched in Fe_2O_3, AK55-56 depleted in K_2O), A29 (Dithakong: highly enriched in Cr), A8 (Klipfontein: enriched in Fe_2O_3), A10 (Klipfontein: enriched in Mn) as well as the four “Other Karoo” (2 x Carnavon, Beaufort West and Victoria West).

The analysis shows a definite clustering of the sherds. I have delineated the three main clusters with ellipses. These have no statistical meaning, merely serving to emphasis them for the purpose of discussion. Cluster A covers all the Karoo sherds. It overlaps with the ‘Gordonia’ sherds (Cluster C). The problem is that the exact location from whence these sherds were collected is not known. They may very well come from a Karoo substrate. There is also an apparent overlap with three other sherds. The Griqualand Sequence sherd is from Kathu whilst the two Olifantshoek sherds are A54, Luka Jantjie (the upper) and AK50, Nokanna (the lower). On the third axis (figure 4.7.3), these three definitely pull away from cluster A. They might, therefore, be an extension of Cluster B although I did not include them in the ellipse. The other outliers represent AK52, Tlhame and the other supplementary points listed above.

4.7.6 Conclusions

In my previous publication of this data (Jacobson et al. 2002f) I had interpreted the Nokanna sherd as an import from the Type R area. I am not so sure of this now and would prefer a more conservative interpretation until further samples can be analysed. Whether the variability of the Luka Jantjie sherds are a reflection of local clay variability or reflect some, at least, non-local sherds will need to await further research. Certainly, as a mid-19th century site which was probably involved in the Tswana resistance to colonialism, there may have been a substantial movement of people in and out of the site together with their belongings (Snyman 1992).

To conclude, it is likely that clusters A and B define regional compositional profiles but further work will be needed to confirm this.

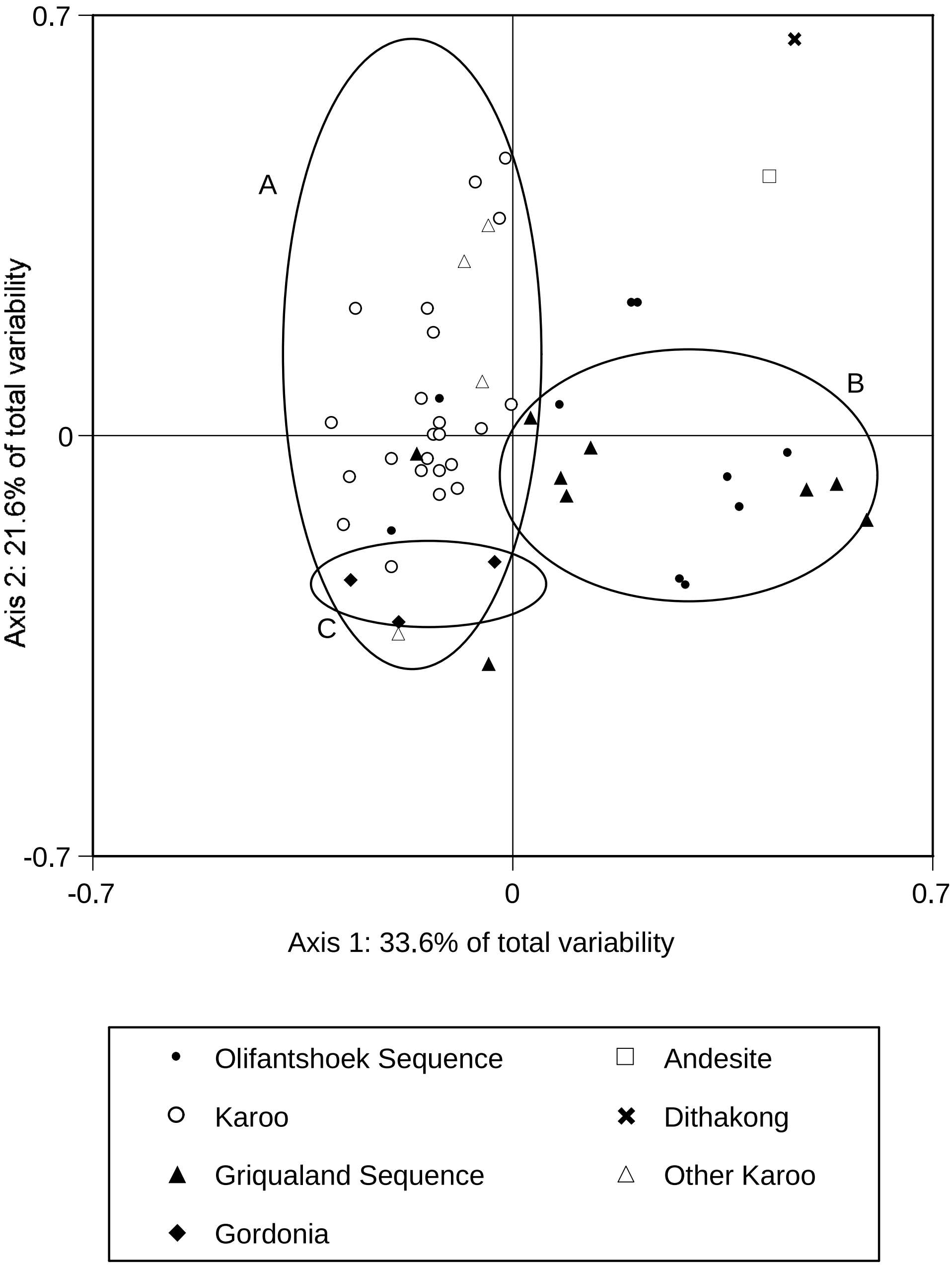

Figure 4.7.2. Plot of the first two axes for the Northern Cape sherds. Note that the ellipses have no statistical function but serve merely to delineate apparent groups more clearly.

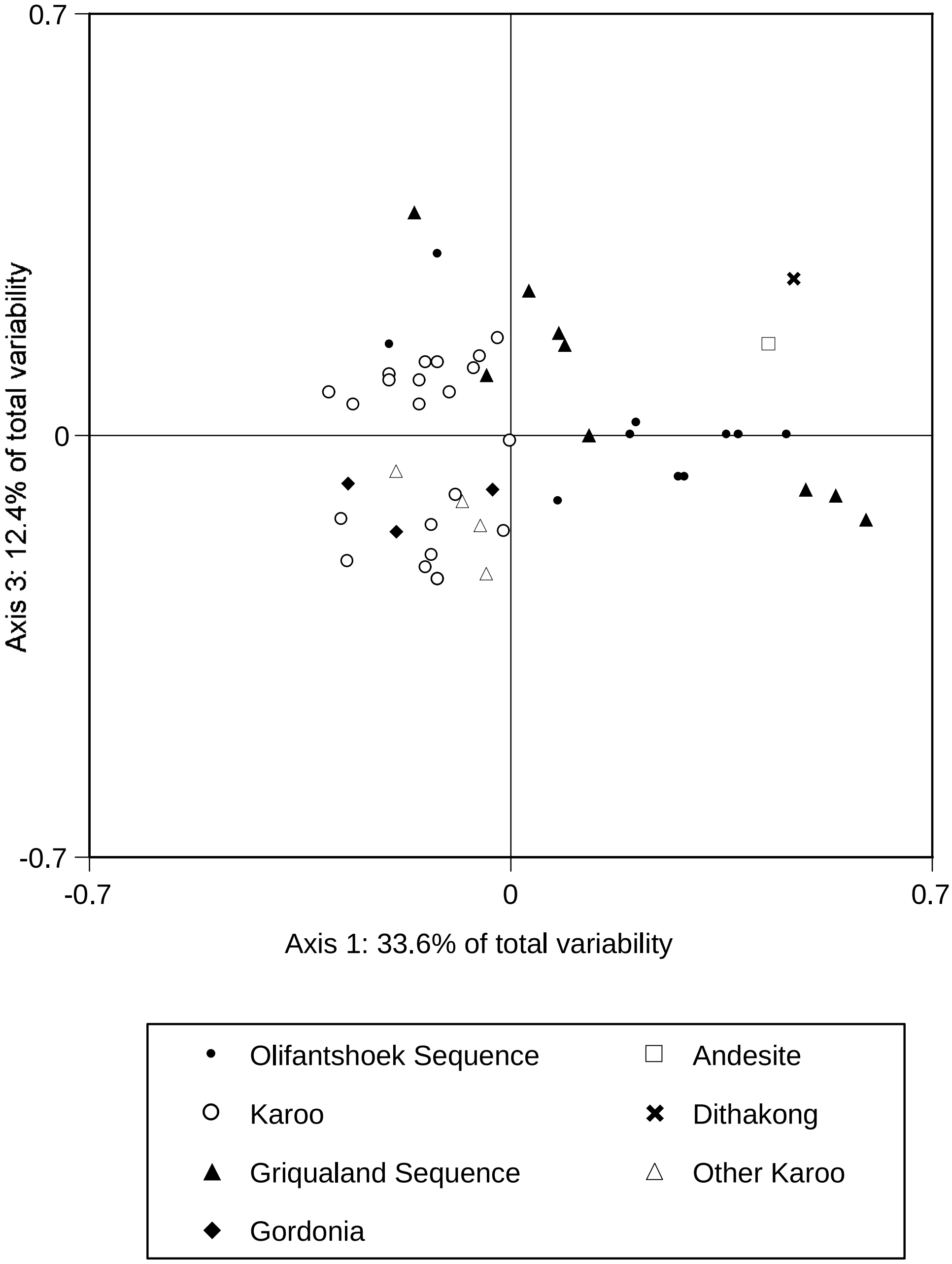

Figure 4.7.3. Plot of the first and third axes for the Northern Cape sherds.

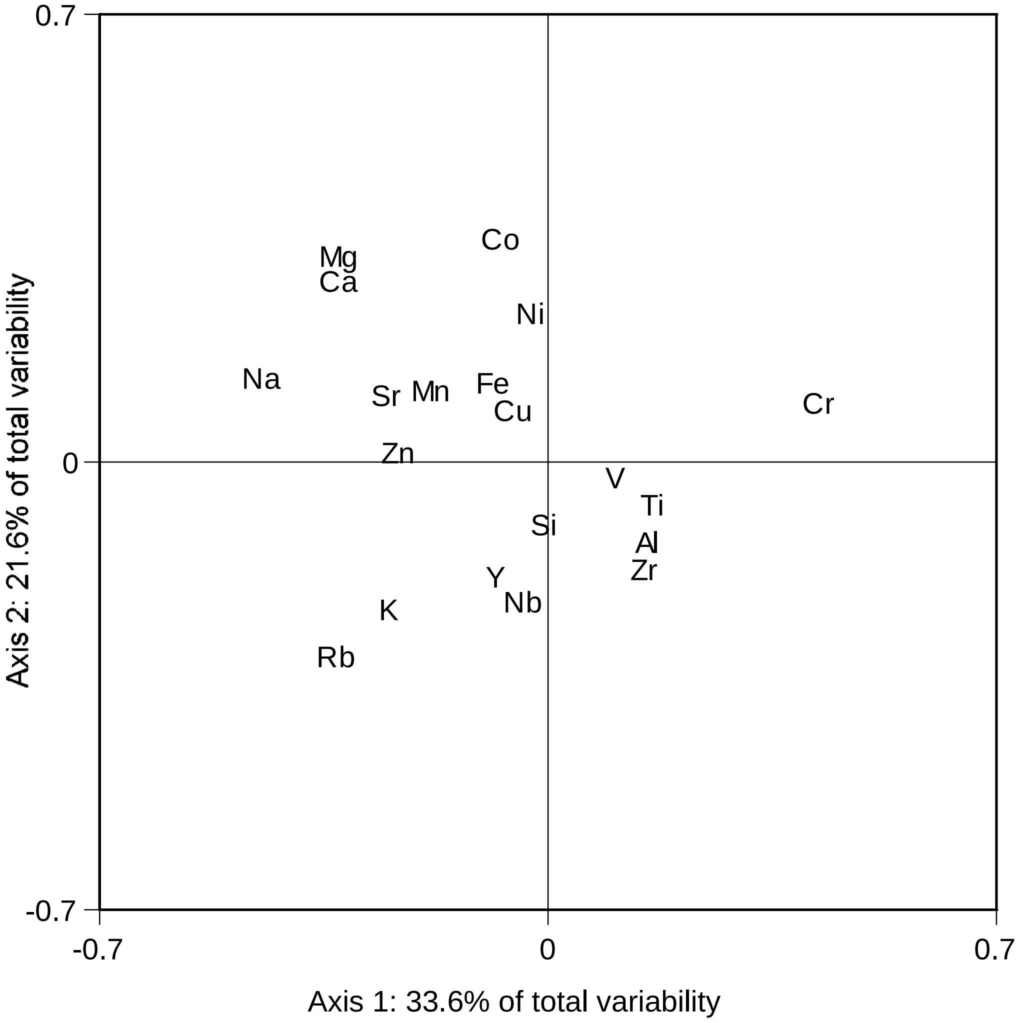

Figure 4.7.4. Plot of the first two axes of the element loadings.

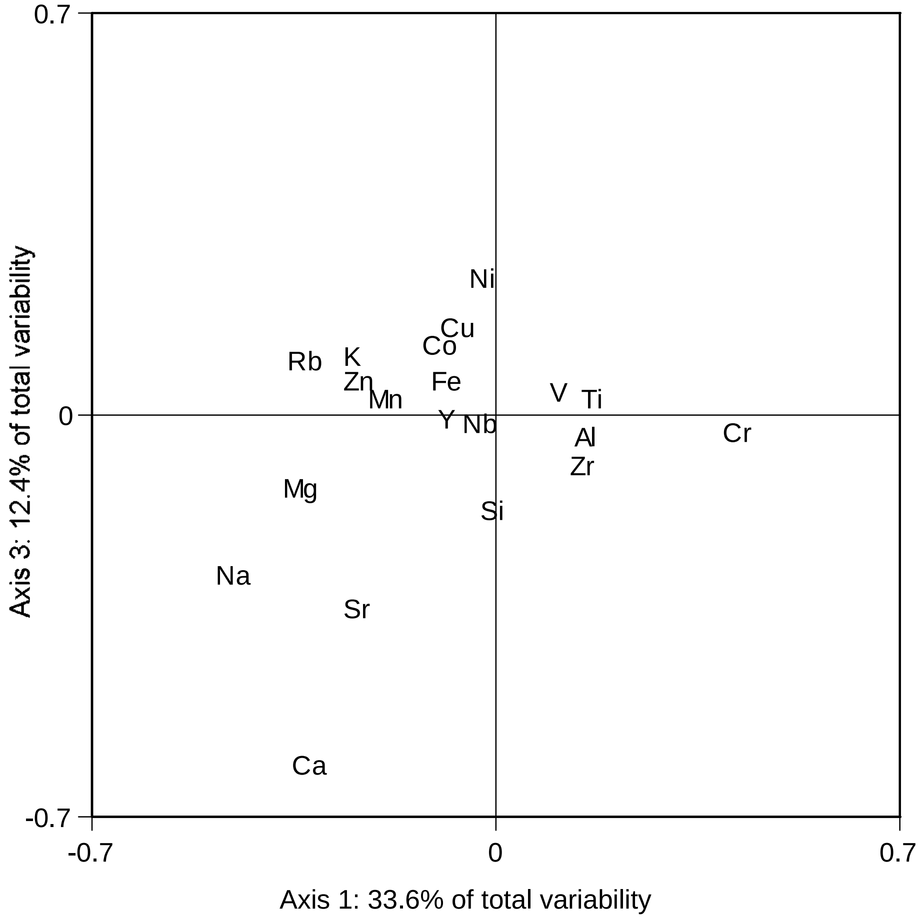

Figure 4.7.5. Plot of the first and third axes of the element loadings.

CHAPTER 5 CONCLUSIONS

There can be no doubt that provenancing pottery can make a substantial contribution to the archaeological interpretation and reconstruction of the past. Although a number of the case studies presented contribute more technical information than archaeological interpretation, they indicate the potential for future research. There are, however, a number of issues that need to be dealt with. I list these in no particular order below.

5.1 THE CASE STUDIES

The case studies presented above are a rather mixed bag in terms of results but they have clearly demonstrated that geochemically non-local sherds can be identified. The best case study, of course, is that of Mutokolwe. It is the best not simply because of analytical precision or any other technical aspect (which are always good) but because the archaeology is good. A well dated, well excavated site where the pottery can be locally provenanced to specific features on site, the provision of sherds which can be attributed to specific phases or facies of the Iron Age sequence all make for a result which can make an important and relevant contribution. Next would be the Limpopo Valley sites which deal with a critically important period in the archaeological past. The only flaw in this study is the lack of feature provenanced sherds rather than a random selection. There is no point, however, in compiling a score card. The point I wish to make is that when I started this project, I had to take what was available for analysis. I think that subject to the recommendations below, the analyst can now show that there is a place for provenance studies in pottery and that a properly integrated study is the best way to go. This does not mean that research into museum collections is of no use. They can provide comparative data but more samples need to be analysed than just the handful used until now.

5.2 RECOMMENDATIONS

5.2.1 What elements to use?

A question often heard at archaeometry conferences revolves around the issue of which elements one should be analysing. There are two issues here. One concerns diagenesis and other forms of contamination which can occur to a sherd. This has been dealt with in chapter 2. The second issue concerns which elements are likely to be the most useful in discriminating between several different clay sources. This is more difficult to answer. The obvious one is “use them all”. The real answer is that it all depends upon the analytical method. Some methods provide a greater precision for certain elements than other methods. Again, is it really necessary to analyse for everything when a number of elements are strongly correlated with each other such as K_2O/Rb and CaO/Sr? Table 5.1 presents summary statistics for the entire data set used in this thesis as well as other relevant data for Southern African pottery. The coefficient of variation (CV) values for these elements is most interesting. The least variable element is SiO_2 with a CV of 8%. There does not seem to be much point in analysing for this element as its variability is so low. Al_2O_3 is also low at 18%. These figures are probably related to the nature of a clay’s composition.

The most variable elements Cr and Ni with a CV of 124% and 127% respectively. P_2O_5 was omitted from this table as it is related to diagenesis (see Chapter 2: table 2.9). It would seem that all the other elements used in this study contribute something to defining a compositional profile.

With regards the close correlation between certain elements, the absolute values are important not just the ratios. Figure 5.1 illustrates this for CaO/Sr and K_2O/Rb. It is therefore not practical to omit one of the pair.

It would seem that the more elements measured, the more precise the provenance is likely to be. It would certainly be of interest to include rare earths and perhaps even isotopes to characterise clays as this would give an indication of *their* source. This is particularly relevant when working with the otherwise very similar Khoisan coastal or inland pottery.

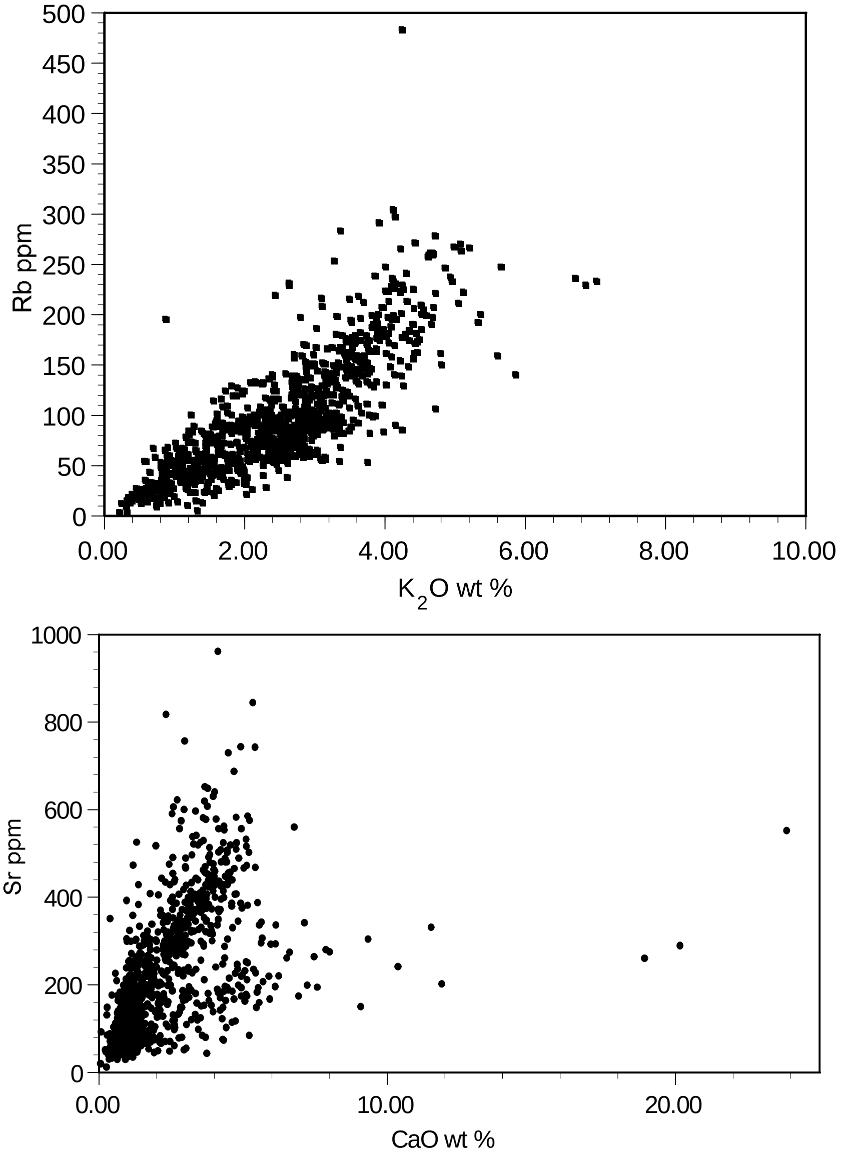

Figure 5.1. Biplots of K_2O and Rb (above) and CaO and Sr (below).

Table 5.1. Summary statistics for the complete data set. This includes data from analyses not used in this thesis as well as from other relevant publications. Only pottery data from southern Africa (e.g. South Africa, Namibia, Zimbabwe, Lesotho and Botswana) was used. All data was first normalised to 100%, volatile and P_2O_5 free.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O
n	1287	1287	1287	1287	1287	1287	1287	1287	1287
Min	44.14	0.13	3.75	1.51	0.00	0.03	0.09	0.00	0.22
Max	90.24	5.43	35.87	33.69	1.00	19.53	23.90	5.17	7.02
Mean	67.88	0.93	16.38	7.10	0.08	1.68	2.22	1.17	2.56
SD	5.59	0.47	3.01	2.78	0.07	1.44	1.75	0.72	1.18
CV%	8	51	18	39	88	86	79	62	46

	Rb	Sr	Y	Zr	Nb	Cu	Ni	Zn	V	Cr	Co
n	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287
Min	3	3	0	11	0	0	5	1	12	0	1
Max	483	959	608	1426	221	231	1200	276	2503	3091	348
Mean	99.9	215.9	27.7	251.0	14.6	34.9	70.8	59.9	137.9	215.0	24.8
SD	62.8	140.4	26.4	118.8	15.1	28.8	89.7	32.2	101.3	265.6	23.6
CV%	63	65	95	47	103	82	127	54	74	124	95

5.2.2 The role of clays in provenance studies

A frequent criticism at conferences is that no clays were analysed together with sherds from a site. It is felt that an understanding of these is critical in the provenance process. Few clays were analysed by myself in the case studies although sediments were collected in a number of cases. Clays are important. The variability of individual clay bodies as well as between clays in the vicinity of a site is important in understanding the meaning of variability in pottery geochemistry. However, it can be a huge task to prospect for clays especially to obtain completion so there is no easy answer to this problem. Sediments are also not the complete answer as they are too coarse (Zhang et al. 2002). Again, although I demonstrated a close fit between the clays and pottery of Mrs Mokoena these were fresh pots, they had not been used or discarded. Whether one can show a direct link between a clay and a used and buried sherd needs investigating under South African conditions. Many Iron Age sherds are buried in ashy middens and the effects of these conditions needs to be investigated.

As a last resort, one can also use a knowledge of local geology to infer what to expect in the way of a compositional profile. You would not expect high Cr values in the western Cape, for example. It is also a matter of common sense. If one has a great deal of variability in the geochemistry of potsherds from one site, the question must be asked as to how varied can the local clay sources be. Some of this variability must come from non-local pottery. Of course, it is also better to err on the conservative side rather than make inflated claims about trade.

5.2.3 Use of a reference material

It is recommended that all laboratories carrying out provenance studies use a common Reference Material (preferably SARM 69) against which to calibrate data so that results from different laboratories can be used interchangeably. This is particularly important when different analytical methods are used. This will also enable a database South African wide database to be established. Duplicate specimens and left over samples should also be curated for future re-examination.

5.2.4 Sampling methodologies

This is one of the crucial areas. I have already discussed this in some detail in chapter 3. It is apparent from the case studies that it is more relevant to do an intensive study on one site that run a few samples from a number of sites. It is important to pick up the total range of variability present particularly if non-local sherds are likely to have a low frequency representation. This cannot be detected from a visual analysis of a sherd whether decorated or not. It is also preferable to analyse sherds that come from carefully excavated sites so as to maximise the interpretive value of the geochemical data.

5.2.5 Ethno-archaeological research

There are still a few individuals in rural areas who are making pottery the traditional way. It is important to carry out detailed studies on their techniques before the knowledge is lost. Understanding clay choices and preparation, tempering, use and discard are important to a better understanding of the archaeological data. It would also be useful to conduct a provenance study on pots and clays where the sources and uses are known and to then work backwards in time in the same area to measure whether there were any changes in clay utilisation over time.

5.2.6 Integration of compositional analysis in archaeology

There is a strong need for archaeologists to be aware of the potential of provenancing and other studies and for them to integrate this into their research programs particularly when they are in the field. They can assist by consulting local communities or individuals where possible about pot making traditions, collecting vessels and sherds in current use as well as taking a selection of clay samples from the vicinity of their sites (even if chosen on geological grounds only). These can then be curated together with the excavated site materials until needed.

5.2.7 Choice of techniques

This study was carried out by XRF. It is a readily available technique that delivers precision data and has a well established methodology. Other methods are equally acceptable. The microprobe is problematical when what is needed are data from a bulk sample as has been demonstrated above. It is useful, however, for specific problems relating to contamination and diagenesis and for investigating the composition of specific grains in a clay matrix (e.g., temper) and in this manner can play a useful role in provenancing a sherd. Thin section analysis is also a valuable tool that can play a greater role in identifying minerals, rock fragments and other inclusions which could prove to be a provenance aid.

5.2.8 Defining “non-local”

What still needs to be unequivocally defined is the meaning of “non-local” or “imported” or even “local”. How far away does a clay body need to be before it can be labelled “non-local”? Arnold (1985) has said in his world wide survey that many potters travel up to 7 km away from home to obtain clay but many do not travel further than 1 km. These definitions need to be cautiously used and clearly defined.

5.2.9 Choice of study area

Finally and perhaps most importantly for future research, the choice of a study area. Based on the research above, it is apparent that there are better study areas than others. The best place for a provenance study is in a region with a varied geology or at the borders of two geochemically dissimilar geologies. The Soutpansberg and the Limpopo Valley are two such places but there are others. Problematic areas are the Cape coastal and the Karoo where one has large widespread uniform geological formations with little internal geochemical variability, based on present knowledge of course. This does not mean, however, that research attention should not be paid to these areas. It will be necessary to develop other means to provenance pottery from these places.

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APPENDICES

SARM 69

CERTIFICATE OF ANALYSIS CERAMIC-1 SARM 69

CERTIFIED REFERENCE MATERIAL

Prepared by and Distributed by:

MINTEK
P/Bag X3015
Randburg 2125
Republic of South Africa

Department of Geology
University of the Free State
PO Box 339
Bloemfontein 9300

1. STATUS OF CERTIFICATE

This is the first issue of the certificate.

2. DATE OF ORIGINAL CERTIFICATION

November 2000

3. AVAILABILITY OF OTHER SIZES OF THE MATERIAL

Only 100 g units of the powdered material are available.

4. SOURCE OF THE MATERIAL

The material was supplied by the McGregor Museum.

5. DESCRIPTION OF THE MATERIAL

Clay potsherd material originating from an iron age site situated in the Orange Free State. There are three mineral phases present, i.e. quartz (SiO_2), feldspar ($CaAl_2Si_2O_8$) and muscovite ($KAl_2(Si_3Al)O_{10}(OH)$).

6. INTENDED USE

As a control sample in the analysis of samples of a similar type.
Verification of analytical methods for ceramics.
As a reference material for the calibration of equipment used for analysing similar materials.

7. STABILITY, TRANSPORTATION AND STORAGE INSTRUCTIONS

Care must be taken to avoid undue vibration, since this could cause segregation within the container.

8. INSTRUCTIONS FOR THE CORRECT USE OF THE MATERIAL

The material should be well mixed and dried at 110°C for over night (see label) before sub-samples are taken. Sub-samples of 0,2 g mass were taken for homogeneity testing, therefore homogeneity cannot be guaranteed on smaller sub-samples.

9. METHOD OF PREPARATION OF THE REFERENCE MATERIAL

Approximately 80 kg of material was reduced in particle size until 95,7% was less than 83,4μm. For full details of the comminution procedure see 17.

10. STATE OF HOMOGENEITY

The material has been shown to be of sufficient homogeneity for its purpose (see 6). See 17 for a full description of the tests carried out as a check on the homogeneity of the material.

11. CERTIFIED PROPERTY VALUES AND CONFIDENCE LIMITS

SARM 69. 95 % Confidence Limits

Constituent	Certified value %	Low	High
SiO_2	66,6	66,1	67,1
Al_2O_3	14,4	14,2	14,5
TOTAL Fe as Fe_2O_3	7,18	7,10	7,25
CaO	2,37	2,33	2,41
K_2O	1,96	1,92	2,00
MgO	1,85	1,83	1,88
MnO	0,129	0,127	0,132
TiO_2	0,777	0,769	0,785

	Certified value mg/kg	Low	High
Ba	518	499	537
Cr	223	215	230
Zn	68	65	70
Ni	53	51	54
Cu	46	43	48
Co	28	27	29
Sc	20	19	21

NOTES:

1. All values (including uncertified values) relate to the dried (110°C) material.
2. The Certified Value is an estimate of the " true " value based upon the best available data at the time of the certification.
3. The 95% Confidence Interval for the Certified Value is the range of values having a 95% chance of containing the certified value, should the certification program be repeated an infinite number of times.
4. The precision of the user's proposed analytical method must be taken into account when using this reference material.

12. TENTATIVE / PROVISIONAL PROPERTY VALUES

Determinant	Tentative value %
Loss on Ignition	3,6
Na_2O	0,79
P_2O_5	0,28

	Tentative value mg/kg
Zr	271
TOTAL V	157
Sr	109
Ce	67
Rb	66
Nd	30
Y	29
Pb	14
Nb	9
Th	9

13. VALUES OBTAINED BY INDIVIDUAL LABORATORIES

Nineteen laboratories in nine countries submitted analytical results on this material. See 17 for all the results.

14. MEASUREMENT TECHNIQUES USED FOR THE CERTIFICATION

Among the techniques used by the contributing laboratories were the following:

Atomic absorption spectrophotometry
Gravimetric analysis
ICP Mass spectrometry
Neutron activation analysis

Optical emission spectroscopy with ICP source
Volumetric analysis
X-ray fluorescence spectrometry

Sample dissolution was mainly by acid digestion or fusion. For further details of the techniques see 17

15. TREATMENT OF THE NUMERICAL VALUES

Statistical tests were used to identify outlying results which were then removed from the main population of results. Estimators of central tendency were then calculated and the most appropriate were assigned as the certified value. For full details of the statistical treatment of the analytical data see 17.

16. COLLABORATING LABORATORIES

Australia	
Amdel Laboratories Limited	Torrensville
General Laboratories Services Pty Ltd	Gosnells
Canada	
Slow Poke Reactor Facility	Toronto
Czech Republic	
Geological Survey Prague	Barrandov
France	
Bureau de Recherches Geologiques & Minieres	Orleans
Germany	
Freie University of Berlin	Berlin
GMBH	Hohr - Grenzhausen
United Kingdom	
Alfred H Knight	Mersyside
The Open University	Milton Keynes
United States of America	
University of Missouri	Missouri
South Africa	
Council for Geoscience	Pretoria
University of Cape Town Geol. Sciences	Cape Town
University of Natal	Natal
University of OFS, Dept Geology	Bloemfontein

Mintek	Randburg
Setpoint (B&B Laboratories)	Bedfordview

17. REFERENCES

Marsland S.A., Hansen R, Oosthuyzen, J. THE PREPARATION AND CERTIFICATION OF A CLAY CERTIFIED REFERENCE MATERIAL. Randburg, 2001.

This report is available from MINTEK, Private Bag X3015, Randburg 2125, Republic of South Africa.

18. NAME OF CERTIFYING OFFICER

Dr D Groot, Manager, Analytical Science Division, MINTEK.

Table A2.1. Data for the Roosfontein sherds.

	r1	r2	r3	r4	r5
SiO_2	48.36	55.98	48.36	66.23	48.33
TiO_2	1.23	0.99	1.24	0.58	1.24
Al_2O_3	17.65	15.30	17.46	13.03	17.34
Fe_2O_3	12.05	7.60	11.87	4.96	11.42
MnO	0.11	0.07	0.10	0.31	0.09
MgO	1.26	2.83	1.21	0.77	1.24
CaO	2.36	3.56	2.40	0.94	2.23
Na_2O	0.62	1.00	0.63	0.42	0.65
K_2O	1.24	1.80	1.21	3.44	1.31
P_2O_5	2.49	1.06	2.13	0.95	2.04
H_2O-	4.79	3.28	4.49	1.91	4.77
LOI	7.61	6.15	8.58	6.25	9.00
TOTAL	99.77	99.62	99.68	99.79	99.66
Rb	24	34	23	82	22
Sr	130	136	136	131	117
Y	20	17	21	21	21
Zr	192	177	190	248	190
Nb	6	7	6	8	5
Cu	75	49	74	25	75
Ni	60	62	57	35	56
Zn	79	101	72	68	74
V	366	191	370	95	382
Cr	427	433	431	120	427
Co	61	43	57	29	51

r1	Roosfontein
r2	Roosfontein
r3	Roosfontein
r4	Roosfontein
r5	Roosfontein

Table A3.1. Data for multiple measurements on the Messum pot.

	KM2	KM3	KM4	KM5	KM6	KM7	KM8	KM9	KM10	KM11
SiO_2	62.58	61.85	61.31	61.93	60.59	60.99	61.48	59.97	60.69	61.44
TiO_2	0.68	0.69	0.68	0.67	0.67	0.68	0.68	0.68	0.67	0.69
Al_2O_3	18.30	17.90	18.23	18.02	18.27	18.01	18.11	17.96	17.99	18.36
Fe_2O_3	5.63	5.60	5.68	5.60	5.56	5.73	5.72	5.96	5.94	5.82
MnO	0.07	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06
MgO	1.34	1.32	1.30	1.35	1.23	1.23	1.26	1.23	1.22	1.24
CaO	0.95	0.97	0.95	1.03	0.84	0.93	0.88	0.86	0.84	0.91
Na_2O	2.47	2.48	2.58	2.36	2.35	2.23	2.30	2.30	2.42	2.40
K_2O	4.92	4.99	4.77	4.88	4.35	4.42	4.41	4.37	4.35	4.45
P_2O_5	0.23	0.28	0.26	0.29	0.21	0.22	0.22	0.20	0.20	0.21
H_2O-	0.69	0.70	0.71	0.77	0.58	0.83	0.61	0.65	0.84	0.75
LOI	2.84	3.34	3.59	3.86	5.03	5.02	5.11	6.07	5.76	4.42
TOTAL	100.70	100.18	100.12	100.82	99.75	100.35	100.84	100.31	100.98	100.75
Rb	270	266	267	263	259	261	261	259	257	261
Sr	87	89	84	93	76	81	78	75	75	80
Y	49	48	48	48	45	48	46	47	47	47
Zr	154	152	155	155	151	153	152	149	151	152
Nb	39	38	40	38	37	38	37	36	37	38
Cu	13	13	11	10	11	9	8	11	13	10
Ni	36	35	36	35	35	34	36	36	38	36
Zn	82	80	81	80	77	77	76	75	75	77
V	120	117	116	119	122	119	122	124	123	118
Cr	94	81	95	85	90	94	93	91	109	100
Co	14	16	11	12	13	13	12	11	10	11

KM2	base
KM3	base
KM4	mid
KM5	base
KM6	rim
KM7	mid
KM8	rim
KM9	mid
KM10	mid
KM11	mid 19gms

Table A3.1 continued.

	KM12	KM13	KM14	Average	sd	CV
SiO_2	60.81	60.6	61.51	61.21	0.70	1.14
TiO_2	0.68	0.68	0.68	0.68	0.01	0.94
Al_2O_3	18.09	18.05	18.27	18.12	0.15	0.82
Fe_2O_3	5.87	5.75	5.68	5.73	0.13	2.27
MnO	0.06	0.06	0.06	0.06	0.00	6.10
MgO	1.20	1.22	1.24	1.26	0.05	3.97
CaO	0.83	0.93	0.91	0.91	0.06	6.47
Na_2O	2.44	2.27	2.20	2.37	0.11	4.61
K_2O	4.41	4.40	4.47	4.55	0.24	5.29
P_2O_5	0.20	0.21	0.22	0.23	0.03	13.39
H_2O-	0.61	0.75	0.64	0.70	0.08	11.86
LOI	5.46	5.20	4.68	4.64	0.98	21.07
TOTAL	100.66	100.12	100.56	100.47	0.36	0.36
Rb	261	259	260	261.85	3.72	1.42
Sr	75	78	80	80.85	5.81	7.19
Y	47	46	47	47.15	1.07	2.27
Zr	152	152	151	152.23	1.69	1.11
Nb	38	37	37	37.69	1.03	2.74
Cu	11	9	9	10.62	1.66	15.64
Ni	39	35	35	35.85	1.34	3.75
Zn	77	78	76	77.77	2.28	2.93
V	126	121	120	120.54	2.85	2.36
Cr	115	93	93	94.85	9.00	9.49
Co	15	13	13	12.62	1.71	13.55

KM12	mid 10gm
KM13	mid 50gm
KM14	mid 38gm

Table A4.2.1. Data for the suite of Khoisan coastal pottery. All samples in this table are from the collection made, numbered and published by J. Rudner (1968). See text for further details.

Sample	WC16	WC38	WC62	WC63	WC64	WC82	WC96	WC97	WC145	WC146
SiO_2	50.82	68.64	54.69	65.40	66.83	61.89	66.88	60.52	59.42	70.06
TiO_2	1.71	1.31	0.66	0.62	0.66	0.91	0.28	0.98	1.35	0.35
Al_2O_3	14.32	13.47	19.52	13.82	13.42	14.52	14.16	15.69	14.05	14.91
Fe_2O_3	10.05	5.17	6.04	5.31	4.51	4.64	3.42	6.68	7.71	4.21
MnO	0.13	0.08	0.06	0.08	0.07	0.04	0.05	0.08	0.13	0.05
MgO	4.41	0.97	1.22	0.84	1.44	1.23	0.61	1.96	2.12	1.07
CaO	4.59	1.25	2.48	0.96	1.81	2.37	0.85	1.95	2.13	0.66
Na_2O	1.74	1.16	2.15	0.90	1.66	2.09	0.70	1.81	1.58	1.18
K_2O	3.90	3.85	4.53	4.49	3.65	4.42	3.35	3.66	3.25	3.23
P_2O_5	0.38	0.16	0.21	0.14	0.27	0.13	0.31	0.17	0.20	0.14
H_2O-	1.41	0.55	1.26	1.27	1.06	0.70	1.83	1.54	1.31	1.21
LOI	6.02	2.99	6.72	6.21	4.15	6.27	6.94	4.27	6.21	3.19
TOTAL	99.48	99.60	99.54	100.04	99.53	99.21	99.38	99.31	99.46	100.26
Rb	483	223	233	246	194	161	152	291	172	283
Sr	220	195	272	124	198	588	102	155	220	128
Y	159	68	162	50	35	18	31	28	34	95
Zr	279	456	324	366	198	392	195	202	221	206
Nb	56	31	30	19	21	24	7	25	18	12
Cu	16	8	11	23	22	7	6	55	37	13
Ni	46	18	22	17	19	9	10	30	33	21
Zn	233	67	107	49	40	29	26	69	168	38
V	214	79	53	65	81	277	44	145	181	54
Cr	105	54	67	72	76	96	49	105	96	76
Co	29	16	7	8	11	10	7	16	21	9

Sample No	Rudner Site No	Site
WC16	12	Port Nolloth
WC38	12	Port Nolloth
WC62	12	Port Nolloth
WC63	12	Port Nolloth
WC64	12	Port Nolloth
WC82	12	McDougall Bay
WC96	12	Port Nolloth
WC97	12	Port Nolloth
WC145	12	Port Nolloth
WC146	12	Port Nolloth

Table A4.2.1 continued.

Sample	WC1	WC75	WC30	WC55	WC71	WC22	WC44	WC45	WC61	WC66
SiO_2	60.48	64.15	78.52	71.56	61.12	70.20	76.23	83.17	61.26	60.56
TiO_2	0.79	0.72	0.41	0.47	0.74	0.68	0.29	0.39	0.50	0.43
Al_2O_3	12.82	12.62	9.84	13.95	14.84	12.93	6.94	9.89	15.46	15.72
Fe_2O_3	7.73	5.76	2.86	3.74	6.90	3.88	3.53	3.09	4.40	4.66
MnO	0.09	0.06	0.05	0.03	0.08	0.03	0.06	0.04	0.05	0.05
MgO	1.78	1.94	0.44	0.61	1.74	0.80	0.61	0.71	0.56	0.87
CaO	2.63	1.55	0.70	0.41	1.10	1.13	0.43	0.41	0.36	0.65
Na_2O	1.03	1.08	0.24	0.11	0.71	0.54	0.75	0.20	0.65	0.60
K_2O	2.41	3.15	0.80	0.82	3.43	1.86	0.74	0.72	3.91	2.47
P_2O_5	0.15	0.17	0.51	0.39	0.17	0.07	0.07	0.14	0.17	0.13
H_2O-	1.46	2.27	1.90	3.50	1.87	1.78	1.38	0.30	2.52	1.61
LOI	7.95	6.21	3.98	5.03	7.20	5.43	9.65	1.61	9.38	11.83
TOTAL	99.32	99.68	100.25	100.62	99.90	99.33	100.68	100.67	99.22	99.58
Rb	100	154	31	46	164	77	22	58	175	153
Sr	170	182	87	51	133	126	30	69	86	181
Y	24	18	13	17	21	30	6	20	19	18
Zr	316	232	233	172	187	329	173	216	238	268
Nb	16	13	6	6	13	11	3	7	12	13
Cu	39	14	4	2	10	4	5	4	3	5
Ni	37	30	11	14	31	27	12	14	13	9
Zn	72	62	14	19	64	28	11	17	28	41
V	165	132	60	80	128	104	58	63	62	52
Cr	197	119	68	95	106	110	92	75	56	37
Co	20	16	10	9	14	11	7	9	8	8

Sample No	Rudner Site No	Site
WC1	13	Kleinsee
WC75	18	Lamberts Bay
WC30	19	Van Puttens Vlei
WC55	19	Van Puttens Vlei
WC71	19	Van Puttens Vlei
WC22	20	Elands Bay
WC44	20	Elands Bay
WC45	20	Elands Bay
WC61	23	Berg River
WC66	24	St Helena Bay, Sandy Point

Table A4.2.1 continued.

Sample	WC21	WC37	WC83	WC84	WC85	WC88	WC89	WC90	WC47	WC67
SiO_2	61.99	67.98	65.41	64.65	62.47	62.41	64.37	68.73	67.30	68.49
TiO_2	0.51	0.39	0.44	0.44	0.45	0.50	0.53	0.42	0.39	0.49
Al_2O_3	17.24	13.71	15.51	16.11	14.32	17.61	14.51	14.15	14.63	15.08
Fe_2O_3	4.67	4.68	4.64	4.46	5.12	5.30	5.04	5.06	4.16	4.57
MnO	0.02	0.05	0.04	0.04	0.05	0.04	0.04	0.06	0.04	0.05
MgO	0.84	1.40	0.70	0.63	1.37	0.87	0.95	0.92	0.76	0.83
CaO	1.10	0.71	1.21	1.15	1.16	1.33	1.15	0.64	0.93	1.25
Na_2O	0.91	0.78	0.81	1.49	0.72	0.85	0.93	0.72	1.13	1.60
K_2O	2.58	2.48	2.68	3.47	2.91	2.61	3.41	2.41	3.26	3.32
P_2O_5	0.12	0.05	0.08	0.10	0.11	0.37	0.06	0.05	0.08	0.06
H_2O-	2.58	1.44	2.75	2.71	1.85	2.64	1.98	1.22	2.66	1.06
LOI	7.13	5.40	4.99	4.15	8.53	5.00	6.52	5.38	3.71	2.51
TOTAL	99.69	99.07	99.26	99.40	99.06	99.53	99.49	99.76	99.05	99.31
Rb	135	132	151	170	135	170	133	141	162	144
Sr	156	107	261	210	135	270	218	94	141	83
Y	6	31	20	17	26	24	28	33	23	13
Zr	180	192	186	203	134	131	202	196	175	139
Nb	10	9	12	12	9	14	13	9	10	7
Cu	4	6	3	2	5	4	5	9	3	1
Ni	9	13	8	7	18	12	15	14	9	10
Zn	29	25	29	28	40	36	31	26	26	26
V	66	61	59	55	81	63	97	63	51	65
Cr	57	50	50	31	115	48	78	66	41	64
Co	11	7	9	6	11	10	8	12	6	8

Sample No	Rudner Site No	Site
WC21	25	Stompneus Bay
WC37	25	Stompneus Bay
WC83	25	Stompneus Bay
WC84	25	Stompneus Bay
WC85	25	Stompneus Bay
WC88	25	Stompneus Bay
WC89	25	Stompneus Bay
WC90	25	Stompneus Bay
WC47	26	Britannia Point
WC67	26	Britannia Bay

Table A4.2.1 continued.

Sample	WC70	WC87	WC69	WC78	WC39	Kb40	WC40	Kb40	Kb40	WC74
SiO_2	65.12	60.11	64.77	66.25	67.28	64.79	64.53	66.73	62.39	59.89
TiO_2	0.45	0.51	0.48	0.65	0.39	0.41	0.55	0.45	0.54	0.44
Al_2O_3	14.16	16.68	15.10	13.94	13.00	13.75	14.74	14.38	14.60	16.25
Fe_2O_3	4.02	5.06	5.11	5.98	4.10	4.41	5.26	4.89	4.72	5.01
MnO	0.05	0.06	0.05	0.05	0.04	0.02	0.05	0.03	0.05	0.05
MgO	0.63	1.66	0.91	1.11	0.98	0.72	0.66	0.55	1.43	1.06
CaO	1.49	1.44	1.10	0.85	0.69	1.06	0.72	1.00	2.08	0.88
Na_2O	1.47	1.19	1.44	0.70	0.96	0.98	0.88	1.67	1.73	1.00
K_2O	2.96	3.34	3.40	2.67	3.31	3.97	2.84	4.07	3.44	3.96
P_2O_5	0.08	0.15	0.14	0.05	0.35	0.29	0.79	0.23	0.38	0.42
H_2O-	1.39	1.88	1.68	1.41	1.99	2.13	3.59	1.80	1.42	1.42
LOI	7.76	7.59	5.19	6.39	6.55	7.85	5.14	3.77	5.87	9.17
TOTAL	99.58	99.67	99.37	100.05	99.64	100.38	99.75	99.57	98.65	99.55
Rb	134	159	150	93	156	156	143	148	143	162
Sr	198	191	170	169	88	142	104	137	169	390
Y	9	45	49	15	33	28	10	32	38	62
Zr	188	200	188	284	245	186	267	240	251	263
Nb	11	13	13	11	10	9	13	10	12	16
Cu	2	2	5	6	3	7	7	12	10	5
Ni	8	12	12	21	7	9	11	11	13	14
Zn	30	43	43	29	33	34	60	47	52	37
V	51	57	55	115	48	49	68	52	71	55
Cr	33	47	36	92	28	47	46	44	55	52
Co	7	10	13	8	8	8	4	7	7	13

Sample No	Rudner Site No	Site
WC70	26	Britannia Point
WC87	26	Britannia Bay
WC69	27	St Martins Point
WC78	28	Paternoster salt pan
WC39	29	Kasteelberg
Kb40	29	Kasteelberg
WC40	29	Kasteelberg
Kb40	29	Kasteelberg
Kb40	29	Kasteelberg
WC74	30	West Bay

Table A4.2.1 continued.

Sample	WC53	WC76	WC79	WC81	WC93	WC94	WC95	WC46	WC49	WC36
SiO_2	58.55	65.89	64.66	69.98	58.11	57.88	67.80	63.05	62.88	63.28
TiO_2	0.22	0.54	0.27	0.40	0.68	0.48	0.46	0.42	0.42	0.40
Al_2O_3	17.28	13.81	15.62	13.29	15.17	15.52	14.70	14.35	15.50	14.11
Fe_2O_3	4.01	5.69	4.36	4.23	5.88	4.70	3.94	4.81	4.97	4.32
MnO	0.03	0.06	0.04	0.05	0.04	0.05	0.02	0.04	0.06	0.04
MgO	0.63	1.44	0.65	0.70	1.10	3.36	0.59	0.61	0.88	0.66
CaO	0.98	1.10	0.88	0.83	1.57	1.32	1.45	1.10	0.96	0.67
Na_2O	0.69	0.76	0.74	0.71	1.16	1.28	1.33	0.77	1.43	0.82
K_2O	3.22	2.43	3.52	2.75	2.76	3.04	3.01	3.16	3.22	2.73
P_2O_5	0.21	0.15	0.26	0.10	0.28	0.25	0.11	0.34	0.36	0.43
H_2O-	2.08	1.67	3.12	1.55	2.22	2.00	2.31	2.31	2.03	2.55
LOI	11.08	5.88	5.28	4.65	10.38	9.68	3.78	8.77	6.30	8.76
TOTAL	98.98	99.42	99.40	99.24	99.35	99.56	99.50	99.73	99.01	98.77
Rb	173	103	163	128	102	160	137	155	171	151
Sr	297	138	211	141	278	136	207	117	163	97
Y	22	22	15	16	59	16	22	33	25	33
Zr	105	144	175	193	204	300	223	197	188	177
Nb	9	9	10	9	14	13	11	11	12	10
Cu	1	9	4	3	5	2	2	2	3	2
Ni	10	23	11	10	24	7	7	7	8	10
Zn	22	46	20	23	28	37	26	35	46	42
V	40	94	51	68	130	61	49	51	59	51
Cr	52	155	71	49	86	39	37	35	35	420
Co	7	9	5	7	14	4	8	9	4	6

Sample No	Rudner Site No	Site
WC53	32	Danger bay
WC76	32	Danger Bay
WC79	32	Danger Point
WC81	32	Morrison's Point
WC93	32	Danger Bay
WC94	32	Danger Bay
WC95	32	Danger Bay
WC46	33	Noordbaaikop Cave
WC49	33	Noordbaaikop Cave
WC36	37	Saldanha Cave

Table A4.2.1 continued.

Sample	WC118	WC119	WC120	WC72	WC29	WC34	WC50	WC54	WC60	WC77
SiO_2	69.21	64.62	64.26	64.59	63.30	63.47	61.46	61.28	64.11	62.57
TiO_2	0.55	0.43	0.47	0.43	0.24	0.21	0.62	0.40	0.27	0.26
Al_2O_3	13.29	17.38	16.19	15.84	17.96	16.99	15.10	14.92	17.51	16.10
Fe_2O_3	3.49	4.98	4.78	5.02	3.63	3.69	5.26	4.01	3.98	4.00
MnO	0.04	0.04	0.04	0.04	0.04	0.03	0.06	0.04	0.04	0.05
MgO	1.09	0.98	0.81	0.90	0.57	0.65	1.53	0.60	0.50	0.56
CaO	0.82	0.85	0.88	1.16	1.10	0.88	1.66	1.28	1.29	1.09
Na_2O	0.79	0.93	1.33	0.75	0.68	0.87	1.17	0.85	0.70	0.78
K_2O	3.51	3.53	3.11	2.78	3.70	3.83	2.66	3.13	3.66	3.47
P_2O_5	0.17	0.41	0.11	0.17	0.48	0.12	0.12	0.09	0.43	0.23
H_2O-	1.25	1.48	2.06	2.23	2.41	2.62	1.68	2.93	2.45	2.12
LOI	5.03	3.65	5.22	5.38	4.93	5.60	7.81	9.53	5.91	8.29
TOTAL	99.24	99.28	99.26	99.29	99.04	98.96	99.13	99.06	100.85	99.52
Rb	100	165	167	144	213	223	92	159	184	180
Sr	197	181	146	253	356	148	205	176	426	248
Y	17	18	27	24	41	30	19	8	39	35
Zr	295	132	189	142	121	103	153	172	132	129
Nb	10	12	14	11	11	11	11	10	12	11
Cu	6	4	2	5	2	1	11	3	4	3
Ni	17	10	12	13	9	9	29	7	10	11
Zn	27	32	36	34	24	25	43	23	24	23
V	86	60	56	63	32	33	132	55	33	42
Cr	68	47	46	73	53	42	105	36	56	61
Co	6	11	14	4	6	5	14	7	8	8

Sample No	Rudner Site No	Site
WC118	37	Saldanha Bay
WC119	37	Saldanha Bay
WC120	37	Saldanha Bay
WC72	38	Lynch Point
WC29	41	Saldanha Peninsula
WC34	41	Saldanha Peninsula
WC50	41	Saldanha Peninsula
WC54	41	Saldanha Peninsula
WC60	41	Saldanha Peninsula
WC77	41	Saldanha Peninsula

Table A4.2.1 continued.

Sample	WC121	WC122	WC123	WC124	WC125	WC35	WC136	WC137	WC138	WC139
SiO_2	62.01	64.71	63.53	62.46	67.52	61.53	60.95	63.70	65.57	69.36
TiO_2	0.46	0.64	0.42	0.25	0.41	0.63	0.43	0.47	0.64	0.40
Al_2O_3	16.51	13.24	16.05	17.39	15.23	15.25	16.33	14.47	13.55	12.85
Fe_2O_3	4.48	5.19	4.45	4.14	4.28	6.15	3.55	4.12	5.57	3.99
MnO	0.05	0.10	0.04	0.04	0.04	0.07	0.04	0.05	0.05	0.05
MgO	0.52	1.52	0.83	0.52	0.55	1.44	0.59	0.88	1.49	0.49
CaO	0.85	1.44	1.39	1.21	0.73	1.76	1.15	0.87	0.84	0.85
Na_2O	0.51	0.61	0.83	0.66	1.00	1.30	1.59	1.83	1.37	1.43
K_2O	3.98	3.46	2.87	3.51	3.39	2.54	3.91	3.65	2.63	3.51
P_2O_5	0.07	0.11	0.53	0.42	0.07	0.13	0.17	0.10	0.09	0.23
H_2O-	1.74	1.24	1.51	1.72	1.18	1.62	2.41	1.62	1.49	1.36
LOI	8.31	6.92	6.68	7.15	4.91	6.69	7.81	7.58	5.98	5.06
TOTAL	99.49	99.18	99.13	99.47	99.31	99.11	98.93	99.34	99.27	99.58
Rb	181	146	124	187	153	90	161	223	113	174
Sr	122	194	252	523	164	215	178	117	127	155
Y	22	28	9	39	19	22	34	18	20	15
Zr	224	198	171	129	184	154	247	187	193	187
Nb	16	10	9	11	9	12	17	10	10	8
Cu	1	6	4	5	3	12	3	5	13	8
Ni	6	26	11	10	13	29	8	15	32	9
Zn	27	51	28	25	31	43	21	27	43	18
V	62	115	59	40	47	134	45	72	129	56
Cr	30	93	47	62	55	110	30	64	115	47
Co	5	13	7	9	9	12	8	9	14	8

Sample No	Rudner Site No	Site
WC121	41	Saldanha Peninsula
WC122	41	Saldanha Peninsula
WC123	41	Saldanha Peninsula
WC124	41	Saldanha Peninsula
WC125	41	Saldanha Peninsula
WC35	42	Jut Bay
WC136	43	Vondelingbaai
WC137	43	Vondelingbaai
WC138	43	Vondelingbaai
WC139	43	Vondelingbaai

Table A4.2.1 continued.

Sample	WC73	WC2	WC3	WC4	WC5	WC6	WC7	WC8	WC9	WC10
SiO_2	63.64	67.58	63.25	61.18	64.51	61.16	72.04	65.66	64.25	73.52
TiO_2	0.81	0.67	0.32	0.54	0.65	0.21	0.47	0.39	0.32	0.44
Al_2O_3	14.15	13.23	14.86	18.07	14.64	16.51	10.85	17.94	15.09	9.33
Fe_2O_3	5.57	4.26	6.06	4.80	6.32	3.27	6.44	4.45	4.99	5.47
MnO	0.05	0.03	0.05	0.02	0.05	0.02	0.02	0.03	0.04	0.06
MgO	1.35	0.84	0.64	1.55	1.53	0.45	0.54	0.76	0.71	1.11
CaO	1.87	1.10	0.99	1.02	2.13	0.64	0.78	0.56	0.95	0.75
Na_2O	1.10	1.01	1.66	0.47	1.37	1.17	0.36	1.55	1.80	0.23
K_2O	2.19	1.86	3.87	2.02	2.27	3.86	0.76	3.66	4.07	1.16
P_2O_5	0.11	0.08	0.14	0.12	0.20	0.13	0.06	0.20	0.11	0.11
H_2O-	1.91	1.22	1.45	3.98	2.11	1.46	2.48	1.21	1.56	1.62
LOI	6.65	8.08	6.82	6.63	3.81	11.04	5.48	3.63	6.00	6.50
TOTAL	99.40	99.96	100.11	100.40	99.59	99.92	100.28	100.04	99.89	100.30
Rb	76	75	222	131	114	206	35	128	225	43
Sr	176	109	117	165	267	75	103	93	135	95
Y	22	25	10	17	26	24	11	30	10	17
Zr	177	273	142	190	220	100	156	195	123	169
Nb	11	11	10	10	10	9	7	11	10	7
Cu	9	5	10	1	10	0	3	4	4	9
Ni	27	27	15	15	20	9	21	9	12	36
Zn	36	30	22	19	47	26	13	28	22	30
V	144	124	67	76	111	33	102	54	60	89
Cr	134	111	82	64	63	47	199	35	59	109
Co	13	14	2	9	16	9	9	4	8	20

Sample No	Rudner Site No	Site
WC73	44	Abrahamskraal
WC2	45	Yzerfontein
WC3	45	Yzerfontein
WC4	45	Yzerfontein
WC5	45	Yzerfontein
WC6	45	Yzerfontein
WC7	45	Yzerfontein
WC8	45	Yzerfontein
WC9	45	Yzerfontein
WC10	45	Yzerfontein

Table A4.2.1 continued.

Sample	WC11	WC13	WC14	WC15	WC17	WC18	WC24	WC98	WC99	WC100
SiO_2	55.27	62.06	65.49	62.64	65.19	62.11	72.51	67.52	66.57	66.81
TiO_2	0.24	0.48	0.51	0.68	0.53	0.35	0.42	0.46	0.52	0.51
Al_2O_3	18.60	15.49	16.56	16.81	17.55	15.07	13.31	13.30	17.84	16.29
Fe_2O_3	4.43	5.10	3.56	6.46	5.29	3.92	3.57	5.42	5.27	3.16
MnO	0.02	0.04	0.03	0.06	0.04	0.02	0.04	0.05	0.05	0.04
MgO	0.70	0.77	0.95	1.39	0.70	0.60	0.67	0.63	0.71	0.79
CaO	1.03	0.78	1.51	2.31	1.41	1.28	0.60	0.84	1.28	1.42
Na_2O	0.98	1.31	2.01	1.64	2.18	1.44	0.51	1.35	1.46	1.40
K_2O	3.47	4.21	4.46	2.21	2.89	3.61	3.11	4.24	2.93	4.35
P_2O_5	0.21	0.23	0.07	0.10	0.09	0.11	0.12	0.29	0.07	0.10
H_2O-	2.48	2.31	0.96	2.03	1.15	2.20	1.39	1.03	0.51	1.08
LOI	12.62	7.36	3.52	3.43	3.35	9.41	2.97	4.41	2.05	3.50
TOTAL	100.05	100.14	99.63	99.76	100.37	100.12	99.22	99.54	99.26	99.45
Rb	188	190	197	136	167	148	135	209	186	199
Sr	135	154	192	278	163	163	111	151	123	194
Y	17	28	14	21	24	18	22	21	27	13
Zr	96	282	308	180	206	227	209	199	220	304
Nb	8	18	21	11	16	9	8	11	17	21
Cu	1	6	4	8	4	3	3	9	5	4
Ni	10	10	12	23	9	11	8	10	11	10
Zn	23	30	21	53	34	31	29	21	37	21
V	46	58	47	102	61	42	52	75	60	48
Cr	54	42	34	73	44	47	37	59	39	29
Co	9	5	6	29	5	9	5	7	10	5

Sample No	Rudner Site No	Site
WC11	45	Yzerfontein
WC13	45	Yzerfontein
WC14	45	Yzerfontein
WC15	45	Yzerfontein
WC17	45	Yzerfontein
WC18	45	Yzerfontein
WC24	45	Yzerfontein
WC98	45	Yzerfontein
WC99	45	Yzerfontein
WC100	45	Yzerfontein

Table A4.2.1 continued.

Sample	WC101	WC102	WC103	WC104	WC105	WC106	WC107	WC19	WC20	WC25
SiO_2	66.03	69.37	66.67	68.30	62.79	70.30	74.02	64.27	54.82	60.75
TiO_2	0.33	0.29	0.26	0.67	0.51	0.49	0.44	0.59	1.20	0.48
Al_2O_3	14.91	15.84	13.22	14.21	17.85	10.54	9.48	13.47	17.59	19.24
Fe_2O_3	5.43	5.04	4.21	4.90	4.79	6.06	4.96	6.12	8.60	5.88
MnO	0.06	0.03	0.06	0.07	0.04	0.03	0.08	0.06	0.04	0.02
MgO	0.75	1.15	0.60	1.45	0.72	0.59	1.12	3.35	1.54	0.50
CaO	0.87	0.46	0.73	1.38	0.98	0.84	0.68	2.40	2.30	1.06
Na_2O	1.30	0.83	0.77	1.40	0.18	0.07	0.05	0.88	0.98	0.42
K_2O	3.84	3.15	3.60	2.50	1.88	0.72	1.08	1.50	1.88	2.53
P_2O_5	0.11	0.10	0.10	0.11	0.11	0.07	0.08	0.10	0.26	0.12
H_2O-	0.85	0.34	1.34	0.98	3.54	3.11	1.69	1.85	2.83	3.51
LOI	4.51	2.41	7.88	2.88	5.76	6.41	5.78	5.91	7.41	5.83
TOTAL	98.99	99.01	99.44	98.85	99.15	99.23	99.46	100.50	99.45	100.34
Rb	236	253	185	96	132	30	44	71	72	136
Sr	96	64	94	215	178	111	87	184	276	191
Y	12	32	18	32	18	10	16	26	15	20
Zr	141	509	189	260	198	153	157	261	150	174
Nb	11	95	13	13	10	6	6	8	15	11
Cu	8	12	8	16	1	3	9	16	19	5
Ni	14	16	12	34	13	24	31	32	52	13
Zn	23	26	18	43	18	14	22	49	49	20
V	66	35	43	119	76	102	92	132	221	82
Cr	69	62	72	108	59	222	93	168	233	81
Co	1	4	8	9	13	12	19	9	16	5

Sample No	Rudner Site No	Site
WC101	45	Yzerfontein
WC102	45	Yzerfontein
WC103	45	Yzerfontein
WC104	45	Yzerfontein
WC105	45	Yzerfontein
WC106	45	Yzerfontein
WC107	45	Yzerfontein
WC19	46	Modderrivier
WC20	46	Modderrivier
WC25	46	Modderrivier

Table A4.2.1 continued.

Sample	WC26	WC27	WC28	WC31	WC32	WC52	WC131	WC132	WC133	WC134
SiO_2	75.43	62.94	65.17	63.57	57.41	68.54	56.77	63.80	61.08	66.55
TiO_2	0.44	0.89	0.85	0.40	0.97	0.50	0.49	0.48	0.44	0.49
Al_2O_3	9.95	16.27	15.90	14.75	16.57	13.71	16.14	15.21	15.24	15.55
Fe_2O_3	2.99	6.83	6.69	5.23	6.57	8.17	6.84	5.08	4.40	3.43
MnO	0.02	0.07	0.08	0.03	0.07	0.04	0.05	0.04	0.04	0.05
MgO	0.44	1.42	1.56	0.60	1.20	0.93	1.00	0.61	1.53	0.50
CaO	0.72	1.15	1.72	1.46	1.89	0.76	1.10	1.02	0.69	0.92
Na_2O	1.46	0.72	1.18	1.18	0.97	0.38	0.27	1.79	1.24	1.99
K_2O	0.81	2.97	2.27	2.95	2.23	1.69	3.03	4.18	3.31	4.76
P_2O_5	0.52	0.12	0.11	0.09	0.09	0.18	0.15	0.11	0.10	0.12
H_2O-	1.17	2.54	1.06	1.96	2.10	1.76	2.59	1.67	1.73	1.08
LOI	5.05	3.88	3.17	7.45	9.45	3.74	11.13	5.41	9.86	3.70
TOTAL	99.00	99.80	99.76	99.67	99.52	100.40	99.56	99.40	99.66	99.14
Rb	195	132	94	149	70	89	145	200	152	211
Sr	157	178	232	191	203	147	149	184	101	173
Y	10	28	40	18	13	16	27	20	17	13
Zr	179	229	267	191	216	307	178	273	199	329
Nb	11	16	17	11	13	10	9	20	10	20
Cu	5	9	18	3	17	7	14	5	2	5
Ni	7	25	36	8	37	23	25	10	9	7
Zn	14	54	53	29	38	23	56	24	33	23
V	49	147	170	58	188	146	132	55	68	44
Cr	39	90	119	45	181	110	95	21	43	26
Co	6	14	12	8	12	9	16	10	11	2

Sample No	Rudner Site No	Site
WC26	46	Modderrivier
WC27	46	Modderrivier
WC28	46	Modderrivier
WC31	46	Modderrivier
WC32	46	Modderrivier
WC52	46	Modderrivier
WC131	46	Modderrivier
WC132	46	Modderrivier
WC133	46	Modderrivier
WC134	46	Modderrivier

Table A4.2.1 continued.

Sample	WC135	WC33	WC48	WC59	WC108	WC109	WC110	WC111	WC112	WC113
SiO_2	62.88	72.11	64.25	72.55	67.49	65.56	65.81	61.58	63.69	62.83
TiO_2	0.43	0.54	0.49	0.38	0.34	0.71	0.74	0.72	0.61	0.74
Al_2O_3	15.22	12.90	15.86	13.75	14.01	15.99	15.90	15.39	15.55	15.22
Fe_2O_3	4.39	5.40	4.01	4.51	3.94	6.03	4.99	5.99	5.55	6.17
MnO	0.03	0.04	0.05	0.03	0.04	0.04	0.04	0.05	0.05	0.07
MgO	0.63	0.64	0.73	0.57	0.63	1.45	0.62	1.13	1.33	2.44
CaO	0.78	0.70	1.63	0.73	1.11	2.26	0.65	1.63	2.72	1.16
Na_2O	1.34	0.28	1.44	0.42	0.54	0.97	0.25	0.72	1.17	0.53
K_2O	3.28	1.49	4.98	1.03	3.07	2.34	3.67	2.20	2.13	3.27
P_2O_5	0.11	0.13	0.34	0.11	0.12	0.17	0.13	0.13	0.18	0.13
H_2O-	1.83	1.68	1.26	1.99	2.67	1.28	1.93	2.19	1.39	2.11
LOI	8.62	4.21	4.76	3.58	5.48	2.89	4.32	7.31	5.64	4.40
TOTAL	99.54	100.12	99.80	99.65	99.44	99.69	99.05	99.04	100.01	99.07
Rb	153	76	192	57	148	124	110	93	117	177
Sr	117	98	244	106	145	312	162	243	307	207
Y	19	23	11	9	33	28	9	20	35	23
Zr	243	282	305	174	177	236	322	180	246	197
Nb	10	12	20	11	8	9	16	15	9	14
Cu	4	3	6	4	2	7	7	13	8	8
Ni	10	13	7	11	10	22	7	29	24	27
Zn	33	20	23	16	23	53	31	43	49	53
V	69	103	49	72	58	103	84	143	81	125
Cr	41	64	26	63	36	60	45	113	71	92
Co	7	8	9	12	5	23	10	11	17	14

Sample No	Rudner Site No	Site
WC135	46	Modderrivier
WC33	48	Bokbaai
WC48	48	Bokbaai
WC59	48	Bokbaai
WC108	48	Bokbaai
WC109	48	Bokbaai
WC110	48	Bokbaai
WC111	48	Bokbaai
WC112	48	Bokbaai
WC113	48	Bokbaai

Table A4.2.1 continued.

Sample	WC114	WC115	WC116	WC117	WC91	WC92	WC23	WC126	WC127	WC128
SiO_2	66.13	64.49	63.97	72.85	68.91	67.74	nd	70.56	68.21	62.17
TiO_2	0.82	0.84	0.58	0.40	0.44	0.47	nd	0.55	0.49	0.56
Al_2O_3	15.60	14.24	15.29	12.54	11.99	14.90	nd	12.83	12.04	15.25
Fe_2O_3	5.51	6.51	5.18	3.84	4.34	4.56	nd	4.83	4.80	5.54
MnO	0.04	0.08	0.01	0.05	0.05	0.04	nd	0.04	0.05	0.06
MgO	1.56	2.22	0.65	0.78	1.07	0.61	nd	0.68	0.71	0.89
CaO	1.23	1.75	0.96	0.66	0.49	1.00	nd	0.65	0.68	1.06
Na_2O	0.90	0.68	0.51	0.53	0.37	0.61	nd	0.16	0.23	0.35
K_2O	3.29	2.31	3.03	2.89	2.00	3.21	nd	2.83	3.03	2.14
P_2O_5	0.08	0.12	0.11	0.07	0.08	0.27	nd	0.07	0.19	0.07
H_2O-	1.47	1.53	1.89	1.41	1.24	2.25	nd	1.30	1.20	2.05
LOI	3.24	4.66	7.41	3.33	8.44	4.32	nd	5.11	7.95	9.31
TOTAL	99.87	99.43	99.59	99.35	99.42	99.98	nd	99.61	99.58	99.45
Rb	156	116	82	126	108	176	164	90	88	74
Sr	174	336	251	138	77	183	196	125	136	200
Y	26	32	10	67	45	23	19	22	21	29
Zr	187	229	235	168	151	196	189	314	277	308
Nb	14	14	16	8	7	11	10	10	10	11
Cu	18	11	5	4	4	5	7	5	5	5
Ni	36	41	12	12	24	12	7	16	12	25
Zn	51	47	22	26	23	27	23	22	22	21
V	135	145	107	59	84	73	57	90	88	115
Cr	117	145	53	43	100	60	38	71	59	98
Co	13	17	11	8	10	8	11	15	14	18

Sample No	Rudner Site No	Site
WC114	48	Bokbaai
WC115	48	Bokbaai
WC116	48	Bokbaai
WC117	48	Bokbaai
WC91	49	Melkbos
WC92	49	Melkbos
WC23	50	Blouberg
WC126	50	Blouberg
WC127	50	Blouberg
WC128	50	Blouberg

Table A4.2.1 continued.

Sample	WC129	WC130	CP8	CP23	CP33	CP5	CP10	CP12	CP13	CP37
SiO_2	66.37	61.85	66.42	66.46	64.16	61.54	61.37	63.41	63.46	64.27
TiO_2	0.38	0.69	0.43	0.47	0.50	0.43	0.47	0.55	0.83	0.79
Al_2O_3	17.10	14.85	16.10	17.24	17.84	16.48	16.13	18.22	13.97	16.55
Fe_2O_3	4.55	6.70	4.96	2.68	4.27	4.74	4.41	3.57	5.52	7.55
MnO	0.04	0.05	0.03	0.02	0.02	0.01	0.02	0.03	0.06	0.05
MgO	0.63	1.36	0.67	0.59	0.61	0.80	0.56	0.75	1.83	1.42
CaO	0.74	1.25	0.64	0.81	0.98	1.10	1.12	0.86	2.87	0.87
Na_2O	0.72	0.42	1.19	2.26	1.00	1.69	0.58	0.97	0.87	0.94
K_2O	4.53	2.43	3.36	4.08	3.17	3.82	3.07	3.64	2.05	2.74
P_2O_5	0.44	0.19	0.10	0.16	0.07	0.30	0.09	0.14	0.09	0.12
H_2O-	1.15	2.15	2.50	1.32	2.12	2.12	3.56	1.74	2.91	0.63
LOI	2.55	7.55	4.07	3.65	6.11	6.57	8.95	6.07	6.07	4.80
TOTAL	99.20	99.49	100.47	99.74	100.85	99.60	100.33	99.95	100.53	100.73
Rb	166	160	179	241	160	154	175	182	100	147
Sr	197	180	113	146	159	213	145	169	237	153
Y	18	24	12	14	14	13	12	18	12	25
Zr	190	236	162	163	173	169	160	163	168	211
Nb	11	14	13	14	17	10	9	15	13	14
Cu	nd	10	5	3	1	5	3	4	34	24
Ni	nd	24	10	13	10	9	10	11	31	21
Zn	nd	47	26	23	19	32	19	38	45	66
V	56	139	59	52	58	53	69	77	156	139
Cr	46	103	49	57	36	38	62	58	114	121
Co	9	10	8	8	5	8	6	8	14	6

Sample No	Rudner Site No	Site
WC129	50	Blouberg
WC130	50	Blouberg
CP8	51	Milnerton
CP23	53	Sandy Bay
CP33	53	Sandy Bay
CP5	54	Hout Bay
CP10	54	Hout Bay
CP12	54	Hout Bay
CP13	54	Hout Bay
CP37	54	Hout Bay

Table A4.2.1 continued.

Sample	CP38	CP43	CP45	CP47	CP16	CP22	CP28	CP36	CP2	CP20
SiO_2	55.60	63.06	62.58	72.68	69.79	57.28	65.48	67.22	63.01	62.31
TiO_2	0.92	0.75	0.43	0.42	0.20	0.65	0.58	0.54	0.42	0.47
Al_2O_3	15.14	16.59	17.26	13.14	14.55	16.65	14.95	14.34	15.62	18.55
Fe_2O_3	7.93	6.59	5.24	3.80	5.74	5.54	4.45	4.27	6.17	5.36
MnO	0.03	0.04	0.02	0.01	0.01	0.04	0.01	0.02	0.03	0.02
MgO	1.05	1.36	0.64	0.37	0.60	1.16	0.69	0.60	0.75	0.63
CaO	1.49	1.05	1.19	0.71	0.71	1.35	0.67	0.62	1.16	0.82
Na_2O	1.15	0.87	0.92	0.45	0.82	1.13	0.78	1.13	1.43	1.02
K_2O	2.54	2.54	3.93	2.12	2.66	3.58	4.23	4.05	3.40	3.70
P_2O_5	0.06	0.12	0.15	0.07	0.07	0.09	0.06	0.10	0.21	0.15
H_2O-	2.59	0.89	2.59	2.11	1.00	2.64	2.37	1.79	2.59	1.94
LOI	11.48	5.65	5.90	3.72	4.18	9.28	5.89	5.19	5.67	4.84
TOTAL	99.98	99.51	100.85	99.60	100.33	99.39	100.16	99.87	100.46	99.81
Rb	120	139	229	88	197	228	171	183	212	207
Sr	242	191	299	143	60	148	133	133	190	136
Y	26	24	10	12	29	38	135	62	9	15
Zr	156	206	113	207	115	182	243	254	133	138
Nb	17	15	12	8	8	13	12	11	12	13
Cu	13	20	6	3	4	6	4	5	6	5
Ni	36	22	14	9	20	19	19	13	15	13
Zn	52	65	34	14	21	41	30	25	23	21
V	178	135	67	57	50	90	73	74	70	82
Cr	154	109	54	61	66	71	49	43	64	69
Co	14	6	10	9	7	10	37	14	7	11

Sample No	Rudner Site No	Site
CP38	54	Hout Bay
CP43	54	Hout Bay
CP45	54	Hout Bay
CP47	54	Hout Bay
CP16	55	Noordhoek
CP22	55	Noordhoek
CP28	55	Noordhoek
CP36	55	Noordhoek
CP2	56	Kommetjie
CP20	56	Kommetjie

Table A4.2.1 continued.

Sample	CP31	CP32	CP35	CP4	CP40	CP50	CP30	CP34	CP3	CP49
SiO_2	67.46	66.85	67.12	59.45	60.49	67.54	64.84	64.50	64.73	60.26
TiO_2	0.47	0.45	0.44	0.46	0.48	0.56	0.44	0.51	0.59	0.93
Al_2O_3	16.25	16.01	13.98	16.43	15.04	17.46	16.70	16.13	16.47	16.56
Fe_2O_3	4.25	3.83	5.08	5.62	6.18	5.14	3.77	5.49	4.35	7.06
MnO	0.01	0.02	0.02	0.04	0.02	0.02	0.01	0.04	0.03	0.05
MgO	0.46	0.62	0.49	1.06	1.13	0.61	0.56	0.70	0.85	1.80
CaO	0.91	1.03	0.81	1.30	0.91	0.90	0.55	1.21	0.96	1.50
Na_2O	0.69	1.42	0.49	1.32	0.85	1.04	0.76	1.61	0.95	1.80
K_2O	2.66	3.65	3.24	4.45	2.75	3.19	3.42	3.58	3.85	3.12
P_2O_5	0.17	0.12	0.22	0.13	0.34	0.07	0.15	0.49	0.13	0.23
H_2O-	2.55	1.92	2.60	2.99	2.69	0.94	1.62	1.39	2.33	2.05
LOI	5.06	4.48	5.50	7.61	8.99	2.40	7.75	4.36	5.19	5.32
TOTAL	100.94	100.40	99.99	100.86	99.87	99.87	100.57	100.01	100.43	100.68
Rb	126	176	148	237	109	180	141	187	231	148
Sr	166	145	158	286	90	124	74	166	173	197
Y	13	23	11	9	6	36	11	21	24	28
Zr	271	197	181	145	149	174	157	185	211	210
Nb	12	11	10	12	10	21	10	12	16	16
Cu	2	4	1	8	5	3	1	9	5	22
Ni	8	10	8	13	13	9	7	13	14	43
Zn	13	20	18	42	90	22	39	35	43	58
V	52	52	53	56	70	52	59	76	78	154
Cr	45	46	56	48	70	30	44	66	62	132
Co	1	7	7	10	10	7	3	9	7	15

Sample No	Rudner Site No	Site
CP31	56	Kommetjie
CP32	56	Kommetjie
CP35	56	Kommetjie
CP4	57	Witsands
CP40	57	Witsands
CP50	57	Witsands
CP30	58	Witsands Cave
CP34	58	Witsands Cave
CP3	59	Schusters Bay
CP49	59	Schusters Bay

Table A4.2.1 continued.

Sample	WC143	CP44	CP27	CP1	CP9	CP14	CP17	CP18	CP19	CP21
SiO_2	60.47	65.53	59.61	68.71	63.15	58.32	59.19	70.19	62.24	69.65
TiO_2	0.49	0.64	0.50	0.52	0.57	0.52	0.58	0.41	0.54	0.43
Al_2O_3	16.32	14.86	16.20	12.32	17.95	14.29	16.31	12.34	17.29	13.75
Fe_2O_3	4.86	5.28	5.30	4.66	3.83	6.09	7.35	3.70	3.62	2.64
MnO	0.04	0.01	0.03	0.02	0.02	0.05	0.02	0.01	0.02	0.01
MgO	0.63	0.53	0.79	0.69	0.74	0.70	0.74	0.41	0.57	0.31
CaO	1.22	0.40	1.20	0.66	0.83	0.88	0.88	0.57	0.71	0.61
Na_2O	0.56	0.31	0.71	0.53	0.84	0.67	0.63	0.36	0.67	0.45
K_2O	3.14	2.79	4.16	2.50	3.63	2.71	3.14	1.72	3.85	3.13
P_2O_5	0.11	0.10	0.39	0.09	0.14	0.16	0.08	0.10	0.13	0.09
H_2O-	2.33	1.43	3.12	1.67	2.62	3.05	2.67	1.69	2.25	4.89
LOI	9.21	8.77	8.15	7.50	6.46	12.55	8.43	8.55	8.23	3.63
TOTAL	99.38	100.65	100.16	99.87	100.78	99.99	100.02	100.05	100.12	99.59
Rb	173	104	207	87	207	141	192	94	180	137
Sr	180	78	257	124	123	112	127	81	126	121
Y	19	7	21	18	16	7	22	10	14	11
Zr	209	263	159	271	171	160	182	236	182	203
Nb	14	12	13	9	15	11	16	7	14	8
Cu	4	5	3	2	3	7	4	0	2	0
Ni	13	15	10	15	13	12	11	12	10	10
Zn	36	24	35	20	41	20	39	15	27	14
V	69	96	78	80	84	96	100	56	75	76
Cr	70	70	60	63	73	86	61	57	72	47
Co	9	9	9	13	8	5	6	4	7	8

Sample No	Rudner Site No	Site
WC143	59	Schusters Bay
CP44	61	Olifantsbos
CP27	62	Platboom
CP1	63	Cape Point
CP9	64	Buffels Bay
CP14	64	Buffels Bay
CP17	64	Buffels Bay
CP18	64	Buffels Bay
CP19	64	Buffels Bay
CP21	64	Buffels Bay

Table A4.2.1 continued.

Sample	CP24	CP25	CP29	CP41	CP42	CP46	CP48	CP6	WC141	CP15
SiO_2	63.44	70.42	49.49	59.90	65.66	75.51	57.84	63.26	61.29	63.49
TiO_2	0.51	0.41	0.42	0.46	0.54	0.36	0.57	0.59	0.43	0.37
Al_2O_3	15.36	14.14	17.05	16.07	17.10	10.67	16.59	17.12	16.38	15.46
Fe_2O_3	3.66	3.14	8.59	5.05	3.37	1.90	7.28	3.36	4.52	3.57
MnO	0.03	0.02	0.03	0.03	0.03	0.02	0.04	0.03	0.05	0.01
MgO	0.72	0.31	0.49	0.65	0.62	1.49	0.81	0.55	1.59	0.43
CaO	0.91	0.82	0.73	1.15	0.73	0.63	1.00	0.81	0.86	0.88
Na_2O	0.84	0.33	0.60	0.87	0.68	0.35	0.81	1.29	1.79	0.77
K_2O	3.01	2.06	2.94	3.01	3.83	2.36	3.37	4.03	3.53	3.56
P_2O_5	0.07	0.12	0.13	0.12	0.10	0.09	0.27	0.31	0.15	0.07
H_2O-	2.81	2.41	2.63	2.66	2.65	1.43	2.74	1.85	1.64	2.49
LOI	8.70	5.77	16.40	9.39	4.66	4.96	8.69	6.46	6.86	8.83
TOTAL	100.06	99.95	99.50	99.36	99.97	99.77	100.01	99.66	99.09	99.93
Rb	179	77	174	162	226	94	199	171	191	161
Sr	116	157	81	132	130	76	162	138	124	103
Y	17	6	8	18	21	11	22	10	22	25
Zr	176	134	101	150	175	187	192	205	109	183
Nb	13	7	11	10	15	5	17	20	10	7
Cu	2	1	3	4	4	2	6	4	5	1
Ni	13	7	13	11	10	15	13	10	21	11
Zn	36	10	19	21	36	12	44	25	31	14
V	72	90	131	71	60	40	95	67	109	46
Cr	64	45	70	66	56	69	71	39	102	52
Co	7	5	6	3	7	10	5	7	11	7

Sample No	Rudner Site No	Site
CP24	64	Buffels Bay
CP25	64	Buffels Bay
CP29	64	Buffels Bay
CP41	64	Buffels Bay
CP42	64	Buffels Bay
CP46	64	Buffels Bay
CP48	64	Buffels Bay
CP6	67	Simonstown
WC141	67	Millers Point
CP15	69	Fish Hoek

Table A4.2.1 continued.

Sample	CP26	CP39	WC142	CP7	CP11	SC43	SC1	SC2	SC3	SC4
SiO_2	57.56	59.17	62.59	63.48	64.90	65.52	54.07	71.84	57.23	63.28
TiO_2	0.57	0.60	0.48	0.27	0.55	0.34	0.55	0.49	0.54	0.43
Al_2O_3	16.59	17.81	17.77	17.65	18.10	15.61	17.94	15.42	20.20	17.40
Fe_2O_3	5.34	6.70	3.16	4.33	3.74	3.88	11.31	1.40	6.11	4.61
MnO	0.01	0.02	0.04	0.02	0.04	0.02	0.02	0.01	0.01	0.02
MgO	0.52	0.75	0.51	0.47	0.80	0.68	1.11	0.46	0.99	0.66
CaO	0.89	0.95	1.23	0.28	0.90	0.75	1.62	0.88	1.22	0.93
Na_2O	0.56	0.67	0.64	0.95	1.58	1.57	0.50	0.35	1.30	1.23
K_2O	2.24	2.68	3.66	3.67	3.71	3.73	1.98	2.00	3.03	3.15
P_2O_5	0.30	0.45	0.37	0.30	0.14	0.06	0.12	0.05	0.20	0.15
H_2O-	2.50	3.14	3.15	3.18	2.03	2.41	3.17	2.81	2.62	2.11
LOI	13.11	6.21	5.69	5.84	3.86	5.61	8.58	3.97	6.97	6.14
TOTAL	100.19	99.15	99.29	100.44	100.35	100.18	100.97	99.68	100.42	100.11
Rb	102	151	172	178	174	197	103	90	152	161
Sr	138	137	222	129	171	149	301	143	219	162
Y	6	8	20	28	31	6	25	19	9	15
Zr	152	138	171	126	163	145	250	285	175	147
Nb	10	14	13	11	18	9	10	10	13	9
Cu	0	2	3	2	5	2	12	0	6	2
Ni	10	9	10	9	9	10	40	5	7	13
Zn	17	24	25	29	20	14	36	10	23	21
V	132	89	62	38	49	44	154	45	91	63
Cr	64	57	59	58	29	50	144	32	46	65
Co	11	10	8	5	8	10	15	5	7	7

Sample No	Rudner Site No	Site
CP26	69	Fish Hoek
CP39	69	Fish Hoek
WC142	69	Clovelly
CP7	70	Lakeside
CP11	72	Cape Flats
SC43	77	Rooiels
SC1	80	Cape Hangklip
SC2	80	Cape Hangklip
SC3	80	Cape Hangklip
SC4	80	Cape Hangklip

Table A4.2.1 continued.

Sample	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13	SC14
SiO_2	68.06	67.76	64.42	62.95	61.11	68.88	60.82	66.34	69.48	62.58
TiO_2	0.37	0.45	0.42	0.37	0.35	0.39	0.45	0.31	0.60	0.35
Al_2O_3	10.38	14.47	11.83	16.18	16.03	10.67	13.76	15.46	12.56	16.73
Fe_2O_3	5.66	1.48	6.21	4.72	3.73	5.02	6.04	4.07	4.61	4.17
MnO	0.03	0.01	0.04	0.02	0.04	0.02	0.02	0.01	0.03	0.02
MgO	0.70	0.46	1.10	0.61	0.51	0.86	0.61	0.52	0.58	0.70
CaO	0.74	0.76	1.04	0.75	0.68	0.92	1.19	1.01	0.75	0.98
Na_2O	0.64	0.14	0.77	0.82	0.56	0.57	0.45	0.84	0.62	1.59
K_2O	1.15	2.41	1.54	3.03	3.00	1.38	2.04	1.97	2.80	4.70
P_2O_5	0.10	0.04	0.08	0.10	0.05	0.04	0.13	0.16	0.06	0.09
H_2O-	2.19	2.14	2.42	2.14	2.19	2.38	3.50	2.17	2.00	2.28
LOI	8.97	9.42	9.58	8.12	10.79	8.87	10.49	6.52	6.00	5.91
TOTAL	98.99	99.54	99.45	99.81	99.04	100.00	99.50	99.38	100.09	100.10
Rb	64	120	109	179	158	114	110	94	99	222
Sr	117	90	157	130	94	137	227	171	143	177
Y	15	9	27	11	24	32	24	16	58	33
Zr	285	253	197	117	142	157	135	233	373	164
Nb	4	9	6	10	9	5	6	9	11	11
Cu	7	0	8	3	5	3	4	1	5	3
Ni	26	7	30	15	13	24	46	9	14	12
Zn	15	11	22	20	19	15	34	17	24	26
V	97	50	107	127	55	102	129	49	82	46
Cr	127	48	138	75	65	131	114	65	56	38
Co	14	6	17	8	12	14	19	6	18	9

Sample No	Rudner Site No	Site
SC5	80	Cape Hangklip
SC6	80	Cape Hangklip
SC7	80	Cape Hangklip
SC8	80	Cape Hangklip
SC9	80	Cape Hangklip
SC10	80	Cape Hangklip
SC11	80	Cape Hangklip
SC12	80	Cape Hangklip
SC13	80	Cape Hangklip
SC14	80	Cape Hangklip

Table A4.2.1 continued.

Sample	SC15	SC16	SC17	SC18	SC19	SC20	SC21	SC22	SC23	SC24
SiO_2	67.91	68.35	64.28	69.16	66.26	67.58	68.11	69.89	61.72	57.56
TiO_2	0.45	0.12	0.34	0.36	0.33	0.36	0.41	0.35	0.28	0.39
Al_2O_3	14.33	14.86	15.72	13.95	16.17	17.24	14.08	10.96	13.34	15.41
Fe_2O_3	3.43	3.01	3.91	2.94	3.01	4.45	5.51	6.03	6.90	5.69
MnO	0.02	0.04	0.02	0.01	0.02	0.03	0.03	0.02	0.02	0.03
MgO	0.62	0.39	0.52	0.44	0.51	0.80	0.62	0.78	0.48	0.86
CaO	0.98	0.60	0.80	0.85	0.84	0.94	1.06	0.79	1.18	1.59
Na_2O	1.24	1.03	1.40	0.87	1.27	0.85	1.07	0.87	0.74	0.99
K_2O	3.51	3.83	3.88	2.33	3.36	0.96	2.50	1.98	2.90	2.74
P_2O_5	0.06	0.08	0.06	0.07	0.08	0.08	0.24	0.14	0.05	0.07
H_2O-	2.06	2.02	1.78	1.97	3.16	1.69	2.05	2.09	3.39	3.41
LOI	4.61	5.27	6.86	6.59	4.84	4.91	4.00	5.60	8.95	11.13
TOTAL	99.22	99.60	99.57	99.54	99.85	99.89	99.68	99.50	99.95	99.87
Rb	130	297	225	108	196	67	103	133	142	133
Sr	129	88	114	114	190	130	234	134	215	228
Y	29	46	26	17	20	71	10	40	38	97
Zr	196	108	165	142	163	209	244	114	171	128
Nb	11	10	10	8	10	12	11	7	10	7
Cu	4	2	4	0	1	1	6	7	2	0
Ni	10	10	9	9	8	9	5	22	9	18
Zn	17	13	20	12	17	27	15	17	15	37
V	56	16	45	47	37	52	61	105	52	66
Cr	36	32	40	45	28	62	43	82	64	49
Co	8	5	8	5	6	6	8	11	9	11

Sample No	Rudner Site No	Site
SC15	80	Cape Hangklip
SC16	80	Cape Hangklip
SC17	80	Cape Hangklip
SC18	80	Cape Hangklip
SC19	80	Cape Hangklip
SC20	80	Cape Hangklip
SC21	80	Cape Hangklip
SC22	80	Cape Hangklip
SC23	80	Cape Hangklip
SC24	80	Cape Hangklip

Table A4.2.1 continued.

Sample	SC25	SC26	SC98	SC74	SC75	SC81	SC82	SC83	SC84	SC85
SiO_2	65.94	56.45	70.12	65.77	69.95	71.47	55.53	65.26	65.23	62.43
TiO_2	0.47	0.95	0.59	0.35	0.33	0.59	0.48	0.37	0.45	0.47
Al_2O_3	17.08	17.26	13.20	15.73	12.74	10.32	17.56	17.62	15.08	15.81
Fe_2O_3	3.59	8.05	4.33	5.12	5.33	4.96	4.99	4.60	4.50	4.48
MnO	0.01	0.04	0.02	0.01	0.01	0.04	0.02	0.04	0.02	0.02
MgO	0.52	1.75	0.54	0.68	0.63	0.79	0.38	0.66	0.99	0.54
CaO	0.57	1.38	0.10	0.97	0.75	1.27	0.39	0.98	1.00	1.13
Na_2O	1.22	1.98	0.37	1.24	0.72	0.84	0.43	0.47	1.82	0.87
K_2O	3.42	4.00	2.90	3.04	1.54	1.10	2.57	0.86	2.91	3.25
P_2O_5	0.11	0.05	0.12	0.15	0.04	0.05	0.11	0.14	0.07	0.08
H_2O-	1.83	2.51	2.86	1.85	2.17	1.93	2.24	1.68	1.82	3.35
LOI	4.70	5.20	4.64	4.72	5.35	6.14	14.91	7.06	5.78	7.35
TOTAL	99.46	99.62	99.79	99.63	99.56	99.50	99.61	99.74	99.67	99.78
Rb	139	184	107	120	70	61	152	50	120	182
Sr	110	268	90	196	131	150	65	123	149	191
Y	17	26	15	36	12	25	11	31	34	16
Zr	205	179	303	231	206	336	176	219	167	174
Nb	11	18	16	11	7	9	9	12	8	10
Cu	2	16	6	3	2	8	7	4	4	3
Ni	7	42	8	10	8	19	10	11	15	9
Zn	15	62	25	14	12	10	21	21	33	18
V	55	167	73	56	53	69	92	58	65	74
Cr	42	164	39	75	49	102	59	87	58	55
Co	8	21	7	6	10	15	10	10	15	5

Sample No	Rudner Site No	Site
SC25	80	Cape Hangklip
SC26	80	Cape Hangklip
SC98	81	Palmiet River
SC74	82	Hawston
SC75	82	Hawston
SC81	82	Hawston
SC82	82	Hawston
SC83	82	Hawston
SC84	82	Hawston
SC85	82	Hawston

Table A4.2.1 continued.

Sample	SC86	SC87	SC88	SC89	SC90	WC140	SC47	SC95	SC79	SC92
SiO_2	57.73	64.58	72.83	61.00	65.55	69.49	61.84	62.94	69.99	62.45
TiO_2	0.49	0.34	0.36	0.84	0.60	0.62	0.27	0.29	0.32	0.59
Al_2O_3	16.67	14.75	13.37	15.48	14.29	11.39	14.81	14.74	13.98	14.43
Fe_2O_3	4.36	3.06	5.73	6.32	4.74	5.34	4.54	5.07	2.57	4.68
MnO	0.02	0.03	0.02	0.04	0.02	0.03	0.02	0.02	0.02	0.02
MgO	0.60	0.35	0.57	1.31	0.57	0.49	0.64	0.58	0.63	0.67
CaO	1.47	1.03	0.56	1.64	0.82	1.10	1.21	1.06	0.83	1.29
Na_2O	0.66	1.48	0.69	0.95	0.49	0.43	0.69	0.48	1.72	0.86
K_2O	2.53	4.06	1.55	2.49	3.39	1.18	1.44	2.35	3.92	1.15
P_2O_5	0.09	0.08	0.09	0.07	0.15	0.07	0.08	0.06	0.08	0.08
H_2O-	3.72	2.05	1.27	2.65	2.57	2.94	2.81	4.20	1.49	2.69
LOI	11.20	7.86	2.45	7.05	6.23	7.18	11.01	8.24	4.30	10.58
TOTAL	99.54	99.67	99.49	99.84	99.42	100.26	99.36	100.03	99.85	99.49
Rb	150	209	73	125	111	55	63	120	195	58
Sr	265	144	96	233	181	151	134	114	147	171
Y	11	24	14	29	12	29	23	42	14	66
Zr	236	159	220	166	314	253	180	227	158	276
Nb	10	9	8	16	12	9	8	13	10	13
Cu	3	3	5	13	7	3	3	0	2	0
Ni	11	10	13	30	13	17	11	10	7	11
Zn	20	19	13	40	26	16	16	11	13	15
V	78	41	55	126	81	101	57	51	37	78
Cr	63	44	73	119	50	96	83	71	22	160
Co	8	7	11	15	5	7	12	6	3	7

Sample No	Rudner Site No	Site
SC86	82	Hawston
SC87	82	Hawston
SC88	82	Hawston
SC89	82	Hawston
SC90	82	Hawston
WC140	82	Hawston
SC47	85	Die Kelders
SC95	86	Gansbaai
SC79	87	Sandy Bay
SC92	87	Sandy Bay

Table A4.2.1 continued.

Sample	SC105	SC27	SC28	SC29	SC30	SC31	SC32	SC33	SC34	SC35
SiO_2	68.06	64.32	67.97	67.39	68.24	75.50	58.45	67.23	64.19	62.09
TiO_2	0.58	0.63	0.46	0.46	0.42	0.63	0.25	0.33	0.69	0.29
Al_2O_3	14.31	12.01	15.19	14.68	13.98	11.02	15.79	18.32	13.50	16.14
Fe_2O_3	3.94	9.12	3.57	4.21	4.11	3.74	7.40	3.21	5.01	3.98
MnO	0.03	0.09	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.01
MgO	0.99	0.97	0.54	1.20	0.53	0.90	0.61	0.62	0.89	0.58
CaO	0.87	0.66	0.81	2.27	0.83	0.66	0.93	0.92	1.12	1.21
Na_2O	0.70	0.49	0.97	0.83	1.21	0.68	0.77	0.50	0.77	0.72
K_2O	1.53	1.77	2.83	1.16	3.21	1.39	2.51	0.74	2.01	2.02
P_2O_5	0.16	0.03	0.24	0.06	0.08	0.05	0.05	0.14	0.06	0.10
H_2O-	2.83	1.93	2.91	2.42	1.96	2.32	2.22	2.63	2.77	3.26
LOI	6.44	7.62	4.07	5.67	6.26	3.96	11.66	4.99	9.24	9.63
TOTAL	100.44	99.64	99.57	100.37	100.85	100.87	100.66	99.65	100.28	100.03
Rb	79	98	124	73	123	73	117	48	100	84
Sr	148	126	176	211	149	126	146	139	183	182
Y	24	28	15	38	7	10	57	48	15	13
Zr	289	260	236	191	229	258	173	216	272	170
Nb	12	11	11	7	10	9	7	9	10	8
Cu	1	12	3	0	4	5	2	0	8	0
Ni	19	40	6	20	9	19	13	10	22	9
Zn	12	34	15	9	13	17	15	27	22	28
V	87	166	54	80	53	100	58	49	114	51
Cr	105	126	33	83	47	96	92	73	115	78
Co	7	32	6	19	1	8	4	5	12	7

Sample No	Rudner Site No	Site
SC105	87	Sandy Bay
SC27	88	Pearly Beach
SC28	88	Pearly Beach
SC29	88	Pearly Beach
SC30	88	Pearly Beach
SC31	88	Pearly Beach
SC32	88	Pearly Beach
SC33	88	Pearly Beach
SC34	88	Pearly Beach
SC35	88	Pearly Beach

Table A4.2.1 continued.

Sample	SC36	SC37	SC38	SC97	SC101	SC106	SC128	SC104	SC110	SC113
SiO_2	63.62	63.96	66.15	71.57	67.77	65.11	68.76	56.45	72.45	63.65
TiO_2	0.77	0.74	0.36	0.70	0.37	0.35	0.30	0.58	0.66	0.76
Al_2O_3	15.52	13.20	12.73	13.60	13.61	17.76	14.02	15.34	10.77	15.94
Fe_2O_3	3.93	5.32	4.38	8.29	3.52	3.50	3.97	6.10	3.83	4.40
MnO	0.02	0.03	0.02	0.16	0.02	0.03	0.02	0.52	0.03	0.01
MgO	1.07	1.07	1.27	2.06	0.52	0.72	0.40	3.13	0.91	1.37
CaO	1.12	1.00	3.70	0.87	0.69	1.13	1.03	3.56	1.33	1.13
Na_2O	0.53	0.71	0.67	0.16	0.84	0.91	0.50	0.80	0.69	0.80
K_2O	1.52	1.78	1.09	1.98	3.73	0.97	2.12	2.81	1.40	1.64
P_2O_5	0.06	0.08	0.03	0.03	0.04	0.17	0.13	0.07	0.20	0.11
H_2O-	3.25	3.15	3.07	0.01	1.85	2.54	2.99	1.94	2.03	2.81
LOI	8.70	9.60	7.35	0.45	7.25	7.67	5.26	9.76	5.53	7.84
TOTAL	100.11	100.64	100.82	99.88	100.21	100.86	99.50	101.06	99.83	100.46
Rb	85	92	84	92	195	39	104	139	73	88
Sr	189	194	238	58	140	181	206	412	196	181
Y	25	12	52	20	21	52	39	32	16	29
Zr	271	250	127	198	231	214	281	183	242	261
Nb	10	10	5	15	12	13	12	13	13	14
Cu	0	7	0	28	4	0	0	32	7	1
Ni	22	24	24	62	11	10	8	51	15	26
Zn	15	23	12	40	16	14	11	63	18	17
V	118	117	84	183	53	62	46	106	93	123
Cr	105	118	80	358	53	75	62	130	86	111
Co	16	16	41	13	7	6	5	10	7	10

Sample No	Rudner Site No	Site
SC36	88	Pearly Beach
SC37	88	Pearly Beach
SC38	88	Pearly Beach
SC97	89	Quoin Point
SC101	89	Quoin Point
SC106	89	Quoin Point
SC128	89	Die Dam
SC104	90	Die Lagoon
SC110	90	Die Lagoon
SC113	90	Die Lagoon

Table A4.2.1 continued.

Sample	SC80	SC125	SC103	SC116	SC102	SC115	SC41	SC42	SC45	SC46
SiO_2	69.28	66.19	63.70	68.25	67.01	65.65	58.45	71.49	67.32	68.21
TiO_2	0.54	0.29	0.24	0.72	0.28	0.54	0.54	0.53	0.51	0.59
Al_2O_3	14.88	14.95	12.36	14.07	13.84	13.71	15.83	13.52	13.75	15.11
Fe_2O_3	5.91	4.38	6.39	3.63	7.48	4.20	5.03	3.93	3.99	4.04
MnO	0.03	0.04	0.03	0.02	0.02	0.03	0.02	0.03	0.03	0.01
MgO	1.04	0.51	0.58	1.15	0.47	0.86	0.92	1.30	1.33	0.64
CaO	0.65	0.71	1.21	0.70	1.03	1.39	1.40	1.27	1.61	0.94
Na_2O	0.66	1.07	0.72	0.99	0.72	1.82	0.74	1.05	0.93	0.90
K_2O	1.90	2.42	2.92	1.78	2.37	3.56	2.45	1.29	1.33	1.88
P_2O_5	0.09	0.07	0.08	0.13	0.08	0.04	0.20	0.15	0.27	0.08
H_2O-	0.77	2.36	2.61	2.37	2.41	1.88	3.58	1.86	2.39	2.81
LOI	3.90	6.88	9.41	6.02	5.10	5.75	11.27	3.75	6.99	4.73
TOTAL	99.65	99.87	100.25	99.83	100.81	99.43	100.43	100.17	100.45	99.94
Rb	124	117	130	83	108	166	152	44	66	86
Sr	93	135	248	168	322	186	130	153	83	112
Y	25	35	44	25	52	39	61	33	19	19
Zr	298	231	186	318	210	336	243	357	437	314
Nb	9	11	11	13	14	15	14	7	9	9
Cu	11	0	6	1	3	3	1	15	15	1
Ni	31	12	13	22	11	15	22	58	66	16
Zn	28	16	12	13	13	28	36	38	34	22
V	123	46	51	108	48	57	87	81	87	90
Cr	138	75	88	108	75	62	82	106	118	67
Co	18	10	6	8	5	8	16	26	27	9

Sample No	Rudner Site No	Site
SC80	91	Cape Agulhas
SC125	92	Arniston
SC103	93	Ryspunt, Arniston
SC116	93	Rysbaai
SC102	94	Skipskop
SC115	94	Skipskop
SC41	101	Still Bay
SC42	103	Fish Bay
SC45	103	Fish Bay
SC46	103	Fish Bay

Table A4.2.1 continued.

Sample	SC49	SC50	SC51	SC52	SC53	SC76	SC121	SC124	SC108	SC114
SiO_2	69.16	67.50	70.33	61.53	71.20	77.70	64.34	56.92	62.22	61.15
TiO_2	0.53	0.44	0.50	0.54	0.33	0.51	0.42	0.52	0.52	0.64
Al_2O_3	10.87	13.65	13.25	17.00	13.25	8.41	16.11	14.79	17.46	12.91
Fe_2O_3	4.84	5.29	4.02	4.86	3.90	3.34	4.54	4.33	5.73	6.00
MnO	0.02	0.02	0.04	0.04	0.02	0.04	0.03	0.02	0.02	0.08
MgO	0.50	0.96	1.17	0.91	0.39	0.53	0.96	1.59	0.84	1.11
CaO	0.95	1.03	1.52	1.16	0.61	0.70	1.04	8.25	1.15	0.91
Na_2O	0.65	1.53	0.71	0.71	1.53	0.34	1.36	0.56	1.16	0.94
K_2O	1.85	2.66	1.72	2.10	2.97	0.74	3.57	1.11	1.79	1.88
P_2O_5	0.05	0.07	0.11	0.16	0.04	0.06	0.15	0.13	0.05	0.14
H_2O-	2.34	1.16	1.98	4.14	2.08	1.72	2.38	2.12	3.50	2.79
LOI	7.68	5.48	4.23	6.49	3.29	5.60	4.95	9.90	6.39	8.56
TOTAL	99.44	99.79	99.58	99.64	99.61	99.69	99.85	100.24	100.83	97.11
Rb	91	108	85	115	151	31	238	34	121	82
Sr	116	115	148	153	96	94	160	302	173	142
Y	34	52	34	49	16	12	59	11	39	17
Zr	484	177	271	291	218	344	256	237	258	257
Nb	8	9	8	10	8	8	15	12	16	12
Cu	4	4	6	7	2	11	2	3	2	13
Ni	14	13	23	41	10	13	20	19	17	28
Zn	19	37	37	30	20	28	29	14	26	41
V	76	60	93	108	51	62	56	105	81	123
Cr	69	52	83	110	50	61	63	108	82	169
Co	14	7	7	15	8	8	8	7	7	8

Sample No	Rudner Site No	Site
SC49	103	Fish Bay
SC50	103	Fish Bay
SC51	103	Fish Bay
SC52	103	Fish Bay
SC53	103	Fish Bay
SC76	104	Flesh Bay
SC121	104	Flesh Bay
SC124	104	Flesh Bay
SC108	106	Klein Brak
SC114	107	Groot Brak River

Table A4.2.1 continued.

Sample	SC117	SC120	SC127	SC39	SC44	SC122	SC96	SC100	SC109	SC77
SiO_2	59.65	65.69	60.34	60.34	64.45	70.60	65.55	67.63	74.75	74.45
TiO_2	0.40	0.14	0.45	0.60	0.50	0.37	0.36	0.55	0.76	0.54
Al_2O_3	18.41	15.98	10.57	16.21	15.45	12.81	15.74	12.52	10.55	8.33
Fe_2O_3	8.23	2.65	5.33	9.16	4.75	4.75	6.10	5.35	3.82	3.25
MnO	0.01	0.03	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.03
MgO	0.66	0.59	0.44	0.59	1.03	1.04	0.72	0.86	0.54	0.62
CaO	1.01	0.80	1.03	0.81	0.71	0.58	1.04	1.34	1.07	0.87
Na_2O	1.45	2.26	0.37	0.73	1.82	12.25	1.27	0.69	0.55	0.46
K_2O	3.26	3.68	1.20	4.22	2.20	2.45	1.43	0.95	0.84	0.52
P_2O_5	0.07	0.24	0.10	0.38	0.15	0.19	0.10	0.06	0.09	0.06
H_2O-	2.88	1.88	3.38	1.31	2.89	1.30	3.14	2.06	2.74	2.38
LOI	4.30	5.88	12.89	5.41	6.08	4.11	4.45	7.54	4.59	8.01
TOTAL	100.33	99.82	96.11	99.78	100.05	110.46	99.92	99.57	100.32	99.52
Rb	215	247	80	205	124	nd	74	53	59	24
Sr	187	103	112	121	100	nd	241	124	169	100
Y	24	15	18	31	19	nd	18	17	35	20
Zr	128	84	309	228	201	nd	168	278	667	322
Nb	16	12	8	20	11	nd	12	12	16	7
Cu	5	2	0	10	4	5	3	4	2	6
Ni	15	10	15	13	14	15	16	17	16	11
Zn	26	26	12	46	28	25	26	26	16	17
V	62	26	96	101	75	nd	66	94	75	66
Cr	62	52	101	71	87	nd	79	102	84	81
Co	5	6	5	8	9	nd	7	7	9	10

Sample No	Rudner Site No	Site
SC117	107	Groot Brak River
SC120	107	Groot Brak River
SC127	107	Groot Brak River
SC39	109	Oakhurst
SC44	109	Oakhurst
SC122	109	Oakhurst
SC96	110	Sedgefield
SC100	110	Sedgefield
SC109	110	Sedgefield
SC77	111	Goukamma River

Table A4.2.1 continued.

Sample	SC78	SC40	SC119	SC126	SC54	SC55	SC56	SC62	SC63	SC64
SiO_2	69.93	60.12	72.83	69.49	75.95	78.32	78.67	nd	61.57	80.75
TiO_2	0.59	0.79	0.50	0.63	0.58	0.56	0.65	nd	0.59	0.52
Al_2O_3	11.35	15.65	10.18	12.79	8.99	8.25	8.18	nd	15.02	7.35
Fe_2O_3	4.42	7.66	4.62	4.87	4.11	3.38	3.46	nd	6.52	4.06
MnO	0.04	0.03	0.01	0.02	0.02	0.01	0.02	nd	0.03	0.02
MgO	0.67	1.15	0.39	0.84	0.78	0.47	0.46	nd	0.83	0.35
CaO	0.85	0.66	1.07	0.95	0.86	0.67	0.63	nd	2.67	0.68
Na_2O	0.81	4.83	0.26	0.28	0.41	0.54	0.42	nd	0.50	0.45
K_2O	1.45	2.53	1.44	2.22	1.35	0.94	1.23	nd	1.43	0.83
P_2O_5	0.06	0.12	0.20	0.17	0.26	0.12	0.12	nd	0.06	0.11
H_2O-	2.41	1.33	2.53	2.98	2.45	1.65	2.08	nd	4.16	1.58
LOI	7.28	4.93	5.22	4.79	3.85	4.69	3.67	nd	6.48	3.16
TOTAL	99.86	99.80	99.25	100.03	99.61	99.60	99.59	nd	99.86	99.86
Rb	101	127	78	116	62	53	45	92	73	45
Sr	132	92	154	154	111	102	173	111	231	103
Y	20	15	17	27	17	18	32	17	20	19
Zr	612	457	186	318	253	460	338	174	288	475
Nb	10	14	10	13	7	8	7	9	9	8
Cu	4	11	6	4	5	3	5	9	4	6
Ni	20	27	20	16	24	14	12	27	23	13
Zn	17	39	20	25	34	18	16	41	26	15
V	76	152	102	92	106	77	76	157	120	74
Cr	92	146	105	119	218	79	90	269	119	89
Co	15	9	5	8	15	9	9	9	11	13

Sample No	Rudner Site No	Site
SC78	111	Goukamma River
SC40	113	Robberg cave
SC119	119	Goedgeloof
SC126	119	Goedgeloof
SC54	120	Kromme Bay
SC55	120	Kromme Bay
SC56	120	Kromme Bay
SC62	120	Kromme Bay
SC63	120	Kromme Bay
SC64	120	Kromme Bay

Table A4.2.1 continued.

Sample	SC65	SC66	SC67	SC68	SC69	SC70	SC71	SC72	SC73	SC57
SiO_2	65.21	69.09	74.86	80.04	66.61	69.49	54.22	57.88	72.96	65.15
TiO_2	0.63	0.56	0.60	0.59	0.71	0.84	1.48	0.62	0.62	0.67
Al_2O_3	16.37	11.96	8.84	8.71	13.16	11.81	15.98	13.88	9.99	15.32
Fe_2O_3	7.42	4.33	3.70	2.79	6.77	4.72	10.00	6.13	4.67	5.69
MnO	0.03	0.03	nd	0.03	0.03	0.02	0.21	0.02	0.03	0.01
MgO	1.06	0.69	0.57	0.47	2.39	0.79	3.55	0.74	0.72	0.87
CaO	2.68	1.11	0.97	0.66	0.90	1.08	6.16	1.43	1.09	0.99
Na_2O	0.60	0.32	0.51	0.53	0.80	0.80	1.58	0.66	0.43	0.46
K_2O	1.62	1.55	1.03	1.19	2.22	1.97	0.83	1.60	1.33	2.03
P_2O_5	0.11	0.13	0.23	0.15	0.19	0.12	0.13	0.17	0.10	0.20
H_2O-	0.78	3.66	2.55	0.96	1.31	2.30	1.60	3.81	1.63	2.62
LOI	3.21	6.18	5.76	3.58	5.58	5.84	3.78	12.84	5.86	5.76
TOTAL	99.72	99.61	99.62	99.70	100.67	99.78	99.52	99.78	99.43	99.77
Rb	108	88	64	55	105	95	29	68	68	104
Sr	132	141	123	98	148	170	259	154	113	194
Y	25	19	20	22	33	34	25	16	21	26
Zr	332	365	405	425	382	406	208	307	271	301
Nb	12	8	8	8	12	13	11	8	9	11
Cu	65	5	3	8	13	11	65	4	6	11
Ni	27	22	14	15	25	19	133	16	26	21
Zn	30	28	19	23	35	30	49	21	36	42
V	125	95	81	94	134	114	258	120	120	113
Cr	140	105	93	89	122	99	398	136	239	118
Co	9	13	15	22	15	10	53	8	15	9

Sample No	Rudner Site No	Site
SC65	120	Kromme Bay
SC66	120	Kromme Bay
SC67	120	Kromme Bay
SC68	120	Kromme Bay
SC69	120	Kromme Bay
SC70	120	Kromme Bay
SC71	120	Kromme Bay
SC72	120	Kromme Bay
SC73	120	Kromme Bay
SC57	121	Jeffrey's Bay

Table A4.2.1 continued.

Sample	SC58	SC59	SC60	SC61	SC48	SC107	SC93	SC94	SC91	SC111
SiO_2	67.60	nd	nd	nd	75.27	72.81	64.12	62.16	72.86	61.83
TiO_2	0.55	nd	nd	nd	0.62	0.65	0.33	1.00	0.42	0.49
Al_2O_3	13.32	nd	nd	nd	10.05	11.76	19.70	13.27	9.43	15.55
Fe_2O_3	5.21	nd	nd	nd	4.70	6.04	5.27	5.02	4.56	4.57
MnO	0.05	nd	nd	nd	0.02	0.02	0.03	0.02	0.04	0.02
MgO	0.87	nd	nd	nd	0.87	0.97	0.49	1.09	1.18	0.72
CaO	1.03	nd	nd	nd	0.87	0.46	0.69	1.60	0.85	0.90
Na_2O	0.53	nd	nd	nd	0.53	0.74	1.12	0.64	0.52	1.13
K_2O	1.47	nd	nd	nd	1.43	1.71	3.46	1.68	1.32	3.92
P_2O_5	0.14	nd	nd	nd	0.06	0.03	0.30	0.11	0.04	0.08
H_2O-	3.23	nd	nd	nd	1.27	1.09	1.24	3.42	1.71	2.23
LOI	5.84	nd	nd	nd	3.93	3.70	3.04	9.71	7.57	9.11
TOTAL	99.84	nd	nd	nd	99.62	99.98	99.79	99.72	100.50	100.55
Rb	77	126	57	104	81	88	218	89	72	190
Sr	194	215	81	112	194	68	125	259	92	156
Y	21	34	19	21	17	8	18	32	20	18
Zr	278	315	295	197	258	143	119	486	236	244
Nb	8	11	10	9	8	14	13	16	9	21
Cu	6	9	23	6	9	8	5	7	12	1
Ni	31	31	33	21	29	18	15	23	34	8
Zn	26	33	58	40	36	33	23	48	28	30
V	110	132	111	107	125	149	60	146	78	56
Cr	103	144	233	104	248	145	61	304	138	25
Co	17	34	17	13	13	6	8	7	9	6

Sample No	Rudner Site No	Site
SC58	121	Jeffrey's Bay
SC59	121	Jeffrey's Bay
SC60	121	Jeffrey's Bay
SC61	121	Jeffrey's Bay
SC48	124	Gamtoos River mouth
SC107	130	The Willows, PE
SC93	139	Perdekloof
SC94	139	Perdekloof
SC91	147	Kleinmond
SC111	147	Kleinmond

Table A4.2.1 continued.

Sample	WC12	WC41	WC42	WC43	WC51	WC56	WC68	WC80	WC86	SC99
SiO_2	60.18	69.15	55.40	62.56	57.99	61.88	63.57	61.51	59.60	61.64
TiO_2	0.54	0.73	1.13	0.61	0.22	0.74	0.32	0.51	0.24	0.37
Al_2O_3	16.85	13.67	14.68	17.67	17.63	15.31	14.56	16.73	18.61	15.18
Fe_2O_3	5.95	6.42	11.35	9.41	4.01	5.34	4.08	5.38	4.57	3.42
MnO	0.05	0.10	0.16	0.24	0.05	0.08	0.03	0.05	0.04	0.02
MgO	0.93	1.07	3.10	2.26	0.52	1.27	0.77	1.09	0.72	0.54
CaO	0.74	1.46	4.50	1.04	0.51	1.24	0.85	1.45	1.12	1.42
Na_2O	1.56	1.12	0.71	0.46	0.65	1.22	0.85	1.22	0.59	0.79
K_2O	3.12	2.34	1.32	2.73	3.32	4.32	3.30	3.76	2.87	3.69
P_2O_5	0.09	0.09	0.23	0.20	0.64	0.08	0.08	0.14	0.12	0.08
H_2O-	1.26	0.69	1.78	0.36	3.94	1.50	2.27	1.56	3.43	3.36
LOI	9.08	2.15	4.52	1.71	10.47	6.50	8.66	6.05	7.49	10.06
TOTAL	100.35	98.99	98.88	99.25	99.95	99.48	99.34	99.45	99.40	100.57
Rb	162	219	23	159	180	221	179	158	167	139
Sr	87	125	197	158	224	135	147	289	236	224
Y	16	39	25	36	32	81	11	54	13	10
Zr	196	298	153	191	103	1174	148	167	96	136
Nb	14	17	12	13	9	20	9	14	10	11
Cu	7	20	86	51	3	9	2	5	1	2
Ni	16	31	48	40	10	14	12	12	8	9
Zn	48	58	72	119	38	36	14	47	20	11
V	68	123	226	155	35	67	45	60	51	45
Cr	70	145	206	124	64	55	34	47	50	41
Co	8	14	42	19	10	7	4	8	6	6

Sample No	Rudner Site No	Site
WC12	x	Ceres
WC41	x	Beesdam, Carnavon
WC42	x	Peerboom, Carnavon
WC43	x	Vlakmyn, van Rhynsdorp area
WC51	x	Hopefield
WC56	x	Komkans, van Rhynsdorp area
WC68	x	Springfield (Cape Agulhas area)
WC80	x	Holbaai, Vredenburg
WC86	x	Hopefield
SC99	x	Vermont (Hawston area)

Table A4.2.1 continued.

Sample	SC112	SC118	SC123	WC144
SiO_2	58.22	69.51	73.21	63.59
TiO_2	0.37	0.48	0.73	0.77
Al_2O_3	13.75	11.50	8.51	18.24
Fe_2O_3	10.77	6.22	3.98	7.39
MnO	0.04	0.03	0.02	0.08
MgO	0.67	0.68	0.73	2.17
CaO	1.12	0.61	1.76	2.36
Na_2O	1.08	0.51	0.32	1.57
K_2O	4.26	1.46	0.92	1.72
P_2O_5	0.09	0.14	0.03	0.10
H_2O-	2.10	1.00	1.98	0.34
LOI	7.43	6.78	7.93	1.02
TOTAL	99.90	98.92	100.12	99.35
Rb	278	93	50	102
Sr	219	88	201	153
Y	100	18	20	20
Zr	194	385	328	244
Nb	17	12	14	13
Cu	5	16	7	21
Ni	18	23	18	37
Zn	26	17	8	54
V	51	112	87	167
Cr	92	134	113	178
Co	10	12	7	14

Sample No	Rudner Site No	Site
SC112	x	Die Grys, Bredasdorp area
SC118	x	Struisbaai (Cape Agulhas area)
SC123	x	Koppie Alleen (east of Arniston)
WC144	x	Cape Peninsula surface

Table A4.2.2. Data for the Namibian coastal sherds.

	bz15	bz16	bz18	bz19	bz20	bz30	bz36	bz37	mx	D34
SiO_2	61.58	54.66	66.14	57.49	56.17	59.99	60.28	50.05	56.12	60.27
TiO_2	0.21	0.70	0.37	0.30	0.74	0.34	0.87	1.37	0.72	0.78
Al_2O_3	18.59	19.04	14.33	18.07	19.06	19.58	16.06	15.61	19.58	17.28
Fe_2O_3	3.65	5.04	3.71	3.06	5.18	4.68	6.17	9.41	5.49	6.09
MnO	0.07	0.04	0.05	0.03	0.05	0.11	0.05	0.17	0.06	0.07
MgO	0.55	0.96	0.73	1.14	1.04	0.89	0.87	3.07	1.13	1.39
CaO	1.60	1.11	1.04	1.57	1.11	1.10	0.96	6.14	1.02	2.02
Na_2O	3.03	4.14	2.10	2.54	1.08	4.80	1.44	1.28	1.61	2.64
K_2O	3.43	6.17	3.93	4.78	6.37	3.93	3.94	3.07	6.32	4.01
P_2O_5	0.05	0.09	0.19	0.13	0.11	0.07	0.10	0.39	0.08	0.16
H_2O-	0.81	1.18	0.61	1.36	1.17	0.95	1.32	1.13	1.43	1.05
LOI	5.10	6.99	6.64	9.60	8.20	3.75	8.39	7.71	6.35	4.24
TOTAL	98.67	100.12	99.84	100.07	100.28	100.19	100.45	99.40	99.91	100.00
Rb	146	236	177	200	233	304	174	125	229	201
Sr	242	169	112	149	159	72	111	558	159	167
Y	22	26	26	18	25	66	65	63	25	46
Zr	85	369	192	96	365	106	279	339	373	412
Nb	13	21	13	20	20	68	18	19	19	24
Cu	12	18	10	3	14	21	12	15	15	19
Ni	15	18	15	11	18	17	18	38	20	22
Zn	43	41	30	30	43	81	66	97	41	64
V	87	128	53	43	128	49	96	180	120	93
Cr	74	73	62	38	75	67	56	136	82	55
Co	3	11	4	2	13	1	5	26	12	10

bz15: Meob Bay
bz16: Meob Bay
bz18: Meob Bay
bz19: Meob Bay
bz20: Meob Bay
bz30: Meob Bay
bz36: Meob Bay
bz37: Meob Bay
mx: Meob Bay
D34: Kuiseb River mouth

Table A4.2.2 continued.

	D35	D36	ak21	ak22	WC58	WC65
SiO_2	62.61	62.85	60.71	59.76	64.31	63.45
TiO_2	0.37	0.72	0.72	0.84	1.11	0.35
Al_2O_3	17.14	15.82	17.29	13.70	12.77	19.60
Fe_2O_3	4.95	5.95	5.95	9.07	8.41	4.83
MnO	0.07	0.11	0.07	0.08	0.13	0.10
MgO	1.01	0.85	1.54	2.06	1.98	1.04
CaO	1.37	1.24	2.00	1.68	1.80	1.18
Na_2O	2.88	2.08	2.51	1.04	1.21	2.17
K_2O	3.89	3.85	4.31	2.36	2.16	3.66
P_2O_5	0.10	0.16	0.12	0.09	0.14	0.14
H_2O-	0.71	0.82	0.83	1.24	0.81	0.36
LOI	4.34	5.84	5.14	8.22	4.71	2.54
TOTAL	99.44	100.29	101.19	100.14	99.54	99.42
Rb	199	233	185	92	128	210
Sr	124	115	195	155	135	78
Y	53	34	39	22	59	20
Zr	181	215	357	152	337	128
Nb	27	53	25	13	16	20
Cu	19	25	23	109	38	17
Ni	21	25	19	48	31	18
Zn	66	82	66	79	79	55
V	62	90	89	188	217	58
Cr	61	65	51	174	141	94
Co	6	8	12	15	22	13

D35:	Kuiseb River mouth
D36:	Kuiseb River mouth
ak21:	Kuiseb River mouth
ak22:	Chamois Bay
WC58:	Claratal
WC65:	Swakopmund

Table A4.2.3. Data for the Namaqualand sherds.

	vm51	vm52	vm53	vm57	vm58	vm59	vm60	vm61
SiO_2	68.35	54.65	74.14	61.54	53.93	35.56	62.57	75.28
TiO_2	0.62	0.74	0.39	0.77	1.33	0.57	0.79	0.44
Al_2O_3	12.88	10.63	10.86	13.71	33.71	9.15	13.70	9.74
Fe_2O_3	6.40	7.76	4.14	8.60	3.40	5.91	8.43	4.70
MnO	0.18	0.11	0.01	0.11	0.09	0.09	0.10	0.03
MgO	0.85	3.41	0.28	1.06	0.27	7.91	1.08	0.64
CaO	1.77	10.40	0.82	1.93	0.45	19.15	1.97	0.74
Na_2O	1.44	1.57	0.56	1.45	0.08	1.25	1.46	0.38
K_2O	3.32	0.69	1.61	2.59	0.73	0.53	2.68	1.69
P_2O_5	0.19	0.09	0.04	0.13	0.16	0.31	0.12	0.12
H_2O-	0.48	1.60	2.25	1.83	0.88	2.11	1.71	1.51
LOI	2.10	7.72	3.56	4.69	3.34	17.34	4.50	3.74
TOTAL	98.58	99.37	98.66	98.41	98.37	99.88	99.11	99.01
Rb	150	18	124	82	17	21	84	71
Sr	144	329	169	157	174	550	155	72
Y	40	18	15	40	20	43	41	22
Zr	350	132	125	974	375	64	970	203
Nb	24	11	8	44	17	21	44	13
Cu	22	30	5	49	19	26	46	15
Ni	29	29	14	30	23	49	31	24
Zn	57	60	19	63	28	61	63	40
V	104	211	95	217	130	201	225	99
Cr	76	88	63	102	251	111	107	102
Co	26	29	17	32	8	18	32	17

vm51	7355: Augrabies
vm52	7354: Rooidam
vm53	436: Bushmanland
vm57	7052: Gordonia
vm58	7054: Rooidam (red slip)
vm59	7054: Rooidam (red slip)
vm60	7052: Gordonia
vm61	7052: Gordonia

Table A4.2.4. Data for the sherds from the Cape Folded Belt and the Karoo.

	vm35	vm36	vm37	vm38	vm39	vm40	vm41	vm42	vm43	vw
SiO_2	73.67	64.91	68.93	75.93	63.89	62.14	66.75	61.22	64.73	59.67
TiO_2	0.64	0.88	0.66	0.44	0.62	0.91	0.64	0.76	0.43	0.92
Al_2O_3	11.67	15.11	14.52	13.30	10.35	13.17	12.00	19.82	15.81	15.64
Fe_2O_3	5.08	8.63	6.16	2.57	10.12	9.61	6.93	8.20	4.40	7.91
MnO	0.03	0.15	0.07	0.02	0.05	0.19	0.12	0.13	0.06	0.10
MgO	0.66	2.16	1.70	0.39	1.20	0.80	2.09	1.96	0.34	2.58
CaO	0.62	0.84	0.53	0.47	0.90	0.47	0.88	0.89	0.91	2.94
Na_2O	0.21	1.17	1.11	0.20	0.70	0.16	0.65	1.18	1.14	1.13
K_2O	2.25	2.19	2.84	0.95	2.58	1.74	2.13	3.39	5.06	2.13
P_2O_5	0.20	0.20	0.20	0.26	0.44	0.32	0.38	0.12	0.49	0.20
H_2O-	0.88	0.68	0.44	1.79	2.50	1.89	1.94	0.52	1.32	2.16
LOI	2.42	1.91	1.32	3.48	6.45	7.12	4.37	1.55	3.78	4.32
TOTAL	98.33	98.83	98.48	99.80	99.80	98.52	98.88	99.74	98.47	99.70
Rb	nd	nd	nd	nd	nd	nd	nd	nd	nd	78
Sr	nd	nd	nd	nd	nd	nd	nd	nd	nd	169
Y	nd	nd	nd	nd	nd	nd	nd	nd	nd	28
Zr	nd	nd	nd	nd	nd	nd	nd	nd	nd	195
Nb	nd	nd	nd	nd	nd	nd	nd	nd	nd	14
Cu	nd	nd	nd	nd	nd	nd	nd	nd	nd	25
Ni	nd	nd	nd	nd	nd	nd	nd	nd	nd	26
Zn	nd	nd	nd	nd	nd	nd	nd	nd	nd	85
V	nd	nd	nd	nd	nd	nd	nd	nd	nd	173
Cr	nd	nd	nd	nd	nd	nd	nd	nd	nd	240
Co	nd	nd	nd	nd	nd	nd	nd	nd	nd	37

vm35	7251: Aspoort
vm36	7251: Aspoort
vm37	7251: Aspoort
vm38	7246: ??Doornriver
vm39	7246: ??Doornriver
vm40	7246: ??Doornriver
vm41	7246: ??Doornriver
vm42	7247: Matjiesriver shelter
vm43	7265: ?Karoo
vw	Biesjiesfontein, Victoria West

Table A4.2.4 continued.

	vm45	vm47	vm49	vm50	vm54	vm55	WC12	vm56	vm62	vm63
SiO_2	63.50	56.95	58.88	61.35	60.54	58.96	60.18	61.56	66.23	50.37
TiO_2	0.72	0.78	0.96	0.59	0.56	0.55	0.54	0.52	0.34	0.83
Al_2O_3	16.58	15.08	14.16	16.45	16.44	15.96	16.85	12.43	13.08	14.70
Fe_2O_3	5.94	9.60	9.15	5.77	6.35	5.33	5.95	4.66	4.08	9.19
MnO	0.06	0.20	0.13	0.04	0.04	0.04	0.05	0.02	0.03	0.10
MgO	1.95	3.58	3.34	1.32	0.68	0.86	0.93	0.78	0.47	4.27
CaO	1.89	5.23	5.63	0.99	0.69	0.95	0.74	0.40	1.06	6.75
Na_2O	1.30	1.00	1.59	1.13	1.45	2.13	1.56	0.42	1.13	1.34
K_2O	3.20	1.06	1.13	3.00	3.03	3.09	3.12	2.70	3.00	1.15
P_2O_5	0.18	0.13	0.23	0.17	0.08	0.09	0.09	0.17	0.09	0.78
H_2O-	0.85	2.13	1.14	1.57	1.24	1.81	1.26	1.76	1.96	2.42
LOI	2.38	4.20	4.33	5.97	8.70	9.16	9.08	13.90	7.26	6.54
TOTAL	98.55	99.94	100.67	98.35	99.80	98.93	100.35	99.32	98.73	98.44
Rb	nd	40	33	127	167	158	162	93	164	34
Sr	nd	157	217	219	87	103	87	59	102	192
Y	nd	21	16	14	11	10	16	10	20	18
Zr	nd	159	148	205	195	185	196	241	137	128
Nb	nd	10	11	11	15	14	14	8	10	10
Cu	nd	67	53	18	7	6	7	14	2	59
Ni	nd	76	55	18	11	10	16	22	10	67
Zn	nd	89	63	73	49	51	48	49	22	81
V	nd	229	219	133	70	64	68	100	59	224
Cr	nd	328	276	74	61	49	70	99	57	355
Co	nd	56	47	20	24	18	8	19	15	42

vm45	5709: Victoria West
vm47	5768: Aliwal North
vm49	8227: Oskloof, Beaufort West
vm50	8227: Oskloof, Beaufort West
vm54	6879: Ceres (spout and boss sherd)
vm55	6879: Ceres
WC12	Ceres
vm56	6269: Waterkloof Cave, Oudtshoorn
vm62	1121: Smithfield
vm63	1121: Smithfield

Table A4.2.4 continued.

	vm64	vm65	vm66	Vm48	WC41	WC42	vm2	vm30	vm31	vm32
SiO_2	58.07	59.65	58.23	60.71	69.15	55.4	62.18	60.12	61.36	68.15
TiO_2	0.78	0.74	0.54	0.85	0.73	1.13	0.79	0.68	0.82	0.44
Al_2O_3	15.44	17.23	12.87	13.77	13.67	14.68	16.43	15.59	17.61	13.65
Fe_2O_3	7.86	7.22	4.23	7.37	6.42	11.35	6.82	7.44	6.57	5.29
MnO	0.07	0.08	0.09	0.07	0.10	0.16	0.12	0.09	0.07	0.04
MgO	2.69	1.40	1.38	2.42	1.07	3.10	1.33	1.85	1.49	0.72
CaO	4.42	1.30	6.27	2.64	1.46	4.50	0.99	0.88	1.02	0.80
Na_2O	1.34	0.50	0.59	1.13	1.12	0.71	0.92	1.07	0.89	0.73
K_2O	0.91	3.81	3.21	1.76	2.34	1.32	3.25	3.20	3.04	2.82
P_2O_5	0.10	0.48	0.31	0.28	0.09	0.23	0.19	0.30	0.53	0.27
H_2O-	2.93	1.96	1.86	2.29	0.69	1.78	1.50	1.37	1.66	1.62
LOI	4.56	4.53	8.88	6.47	2.15	4.52	4.13	5.80	4.70	4.55
TOTAL	99.17	98.90	98.46	99.76	98.99	98.88	98.65	98.39	99.76	99.08
Rb	27	140	102	54	219	23	107	139	141	119
Sr	244	138	339	146	125	197	100	105	205	128
Y	17	26	22	14	39	25	24	24	33	12
Zr	194	193	234	205	298	153	236	249	223	202
Nb	8	15	12	9	17	12	13	12	15	12
Cu	80	27	20	22	20	86	39	32	25	12
Ni	71	31	25	43	31	48	47	43	28	23
Zn	70	84	63	64	58	72	79	77	98	46
V	192	123	86	188	123	226	228	150	150	69
Cr	300	102	81	261	145	206	187	165	105	52
Co	42	30	16	35	14	42	32	35	27	20

vm64	798 Smithfield
vm65	5598 Modderpoort rock shelter, Ladybrand
vm66	5598 Modderpoort rock shelter, Ladybrand
vm48	Carnavon
WC41	Beesdam, Carnavon
WC42	Peerboom, Carnavon
vm2	5633 Phomong, Lesotho
vm30	7267 Klipfonteinrand
vm31	7267 Klipfonteinrand
vm32	7267 Klipfonteinrand

Table A4.2.4 continued.

	vm33	vm34
SiO_2	63.57	65.28
TiO_2	0.90	0.68
Al_2O_3	15.26	14.91
Fe_2O_3	6.52	5.18
MnO	0.07	0.05
MgO	0.88	0.85
CaO	1.00	0.77
Na_2O	2.18	1.39
K_2O	3.73	2.73
P_2O_5	0.15	0.25
H_2O-	0.62	1.35
LOI	4.38	5.18
TOTAL	99.26	98.62
Rb	178	nd
Sr	102	nd
Y	35	nd
Zr	423	nd
Nb	17	nd
Cu	24	nd
Ni	21	nd
Zn	74	nd
V	103	nd
Cr	68	nd
Co	23	nd

vm33	7263 Bulshoek Pass, Clanwilliam
vm34	7263 Bulshoek Pass, Clanwilliam

Table A4.2.5. Data for the Cape sediment samples.

	AC8	AC12	AC13	AC15	AC16	AC17	AC18	AC20	AC21	AC22
SiO_2	68.30	59.39	62.67	70.50	61.82	63.15	63.48	66.55	60.59	78.2
TiO_2	0.61	0.86	0.83	0.53	0.79	0.63	0.74	0.62	0.88	0.65
Al_2O_3	13.16	14.36	13.3	12.29	12.90	13.21	12.96	14.44	16.44	8.46
Fe_2O_3	3.32	5.72	5.09	2.79	4.54	3.84	5.29	4.41	5.99	3.13
MnO	0.09	0.09	0.08	0.10	0.09	0.07	0.07	0.09	0.09	0.05
MgO	1.55	2.38	1.90	1.20	1.98	1.13	1.79	1.22	1.60	1.00
CaO	2.23	1.60	1.81	1.99	3.82	1.56	3.60	1.86	1.66	0.89
Na_2O	1.75	0.71	0.96	2.03	1.55	4.94	1.05	2.15	2.00	1.53
K_2O	3.89	3.18	3.16	4.08	3.22	4.35	2.74	3.94	3.83	2.74
P_2O_5	0.13	0.12	0.09	0.01	0.12	0.07	0.17	0.16	0.23	0.00
H_2O-	1.04	2.24	1.68	3.78	1.26	1.52	1.07	0.68	1.07	0.76
LOI	3.44	8.73	7.46	0.00	7.06	5.53	6.12	3.75	6.59	2.21
TOTAL	99.51	99.38	99.03	99.30	99.15	100.00	99.08	99.87	100.97	99.62
Rb	161	166	161	154	146	224	123	190	203	102
Sr	188	105	115	128	170	149	154	142	206	105
Y	32	40	47	31	33	44	29	46	66	23
Zr	243	237	302	266	342	373	266	382	349	401
Nb	17	19	20	14	16	15	13	17	24	16
Cu	18	42	31	13	25	12	52	31	529	10
Ni	15	33	27	13	21	15	30	22	55	13
Zn	57	101	88	48	78	71	441	59	118	36
V	72	116	105	46	102	52	120	76	83	52
Cr	59	108	95	48	73	57	144	86	86	86
Co	6	20	18	9	14	11	16	13	19	8

AC8	Foot of Anenous Pass: Rietkloof gate stream sediment
AC12	T'Goep River, near Pofadder
AC13	T'Goep River, near pofadder
AC15	Foot of Anenous Pass: Rietkloof Gate stream sediment
AC16	Port Nolloth Road
AC17	Green river terrace (Springbok)
AC18	Orange River terrace at Vioolsdrif
AC20	River between Vioolsdrif and Springbok
AC21	River north of Springbok
AC22	River sediment east of Port Nolloth

Table A4.2.5. continued.

	AC24	AC26	AC27	AC29	AC30	AC31	AC32	AC33	AC35	AC36
SiO_2	57.50	67.34	76.07	63.87	57.52	86.00	78.03	64.28	63.08	82.77
TiO_2	0.85	0.62	0.56	0.72	0.75	0.44	0.48	0.73	0.49	0.15
Al_2O_3	14.67	14.00	11.22	11.52	13.73	6.19	4.59	15.06	17.41	7.57
Fe_2O_3	5.65	3.99	2.63	4.84	6.10	3.26	2.25	6.04	3.60	1.26
MnO	0.14	0.06	0.06	0.10	0.12	0.06	0.04	0.10	0.02	0.02
MgO	2.55	1.17	0.27	2.58	3.18	0.92	0.68	2.36	0.62	0.03
CaO	3.70	1.29	0.42	2.14	2.23	0.17	5.44	0.35	0.02	0.14
Na_2O	1.33	1.37	1.15	0.73	0.59	0.56	0.18	0.89	0.69	0.65
K_2O	3.30	4.42	5.84	2.98	3.42	1.40	0.90	3.48	5.65	4.14
P_2O_5	0.10	0.03	0.00	0.15	0.19	0.00	0.00	0.02	0.00	0.03
H_2O-	1.04	0.85	0.24	2.29	2.99	0.03	0.61	0.67	3.99	0.29
LOI	8.87	4.48	1.47	7.41	9.08	0.18	6.58	5.18	4.29	2.41
TOTAL	99.7	99.62	99.93	99.33	99.90	99.21	99.78	99.16	99.86	99.46
Rb	180	221	360	124	153	53	41	149	347	181
Sr	199	107	71	134	134	27	230	37	40	30
Y	33	49	43	27	25	18	18	30	31	15
Zr	260	387	585	182	148	187	318	198	193	212
Nb	23	14	19	16	16	10	10	15	13	3
Cu	53	110	22	24	29	14	15	27	9	4
Ni	34	20	11	24	27	20	12	39	10	9
Zn	90	67	36	79	101	50	62	103	36	37
V	116	60	39	92	111	62	43	128	61	13
Cr	130	61	36	125	145	82	60	117	52	35
Co	22	9	4	16	22	10	3	24	5	2

AC24	Tributary of Orange River near Vioolsdrif
AC26	River sediment at Goegap Nature reserve, Springbok
AC27	Soil, Goegap Nature reserve Springbok
AC29	River terrace east of Port Nolloth
AC30	River sediment east of Port Nolloth
AC31	River terrace east of Van Rhynsdorp
AC32	Wiedou River terrace north of Oliphants River
AC33	River sediment east of Van Rhynsdorp
AC35	Chapman ' s Peak
AC36	St Helena Bay (on granite)

Table A4.2.5. continued.

	AC38	AC39	AC41	AC50	AC53	AC54	AC55	AC56	AC57	AC58
SiO_2	72.29	73.82	71.61	85.65	62.20	75.15	88.38	61.36	60.83	65.25
TiO_2	0.98	0.82	0.52	0.51	0.68	0.32	0.38	0.57	0.64	0.61
Al_2O_3	11.23	10.68	12.09	3.19	15.48	11.46	4.46	17.73	19.62	18.1
Fe_2O_3	4.67	4.82	3.64	7.56	7.20	1.82	1.91	7.58	3.86	3.78
MnO	0.08	0.10	0.06	0.04	0.14	0.04	0.01	0.02	0.03	0.03
MgO	1.06	1.31	1.07	0.11	1.58	0.17	0.12	0.78	0.29	0.41
CaO	1.07	0.20	1.47	0.08	1.99	0.57	0.04	0.12	0.01	0.07
Na_2O	1.04	1.00	2.15	0.00	0.99	2.56	0.00	1.32	2.02	0.37
K_2O	2.40	2.19	2.50	0.38	3.05	4.72	0.38	4.01	0.78	2.53
P_2O_5	0.10	0.09	0.13	0.08	0.13	0.00	0.03	0.13	0.06	0.08
H_2O-	0.82	0.72	0.52	0.35	1.08	1.52	1.05	1.29	4.63	1.21
LOI	3.59	4.15	3.93	1.53	5.14	0.86	3.01	5.76	8.08	7.34
TOTAL	99.33	99.90	99.69	99.48	99.66	99.19	99.77	100.67	100.85	99.78
Rb	87	94	95	15	141	148	29	198	41	150
Sr	110	44	258	33	117	88	8	43	44	53
Y	30	31	26	18	30	19	17	20	27	37
Zr	427	295	306	401	183	413	330	181	221	414
Nb	15	15	12	10	12	7	12	17	26	25
Cu	21	20	16	14	35	6	1	18	8	3
Ni	21	28	18	10	24	8	10	12	15	11
Zn	63	84	80	30	91	24	12	48	17	26
V	111	98	72	160	139	28	28	76	48	61
Cr	100	113	52	100	81	32	46	74	53	43
Co	13	19	12	15	18	3	2	14	5	6

AC38	River North of Van Rhyns Dorp
AC39	River terrace east of Van Rhynsdorp
AC41	Laingsburg River
AC50	Soil at foot of Piekenier's Pass
AC53	Calvinia
AC54	10 km north of Van Rhynsdorp
AC55	Kirstenbosch
AC56	Hout Bay beginning of Chapman's Peak Drive
AC57	Camps Bay Rd at Kloof Nek
AC58	Castle rocks, Cape Peninsula

Table A4.2.5. continued.

	AC61	AC62	AC63	AC64	AC66	AC60	AC60B	AC200	AC201
SiO_2	79.67	67.02	91.52	94.37	87.07	77.70	77.75	62.15	61.27
TiO_2	0.37	0.80	0.63	0.32	0.36	0.52	0.53	0.91	0.92
Al_2O_3	6.03	14.40	2.28	1.84	3.04	10.72	10.17	15.24	16.26
Fe_2O_3	7.29	5.08	1.46	1.47	2.69	5.03	4.37	7.73	7.51
MnO	0.02	0.07	0.03	0.02	0.03	0.04	0.03	0.04	0.04
MgO	0.25	0.95	0.21	0.06	0.45	0.50	0.47	0.38	0.43
CaO	0.13	0.36	0.28	0.02	0.75	0.19	0.57	0.05	0.08
Na_2O	0.16	0.41	0.09	0.00	0.30	0.08	0.10	0.06	0.06
K_2O	0.60	2.63	0.46	0.30	0.50	1.15	1.16	1.45	1.45
P_2O_5	0.07	0.12	0.00	0.00	0.00	0.10	0.09	0.04	0.05
H_2O-	0.68	1.15	0.48	0.15	0.64	0.65	0.58	5.23	5.20
LOI	4.40	6.46	1.84	0.98	3.53	3.41	4.01	6.10	6.59
TOTAL	99.67	99.45	99.28	99.53	99.36	100.09	99.83	99.38	99.86
Rb	27	119	15	6	11	101	99	54	50
Sr	28	56	31	11	64	23	25	41	58
Y	14	35	14	10	13	23	23	14	13
Zr	545	309	1005	266	291	335	362	281	306
Nb	7	17	16	9	9	8	7	16	16
Cu	11	13	2	3	9	12	10	16	14
Ni	14	24	10	5	13	23	20	7	8
Zn	27	88	18	10	33	46	45	26	27
V	80	108	39	23	42	115	103	174	155
Cr	80	112	63	50	64	112	91	130	122
Co	15	15	3	1	3	30	21	21	21

AC61	Malmesbury
AC62	10 km south of Laingsburg
AC63	Velddrif
AC64	Citrusdal
AC66	Oliphants river
AC60	Durbanville
AC60B	Durbanville
AC200	Malmsbury clay above UCT
AC201	Malmsbury clay above UCT

Table A4.3.1. Data for clays from the Kavango and Caprivi, Namibia.

Sample	D9	D10	D30	D13	D14	D15	D16	D29	D18	D22
SiO_2	58.07	57.50	63.51	66.51	70.56	71.55	58.09	64.06	72.64	73.12
TiO_2	1.00	1.07	0.90	0.79	0.75	0.74	0.87	0.83	0.87	0.89
Al_2O_3	20.09	22.32	18.21	16.97	14.37	14.00	19.48	17.03	12.45	12.37
Fe_2O_3	5.51	6.18	4.33	3.82	3.03	3.24	4.82	4.63	3.32	3.31
MnO	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.02	0.01
MgO	0.32	0.33	0.25	0.20	0.27	0.21	0.43	0.34	0.43	0.37
CaO	0.55	0.49	0.46	0.36	0.41	0.42	0.52	0.45	0.49	0.50
Na_2O	0.12	0.07	0.08	0.14	0.18	0.22	0.09	0.14	0.08	0.08
K_2O	1.42	1.41	1.27	1.39	1.63	1.67	1.36	1.50	0.82	0.83
P_2O_5	0.04	0.02	0.03	0.02	0.04	0.04	0.05	0.03	0.02	0.00
H_2O-	1.88	2.46	2.77	1.92	2.18	1.85	3.48	2.55	3.40	3.07
LOI	10.86	9.20	8.13	7.65	6.18	6.05	10.52	7.97	5.34	5.62
TOTAL	99.89	101.08	99.97	99.80	99.63	100.02	99.75	99.56	99.88	100.17
Rb	72	77	66	61	63	63	81	74	35	35
Sr	63	60	57	61	64	66	59	63	38	39
Y	30	32	26	24	17	18	27	18	28	29
Zr	204	204	216	252	354	354	184	249	306	309
Nb	15	17	14	12	11	11	13	13	13	13
Cu	55	57	54	53	51	52	55	52	58	58
Ni	37	38	34	32	26	25	37	31	40	40
Zn	65	65	55	58	50	47	70	55	28	28
V	194	212	173	168	153	149	205	159	172	172
Cr	91	91	82	79	69	70	93	83	88	89
Co	22	25	20	21	13	15	23	16	24	25

D9	Guma K12: clay and temper mixture
D10	Guma K10: rejected clay
D30	Guma K11: rejected clay
D13	Halili: clay
D14	Kapako K15: clay
D15	Kapako K16: clay and temper mixture
D16	Katere K4: rejected clay
D29	Katere K9: rejected clay
D18	Katima Mulilo: clay
D22	Katima Mulilo: clay (duplicate)

Table A4.3.1 continued.

Sample	D17	D26	D27	D42	D19	D24	D23	D28
SiO_2	84.68	83.36	83.71	82.87	67.55	62.57	78.93	78.59
TiO_2	0.29	0.31	0.30	0.32	0.72	0.93	0.40	0.40
Al_2O_3	3.19	3.60	3.35	3.65	13.45	16.35	7.79	7.95
Fe_2O_3	1.76	1.94	2.60	1.92	3.76	4.66	2.94	3.13
MnO	0.03	0.03	0.04	0.03	0.04	0.10	0.04	0.05
MgO	0.05	0.06	0.04	0.13	0.50	0.59	0.36	0.36
CaO	0.43	0.49	0.44	0.50	0.83	0.97	0.59	0.59
Na_2O	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
K_2O	0.31	0.34	0.32	0.37	0.50	0.53	0.34	0.30
P_2O_5	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.01
H_2O-	2.81	2.70	2.53	2.61	4.83	4.73	3.36	3.33
LOI	6.01	6.88	6.38	7.32	7.67	8.55	4.80	4.68
TOTAL	99.59	99.74	99.74	99.75	99.89	100.02	99.57	99.39
Rb	13	16	15	17	29	40	25	24
Sr	23	25	24	26	49	51	51	47
Y	0	1	0	1	26	31	9	9
Zr	114	110	118	115	207	279	147	142
Nb	2	2	2	2	10	13	4	5
Cu	48	49	52	47	62	61	49	51
Ni	18	20	24	20	45	51	24	26
Zn	13	15	13	15	20	24	17	16
V	81	93	92	91	207	232	69	69
Cr	52	59	74	56	88	107	54	57
Co	6	9	8	8	20	31	11	13

D17:	Linyanti: clay
D26:	Linyanti: clay (duplicate)
D27:	Linyanti: clay (duplicate)
D42:	Linyanti: clay (duplicate)
D19	Ngoma: clay
D24	Ngoma: clay (duplicate)
D23	Oshombo, Oshakati: clay
D28	Oshombo, Oshakati: clay (duplicate)

Table A4.3.2. Data for sherds from the Kavango.

Sample	D11	D20	D21	D12	D25	bz14	bz23	bz41
SiO_2	63.22	71.06	75.69	65.72	77.48	83.06	63.71	72.04
TiO_2	0.73	0.94	0.71	0.82	0.79	0.51	0.79	0.74
Al_2O_3	15.03	17.28	12.36	19.19	14.25	8.22	17.12	15.69
Fe_2O_3	8.20	6.55	5.33	5.19	4.08	3.10	4.06	3.91
MnO	0.12	0.02	0.06	0.03	0.04	0.03	0.07	0.02
MgO	0.23	0.41	0.63	0.30	0.49	0.97	0.59	0.21
CaO	0.62	0.79	0.74	0.83	0.72	0.31	2.35	1.04
Na_2O	0.55	0.08	0.08	0.10	0.09	1.25	0.11	0.09
K_2O	1.84	0.55	0.90	1.12	0.58	0.80	1.42	1.30
P_2O_5	0.20	0.09	0.19	0.22	0.03	0.05	0.05	0.08
H_2O-	0.47	0.35	0.78	1.14	0.30	0.41	2.54	1.70
LOI	8.72	1.41	2.49	4.84	1.38	1.70	7.06	3.57
TOTAL	99.93	99.53	99.96	99.50	100.23	100.41	99.87	100.39
Rb	21	25	60	73	35	53	57	54
Sr	31	38	49	74	53	83	386	199
Y	0	30	22	27	31	14	20	14
Zr	172	297	231	182	242	215	153	223
Nb	0	15	11	14	12	8	12	11
Cu	48	68	66	61	67	13	19	16
Ni	51	44	42	36	45	19	24	19
Zn	53	54	50	72	20	16	40	37
V	177	231	166	184	199	85	192	157
Cr	165	108	89	84	88	63	95	88
Co	17	18	21	20	20	10	19	13

D11	Halili K2 potsherd
D20	Ihaha potsherd
D21	Ihaha potsherd
D12	Katere K5 potsherd
D25	Ngoma potsherd
bz14	Ovamboland potsherd
bz23	Vungu Vungu potsherd
bz41	Vungu Vungu potsherd

Table A4.3.2. continued.

	pc1	pc2	pc3	pc4	pc5	pc6
SiO_2	73.04	73.04	79.84	77.63	75.29	81.88
TiO_2	0.97	0.77	0.49	0.60	0.54	0.63
Al_2O_3	12.24	11.97	6.34	9.66	8.25	7.74
Fe_2O_3	4.85	3.56	3.09	4.24	3.66	3.41
MnO	0.02	0.02	0.03	0.05	0.04	0.03
MgO	0.46	0.50	0.29	0.59	1.19	0.42
CaO	0.96	1.10	1.27	1.81	2.44	1.00
Na_2O	0.18	0.04	0.03	0.08	0.04	nd
K_2O	1.48	1.00	0.69	0.67	0.77	0.74
P_2O_5	0.18	0.10	0.44	0.10	0.65	0.19
H2O-	1.72	2.98	2.18	1.32	1.84	1.09
LO1	3.89	5.10	4.70	2.59	4.96	2.49
TOTAL	99.99	100.18	99.39	99.34	99.67	99.62
Rb	54	33	15	28	27	25
Sr	66	58	49	73	95	51
Y	23	17	9	14	11	10
Zr	335	191	155	151	137	215
Nb	17	12	7	11	9	11
Cu	19	16	12	20	14	19
Ni	29	29	23	31	25	23
Zn	33	22	17	21	29	24
V	150	234	170	248	198	188
Cr	117	145	112	154	121	143
Co	21	19	15	22	17	14

pc1	Linyanti potsherd
pc2	Linyanti potsherd
pc3	Linyanti potsherd
pc4	Linyanti potsherd
pc5	Linyanti potsherd
pc6	Linyanti potsherd

Table A4.3.3. Date for Botswana pottery.

	KS2	KS3	RB01	RB03	RB05	RB06	RB07	RB08	RB09	b1
SiO_2	56.92	56.88	57.42	52.46	57.23	54.22	54.77	60.36	54.35	82.81
TiO_2	1.15	1.14	0.79	1.11	0.87	0.83	0.97	1.15	1.19	0.17
Al_2O_3	8.63	8.71	12.97	16.35	14.91	16.05	17.64	15.04	18.46	3.44
Fe_2O_3	11.03	11.09	11.52	11.41	7.12	9.45	9.67	6.72	12.59	3.30
MnO	0.15	0.15	0.16	0.15	0.08	0.13	0.12	0.12	0.19	0.01
MgO	13.59	13.77	5.75	3.51	2.09	2.01	2.44	2.12	3.70	0.52
CaO	4.27	4.32	3.23	5.32	1.95	3.26	3.11	3.39	4.66	1.10
Na_2O	0.35	0.36	0.96	1.36	3.25	3.52	0.86	2.02	1.22	0.00
K_2O	2.61	2.61	1.49	1.25	2.53	1.89	2.35	2.54	1.29	0.42
P_2O_5	0.10	0.10	0.26	0.19	0.30	0.10	0.30	0.21	0.12	0.13
H_2O-	0.03	0.04	2.32	2.57	3.75	3.63	2.34	2.06	0.40	2.91
LOI	0.76	0.89	2.89	3.88	5.39	4.71	4.64	3.64	1.21	4.82
TOTAL	99.59	100.06	99.76	99.56	99.47	99.80	99.21	99.37	99.38	99.63
Rb	231	229	46	41	82	54	60	90	49	27
Sr	73	71	156	205	156	297	130	396	115	148
Y	22	22	17	20	22	15	22	20	22	0
Zr	237	239	182	160	204	208	160	284	173	55
Nb	22	21	9	9	9	7	9	12	9	1
Cu	148	143	61	50	32	69	54	42	61	51
Ni	931	916	570	160	67	96	138	86	173	43
Zn	99	96	90	82	80	78	74	77	88	23
V	141	140	171	226	110	183	179	123	245	97
Cr	872	867	1859	411	167	175	323	180	424	56
Co	75	69	67	51	26	40	42	26	57	33

KS2: Lobatsi: modern pot
KS3: Lobatsi: modern pot; duplicate of KS2
RB01: Site A78: Toutswe style sherd
RB03: Site A78: Toutswe style sherd
RB05: Site A78: plain sherd
RB06: Site A78: Toutswe style sherd
RB07: Site A78: plain sherd
RB08: Site A78: Mapungubwe style sherd
RB09: Site A78: Base of open bowl: either Toutswe or Mapungubwe
b1: Divuyu 1g

Table A4.3.3 continued.

	b2	bp1	bp10	b3	b4	b5	bp8	bp9	b6	bp11
SiO_2	68.09	67.25	79.20	67.54	77.45	80.06	85.12	73.96	67.04	69.07
TiO_2	0.63	0.62	0.20	0.51	0.47	0.61	0.50	0.45	0.75	0.79
Al_2O_3	13.46	13.32	4.10	12.42	9.81	8.13	6.26	9.08	16.08	16.37
Fe_2O_3	2.26	2.37	4.52	4.15	5.51	3.38	2.93	4.63	3.21	3.42
MnO	0.02	0.01	0.04	0.02	0.17	0.04	0.03	0.13	0.03	0.03
MgO	0.20	0.37	1.72	0.31	0.59	0.33	0.46	0.75	0.63	0.65
CaO	2.41	2.46	2.18	2.53	1.20	1.41	0.89	1.78	2.54	1.31
Na_2O	0.00	0.06	0.08	0.07	0.35	0.29	0.19	0.06	0.56	0.69
K_2O	0.57	0.61	0.56	0.80	0.79	0.80	0.63	0.80	0.13	0.11
H_2O-	3.18	3.57	1.84	1.99	0.83	0.89	0.92	2.05	0.96	1.42
LOI	8.13	8.27	5.33	9.35	2.46	3.75	2.39	5.80	5.72	4.13
TOTAL	99.86	99.96	100.26	99.83	99.70	99.77	100.41	99.56	100.24	100.20
Rb	43	67	54	33	32	30	33	65	75	100
Sr	620	554	253	146	70	71	59	78	384	249
Y	73	57	3	22	18	16	7	12	23	19
Zr	95	86	50	133	135	276	249	109	252	255
Nb	8	2	3	6	6	9	2	1	13	9
Cu	48	10	27	76	73	60	15	21	63	16
Ni	32	24	27	40	50	28	20	29	28	20
Zn	20	23	28	13	15	15	19	20	37	38
V	149	155	100	151	156	117	103	148	155	174
Cr	114	144	98	90	71	68	84	85	69	95
Co	10	9	29	13	18	13	12	21	14	15

b2: Divuyu
bp1: Divuyu
bp10: Divuyu
b3: Serondella
b4: Serondella
b5: Serondella
bp8: Serondella: rim
bp9: Serondella: comb stamped rim
b6: Qugana
bp11: Qugana

Table A4.3.3 continued.

	bp12	b7	b8	bp7	b9	b14	bp16	bp17	b13	bp13
SiO_2	66.57	76.09	47.31	60.32	79.55	63.03	68.46	79.41	61.25	65.14
TiO_2	0.76	0.23	0.57	0.63	0.21	0.88	0.71	0.21	0.73	0.71
Al_2O_3	17.05	4.68	12.77	15.32	4.09	18.03	15.58	3.97	15.52	14.23
Fe_2O_3	4.09	4.8	2.56	4.09	4.40	4.86	3.49	4.57	3.64	3.63
MnO	0.04	0.02	0.02	0.03	0.04	0.06	0.02	0.05	0.04	0.05
MgO	0.90	0.03	0.06	0.36	0.46	0.51	0.20	0.46	0.41	0.37
CaO	2.44	0.08	0.34	0.53	1.58	2.46	2.00	1.56	2.26	1.60
Na_2O	0.31	0.00	0.00	0.01	0.00	0.23	0.08	0.09	1.59	1.56
K_2O	1.86	0.19	0.55	0.80	0.88	2.00	1.16	0.53	1.37	1.29
P_2O_5	0.64	0.5	0.18	0.56	0.34	0.32	0.39	0.51	0.09	0.09
H_2O-	0.87	4.2	5.84	4.82	1.91	1.41	2.61	2.54	3.25	2.49
LOI	3.91	9.03	29.48	12.93	6.19	5.83	4.90	5.88	8.67	8.44
TOTAL	99.44	99.85	99.68	100.40	99.65	99.62	99.60	99.78	98.82	99.60
Rb	96	3	18	55	51	99	83	54	57	74
Sr	488	18	43	59	224	438	356	258	452	406
Y	25	1	9	10	6	32	14	4	18	16
Zr	239	68	191	159	66	191	217	55	231	247
Nb	10	1	5	3	2	15	7	0	12	6
Cu	27	55	45	17	59	61	15	20	62	18
Ni	23	38	28	21	42	37	20	25	30	18
Zn	44	7	27	29	25	59	34	23	35	35
V	183	141	201	187	90	183	145	91	155	162
Cr	115	86	84	112	66	84	98	95	76	102
Co	18	12	13	14	26	27	14	30	15	15

bp12: Qugana: pitted surface
b7: Depression Cave
b8: Depression Cave
bp7: Depression Cave: crosshatching
b9: N!oma
b14: N!oma
bp16: N!oma: thin sherd, pitted surface
bp17: N!oma: thick sherd, pitted surface
b13: Xaro
bp13: Xaro: punctate rim

Table A4.3.3 continued.

	bp14	bp15	b10	b11	bp3	bp4	bp5	bp6	mh	b12
SiO_2	66.09	63.18	65.32	64.21	61.26	61.11	59.61	61.23	61.53	56.28
TiO_2	0.43	0.52	1.33	1.15	1.42	1.41	1.39	1.17	1.42	0.65
Al_2O_3	12.05	13.92	10.68	11.95	11.6	11.54	11.36	10.21	11.74	14.87
Fe_2O_3	3.75	4.12	10.10	9.45	10.88	10.79	10.65	8.86	11.13	3.65
MnO	0.03	0.04	0.27	0.29	0.33	0.32	0.30	0.30	0.33	0.04
MgO	0.44	0.29	2.60	1.75	2.96	3.05	3.34	2.83	3.25	0.20
CaO	2.46	2.52	4.23	3.51	4.30	4.23	4.34	5.01	4.32	1.10
Na_2O	1.41	1.45	1.45	1.36	1.49	1.28	1.42	1.02	1.29	0.07
K_2O	0.82	1.05	0.74	1.33	0.80	0.78	0.81	0.93	0.82	1.24
P_2O_5	0.07	0.06	0.18	0.20	0.26	0.27	0.26	0.39	0.26	2.22
H_2O-	2.48	3.14	0.15	0.48	0.71	0.77	0.92	1.19	0.66	4.50
LOI	9.62	9.00	2.59	3.49	3.15	4.01	4.77	6.22	2.89	15.13
TOTAL	99.65	99.29	99.64	99.17	99.16	99.56	99.17	99.36	99.64	99.95
Rb	41	80	26	59	38	40	39	39	40	41
Sr	404	572	183	209	186	192	183	225	187	152
Y	12	10	44	67	46	46	45	46	53	13
Zr	93	76	366	385	333	319	326	326	365	163
Nb	2	2	19	23	18	18	17	15	21	8
Cu	19	23	109	100	69	75	77	76	76	59
Ni	18	21	115	99	116	121	115	100	120	30
Zn	43	32	206	210	232	242	229	249	259	66
V	142	161	191	170	229	234	234	185	211	174
Cr	85	88	169	154	242	246	239	206	243	84
Co	18	17	33	21	41	39	43	35	46	12

bp14:	Xaro: horizontal incisions
bp15:	Xaro: punctate rim
b10:	Kgwebe Hills: thin piece
b11:	Kgwebe Hills: thin sherd
bp3:	Kgwebe Hills: thin sherd
bp4:	Kgwebe Hills: thick sherd
bp5:	Kgwebe Hills: thick sherd, inclusions
bp6:	Kgwebe Hills: thick sherd
mh:	Kgwebe Hills: layer 2
b12:	Tsodilo Hills: float

Table A4.3.3 continued.

	bp2	bz1	bz2	bz3	bz4	bz5	bz6	bz7	bz8	bz9
SiO_2	54.76	73.43	72.08	47.14	57.15	57.69	51.17	60.18	71.65	35.26
TiO_2	0.66	0.65	0.65	0.56	0.60	0.59	0.71	0.54	0.57	0.40
Al_2O_3	14.67	15.12	14.77	11.87	14.28	14.73	15.15	12.14	12.69	11.50
Fe_2O_3	3.48	3.82	3.86	2.88	3.33	3.21	3.44	3.50	3.54	2.79
MnO	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02
MgO	0.22	0.21	0.24	0.52	0.47	0.53	0.34	0.27	0.41	0.29
CaO	1.15	0.99	0.99	15.15	2.59	2.10	0.80	10.53	3.17	1.02
Na_2O	0.02	0.07	0.03	0.26	0.11	0.14	0.02	0.21	0.09	0.00
K_2O	1.10	1.17	1.00	1.46	1.35	1.61	1.02	0.84	1.03	0.95
P_2O_5	1.84	0.38	0.19	11.00	0.33	0.19	0.21	7.30	1.83	0.20
H_2O-	4.12	0.74	1.35	1.68	2.90	2.97	4.78	1.08	0.98	4.81
LOI	17.42	3.62	4.89	7.51	16.99	16.84	22.50	4.03	4.22	42.55
TOTAL	99.47	100.23	100.08	100.05	100.13	100.63	100.17	100.65	100.21	99.79
Rb	61	47	41	57	38	44	40	42	43	32
Sr	113	65	121	258	118	116	82	200	233	72
Y	9	20	21	19	13	12	18	19	21	3
Zr	138	215	238	149	123	120	198	198	206	66
Nb	2	11	10	12	7	6	7	10	10	0
Cu	15	18	17	16	14	12	6	14	15	16
Ni	19	24	25	15	21	20	19	19	19	17
Zn	48	33	31	72	32	30	47	54	39	30
V	190	163	168	91	175	176	186	103	135	194
Cr	106	92	96	51	89	87	106	72	81	96
Co	14	14	17	8	18	14	16	10	13	17

bp2: Tsodilo Hills: float
bz1: Tsodilo 9b
bz2: Tsodilo 9b: decorated rim
bz3 Tsodilo 9a: bone and ?charcoal tempered
bz4: Tsodilo 24.1: charcoal tempered
bz5 Tsodilo24: charcoal tempered, vesicles
bz6: Tsodilo 9: thick coarse sherd, charcoal tempered: duplicate of bz12
bz7 Tsodilo 21: rim sherd, bone and ?charcoal tempered
bz8: Tsodilo 9b
bz9: Tsodilo 12 cross hatched thick rim sherd, charcoal tempered

Table A4.3.3 continued.

	bz10	bz11	bz12	bz28
SiO_2	45.65	73.45	51.10	51.23
TiO_2	0.54	0.18	0.70	0.70
Al_2O_3	11.18	3.28	14.41	15.12
Fe_2O_3	2.67	3.66	3.61	3.39
MnO	0.01	0.04	0.03	0.02
MgO	0.42	0.33	0.33	0.28
CaO	15.63	0.54	0.40	0.49
Na_2O	0.23	0.08	0.03	0.01
K_2O	1.05	0.33	0.93	0.94
P_2O_5	11.06	0.89	0.24	0.16
H_2O-	1.57	3.90	5.30	5.78
LOI	8.84	13.84	23.05	22.22
TOTAL	98.85	100.52	100.13	100.34
Rb	47	15	37	37
Sr	287	60	49	55
Y	18	1	17	19
Zr	150	57	209	198
Nb	11	0	8	7
Cu	12	0	5	5
Ni	16	20	18	18
Zn	67	22	33	37
V	91	101	196	189
Cr	50	87	109	104
Co	6	21	15	15

bz10:	Tsodilo 9a: bone and ?charcoal tempered
bz11:	Tsodilo 14: charcoal and quartz tempered
bz12:	Tsodilo 9: duplicate of bz6
bz28:	Tsodilo 9c3: charcoal tempered

Table A4.3.3 continued.

	T200	T201	T202	T203	T204	T205	T207	T208
SiO_2	50.95	54.97	55.48	54.28	54.81	60.04	55.68	56.92
TiO_2	0.96	0.87	1.03	0.66	0.69	1.14	0.79	0.82
Al_2O_3	17.22	17.65	15.37	19.34	16.01	14.80	17.67	17.46
Fe_2O_3	10.7	8.32	8.90	8.79	8.85	12.12	8.31	8.21
MnO	0.15	0.13	0.13	0.16	0.14	0.15	0.11	0.13
MgO	4.82	3.10	2.82	4.62	4.47	2.87	2.71	2.57
CaO	6.86	5.01	5.23	6.76	5.75	2.49	4.61	4.53
Na_2O	1.39	1.37	1.07	1.42	1.12	0.41	1.11	1.19
K_2O	1.45	1.28	2.17	1.16	1.58	1.23	1.64	1.59
P_2O_5	0.29	0.09	0.74	0.21	0.26	0.19	0.18	0.19
H_2O-	1.10	1.68	1.35	0.59	1.25	1.25	1.59	1.59
LOI	4.67	5.3	4.94	2.35	4.89	3.54	4.68	4.26
TOTAL	100.56	99.77	99.23	100.34	99.82	100.23	99.08	99.46
Rb	36	41	62	26	41	31	33	36
Sr	197	233	341	172	194	129	217	234
Y	18	14	20	14	17	19	12	13
Zr	106	124	173	102	145	146	112	119
Nb	7	6	8	6	6	10	4	4
Cu	62	38	49	53	44	80	45	37
Ni	86	77	72	87	92	61	74	69
Zn	65	48	71	58	70	73	59	60
V	319	212	229	156	176	258	184	197
Cr	129	223	141	199	298	249	222	206
Co	46	43	35	43	40	27	50	44

T200:	Toutswe: base of beaker
T201:	Toutswe: base of beaker 15/41/1
T202:	Toutswe: jar15/41/1
T203:	Toutswe: jar 15/41/1
T204:	Toutswe: base of beaker 15/41/1
T205:	Toutswe: jar 15/41/1
T207:	Toutswe: 15/41/1
T208:	Toutswe: 15/41/1

Table A4.3.4. Data for sediments and daga from Botswana.

	KS1	RB02	RB04	RB10	RB11A	RB11B	RB12	RB13	RB14
SiO_2	54.58	71.37	72.19	72.12	75.42	75.32	62.74	63.61	80.27
TiO_2	1.53	0.49	0.45	0.35	0.35	0.31	0.39	0.31	0.59
Al_2O_3	13.12	14.24	14.03	13.37	13.67	13.15	10.39	8.21	3.45
Fe_2O_3	13.09	3.18	2.93	2.50	2.50	2.33	3.17	2.36	1.78
MnO	0.16	0.04	0.03	0.03	0.04	0.04	0.08	0.07	0.04
MgO	3.26	0.44	0.29	0.59	0.49	0.39	2.10	2.75	1.23
CaO	2.34	1.69	1.31	1.74	1.66	1.51	3.99	3.77	3.55
Na_2O	0.14	1.73	2.56	2.18	0.73	1.00	1.28	0.98	0.22
K_2O	0.44	1.76	1.60	2.29	1.98	1.97	1.86	1.66	1.67
P_2O_5	0.04	0.17	0.09	0.13	0.05	0.04	0.88	1.14	0.44
H_2O-	4.76	1.90	1.97	0.91	0.36	0.55	6.52	8.44	1.68
LOI	6.19	2.57	2.55	2.99	2.42	2.28	5.87	5.80	4.77
TOTAL	99.65	99.58	100.00	99.20	99.67	98.89	99.27	99.10	99.69
Rb	21	43	36	58	55	55	49	43	44
Sr	49	164	149	187	168	167	246	229	167
Y	15	6	4	5	7	7	3	1	4
Zr	185	234	206	189	245	235	170	150	328
Nb	8	3	2	2	1	1	1	0	4
Cu	119	9	6	9	6	6	23	23	15
Ni	489	29	31	29	23	19	45	52	11
Zn	70	29	25	33	30	26	85	100	53
V	382	42	28	36	34	27	44	24	52
Cr	592	81	117	88	77	71	120	116	38
Co	79	7	6	5	5	2	11	6	3

KS1	Lobatsi: clay
RB02	Break Pressure Tank: daga
RB04	Break Pressure Tank: daga
RB10	Break Pressure Tank A78L: sediment
RB11A	Break Pressure Tank A78: lumpy sediment
RB11B	Break Pressure Tank A78: fine sediment
RB12	Break Pressure Tank A78A: sediment
RB13	Break Pressure Tank A78D: sediment
RB14	Break Pressure Tank MKA L sediment

Table A4.4.1a. Data for the Schroda pottery.

	LM401	LM402	LM403	LM404	LM405	LM406	LM407	LM408	LM409	LM410
SiO_2	59.42	61.58	59.87	61.57	55.94	63.06	59.99	57.28	57.59	57.47
TiO_2	1.94	1.23	2.01	1.44	1.82	1.11	1.55	1.21	1.66	1.22
Al_2O_3	14.56	13.74	15.39	15.47	13.1	16.39	16.26	16.67	14.58	16.40
Fe_2O_3	8.08	6.58	8.67	6.98	8.38	5.44	8.83	7.14	7.84	12.63
MnO	0.11	0.09	0.11	0.10	0.12	0.03	0.11	0.05	0.11	0.05
MgO	3.34	2.44	2.18	1.92	4.23	0.55	2.05	1.12	2.56	0.79
CaO	4.24	2.51	4.43	4.21	4.74	1.93	3.46	3.43	3.61	1.56
Na_2O	1.83	1.00	2.09	1.40	1.19	1.71	2.02	2.35	1.30	0.15
K_2O	2.73	2.16	2.45	2.14	2.54	4.48	2.45	3.10	2.16	0.91
P_2O_5	0.35	0.17	0.38	0.26	0.32	0.12	0.30	0.23	0.34	0.17
H_2O-	0.49	2.84	0.43	1.48	2.24	1.23	0.84	2.27	2.80	2.81
LOI	1.27	4.3	1.94	2.86	4.33	2.72	1.30	2.94	4.54	4.98
TOTAL	98.36	98.64	99.95	99.83	98.95	98.77	99.16	97.79	99.09	99.14
Rb	92	65	86	87	77	106	100	54	73	19
Sr	486	319	451	445	514	277	329	650	371	184
Y	24	20	24	21	23	18	23	25	21	19
Zr	373	262	368	310	307	419	317	493	294	175
Nb	21	14	23	17	18	17	19	18	18	9
Cu	72	45	89	49	52	33	79	27	65	66
Ni	120	111	65	60	205	29	72	25	87	82
Zn	93	81	93	80	88	48	105	66	85	60
V	181	143	185	153	184	110	196	92	170	335
Cr	285	254	133	130	420	86	205	51	187	190
Co	29	34	37	33	44	18	39	23	35	56

LM401	Zhizo A
LM402	Zhizo A
LM403	Zhizo A
LM404	Zhizo A
LM405	Zhizo A
LM406	Zhizo A
LM407	Zhizo A
LM408	Zhizo A
LM409	Zhizo A
LM410	Atypical ?Late Matakoma

Table A4.4.1a continued.

	LM411	LM412	LM413a	LM413b	LM414	LM415	LM416	LM417	LM418	LM419
SiO_2	59.56	60.39	nd	58.71	56.81	50.07	60.05	58.64	59.24	58.02
TiO_2	1.65	1.80	nd	2.09	2.16	1.51	1.91	1.81	1.80	1.82
Al_2O_3	14.98	13.29	nd	14.32	14.59	20.19	15.21	14.36	14.63	13.99
Fe_2O_3	7.35	6.93	nd	7.96	8.62	12.58	7.97	7.22	7.35	8.41
MnO	0.09	0.10	nd	0.09	0.10	0.06	0.11	0.09	0.09	0.13
MgO	1.93	2.19	nd	2.28	2.30	1.29	2.10	1.96	1.89	3.51
CaO	3.57	3.86	nd	4.46	4.81	1.40	4.31	4.26	3.99	3.63
Na_2O	1.63	1.42	nd	1.49	1.65	0.23	1.90	1.87	2.08	1.44
K_2O	2.88	2.29	nd	2.90	2.63	1.42	2.52	2.70	2.65	2.40
P_2O_5	0.34	0.31	nd	0.39	0.42	0.16	0.38	0.29	0.29	0.28
H_2O-	1.65	2.39	nd	1.74	1.93	3.46	0.40	1.88	1.75	1.25
LOI	3.54	3.87	nd	3.23	2.90	6.22	1.49	3.30	2.59	3.10
TOTAL	99.17	98.84	nd	99.66	98.92	98.59	98.35	98.38	98.35	97.98
Rb	93	73	85	87	82	27	86	88	78	80
Sr	450	347	469	463	530	244	426	455	423	440
Y	20	21	20	22	23	16	22	19	17	26
Zr	330	301	334	333	332	133	372	344	346	343
Nb	18	18	21	22	23	8	21	19	16	20
Cu	73	66	89	87	102	112	73	75	71	54
Ni	54	58	53	55	59	120	60	52	56	145
Zn	87	76	85	87	105	66	90	81	79	92
V	159	167	180	181	179	461	174	153	155	184
Cr	123	143	101	106	113	576	131	115	117	326
Co	31	30	30	33	35	61	31	32	35	40

LM411	Atypical: ?
LM412	Atypical: ?
LM413a	Zhizo A
LM413b	Zhizo A: duplicate of LM413a
LM414	Atypical: ?
LM415	Atypical: ?
LM416	Zhizo A
LM417	Zhizo A
LM418	Zhizo A
LM419	Zhizo A

Table A4.4.1a continued.

	LM420	LM421	LM422	LM423	LM424	LM425	LM426	LM427	LM428	LM429
SiO_2	60.68	61.19	60.61	62.99	60.34	59.88	59.29	64.32	56.61	59.88
TiO_2	1.53	1.51	1.69	0.95	1.95	1.82	1.76	1.38	2.03	2.10
Al_2O_3	16.32	14.52	13.84	16.11	15.00	14.21	14.87	15.07	13.48	15.5
Fe_2O_3	7.73	6.56	6.92	4.82	7.57	8.60	7.39	6.56	7.80	8.38
MnO	0.12	0.09	0.09	0.04	0.10	0.13	0.11	0.10	0.11	0.11
MgO	2.27	1.67	1.92	0.71	1.88	3.13	2.43	1.42	3.49	2.11
CaO	3.75	3.44	4.95	1.73	4.24	3.33	4.29	2.92	4.61	4.40
Na_2O	1.87	1.59	1.66	1.66	2.27	1.35	1.96	2.15	1.76	2.34
K_2O	2.57	2.79	2.82	3.95	2.60	2.55	2.52	2.78	2.74	2.52
P_2O_5	0.28	0.25	0.40	0.18	0.34	0.38	0.27	0.23	0.34	0.34
H_2O-	0.48	1.93	1.34	1.61	0.80	0.93	1.28	0.61	2.19	0.41
LOI	1.11	2.87	2.67	3.36	1.55	2.26	2.44	0.97	2.78	0.73
TOTAL	98.71	98.41	98.91	98.11	98.64	98.57	98.61	98.51	97.94	98.82
Rb	103	89	79	85	83	84	78	99	75	85
Sr	315	389	500	336	478	399	453	328	554	439
Y	24	18	19	9	23	29	23	19	22	23
Zr	312	320	332	511	377	337	339	387	365	389
Nb	18	17	17	12	22	20	20	17	21	23
Cu	69	58	61	18	82	56	54	54	80	87
Ni	71	50	53	26	58	127	78	53	130	58
Zn	93	76	75	49	80	97	83	73	86	90
V	158	128	155	95	160	186	176	119	160	180
Cr	166	111	117	61	110	326	187	130	315	122
Co	36	27	30	16	31	44	31	29	37	35

LM420	Zhizo A
LM421	Zhizo A
LM422	Zhizo A
LM423	Zhizo A
LM424	Zhizo A
LM425	Zhizo A
LM426	Zhizo A
LM427	Zhizo A
LM428	Zhizo A
LM429	Zhizo A

Table A4.4.1b. Data for the Schroda figurines.

	SF01	SF02	SF03	SF04	SF05	SF06	SF07	SF08	SF09	SF10
SiO_2	62.03	60.39	56.06	63.14	62.42	61.89	60.12	62.07	48.49	63.36
TiO_2	1.14	1.35	2.39	1.03	1.58	1.60	1.65	1.62	3.09	1.45
Al_2O_3	15.63	14.42	14.85	14.46	15.01	15.33	15.21	15.22	11.80	16.26
Fe_2O_3	6.23	6.14	8.35	5.81	7.37	6.93	8.16	7.04	12.77	6.90
MnO	0.11	0.09	0.12	0.11	0.11	0.10	0.13	0.11	0.17	0.12
MgO	1.59	1.59	2.42	1.44	1.64	1.65	1.73	1.66	5.67	1.69
CaO	2.72	3.35	5.74	2.37	3.60	3.59	4.02	3.83	6.76	3.49
Na_2O	1.48	1.83	2.12	1.23	2.23	2.24	2.42	2.30	1.31	2.07
K_2O	3.17	3.09	2.81	3.10	3.20	3.25	3.11	3.23	2.56	3.25
P_2O_5	0.32	0.23	0.40	0.19	0.26	0.29	0.30	0.31	0.41	0.34
H_2O-	2.07	2.18	1.33	2.61	0.52	0.65	0.59	0.62	2.29	0.43
LOI	3.67	4.97	3.58	4.38	2.14	2.33	2.17	2.13	4.39	0.59
TOTAL	100.16	99.63	100.17	99.87	100.08	99.85	99.61	100.14	99.71	99.95
Rb	91	94	70	88	92	87	89	88	32	104
Sr	281	298	511	247	318	398	347	352	608	305
Y	25	18	28	22	23	23	24	23	32	26
Zr	279	319	348	264	353	343	355	361	340	364
Nb	18	16	25	15	20	19	20	20	24	20
Cu	44	59	91	40	69	57	74	66	61	58
Ni	55	50	56	50	54	52	59	54	206	59
Zn	80	64	82	76	75	75	75	74	121	84
V	104	112	166	93	126	117	129	122	229	114
Cr	161	137	104	140	156	145	173	137	546	149
Co	25	24	32	27	27	24	27	26	53	26

SF01	(?) Animal body;	fine clay;	-
SF02	Miscellaneous piece;	coarse clay;	6.A1.2.1
SF03	Kraal wall;	coarse clay;	-
SF04	(?) Human body;	coarse clay;	6.2A.1
SF05	Kraal wall;	coarse clay;	6.AA.4
SF06	Horn;	coarse clay;	6.AA1.1
SF07	Horn;	coarse clay;	6.A1.2.1
SF08	Horn or leg;	coarse clay(?);	6.A1.2.1
SF09	Miscellaneous piece;	fine clay;	C25/1
SF10	Animal body;	fine clay;	6.6C.3

Table A4.4.2. Data for K2 sherds.

	H79	H76	H73	H55A	H55	H51	H50	H46	H43A	H43
SiO_2	60.79	57.06	60.62	59.62	60.00	60.58	64.05	59.42	61.24	60.46
TiO_2	1.38	1.46	1.84	1.37	1.35	1.39	1.09	1.45	1.36	1.42
Al_2O_3	14.24	13.72	15.37	13.57	14.01	14.14	13.64	15.09	13.78	14.18
Fe_2O_3	7.24	8.08	7.91	7.01	6.88	6.58	6.72	8.14	7.11	7.31
MnO	0.10	0.11	0.12	0.09	0.09	0.07	0.10	0.12	0.09	0.09
MgO	3.99	5.13	3.00	4.10	4.14	3.56	2.95	3.96	3.77	4.05
CaO	3.56	3.55	3.60	4.11	3.95	4.04	3.49	3.62	3.85	3.85
Na_2O	1.72	1.06	2.43	1.41	1.31	1.38	0.97	1.68	1.42	1.58
K_2O	2.71	2.34	2.82	2.72	2.69	2.79	2.35	2.49	2.80	2.81
P_2O_5	0.26	0.26	0.29	0.25	0.25	0.25	0.35	0.26	0.41	0.37
H_2O-	0.92	2.45	0.34	1.73	1.75	1.56	0.84	0.83	1.21	0.85
LOI	2.87	4.58	1.08	3.67	3.71	3.72	4.15	3.18	3.17	2.70
TOTAL	99.78	99.80	99.42	99.65	100.13	100.06	100.70	100.24	100.21	99.67
Rb	104	93	100	100	100	101	97	87	98	99
Sr	467	421	457	397	370	393	291	377	445	435
Y	23	21	31	22	19	18	21	31	22	23
Zr	306	254	408	305	286	289	243	306	298	309
Nb	14	11	20	14	11	11	10	18	14	15
Cu	54	57	65	54	57	51	45	46	59	58
Ni	181	238	168	184	176	142	106	190	179	184
Zn	65	59	75	58	58	59	66	67	66	64
V	155	175	174	143	140	134	133	170	146	150
Cr	368	432	347	335	313	276	221	370	307	328
Co	32	40	36	34	32	33	29	36	34	36

H79	K2 E 195 D
H76	K2 E 195 D
H73	K2 E 195 D
H55A	K2 E 195 C
H55	K2 E 195 C
H51	K2 E 195 C
H50	K2 E 195 C
H46	K2 E 195 D
H43A	K2 E 195 C
H43	K2 E 195 C

Table A4.4.2 continued.

	H36A	H31A	H31	H30	H29	H108	H107A	H107	VC29	VC34
SiO_2	nd	66.14	65.67	nd	64.47	62.26	57.18	60.08	60.25	65.08
TiO_2	nd	1.23	1.23	nd	1.43	1.47	1.53	1.66	1.39	1.65
Al_2O_3	nd	15.46	15.05	nd	15.43	15.69	14.16	15.00	12.80	11.69
Fe_2O_3	nd	6.00	6.10	nd	6.89	7.48	8.41	8.98	8.01	7.86
MnO	nd	0.08	0.08	nd	0.09	0.11	0.12	0.14	0.12	0.09
MgO	nd	1.30	1.72	nd	2.20	3.13	5.04	5.51	5.08	3.95
CaO	nd	2.90	2.81	nd	3.12	3.53	5.23	4.01	3.18	3.46
Na_2O	nd	2.20	1.79	nd	2.35	2.26	1.70	0.99	1.56	1.34
K_2O	nd	2.94	2.96	nd	2.93	2.62	2.33	2.38	2.65	2.32
P_2O_5	nd	0.21	0.22	nd	0.24	0.23	0.29	0.27	0.25	0.30
H_2O-	nd	0.25	0.51	nd	0.12	0.13	0.45	0.30	1.20	0.48
LOI	nd	1.37	1.79	nd	0.75	1.03	3.07	1.08	3.02	1.38
TOTAL	nd	100.08	99.93	nd	100.02	99.94	99.51	100.4	99.51	99.60
Rb	95	97	111	100	105	102	88	96	79	66
Sr	346	335	303	456	375	364	466	398	369	386
Y	24	26	19	29	27	30	32	30	25	28
Zr	378	353	329	374	360	347	329	321	299	341
Nb	16	15	10	18	17	19	20	19	16	18
Cu	41	43	42	47	50	60	49	55	51	41
Ni	49	48	48	113	107	148	247	263	250	198
Zn	61	66	64	66	65	70	63	68	89	82
V	146	128	118	156	141	149	171	189	137	140
Cr	163	132	131	293	248	268	442	464	384	344
Co	22	22	21	31	26	33	42	39	40	35

H36A	K2 E195C
H31A	K2 E195E
H31	K2 E195E
H30	K2 E195E
H29	K2 E195E
H108	K2 E195E
H107A	K2 E195E
H107	K2 E95E
VC29	K2
VC34	K2

Table A4.4.2 continued.

	VC35	VC36	VC37	VC38	VC39	VC40	VC41	VC42	VC43	VC44
SiO_2	60.71	59.79	65.62	62.32	58.86	68.99	64.01	60.47	58.38	59.73
TiO_2	1.76	1.38	1.01	1.48	2.64	0.65	1.18	1.76	1.63	1.58
Al_2O_3	11.99	12.48	14.95	13.58	14.08	13.47	13.68	12.17	12.61	13.97
Fe_2O_3	7.24	7.80	6.31	6.89	9.50	5.00	6.42	7.19	7.73	7.88
MnO	0.09	0.11	0.11	0.10	0.14	0.10	0.08	0.11	0.11	0.11
MgO	3.60	5.09	2.09	3.27	4.27	1.69	2.15	3.23	3.53	4.25
CaO	4.32	3.63	1.98	3.09	4.26	2.54	2.48	4.59	4.31	3.59
Na_2O	1.42	1.46	1.10	1.82	1.21	1.37	1.35	1.43	1.55	1.88
K_2O	2.75	2.69	2.24	2.41	2.56	2.54	2.68	2.82	2.62	2.98
P_2O_5	0.40	0.28	0.37	0.23	0.40	0.40	0.30	0.30	0.27	0.31
H_2O-	1.76	1.28	1.28	1.64	0.31	0.73	1.65	1.52	1.99	1.07
LOI	3.53	3.76	2.39	2.70	1.59	2.36	3.46	3.85	5.00	2.56
TOTAL	99.57	99.75	99.45	99.53	99.82	99.84	99.44	99.44	99.73	99.91
Rb	59	77	62	73	81	59	70	63	59	85
Sr	517	381	318	431	560	242	433	487	437	426
Y	25	25	24	23	35	20	25	27	27	25
Zr	324	285	264	371	386	225	264	376	316	331
Nb	16	16	12	15	29	9	14	17	16	17
Cu	40	51	40	36	64	28	31	37	39	37
Ni	137	248	91	143	185	64	84	123	135	186
Zn	73	85	78	71	99	63	77	75	79	86
V	139	134	102	123	222	80	114	146	153	135
Cr	302	354	211	265	419	145	211	288	306	342
Co	30	37	27	29	37	23	26	28	32	32

VC35	K2
VC36	K2
VC37	K2
VC38	K2
VC39	K2
VC40	K2
VC41	K2
VC42	K2
VC43	K2
VC44	K2

Table A4.4.2 continued.

	VC45	VC46	VC47	VC48	H405	H411	H412	H413	H414	H415
SiO_2	57.99	64.32	60.64	63.16	63.22	64.95	62.64	62.71	59.61	60.13
TiO_2	1.54	1.09	1.51	1.51	1.31	1.78	1.52	1.49	1.45	1.41
Al_2O_3	13.38	14.70	13.51	14.39	12.47	12.74	12.58	12.75	13.53	13.68
Fe_2O_3	7.64	5.95	7.98	7.47	6.93	7.47	7.15	7.22	8.26	8.17
MnO	0.09	0.08	0.11	0.11	0.09	0.11	0.10	0.11	0.12	0.12
MgO	4.49	1.37	5.24	3.21	2.34	2.83	3.10	3.01	4.94	4.66
CaO	3.80	2.36	3.67	3.44	3.31	3.18	3.52	3.81	3.28	3.60
Na_2O	1.86	2.08	1.99	2.30	1.25	1.30	1.24	1.34	1.70	1.63
K_2O	3.08	3.38	2.55	2.73	2.25	2.50	2.49	2.45	2.40	2.38
P_2O_5	0.31	0.17	0.26	0.38	0.20	0.27	0.30	0.29	0.23	0.22
H_2O-	1.80	1.33	0.51	0.34	1.83	0.62	1.26	1.35	1.17	0.98
LOI	3.62	2.92	1.40	0.88	4.40	1.52	3.65	3.07	3.00	2.93
TOTAL	99.60	99.75	99.37	99.92	99.60	99.27	99.55	99.60	99.69	99.91
Rb	79	95	88	96	67	70	67	67	80	84
Sr	425	297	404	385	381	355	453	461	370	372
Y	22	19	25	25	26	30	27	28	26	27
Zr	322	322	327	350	367	379	297	290	306	312
Nb	16	13	17	17	14	18	17	17	16	17
Cu	32	38	55	57	43	41	47	45	51	49
Ni	197	54	266	161	99	122	121	121	251	232
Zn	86	72	88	86	69	78	82	81	88	87
V	137	96	128	120	123	143	139	142	146	137
Cr	377	136	398	272	246	303	291	292	387	345
Co	32	21	37	30	30	30	30	32	41	40

VC45	K2: burnished rim sherd
VC46	K2: burnished rim sherd
VC47	K2: line of oblique incisions
VC48	K2
H405	K2
H411	K2
H412	K2
H413	K2
H414	K2
H415	K2

Table A4.4.2 continued.

	LM121	LM122	LM123	LM124	LM125	LM126	LM127	LM128	LM129	LM130
SiO_2	57.85	58.38	63.96	60.16	63.40	61.13	67.75	59.09	61.17	64.41
TiO_2	1.45	1.50	0.83	1.49	1.42	1.43	0.77	1.70	1.50	1.31
Al_2O_3	12.97	13.30	14.03	14.48	13.20	14.18	15.13	13.65	13.80	14.67
Fe_2O_3	8.14	8.21	4.95	8.95	7.01	6.79	5.65	9.27	7.24	6.77
MnO	0.11	0.12	0.06	0.13	0.10	0.10	0.09	0.13	0.10	0.09
MgO	5.36	5.04	1.27	5.30	3.43	2.90	1.55	6.02	4.31	2.89
CaO	4.78	4.12	2.91	3.48	3.50	3.31	1.56	3.85	4.11	3.10
Na_2O	1.39	1.44	1.58	1.58	1.70	1.66	0.96	1.72	1.62	2.15
K_2O	2.40	2.50	3.01	2.27	2.44	2.95	2.41	2.33	2.62	2.79
P_2O_5	0.28	0.29	0.16	0.25	0.23	0.25	0.13	0.29	0.64	0.25
H_2O-	1.44	1.69	1.66	0.34	0.66	1.44	1.12	0.71	0.57	0.33
LOI	3.79	3.48	4.5	0.93	1.83	3.22	2.27	1.67	1.57	0.56
TOTAL	99.96	100.07	98.92	99.36	98.92	99.36	99.39	100.43	99.25	99.32
Rb	78	77	112	91	82	88	69	84	87	98
Sr	464	412	296	364	377	371	176	447	506	353
Y	21	21	11	24	19	17	17	24	19	18
Zr	291	300	249	317	343	325	211	353	326	360
Nb	17	17	11	19	16	16	11	21	17	16
Cu	49	51	33	56	39	57	38	62	48	47
Ni	272	261	37	256	157	123	70	326	198	138
Zn	88	89	64	96	72	79	69	95	85	73
V	158	160	85	169	144	133	113	171	143	126
Cr	416	434	106	437	319	215	178	549	364	265
Co	44	47	17	46	36	24	28	50	40	32

LM121	K2
LM122	K2
LM123	K2
LM124	K2
LM125	K2
LM126	K2
LM127	K2
LM128	K2
LM129	K2
LM130	K2

Table A4.4.2 continued.

	LM131	LM132	LM133	LM134	LM135	LM136A	t17	t18	t255	t8
SiO_2	59.46	61.06	59.58	59.63	61.29	60.59	61.28	61.72	59.89	59.51
TiO_2	1.46	1.26	1.22	1.62	1.55	1.33	1.24	1.17	2.16	2.13
Al_2O_3	13.28	14.40	14.58	13.15	14.02	14.88	15.09	15.06	16.24	16.15
Fe_2O_3	6.47	6.77	7.00	7.54	7.81	8.32	7.79	7.64	8.27	8.45
MnO	0.08	0.10	0.08	0.11	0.12	0.11	0.11	0.10	0.10	0.11
MgO	3.21	2.49	2.65	4.27	3.92	2.30	1.71	1.80	2.29	2.30
CaO	4.05	2.87	2.97	4.04	3.62	3.40	2.62	2.47	4.69	4.73
Na_2O	1.84	1.80	1.23	1.65	1.92	1.81	1.36	1.57	2.58	2.71
K_2O	3.25	3.01	3.01	2.69	2.57	2.61	3.00	3.11	2.42	2.46
P_2O_5	0.69	0.20	0.32	0.25	0.24	0.24	0.28	0.3	0.37	0.39
H_2O-	1.73	1.99	2.15	1.51	0.65	1.08	1.97	1.7	0.18	0.14
LOI	3.05	3.18	4.48	2.33	1.47	1.95	3.32	3.13	0.8	0.87
TOTAL	98.57	99.13	99.27	98.79	99.18	98.62	99.77	99.77	99.99	99.95
Rb	84	93	86	78	88	82	90	91	88	86
Sr	522	367	361	478	401	254	224	243	404	405
Y	15	18	20	18	19	19	28	31	31	30
Zr	308	323	287	326	340	277	254	276	338	339
Nb	16	15	15	16	17	14	10	13	21	20
Cu	59	52	58	53	55	69	71	68	51	53
Ni	148	119	99	228	211	54	55	56	60	62
Zn	99	82	84	80	83	96	91	90	87	87
V	136	123	120	146	142	197	145	140	207	209
Cr	440	233	211	379	352	122	162	159	139	147
Co	33	33	34	46	39	38	28	28	27	26

LM131	K2
LM132	K2
LM133	K2
LM134	K2
LM135	K2
LM136A	K2: Toutswe style: raised band
t17	K2: E195G: Toutswe style
t18	K2: E195G: Toutswe style
t255	K2: E195G: Toutswe style
t8	K2: E195 G: Toutswe style

Table A4.3.3. Data for Leokwe Hill sherds.

	LM201	LM202	LM203	LM204	LM205	LM206	LM207	LM208	LM209	LM210
SiO_2	62.86	65.33	52.3	70.65	61.22	64.5	63.81	63.78	65.83	64.40
TiO_2	1.92	1.07	1.45	0.68	1.53	1.14	1.56	1.00	1.05	1.36
Al_2O_3	14.53	15.26	19.12	14.21	13.62	13.78	14.70	15.36	13.74	13.79
Fe_2O_3	7.76	5.81	7.57	4.94	7.37	6.03	6.90	6.15	6.25	6.92
MnO	0.09	0.08	0.11	0.08	0.10	0.09	0.10	0.08	0.09	0.09
MgO	1.64	1.49	2.33	1.39	2.16	2.49	2.82	1.96	3.01	1.77
CaO	3.25	2.67	4.63	1.61	2.92	2.58	3.53	2.16	2.60	2.56
Na_2O	1.82	2.11	0.57	1.37	1.03	0.89	2.00	0.74	0.96	1.23
K_2O	2.74	3.01	1.58	2.11	2.60	2.21	2.89	2.26	2.23	2.39
P_2O_5	0.34	0.16	0.18	0.18	0.23	0.18	0.34	0.20	0.17	0.22
H_2O-	0.94	0.42	3.11	0.86	2.19	2.26	0.31	2.19	1.09	1.09
LOI	2.01	1.26	5.35	1.19	3.72	3.23	0.40	3.32	2.39	2.39
TOTAL	99.9	98.67	98.30	99.27	98.69	99.38	99.36	99.20	99.41	98.21
Rb	89	121	47	61	68	55	98	63	56	75
Sr	404	281	470	187	391	308	391	295	264	329
Y	21	15	25	11	24	18	20	19	17	22
Zr	346	320	247	200	336	231	348	197	235	332
Nb	20	13	20	5	18	13	16	12	11	16
Cu	62	40	51	34	42	43	42	43	40	43
Ni	51	47	65	64	88	118	100	89	133	86
Zn	86	72	97	66	81	75	83	81	73	78
V	175	109	201	97	157	136	145	133	117	149
Cr	119	136	170	161	262	267	248	209	283	248
Co	32	23	35	23	32	33	28	31	29	35

LM201	Leokwe Hill series
LM202	Leokwe Hill
LM203	Leokwe Hill: Leopards Kopje
LM204	Leokwe Hill
LM205	Leokwe Hill
LM206	Leokwe Hill
LM207	Leokwe Hill
LM208	Leokwe Hill
LM209	Leokwe Hill
LM210	Leokwe Hill

Table A4.3.3. continued.

	LM211	LM212	LM213	LM214	LM215	LM216	LM217	LM218	LM219	LM220
SiO_2	65.45	64.10	66.19	62.43	58.15	64.84	56.31	64.94	60.34	61.63
TiO_2	1.00	0.98	1.10	1.03	1.52	1.70	1.48	1.54	1.45	1.48
Al_2O_3	14.31	13.89	13.80	13.68	14.65	13.63	19.88	14.14	12.32	13.29
Fe_2O_3	5.72	5.57	6.35	6.27	7.87	7.94	7.85	7.43	7.25	7.41
MnO	0.08	0.08	0.11	0.09	0.11	0.10	0.09	0.11	0.09	0.08
MgO	1.69	1.83	2.84	3.19	2.08	2.82	1.93	2.03	3.68	2.10
CaO	2.25	2.14	2.45	2.49	3.33	3.14	2.90	2.65	3.69	2.98
Na_2O	1.16	0.96	1.18	0.81	1.38	1.32	0.53	1.42	1.13	1.15
K_2O	2.14	2.22	2.03	1.99	2.42	2.36	1.62	2.50	2.32	2.45
P_2O_5	0.15	0.15	0.17	0.17	0.27	0.25	0.18	0.25	0.23	0.24
H_2O-	2.06	2.51	1.10	2.53	2.38	0.24	2.30	0.49	2.27	2.34
LOI	3.15	3.88	1.76	4.32	4.40	0.77	4.03	0.60	3.65	3.33
TOTAL	99.16	98.31	99.08	99.00	98.56	99.11	99.10	98.10	98.42	98.48
Rb	57	62	58	56	79	77	47	83	55	66
Sr	290	258	281	273	414	351	336	304	474	411
Y	17	17	19	17	24	26	26	25	18	24
Zr	238	241	296	220	304	386	288	369	318	332
Nb	11	12	13	11	18	20	23	18	15	17
Cu	39	42	43	47	54	49	50	51	44	43
Ni	65	63	132	149	68	120	62	86	159	88
Zn	72	72	71	75	88	84	98	84	74	77
V	119	109	130	125	171	175	212	150	156	159
Cr	186	181	270	287	179	325	157	260	304	272
Co	28	30	35	33	36	39	31	35	35	37

LM211	Leokwe Hill
LM212	Leokwe Hill
LM213	Leokwe Hill
LM214	Leokwe Hill
LM215	Leokwe Hill
LM216	Leokwe Hill
LM217	Leokwe Hill
LM218	Leokwe Hill
LM219	Leokwe Hill
LM220	Leokwe Hill

Table A4.3.3. continued.

	LM221	LM222	LM223	LM224	LM225	LM226	LM227	LM228	LM229	LM230
SiO_2	62.64	62.43	65.97	60.33	62.55	64.53	62.92	61.44	61.64	58.46
TiO_2	1.39	1.59	0.91	1.41	1.15	1.48	1.06	0.83	1.93	1.56
Al_2O_3	14.85	12.70	12.88	14.02	14.52	13.61	13.51	15.42	12.91	14.42
Fe_2O_3	7.15	7.37	5.39	6.44	6.22	6.94	6.01	5.87	8.24	6.80
MnO	0.11	0.10	0.07	0.08	0.09	0.09	0.09	0.08	0.10	0.09
MgO	2.30	2.32	2.03	2.18	2.41	1.65	2.29	1.96	3.94	3.72
CaO	3.10	2.92	2.12	3.31	2.53	2.61	2.44	1.64	3.70	3.23
Na_2O	2.05	1.27	1.12	2.14	0.96	1.29	1.17	0.68	1.48	0.76
K_2O	2.30	2.25	1.96	2.71	2.32	2.57	2.20	2.20	2.50	2.30
P_2O_5	0.15	0.19	0.17	0.18	0.19	0.23	0.17	0.12	0.30	0.30
H_2O-	0.54	1.87	2.52	2.06	2.45	1.63	2.17	3.21	1.08	2.61
LOI	1.77	3.20	3.80	3.62	3.38	2.33	4.28	5.44	1.75	5.00
TOTAL	98.35	98.21	98.94	98.48	98.77	98.96	98.31	98.89	99.57	99.25
Rb	88	61	nd	nd	nd	nd	nd	nd	68	63
Sr	322	380	nd	nd	nd	nd	nd	nd	489	407
Y	20	24	nd	nd	nd	nd	nd	nd	25	23
Zr	389	416	nd	nd	nd	nd	nd	nd	353	293
Nb	16	17	nd	nd	nd	nd	nd	nd	21	16
Cu	51	45	nd	nd	nd	nd	nd	nd	54	49
Ni	70	83	nd	nd	nd	nd	nd	nd	193	141
Zn	67	78	nd	nd	nd	nd	nd	nd	86	92
V	157	170	nd	nd	nd	nd	nd	nd	169	152
Cr	198	252	nd	nd	nd	nd	nd	nd	398	331
Co	31	39	nd	nd	nd	nd	nd	nd	38	35

LM221	Leokwe Hill
LM222	Leokwe Hill
LM223	Leokwe Hill
LM224	Leokwe Hill
LM225	Leokwe Hill
LM226	Leokwe Hill
LM227	Leokwe Hill
LM228	Leokwe Hill
LM229	Leokwe Hill: K2
LM230	Leokwe Hill: ?Woolandale/Map

Table A4.3.3. continued.

	LM231	LM232	LM233	LM234	LM235	LM236	LM237	LM238	LM239	LM240
SiO_2	66.37	59.91	63.73	68.67	60.46	64.63	54.59	57.94	61.36	65.24
TiO_2	0.78	1.99	1.60	0.63	1.75	0.67	0.75	1.59	1.96	1.23
Al_2O_3	13.63	11.96	14.82	13.32	12.56	14.65	18.09	13.91	12.93	14.01
Fe_2O_3	4.90	7.51	6.26	5.21	7.73	4.99	12.40	7.13	8.58	6.64
MnO	0.07	0.10	0.04	0.10	0.12	0.04	0.06	0.08	0.13	0.10
MgO	1.52	3.60	0.62	1.09	3.45	0.38	1.61	3.12	3.93	2.77
CaO	2.42	4.08	1.54	1.49	4.50	1.99	1.45	3.86	4.37	3.23
Na_2O	1.24	1.29	0.19	1.40	1.06	1.29	0.33	1.58	1.61	1.52
K_2O	2.38	2.81	1.07	2.28	2.35	3.09	0.83	2.87	2.53	2.12
P_2O_5	0.12	0.38	0.14	0.17	0.37	0.19	0.23	0.33	0.37	0.20
H_2O-	1.78	2.05	2.35	1.46	1.15	2.05	3.64	2.43	0.46	0.37
LOI	4.05	3.86	5.95	2.96	3.58	5.65	5.52	4.30	2.21	1.80
TOTAL	99.26	99.54	98.31	98.78	99.08	99.62	99.50	99.14	100.44	99.23
Rb	57	62	10	53	64	68	13	86	75	65
Sr	370	551	233	310	507	368	298	554	505	320
Y	15	24	39	16	24	8	5	20	29	20
Zr	233	362	199	246	366	439	116	319	372	288
Nb	11	20	9	10	18	8	7	16	22	15
Cu	27	46	101	33	47	16	72	53	66	46
Ni	67	174	68	59	153	32	122	118	172	127
Zn	62	81	53	58	85	38	62	92	97	74
V	97	161	587	109	173	76	257	139	191	141
Cr	190	386	225	164	344	92	206	259	403	318
Co	23	36	35	26	36	17	45	31	38	30

LM231	Leokwe Hill: K2
LM232	Leokwe Hill: K2
LM233	Leokwe Hill Zhizo A
LM234	Leokwe Hill ZA
LM235	Leokwe Hill ZA
LM236	Leokwe Hill Happy Rest A
LM237	Leokwe Hill Happy Rest A
LM238	Leokwe Hill ZB
LM239	Leokwe Hill ZB
LM240	Leokwe Hill ZB

Table A4.3.3. continued.

	LM241	LM242	LM243	LM244	LM245	LM246	LM247	LM248	LM249	LM250
SiO_2	54.86	60.25	59.40	58.56	63.57	65.54	62.74	58.82	57.80	63.17
TiO_2	2.19	1.44	0.75	1.68	1.38	1.21	1.55	1.91	2.21	1.25
Al_2O_3	15.35	15.69	17.66	13.20	13.90	13.77	13.31	14.29	13.10	14.45
Fe_2O_3	8.90	7.67	5.29	8.42	6.40	6.10	6.55	8.32	8.76	6.19
MnO	0.11	0.13	0.04	0.09	0.12	0.09	0.10	0.11	0.13	0.07
MgO	2.40	3.35	1.03	3.79	2.95	2.63	3.21	2.34	4.89	1.62
CaO	5.07	3.12	2.15	3.60	3.66	3.61	3.85	3.69	4.58	3.05
Na_2O	1.71	0.98	2.40	1.14	1.16	1.18	1.18	1.33	1.66	1.37
K_2O	2.51	2.31	2.39	2.60	2.45	2.10	2.36	2.14	2.47	2.48
P_2O_5	0.35	0.30	0.14	0.32	0.25	0.20	0.28	0.22	0.36	0.21
H_2O-	2.04	0.72	3.09	2.65	1.27	0.67	1.11	2.01	0.53	2.03
LOI	3.29	2.74	4.99	3.49	2.26	2.57	3.20	3.21	1.31	3.58
TOTAL	98.78	98.7	99.33	99.54	99.37	99.67	99.44	98.39	97.80	99.47
Rb	72	75	56	62	56	60	58	57	76	71
Sr	740	393	815	511	436	394	457	433	580	494
Y	26	24	6	25	21	21	21	23	29	18
Zr	318	258	281	319	277	266	300	285	389	278
Nb	24	18	8	19	15	15	17	20	23	15
Cu	78	51	26	54	46	42	42	54	58	39
Ni	59	158	40	160	120	113	144	84	203	54
Zn	100	99	60	86	77	72	76	89	93	75
V	202	164	86	172	137	130	148	220	193	131
Cr	111	380	74	363	288	281	312	178	378	140
Co	39	41	19	39	33	30	31	35	43	27

LM241	Leokwe Hill ZB
LM242	Leokwe Hill Zhizo B
LM243	Leokwe Hill ZB
LM244	Leokwe Hill: K2
LM245	Leokwe Hill ZB
LM246	Leokwe Hill ZB
LM247	Leokwe Hill
LM248	Leokwe Hill
LM249	Leokwe Hill
LM250	Leokwe Hill

Table A4.3.3. continued.

	LM251	LM252	LM253	LM254	LM255	VC31	VC32	HM44	HM45	HM47
SiO_2	63.69	65.42	61.77	66.43	57.78	63.41	56.31	58.71	58.82	58.88
TiO_2	1.05	1.57	1.37	0.99	2.30	1.63	2.18	1.24	1.30	1.31
Al_2O_3	15.48	12.41	13.30	13.96	11.69	14.49	14.21	14.33	14.36	14.56
Fe_2O_3	6.23	6.46	6.40	5.79	8.28	7.62	8.52	6.53	6.67	6.85
MnO	0.10	0.07	0.09	0.10	0.11	0.11	0.13	0.10	0.11	0.11
MgO	2.03	2.31	2.98	2.34	4.61	2.05	3.98	3.12	3.18	3.27
CaO	2.45	3.13	3.40	3.35	5.02	3.01	3.63	3.23	3.31	3.06
Na_2O	1.25	1.33	1.10	1.21	1.43	2.12	0.86	0.89	0.95	1.00
K_2O	2.21	2.65	2.51	2.32	2.29	2.26	3.73	2.66	2.64	2.67
P_2O_5	0.16	0.26	0.23	0.14	0.38	0.63	0.77	0.23	0.24	0.28
H_2O-	1.03	0.77	2.16	1.91	2.35	0.70	1.79	2.81	3.50	2.53
LOI	2.42	2.07	3.88	1.00	2.61	1.43	3.49	6.41	5.50	5.39
TOTAL	98.10	98.45	99.19	99.54	98.85	99.46	99.60	100.26	100.58	99.91
Rb	69	67	60	54	63	77	83	66	60	62
Sr	398	536	527	437	842	351	495	363	388	362
Y	22	19	20	17	26	27	33	21	22	23
Zr	317	303	273	244	379	391	339	232	239	240
Nb	14	17	16	12	23	18	24	12	14	13
Cu	37	35	34	32	60	40	64	49	51	51
Ni	91	84	127	95	197	75	156	122	126	128
Zn	73	66	80	67	91	78	104	80	83	87
V	127	151	152	118	201	140	176	153	163	161
Cr	255	257	310	226	456	184	352	310	331	337
Co	29	31	32	28	38	31	37	35	30	34

LM251	Leokwe Hill
LM252	Leokwe Hill
LM253	Leokwe Hill
LM254	Leokwe Hill ZB
LM255	Leokwe Hill ZB
VC31	Leokwe Hill
VC32	Leokwe Hill
HM44	Leokwe Hill
HM45	Leokwe Hill
HM47	Leokwe Hill

Table A4.4.4. Data for the Mapungubwe sherds.

Sample	H401	H402	H403	H404	H406	H407	H408	H409	H410	H416
SiO_2	65.53	60.10	63.43	60.57	61.59	59.94	57.93	59.57	63.96	63.43
TiO_2	1.10	1.78	1.67	1.50	1.08	1.36	1.56	1.59	1.05	1.41
Al_2O_3	14.91	14.35	15.09	13.22	15.31	15.09	12.25	12.55	13.66	15.28
Fe_2O_3	6.78	7.55	7.64	7.67	5.89	6.71	7.99	8.24	6.60	7.45
MnO	0.11	0.13	0.13	0.11	0.09	0.08	0.10	0.11	0.08	0.10
MgO	1.96	3.57	1.93	3.45	1.53	2.26	6.11	6.38	2.23	2.43
CaO	2.35	4.31	3.16	4.97	3.45	2.65	4.57	4.37	2.74	2.49
Na_2O	2.23	1.86	2.87	2.07	1.95	1.96	2.08	2.14	1.95	2.34
K_2O	2.46	2.81	2.80	2.29	2.98	3.01	2.39	2.27	2.51	2.52
P_2O_5	0.17	0.32	0.21	0.19	0.15	0.21	0.25	0.27	0.20	0.28
H_2O-	0.67	0.85	0.34	0.77	1.26	2.12	1.18	0.57	1.77	0.72
LOI	1.23	2.06	0.56	2.82	3.99	4.46	2.56	1.58	2.95	1.18
TOTAL	99.50	99.69	99.83	99.63	99.27	99.85	98.97	99.64	99.70	99.63
Rb	86	95	102	84	99	96	69	74	69	92
Sr	230	478	380	379	351	357	522	500	327	299
Y	20	27	26	25	21	24	22	22	15	26
Zr	302	361	451	378	342	323	295	299	263	376
Nb	12	16	18	18	12	14	15	16	9	17
Cu	40	56	45	47	39	87	43	46	39	44
Ni	62	116	61	146	54	74	314	332	102	85
Zn	81	93	80	73	68	84	76	81	73	78
V	127	150	137	141	105	131	148	154	98	134
Cr	149	283	153	277	130	181	479	485	207	216
Co	28	30	30	30	24	28	37	40	26	27

H401
H402
H403
H404
H406
H407
H408
H409
H410
H416

Table A4.4.4. continued.

Sample	H417	H418	H419	H420	H421	H422	m114	m12	m12A	m13
SiO_2	62.98	63.82	56.49	65.14	64.25	63.70	62.35	64.47	64.90	63.60
TiO_2	1.35	0.92	1.28	1.12	1.26	1.05	1.18	1.15	1.18	1.20
Al_2O_3	15.00	14.38	16.93	14.42	14.13	13.66	15.07	14.05	14.60	15.00
Fe_2O_3	7.27	5.41	12.78	6.93	6.25	6.63	6.15	5.85	5.84	6.05
MnO	0.11	0.05	0.08	0.05	0.09	0.08	0.07	0.07	0.07	0.08
MgO	2.45	1.26	1.16	1.19	2.02	2.31	1.63	1.42	1.48	1.30
CaO	2.71	2.31	1.33	1.39	3.25	2.79	2.74	2.30	2.26	2.64
Na_2O	2.23	1.88	0.38	0.59	2.04	1.90	1.56	1.69	1.65	1.92
K_2O	2.66	3.15	1.28	0.96	2.68	2.51	2.89	3.12	3.14	2.91
P_2O_5	0.59	0.30	0.18	0.12	0.21	0.20	0.25	0.17	0.15	0.19
H_2O-	1.00	1.97	2.36	2.17	1.13	1.77	1.69	0.92	0.91	1.60
LOI	1.79	4.17	5.48	5.64	2.38	3.08	3.92	4.57	3.82	3.64
TOTAL	100.14	99.62	99.73	99.72	99.69	99.68	99.50	99.78	100.00	100.13
Rb	88	98	13	14	86	67	110	93	92	94
Sr	343	266	169	209	343	330	342	306	296	310
Y	26	18	19	18	21	16	18	24	23	25
Zr	368	285	134	197	329	258	273	301	309	334
Nb	16	12	7	6	13	10	10	12	12	14
Cu	40	44	99	67	49	43	55	48	46	55
Ni	90	44	176	124	75	102	59	55	54	54
Zn	82	73	54	51	72	75	67	58	59	70
V	130	98	401	238	111	105	131	136	132	121
Cr	208	108	379	387	174	217	153	163	164	143
Co	29	23	58	34	24	27	20	20	18	24

H417
H418
H419
H420
H421
H422
m114
m12
m12A
m13

Table A4.4.4. continued.

Sample	m14	m15	m16	m206	m207	m208	m209	m210	m211	m212
SiO_2	61.55	65.17	60.26	59.58	61.58	63.04	61.41	61.11	60.28	59.59
TiO_2	1.37	1.41	1.25	0.37	1.47	1.58	1.51	1.57	1.10	1.12
Al_2O_3	14.99	15.42	15.51	20.45	13.80	14.38	14.43	14.54	14.09	15.04
Fe_2O_3	6.61	6.76	6.68	4.05	6.62	6.86	7.93	7.21	5.99	6.03
MnO	0.09	0.09	0.08	0.07	0.11	0.10	0.13	0.10	0.09	0.09
MgO	1.55	2.17	1.55	2.72	2.73	2.46	3.54	2.62	2.11	2.51
CaO	2.94	2.72	3.55	4.27	4.40	3.36	4.14	3.42	3.65	3.90
Na_2O	2.05	2.10	2.20	0.74	1.86	1.61	1.84	1.89	1.73	1.60
K_2O	2.82	3.07	3.12	1.52	2.30	2.83	2.50	2.66	2.65	2.90
P_2O_5	0.22	0.27	0.24	0.15	0.37	0.30	0.26	0.24	0.16	0.14
H_2O-	1.26	0.03	0.97	2.11	1.16	0.81	0.30	1.27	1.92	1.61
LOI	4.02	0.84	4.56	4.56	2.83	2.62	1.41	3.53	5.00	5.05
TOTAL	99.47	100.05	99.97	100.59	99.23	99.95	99.40	100.16	98.77	99.58
Rb	95	114	102	47	91	94	102	102	110	119
Sr	397	344	345	213	384	324	369	372	314	365
Y	27	31	28	5	22	20	26	26	19	19
Zr	334	359	301	79	305	288	342	330	290	307
Nb	16	18	16	0	15	12	17	17	10	10
Cu	66	37	50	27	54	61	58	71	54	47
Ni	58	84	57	76	56	63	135	58	51	52
Zn	74	71	77	35	65	72	77	81	69	68
V	143	145	154	51	172	161	187	166	123	134
Cr	142	220	163	204	159	142	241	140	143	134
Co	27	21	26	22	25	24	31	26	21	22

m14
m15
m16
m206
m207
m208
m209
m210
m211
m212

Table A4.4.4. continued.

Sample	m213	m214	m254	m70	m85	x215	hp1	hp2	hp3	hp4
SiO_2	61.13	63.17	63.40	64.10	59.29	61.62	59.37	62.08	59.76	61.76
TiO_2	1.11	1.23	1.21	1.15	1.08	1.31	0.68	1.81	1.10	1.75
Al_2O_3	12.67	13.72	13.90	15.52	16.18	15.46	12.16	12.58	11.91	12.52
Fe_2O_3	7.63	6.10	6.22	5.99	6.93	6.84	8.89	7.86	8.11	8.12
MnO	0.12	0.10	0.09	0.10	0.08	0.11	0.14	0.11	0.09	0.11
MgO	2.51	2.63	2.05	1.62	1.58	2.80	6.31	4.84	2.90	4.84
CaO	4.02	2.78	2.75	2.67	3.50	2.97	2.24	4.23	3.69	4.38
Na_2O	0.72	1.74	2.31	3.44	1.77	2.00	1.46	1.29	0.35	1.20
K_2O	1.73	2.49	2.52	2.83	3.19	3.00	1.72	2.55	1.16	2.43
P_2O_5	0.18	0.14	0.16	0.14	0.21	0.20	0.09	0.18	0.05	0.27
H_2O-	2.42	0.96	1.08	0.16	1.37	0.55	1.51	0.46	2.87	0.32
LOI	6.28	3.26	3.41	1.79	4.75	2.11	4.59	1.83	7.73	1.73
TOTAL	100.52	98.32	99.10	99.51	99.93	98.97	99.16	99.82	99.72	99.43
Rb	72	99	86	110	93	112	52	66	23	64
Sr	285	281	305	292	319	348	342	426	187	430
Y	25	21	24	23	25	26	14	25	19	27
Zr	269	329	381	412	242	336	103	371	163	370
Nb	11	11	15	15	13	16	4	18	6	18
Cu	52	45	39	40	49	52	67	57	82	53
Ni	75	75	75	63	65	81	633	218	143	212
Zn	71	59	58	61	79	71	95	80	61	80
V	189	151	141	133	138	153	126	163	249	164
Cr	209	196	202	177	180	207	1429	475	311	463
Co	36	26	25	24	22	22	53	29	32	38

m213	
m214	
m254	
m70	
m85	
x215	
hp1	
hp2	
hp3	Khami style
hp4	

Table A4.4.4. continued.

Sample	LM101	LM102	LM103	LM104	LM105	LM106	LM107	LM108	LM109	LM110
SiO_2	nd	65.13	64.85	62.63	62.35	60.69	63.86	60.85	63.29	60.03
TiO_2	nd	1.20	0.94	1.28	1.22	1.42	1.08	1.31	1.12	1.36
Al_2O_3	nd	13.10	13.58	16.02	14.38	14.19	14.72	12.86	16.20	12.88
Fe_2O_3	nd	6.09	8.79	6.94	6.40	7.18	5.47	6.24	6.08	6.98
MnO	nd	0.09	0.13	0.11	0.08	0.11	0.07	0.08	0.08	0.10
MgO	nd	1.58	1.06	1.79	1.82	2.84	1.29	2.78	1.34	3.95
CaO	nd	2.50	1.24	2.50	2.17	3.97	2.57	4.60	2.54	3.62
Na_2O	nd	1.92	0.95	2.80	1.90	1.57	1.95	1.57	1.81	1.75
K_2O	nd	3.06	2.05	3.27	2.83	2.50	2.99	2.57	2.76	2.56
P_2O_5	nd	0.19	0.25	0.19	0.28	0.70	0.13	0.19	0.22	0.64
H_2O-	nd	1.44	1.57	0.51	1.95	0.78	1.72	1.48	0.64	1.32
LOI	nd	2.66	3.18	0.82	3.22	2.77	2.73	4.58	2.33	4.25
TOTAL	nd	98.96	98.59	98.86	98.60	98.72	98.58	99.11	98.41	99.44
Rb	32	90	76	111	83	81	99	74	102	80
Sr	197	333	194	284	284	434	302	384	270	477
Y	81	15	24	21	18	21	15	18	19	18
Zr	409	291	166	379	372	338	358	355	321	346
Nb	21	13	12	17	15	16	13	15	15	17
Cu	71	52	132	56	68	59	41	45	42	52
Ni	140	70	135	65	60	112	47	96	51	181
Zn	110	65	91	70	66	80	61	65	77	112
V	222	122	187	125	118	147	103	135	129	132
Cr	375	196	349	161	186	235	125	235	132	336
Co	51	25	47	29	30	32	20	27	26	35

LM101	
LM102	Eiland style
LM103	Eiland style
LM104	
LM105	?Woolandale style
LM106	
LM107	
LM108	
LM109	
LM110	

Table A4.4.4. continued.

Sample	LM111	LM112	LM113	LM114	LM115	LM116	LM117	LM118	LM119	LM120
SiO_2	62.44	63.80	57.36	62.20	64.52	61.72	58.58	65.72	62.15	62.73
TiO_2	1.79	1.25	2.07	1.25	1.17	1.30	1.61	0.87	1.59	1.35
Al_2O_3	14.74	15.49	19.56	15.28	15.21	14.24	13.85	14.36	13.46	13.41
Fe_2O_3	8.42	6.68	8.57	7.21	6.45	6.72	7.34	5.08	7.21	6.69
MnO	0.12	0.10	0.13	0.11	0.09	0.09	0.12	0.07	0.11	0.09
MgO	2.22	1.57	2.40	1.80	1.46	2.37	3.63	1.12	2.86	2.73
CaO	2.98	2.75	3.78	3.10	2.60	2.84	4.21	2.48	3.34	3.42
Na_2O	2.22	1.75	1.02	2.04	2.25	1.96	1.62	1.77	1.37	1.52
K_2O	2.40	2.80	1.61	2.66	2.89	2.72	2.77	3.04	2.55	2.57
P_2O_5	0.21	0.21	0.22	0.25	0.27	0.44	0.32	0.34	0.23	0.23
H_2O-	0.29	0.64	0.90	0.78	0.49	1.30	1.48	1.30	1.66	1.67
LOI	0.98	1.71	1.86	2.78	1.22	2.92	3.23	2.62	2.85	2.90
TOTAL	98.81	98.75	99.48	99.46	98.62	98.62	98.76	98.77	99.38	99.31
Rb	94	103	46	101	104	89	81	102	72	79
Sr	286	321	333	318	290	386	442	327	402	377
Y	23	20	29	22	19	21	19	14	23	19
Zr	405	333	267	326	356	365	361	277	341	305
Nb	20	17	23	17	16	16	16	13	18	16
Cu	59	65	70	60	53	52	53	51	56	63
Ni	71	59	76	62	60	97	159	47	115	118
Zn	83	80	98	87	74	75	81	60	81	79
V	217	123	232	137	122	139	153	99	158	126
Cr	185	140	194	163	147	227	316	118	266	225
Co	33	29	37	34	29	31	37	23	36	33

LM111
LM112
LM113
LM114
LM115
LM116
LM117
LM118
LM119
LM120

Table A4.4.4. continued.

Sample	MX01	MX02	MX03	MX04	mxj1	mxj2
SiO_2	64.07	61.13	65.15	61.04	65.09	63.86
TiO_2	1.42	1.15	1.35	1.71	0.73	0.71
Al_2O_3	15.58	15.65	12.73	15.93	14.81	16.26
Fe_2O_3	6.39	8.08	7.43	8.46	6.34	6.78
MnO	0.10	0.11	0.10	0.13	0.04	0.11
MgO	1.90	2.50	2.02	2.95	1.53	1.39
CaO	3.20	4.32	3.15	3.64	1.90	1.44
Na_2O	2.39	2.42	1.59	2.13	1.78	1.29
K_2O	3.57	2.78	2.76	3.23	1.38	3.28
P_2O_5	0.17	0.22	0.15	0.22	0.13	0.37
H_2O-	0.23	0.38	0.76	0.26	1.44	1.47
LOI	0.98	1.46	2.70	1.08	4.45	2.96
TOTAL	100.00	100.20	99.89	100.78	99.62	99.62
Rb	109	84	64	92	29	146
Sr	293	259	225	286	297	177
Y	23	21	23	30	13	29
Zr	342	253	322	354	187	194
Nb	13	10	9	16	11	16
Cu	43	57	46	56	50	57
Ni	79	70	68	112	120	63
Zn	72	81	68	83	40	53
V	118	135	155	143	178	99
Cr	169	165	175	217	398	167
Co	26	31	32	33	37	37

MX01	
MX02	
MX03	
MX04	
mxj1	Eiland style
mxj2	Eiland style

Table A4.4.5. Data for sherds from miscellaneous sites in the Limpopo Valley.

	LM629	LM630	LM631	LM632	LM633	LM634a	LM634b	LM601	LM602	LM603
SiO_2	55.63	61.05	61.32	52.32	61.48	54.96	52.79	65.49	66.40	66.92
TiO_2	1.94	1.68	1.30	1.69	1.29	1.49	1.44	1.04	0.96	1.07
Al_2O_3	20.13	14.29	13.97	19.97	13.80	19.68	21.02	14.56	13.58	12.79
Fe_2O_3	8.35	7.30	6.30	8.43	6.38	7.74	7.68	7.03	5.84	6.36
MnO	0.11	0.08	0.09	0.12	0.08	0.12	0.10	0.09	0.11	0.09
MgO	2.06	2.20	2.82	2.15	2.95	1.69	1.83	3.18	2.81	2.18
CaO	3.72	3.75	3.35	4.10	3.42	3.43	3.29	2.86	2.94	2.81
Na_2O	0.85	1.41	1.81	0.70	1.89	0.66	0.54	1.32	1.29	1.58
K_2O	1.68	2.61	3.08	1.59	3.04	1.74	1.69	1.96	2.06	2.27
P_2O_5	0.19	0.31	0.22	0.21	0.22	0.23	0.16	0.16	0.15	0.16
H_2O-	1.75	1.41	1.63	2.15	1.56	2.60	2.41	0.36	0.87	0.79
LOI	3.59	2.29	2.37	5.07	2.42	4.05	5.32	1.02	1.82	2.32
TOTAL	100.00	98.38	98.26	98.50	98.53	98.39	98.27	99.07	98.83	99.34
Rb	45	84	89	46	90	45	48	68	58	62
Sr	322	418	369	302	370	343	249	268	425	369
Y	26	21	16	29	17	28	26	20	18	17
Zr	279	340	349	292	357	285	274	265	256	258
Nb	24	19	15	24	16	22	22	13	12	12
Cu	33	67	43	63	43	70	53	45	39	47
Ni	63	68	119	69	132	58	66	143	124	86
Zn	90	76	67	98	68	90	93	78	71	63
V	224	144	99	207	110	194	201	153	118	126
Cr	156	115	218	169	242	142	168	380	343	204
Co	37	31	30	38	29	32	35	35	32	32

LM629	Site 2229AD 15: Mapungubwe period 1220-1300
LM630	Site 2229AD 15: thin black sherd
LM631	Site 2229AD 15: K2 sherd
LM632	Site 2229AD 15
LM633	Site 2229AD 15
LM634a	Site 2229AD 15
LM634b	Site 2229AD 15
LM601	Baobab 2229AD 6: Zhizo period. Blouberg sherd
LM602	Baobab: Blouberg sherd
LM603	Baobab: K2 sherd

Table A4.4.5. continued.

	LM604	LM605	LM606	LM607	LM608	LM609	LM610	LM611	LM612	LM613
SiO_2	60.92	61.81	70.28	60.74	60.58	62.63	58.28	64.53	67.98	59.65
TiO_2	1.25	1.26	0.94	1.29	1.24	1.13	2.07	1.00	0.91	1.91
Al_2O_3	13.28	13.78	12.04	14.93	13.63	14.23	11.87	13.77	14.48	12.90
Fe_2O_3	6.75	7.19	6.93	6.67	6.34	6.25	7.79	5.89	5.55	8.40
MnO	0.11	0.12	0.08	0.10	0.08	0.08	0.09	0.08	0.10	0.12
MgO	3.85	3.88	0.66	2.99	3.08	1.67	4.04	2.71	1.94	3.91
CaO	3.72	3.37	1.62	3.54	3.11	3.07	4.36	3.28	2.94	4.29
Na_2O	0.99	1.12	0.25	0.75	0.94	1.27	1.15	1.11	1.36	1.15
K_2O	2.12	2.12	1.57	2.16	2.25	2.10	2.81	2.14	2.09	2.50
P_2O_5	0.34	0.24	0.16	0.32	0.23	0.19	0.37	0.18	0.15	0.35
H_2O-	1.91	1.19	1.32	1.94	3.06	2.14	2.47	1.41	0.39	1.72
LOI	2.91	2.03	3.30	3.60	4.07	3.70	3.00	2.73	1.40	3.05
TOTAL	98.15	98.11	99.15	99.03	98.61	98.46	98.30	98.83	99.29	99.95
Rb	55	58	43	57	59	55	65	57	68	65
Sr	628	523	320	605	539	519	685	517	266	727
Y	19	20	16	24	21	19	26	18	18	27
Zr	255	273	247	250	255	249	358	248	278	336
Nb	14	14	8	15	14	14	22	12	12	22
Cu	42	44	40	41	52	43	58	40	35	67
Ni	206	213	63	137	129	63	152	131	77	156
Zn	77	81	45	85	78	74	91	69	69	95
V	139	151	159	142	149	137	189	136	109	209
Cr	366	387	183	326	306	149	379	261	214	399
Co	38	40	35	34	31	29	38	35	28	47

LM604	Baobab K2 sherd
LM605	Baobab K2 sherd
LM606	Baobab Klingbeil sherd
LM607	Baobab Zhizo sherd
LM608	Baobab
LM609	Baobab
LM610	Baobab
LM611	Baobab
LM612	Baobab
LM613	Baobab

Table A4.4.5. continued.

	LM614	LM615	LM616	LM617	LM618	LM619	LM620	LM621	LM622	sh151
SiO_2	58.84	57.51	61.45	62.62	61.30	60.93	59.20	58.89	64.10	62.06
TiO_2	1.48	1.89	2.11	0.99	1.42	1.27	1.32	1.81	1.45	1.16
Al_2O_3	14.44	12.79	12.48	13.86	13.90	13.56	13.84	14.84	13.44	14.51
Fe_2O_3	7.25	8.47	8.63	5.79	6.95	6.29	7.24	8.02	7.27	6.57
MnO	0.10	0.12	0.13	0.09	0.09	0.08	0.10	0.11	0.10	0.12
MgO	2.46	4.11	3.47	2.19	2.41	3.02	4.09	2.64	2.86	3.30
CaO	4.28	4.60	3.94	3.12	3.41	3.39	3.53	4.99	3.51	2.79
Na_2O	1.50	1.26	1.39	1.08	1.37	0.90	1.25	1.64	1.30	1.14
K_2O	1.82	2.27	2.58	2.26	2.65	2.18	2.16	1.85	2.25	2.19
P_2O_5	0.16	0.45	0.41	0.20	0.29	0.27	0.25	0.23	0.30	0.25
H_2O-	1.89	1.63	0.66	2.40	1.70	2.99	2.32	1.46	0.55	1.34
LOI	3.73	3.20	1.32	3.99	2.98	3.84	3.26	2.30	1.49	4.41
TOTAL	97.95	98.30	98.57	98.59	98.47	98.72	98.56	98.78	98.62	99.84
Rb	49	64	71	55	75	55	56	48	70	56
Sr	377	741	576	594	579	617	646	573	460	415
Y	21	28	30	17	20	19	20	22	21	24
Zr	311	342	377	246	283	246	287	316	342	239
Nb	16	22	21	12	15	14	14	20	16	12
Cu	63	56	52	37	34	47	46	59	50	47
Ni	67	167	164	92	78	121	207	67	102	142
Zn	71	97	92	73	79	78	74	79	74	82
V	189	206	194	117	157	120	176	194	148	127
Cr	182	441	423	244	229	294	418	175	258	218
Co	31	40	42	27	35	29	38	32	32	22

LM614	Baobab
LM615	Baobab
LM616	Baobab
LM617	Baobab
LM618	Baobab
LM619	Baobab
LM620	Baobab
LM621	Baobab
LM622	Baobab
sh151	Den Staat: K2 period site

Table A4.4.5. continued.

	sh152	sh153	sh154	sh155	sh156	sh157	sh158	sh159	sh160	sh161
SiO_2	62.26	59.63	62.06	65.90	63.95	61.08	64.19	66.59	55.65	68.25
TiO_2	0.58	1.65	0.95	1.04	1.52	1.48	1.47	1.00	1.75	0.73
Al_2O_3	11.43	13.60	14.91	15.20	13.10	15.65	13.13	14.17	19.43	13.84
Fe_2O_3	9.39	8.08	6.05	6.12	7.13	7.66	6.85	5.28	8.37	5.05
MnO	0.17	0.13	0.10	0.11	0.11	0.11	0.10	0.07	0.12	0.09
MgO	4.14	4.97	2.07	2.25	3.26	2.48	2.32	1.18	2.63	1.49
CaO	2.25	4.04	1.92	1.95	3.27	3.30	3.11	2.42	3.81	1.63
Na_2O	0.82	1.83	1.15	1.80	1.45	1.58	1.54	2.32	1.00	1.21
K_2O	1.77	2.58	2.38	2.45	2.51	2.17	2.84	3.06	1.82	2.33
P_2O_5	0.19	0.32	0.18	0.26	0.26	0.23	0.25	0.19	0.28	0.21
H_2O-	2.42	0.41	2.50	1.30	0.86	1.39	1.45	1.24	1.37	1.80
LOI	4.10	1.95	5.25	2.10	2.03	2.46	2.70	2.54	3.15	3.26
TOTAL	99.52	99.19	99.52	100.48	99.45	99.59	99.95	100.06	99.38	99.89
Rb	50	77	55	57	61	50	61	87	48	56
Sr	196	501	403	300	441	389	398	390	438	307
Y	13	24	21	22	27	27	26	17	33	18
Zr	127	319	192	197	339	273	334	285	288	185
Nb	5	17	10	12	16	16	15	10	23	9
Cu	51	55	43	44	46	69	41	37	56	33
Ni	279	251	96	107	139	76	85	37	70	75
Zn	84	88	81	86	83	91	77	65	117	70
V	154	149	128	122	149	163	149	88	210	95
Cr	356	326	164	174	250	139	541	70	254	123
Co	33	30	19	19	25	27	21	16	25	16

sh152	Den Staat
sh153	Den Staat
sh154	Den Staat
sh155	Den Staat
sh156	Den Staat
sh157	Den Staat
sh158	Den Staat
sh159	Den Staat
sh160	Den Staat
sh161	Den Staat

Table A4.4.5. continued.

	sh162	LM623	LM624	LM625	LM626	LM627	LM628
SiO_2	63.15	62.27	62.60	51.54	59.48	62.21	57.79
TiO_2	1.42	1.20	1.24	3.16	1.50	1.22	1.78
Al_2O_3	12.74	14.56	14.62	13.96	12.26	22.07	15.11
Fe_2O_3	6.89	6.61	5.79	12.4	7.63	6.86	7.41
MnO	0.09	0.09	0.07	0.15	0.11	0.09	0.08
MgO	3.19	2.37	1.60	1.73	5.17	1.18	1.82
CaO	3.56	2.90	2.87	3.83	4.94	1.46	3.75
Na_2O	1.58	1.97	2.06	1.81	1.88	0.74	1.92
K_2O	2.60	3.36	3.41	3.46	2.28	1.51	2.94
P_2O_5	0.45	0.17	0.17	0.67	0.31	0.17	0.18
H_2O-	1.29	0.89	1.61	0.69	0.62	0.08	1.82
LOI	2.70	1.91	2.94	5.15	2.47	1.18	3.73
TOTAL	99.66	98.30	98.98	98.55	98.65	98.77	98.33
Rb	59	88	92	53	76	56	87
Sr	575	464	487	959	583	286	638
Y	24	19	17	41	21	28	20
Zr	307	328	318	521	323	329	319
Nb	14	16	17	32	17	21	19
Cu	38	50	63	49	48	32	49
Ni	122	100	107	63	227	52	53
Zn	75	76	83	128	76	77	84
V	132	119	132	221	158	176	177
Cr	362	197	221	129	425	146	138
Co	21	32	29	53	42	32	35

sh162	Den Staat
LM623	Edmonsberg (2229AD5): Mapungubwe period
LM624	Edmonsberg
LM625	Edmonsburg: K2 sherd
LM626	Edmonsberg
LM627	Edmonsberg
LM628	Edmonsberg

Table A4.5.1. Data for the Mutokolwe sherds and spindle whorls.

Sample	FW42	FW43	FW44	FW45	FW46	FW47	FW01	FW02	FW03	FW04
SiO_2	60.89	67.90	61.08	55.56	60.37	52.14	58.30	67.29	52.87	65.25
TiO_2	0.95	0.76	0.93	0.96	1.73	2.96	0.77	0.90	3.24	1.09
Al_2O_3	17.91	13.91	17.88	17.41	13.98	15.59	17.22	13.16	15.53	14.55
Fe_2O_3	5.65	6.69	5.70	10.07	11.65	11.45	9.22	6.35	11.93	7.91
MnO	0.05	0.07	0.06	0.09	0.08	0.10	0.09	0.04	0.09	0.08
MgO	0.50	4.23	0.51	3.14	0.68	2.48	2.72	1.15	1.86	1.13
CaO	0.53	1.07	0.52	3.05	0.75	3.62	2.83	0.99	2.77	1.26
Na_2O	0.84	1.33	0.89	0.47	0.20	1.34	0.84	0.95	1.67	1.19
K_2O	4.96	2.36	4.96	0.56	0.64	2.28	0.43	1.70	2.56	1.99
P_2O_5	0.12	0.25	0.17	0.16	0.17	0.49	0.18	0.13	0.63	0.21
H_2O-	2.99	0.39	2.94	1.86	4.03	3.01	2.97	3.19	2.52	1.89
LOI	4.21	0.89	4.32	6.04	5.12	4.00	4.19	3.82	3.70	2.77
TOTAL	99.60	99.85	99.96	99.37	99.40	99.46	99.76	99.67	99.37	99.32
Rb	147	92	145	17	29	69	17	61	74	70
Sr	412	246	414	76	46	587	53	133	598	159
Y	27	16	27	14	29	41	16	16	59	25
Zr	275	253	264	119	222	405	131	311	503	389
Nb	15	11	14	5	10	21	6	8	26	11
Cu	59	32	57	101	111	111	52	44	129	81
Ni	78	330	80	159	75	85	114	50	68	52
Zn	43	67	43	65	50	95	59	44	109	58
V	152	108	155	266	407	252	178	126	202	119
Cr	215	931	222	422	149	99	213	108	46	91
Co	22	36	24	45	44	39	47	21	41	29

FW42:	Motokolwe A: T9 audience chamber
FW43:	Motokolwe A: T9 audience chamber
FW44:	Motokolwe A: T9 audience chamber
FW45:	Motokolwe A: T9 audience chamber
FW46:	Motokolwe A: T9 audience chamber
FW47:	Motokolwe B: Tshivhambo T8; spindle whorl
FW01:	Motokolwe B: Cooking hut T7 Khami style
FW02:	Motokolwe B: Cooking hut T7 Khami style
FW03:	Motokolwe B: Cooking hut T7 Khami style
FW04:	Motokolwe B: Cooking hut T7 Khami style

Table A4.5.1 continued.

Sample	FW05	FW06	FW07	FW23	FW24	FW25	FW26	FW27	FW28	FW29
SiO_2	63.90	54.92	62.66	54.52	63.84	67.77	59.61	52.79	58.34	50.16
TiO_2	0.88	1.48	0.88	0.82	1.51	0.81	1.34	1.40	0.52	1.56
Al_2O_3	14.17	23.94	18.81	20.80	15.99	13.77	16.80	22.79	11.85	21.86
Fe_2O_3	10.85	12.86	5.68	8.76	4.97	4.88	8.16	12.76	8.86	12.72
MnO	0.09	0.06	0.03	0.08	0.04	0.11	0.05	0.05	0.07	0.06
MgO	1.01	1.25	1.03	2.69	0.30	1.14	0.91	1.16	7.19	1.26
CaO	2.03	0.99	0.60	2.73	0.39	0.93	0.26	1.04	2.80	0.56
Na_2O	0.74	0.57	1.06	0.31	0.98	1.04	0.09	0.50	1.50	0.22
K_2O	0.35	0.86	2.08	0.51	3.82	2.55	0.28	0.82	0.66	0.58
P_2O_5	0.23	0.34	0.11	0.35	0.23	0.14	0.25	0.36	0.39	0.34
H_2O-	1.54	0.82	3.04	3.18	2.84	2.67	4.83	2.29	3.10	4.62
LOI	3.78	1.31	3.98	4.21	4.21	3.97	6.65	3.26	4.41	5.63
TOTAL	99.57	99.40	99.96	98.96	99.12	99.78	99.23	99.22	99.69	99.57
Rb	13	39	83	19	90	68	8	37	25	25
Sr	81	126	207	49	349	297	10	125	164	84
Y	20	30	30	18	20	23	14	28	10	28
Zr	124	177	267	124	738	309	176	166	99	183
Nb	6	11	11	5	18	12	5	10	4	9
Cu	165	105	45	73	37	104	92	98	40	93
Ni	87	184	147	125	35	56	93	180	760	167
Zn	72	74	74	71	40	65	48	71	73	68
V	254	378	149	284	153	158	360	380	125	389
Cr	279	480	415	241	102	103	348	496	1813	432
Co	46	48	23	39	15	29	36	54	53	58

FW05: Motokolwe B: Cooking hut T7 Khami style
FW06: Motokolwe B: Cooking hut T7 large water pot no decoration
FW07: Motokolwe B: Cooking hut T7 Tavhatshena style sherd
FW23: Motokolwe B: rainmaking area T5, rim
FW24: Motokolwe B: rainmaking area T5
FW25: Motokolwe B: rainmaking area T5, decorated sherd
FW26: Motokolwe B: rainmaking area T5
FW27: Motokolwe B: Cooking hut T7
FW28: Motokolwe B: Cooking hut T7
FW29: Motokolwe B: Cooking hut T7

Table A4.5.1 continued.

Sample	FW30	FW31	FW32	FW33	FW34	FW35	FW36	FW37	FW38	FW39
SiO_2	51.90	65.62	59.74	59.05	69.34	53.76	51.25	61.33	62.61	62.08
TiO_2	1.36	0.65	0.96	0.89	1.17	0.94	1.29	1.09	0.94	1.10
Al_2O_3	21.87	13.72	13.97	14.28	9.63	18.43	19.61	14.96	18.29	14.82
Fe_2O_3	11.58	5.64	9.99	10.09	9.11	11.04	10.36	7.89	5.43	7.92
MnO	0.06	0.05	0.10	0.11	0.04	0.10	0.06	0.06	0.02	0.07
MgO	0.99	1.55	1.84	2.25	0.72	2.76	0.94	1.33	0.53	1.34
CaO	0.92	1.42	1.74	2.39	0.61	3.42	0.63	1.09	0.29	1.13
Na_2O	0.44	0.60	0.33	0.57	0.15	0.70	0.51	0.80	0.59	0.89
K_2O	0.80	2.04	0.48	0.67	0.45	0.46	0.72	2.12	3.17	2.22
P_2O_5	0.55	0.43	0.12	0.20	0.08	0.20	0.62	0.31	0.10	0.49
H_2O-	3.96	2.71	4.98	3.69	3.21	3.16	5.53	4.03	3.21	3.61
LOI	5.43	5.19	5.61	5.58	5.17	4.98	8.50	4.48	4.31	4.30
TOTAL	99.86	99.62	99.86	99.77	99.68	99.95	100.02	99.49	99.49	99.97
Rb	34	90	26	32	20	20	30	74	173	73
Sr	123	213	43	59	27	78	117	150	146	157
Y	23	18	14	15	18	21	13	20	13	23
Zr	150	221	141	149	230	130	149	382	416	393
Nb	7	6	5	5	7	6	5	13	14	13
Cu	82	51	75	142	95	115	90	81	36	78
Ni	157	57	96	100	58	116	140	54	54	54
Zn	65	54	58	58	37	74	58	49	43	55
V	395	99	239	236	309	320	253	144	126	129
Cr	471	115	140	160	183	186	363	99	171	92
Co	46	21	54	48	39	50	48	30	17	29

FW30: Motokolwe B: Cooking hut T7
FW31: Motokolwe B: Cooking hut T7
FW32: Motokolwe B: rainmaking area T5
FW33: Motokolwe B: rainmaking area T5
FW34: Motokolwe B: rainmaking area T5, rim sherd
FW35: Motokolwe B: rainmaking area T5, decorated sherd (overlapping horizontal lines)
FW36: Motokolwe B: Beer hut T4
FW37: Motokolwe B: Thondo T2 messenger’s hut
FW38: Motokolwe B: Thondo T2 messenger’s hut
FW39: Motokolwe B: Thondo T2 messenger’s hut

Table A4.5.1 continued.

Sample	FW40	FW41	FW52	FW53	FW54	FW55	FW56	FW57	FW58	FW59
SiO_2	61.86	61.48	66.61	63.56	58.40	49.47	60.67	56.63	52.05	62.10
TiO_2	1.11	1.07	0.79	1.06	2.36	0.43	1.01	1.38	2.97	0.93
Al_2O_3	15.09	14.85	15.87	15.38	20.70	15.44	14.70	16.47	15.63	18.44
Fe_2O_3	8.05	7.90	5.59	4.86	7.88	6.91	11.01	8.40	11.60	5.56
MnO	0.05	0.06	0.04	0.04	0.05	0.08	0.12	0.07	0.09	0.03
MgO	1.04	1.28	0.85	1.02	0.91	3.56	1.66	1.98	2.53	0.56
CaO	1.10	1.13	1.17	1.36	1.21	7.87	1.85	2.08	3.65	0.27
Na_2O	0.96	0.95	0.10	1.18	0.45	0.47	0.82	0.40	1.30	0.63
K_2O	1.87	2.17	0.20	4.68	0.95	1.49	0.46	0.54	2.26	3.09
P_2O_5	0.17	0.50	0.73	0.35	0.85	0.46	0.47	0.17	0.50	0.12
H_2O-	4.21	3.74	2.91	2.00	2.30	3.77	2.61	4.52	3.08	3.34
LOI	4.39	4.27	4.82	3.77	3.41	9.55	4.27	6.85	3.86	4.39
TOTAL	99.90	99.40	99.68	99.26	99.47	99.50	99.65	99.49	99.52	99.46
Rb	61	77	14	147	29	79	27	35	68	168
Sr	158	155	164	362	200	288	192	66	600	146
Y	25	22	17	20	42	18	21	17	41	13
Zr	416	402	135	221	274	91	137	193	401	440
Nb	13	13	3	11	13	3	6	8	21	13
Cu	90	80	50	36	116	40	103	88	115	37
Ni	53	56	104	108	165	87	117	92	84	56
Zn	50	55	59	47	86	51	72	69	95	44
V	131	125	203	184	447	124	239	309	257	132
Cr	101	91	209	352	377	118	253	234	86	172
Co	29	31	28	15	34	30	55	38	40	20

FW40:	Motokolwe B: Thondo T2 messenger’s hut, rim sherd
FW41:	Motokolwe B: Thondo T2 messenger’s hut
FW52:	Motokolwe B: T1 midden A4/L4; spindle whorl
FW53:	Motokolwe B: T1 midden A4/L4; spindle whorl
FW54:	Motokolwe B: T1 midden A4/L4; spindle whorl
FW55:	Motokolwe B: T1 midden A4/L4; spindle whorl
FW56:	Motokolwe B: T1 midden A4/L4; spindle whorl
FW57:	Motokolwe B: T7/126/9; Maloko sherd!!!!
FW58:	Duplicate of FW47 (Motokolwe B: Tshivhambo T8; spindle whorl)
FW59:	Duplicate of FW38 (Motokolwe B: Thondo T2 boys’ hut)

Table A4.5.1 continued.

Sample	FW60	FW61	FW62	FW63
SiO_2	59.69	57.29	60.37	53.75
TiO_2	0.94	0.54	1.29	3.12
Al_2O_3	13.84	12.78	16.89	14.95
Fe_2O_3	9.94	9.11	8.25	11.78
MnO	0.12	0.07	0.05	0.10
MgO	1.92	7.49	0.92	1.93
CaO	1.83	2.88	0.28	2.81
Na_2O	0.33	1.35	0.11	1.73
K_2O	0.48	0.65	0.32	2.56
P_2O_5	0.11	0.47	0.26	0.64
H_2O-	4.90	3.08	4.42	2.38
LOI	5.59	4.25	6.28	3.63
TOTAL	99.69	99.96	99.44	99.38
Rb	29	25	10	76
Sr	46	171	12	617
Y	14	11	15	43
Zr	144	94	175	517
Nb	6	5	5	27
Cu	76	41	87	134
Ni	99	815	95	70
Zn	59	75	50	117
V	232	121	355	204
Cr	154	1849	346	52
Co	56	58	37	40

FW60:	Duplicate of FW32 (Motokolwe B: rainmaking area T5)
FW61:	Duplicate of FW28 (Motokolwe B: cooking hut T7)
FW62:	Duplicate of FW26 (Motokolwe B: rainmaking area T5)
FW63:	Duplicate of FW03 (Motokolwe B: Khami decorated sherd)

Table A4.5.2. Data for the miscellaneous Venda sherds.

	HM36	HM37	HM38	HM39	HM40	HM41	HM42	n221	n222	n223
SiO_2	69.20	67.33	58.68	59.08	55.69	56.09	55.81	64.88	67.60	60.28
TiO_2	0.49	0.57	1.08	1.03	0.98	2.06	2.04	0.88	0.90	1.62
Al_2O_3	15.49	14.52	15.57	15.17	15.82	14.99	15.05	13.45	13.85	12.66
Fe_2O_3	4.65	4.82	9.66	9.09	9.70	11.91	11.86	7.49	6.96	9.17
MnO	0.06	0.05	0.13	0.13	0.11	0.08	0.08	0.13	0.12	0.13
MgO	3.15	0.91	2.24	2.81	2.59	1.65	1.84	1.71	1.77	2.85
CaO	2.26	2.00	2.59	2.85	2.62	2.03	2.10	2.36	1.94	3.86
Na_2O	3.07	0.94	2.06	2.00	2.04	1.20	1.34	0.81	0.76	1.28
K_2O	1.50	3.86	1.98	1.82	2.45	1.26	1.81	1.97	1.54	1.49
P_2O_5	0.13	0.33	0.21	0.23	0.28	0.26	0.42	0.19	0.15	0.37
H_2O-	0.22	1.12	1.67	1.50	1.66	2.22	1.72	1.64	1.37	2.03
LOI	0.57	3.34	4.34	4.46	5.95	6.45	6.20	3.77	2.80	3.76
TOTAL	100.79	99.79	100.21	100.17	99.89	100.20	100.27	99.28	99.76	99.50
Rb	43	181	67	55	64	35	42	74	71	46
Sr	339	139	305	310	284	164	177	314	238	334
Y	8	28	18	17	16	26	26	23	26	26
Zr	155	211	163	168	140	247	236	181	223	248
Nb	4	13	8	7	7	12	12	10	11	12
Cu	26	31	74	64	81	139	131	48	41	58
Ni	204	33	159	226	223	195	197	102	93	106
Zn	77	44	84	82	82	87	90	68	61	79
V	74	87	199	193	200	367	354	173	161	241
Cr	561	83	418	649	602	728	732	295	288	262
Co	27	19	47	53	48	56	59	33	31	37

HM36	2329 BB4: Matshava: Venda hill top site
HM37	2329 BB4
HM38	2329 BB3: Manvhela: Venda
HM39	2329 BB3
HM40	2329 BB3
HM41	2329 BB3
HM42	2329 BB3
n221	2229 DA7 Verulam: Mapungubwe period jar
n222	2229 DA7 Verulam: Mapungubwe period jar
n223	2229 DA7 Verulam: Mapungubwe period jar

Table A4.5.2. continued.

	d250	d39	d52	d81	HM34	HM35
SiO_2	65.04	65.64	61.68	63.74	58.90	69.01
TiO_2	0.89	0.86	0.96	0.81	1.04	0.49
Al_2O_3	15.81	16.01	16.45	15.41	16.27	14.77
Fe_2O_3	4.07	4.86	7.99	7.67	10.83	4.33
MnO	0.03	0.06	0.06	0.06	0.12	0.05
MgO	1.37	0.97	1.24	1.75	2.20	3.07
CaO	1.16	1.36	2.13	2.62	2.07	2.27
Na_2O	1.07	1.32	1.59	2.64	1.22	2.81
K_2O	5.32	3.21	1.42	1.14	1.15	1.34
P_2O_5	0.28	0.37	0.32	0.18	0.31	0.21
H_2O-	1.42	1.46	1.78	0.79	2.28	0.43
LOI	3.38	3.36	4.16	3.01	3.96	1.52
TOTAL	99.84	99.48	99.78	99.82	100.35	100.30
Rb	159	118	55	30	23	39
Sr	471	331	287	321	199	345
Y	29	29	17	14	16	7
Zr	402	324	210	168	155	151
Nb	13	13	8	7	6	4
Cu	33	69	71	46	65	24
Ni	184	112	131	150	266	197
Zn	23	34	52	44	70	45
V	129	136	146	203	248	86
Cr	687	386	371	459	1130	530
Co	15	13	28	36	62	27

d250	2230 CC2: Dzata
d39	2230 CC2
d52	2230 CC2
d81	2230 CC2
HM34	2329 BB4: Matshava: Venda hill top site
HM35	2329 BB4

Table A4.5.3. Data for the Princess Hill sherds.

	pm115	pm116	pm120	pm121	pm127	pm163	pm165	pm166	pm167	pm168
SiO_2	57.50	63.97	62.11	62.98	63.83	62.99	63.89	60.59	76.30	65.28
TiO_2	1.49	0.81	0.94	0.76	0.98	1.23	0.72	0.78	1.04	0.85
Al_2O_3	18.25	10.56	10.42	9.96	10.92	11.80	10.47	12.57	11.75	11.66
Fe_2O_3	5.05	4.66	5.66	4.71	5.06	7.02	7.62	9.07	4.10	4.94
MnO	0.03	0.07	0.10	0.08	0.08	0.10	0.08	0.09	0.03	0.06
MgO	1.21	2.63	2.64	2.71	2.44	2.19	2.08	2.30	0.58	2.11
CaO	1.65	4.67	6.03	5.58	5.18	4.75	4.67	4.40	0.53	3.33
Na_2O	0.44	0.33	0.45	0.42	0.60	0.44	0.39	0.43	0.29	0.44
K_2O	1.14	2.20	2.26	1.73	1.82	1.85	1.63	2.13	1.28	1.70
P_2O_5	0.23	0.12	0.15	0.12	0.21	0.17	0.10	0.33	0.09	0.09
H_2O-	3.61	1.91	1.48	1.82	1.97	1.60	1.68	1.25	1.06	2.17
LOI	7.91	6.61	7.21	8.30	6.33	5.62	6.46	5.98	3.50	7.15
TOTAL	98.51	98.54	99.45	99.17	99.42	99.76	99.79	99.92	100.55	99.78
Rb	15	60	45	42	32	37	29	28	5	33
Sr	171	248	272	218	304	250	160	224	62	151
Y	28	24	24	24	24	22	11	12	11	20
Zr	155	197	198	187	224	240	120	113	164	195
Nb	2	9	10	8	9	11	5	5	4	8
Cu	138	30	37	30	29	45	43	49	62	37
Ni	141	78	106	76	109	96	104	126	74	71
Zn	94	62	62	58	61	61	67	91	33	56
V	400	123	144	133	156	178	149	160	203	165
Cr	430	155	196	166	208	209	200	235	121	153
Co	24	16	19	16	16	34	37	45	11	24

pm115	Princess Hill 2229DD2: Mapungubwe period
pm116	Princess Hill
pm120	Princess Hill
pm121	Princess Hill: graphite
pm127	Princess Hill
pm163	Princess Hill
pm165	Princess Hill
pm166	Princess Hill
pm167	Princess Hill
pm168	Princess Hill

Table A4.5.3. continued.

	pm169	pm170	pm171	pm172	pm173	pm174	pm175	pm176
SiO_2	67.25	69.41	63.72	61.99	65.49	70.61	59.19	70.79
TiO_2	0.76	0.95	1.02	1.02	0.72	0.78	1.15	0.97
Al_2O_3	12.04	12.55	10.95	16.38	11.18	11.97	15.13	13.02
Fe_2O_3	4.70	5.05	5.35	8.99	6.43	5.09	11.15	7.26
MnO	0.07	0.08	0.10	0.08	0.10	0.09	0.10	0.10
MgO	1.90	2.18	2.89	1.13	2.02	1.57	1.50	1.73
CaO	3.56	3.25	5.19	2.42	5.75	2.77	2.95	1.92
Na_2O	0.41	0.53	0.29	0.45	0.39	0.15	0.60	1.29
K_2O	1.68	1.94	2.26	1.71	1.39	1.10	2.13	1.52
P_2O_5	0.11	0.13	0.19	0.23	0.10	0.25	0.24	0.14
H_2O-	1.88	1.04	1.87	1.48	1.02	1.69	1.45	0.33
LOI	6.48	3.07	6.15	4.38	5.25	4.34	4.10	1.19
TOTAL	100.84	100.18	99.98	100.26	99.84	100.41	99.69	100.26
Rb	35	31	51	31	33	27	40	41
Sr	162	178	293	184	193	184	229	223
Y	21	23	25	21	19	23	27	19
Zr	204	232	207	189	155	216	229	241
Nb	10	11	11	9	8	11	12	7
Cu	30	29	33	43	41	33	66	42
Ni	65	94	95	94	96	72	148	95
Zn	59	61	64	78	62	52	91	63
V	142	153	144	202	148	154	184	152
Cr	131	177	197	208	170	154	239	314
Co	27	27	28	44	33	24	55	38

pm169	Princess Hill
pm170	Princess Hill
pm171	Princess Hill
pm172	Princess Hill
pm173	Princess Hill
pm174	Princess Hill
pm175	Princess Hill
pm176	Princess Hill

Table A4.6.1. Data for the Lydenburg area sherds.

Sample	SL101	SL102	SL106	SL107	SL108	SL109	SL110	SL111	SL112	SL113
SiO_2	67.02	60.40	64.57	66.48	63.35	68.51	62.11	63.06	61.30	65.15
TiO_2	0.94	1.21	0.94	1.09	1.05	0.96	0.85	0.94	1.16	1.03
Al_2O_3	13.41	18.90	16.86	20.81	18.00	13.00	16.11	13.98	14.59	14.87
Fe_2O_3	4.94	12.23	8.23	6.79	6.04	7.48	10.39	7.94	8.17	7.96
MnO	0.05	0.10	0.17	0.06	0.08	0.09	0.07	0.07	0.11	0.08
MgO	0.82	1.54	0.67	0.96	0.83	0.64	1.88	0.69	0.68	0.80
CaO	2.05	0.74	1.27	1.08	1.51	0.88	1.25	1.35	0.91	1.28
Na_2O	0.25	0.27	0.20	0.22	0.18	0.11	0.15	0.16	0.21	0.16
K_2O	1.32	2.63	0.96	1.04	1.77	1.19	1.00	1.02	1.15	1.09
P_2O_5	3.34	0.31	0.59	0.15	0.48	0.66	0.77	1.53	1.26	1.48
H_2O-	2.16	0.25	1.75	0.14	1.94	2.09	1.72	3.18	4.35	0.14
LOI	3.38	1.18	3.14	0.79	4.56	3.34	3.48	5.05	5.38	4.92
TOTAL	99.68	99.76	99.35	99.61	99.79	98.95	99.78	98.97	99.27	98.96
Rb	79	132	72	59	90	89	64	57	55	55
Sr	223	64	99	36	109	70	112	108	69	91
Y	28	39	29	36	29	36	32	26	32	27
Zr	209	262	235	241	233	227	228	217	243	220
Nb	8	19	10	11	10	12	11	7	12	8
Cu	50	96	59	89	65	40	45	51	59	58
Ni	70	226	119	150	105	87	236	91	92	101
Zn	181	65	68	80	84	65	53	62	68	78
V	198	248	208	291	191	173	206	198	215	213
Cr	450	687	586	645	440	314	1088	477	463	504
Co	18	55	33	31	20	25	40	23	29	26

Sample	Site	Phase
SL101	Doornkop 2530AB5	Lydenburg I east
SL102	Doornkop 2530AB5	Lydenburg I
SL106	Doornkop 2530AB5	Lydenburg II ?
SL107	Doornkop 2530AB5	Lydenburg I
SL108	Doornkop 2530AB5	Lydenburg I
SL109	Doornkop 2530AB5	Lydenburg I
SL110	Doornkop 2530AB5	Lydenburg II
SL111	Doornkop 2530AB5	Lydenburg II
SL112	Doornkop 2530AB5	Lydenburg II
SL113	Doornkop 2530AB5	Lydenburg II

Table A4.6.1. continued.

Sample	SL114	SL105	SL150	SL151	SL187	SL188	SL193	H252	H67	H72
SiO_2	65.25	64.26	60.57	70.46	56.10	63.49	68.24	63.50	65.16	62.98
TiO_2	0.82	0.89	0.98	0.93	1.19	1.07	1.05	0.92	0.91	0.87
Al_2O_3	13.11	13.63	14.93	13.27	14.98	15.79	15.48	14.12	14.11	14.00
Fe_2O_3	9.59	9.00	9.45	9.22	12.82	7.98	10.24	9.49	8.39	9.50
MnO	0.22	0.05	0.08	0.05	0.10	0.08	0.08	0.05	0.10	0.08
MgO	0.59	0.91	1.17	0.64	1.20	1.02	1.37	0.72	0.85	2.39
CaO	1.38	1.13	1.51	0.92	2.25	1.69	1.24	1.24	1.38	3.44
Na_2O	0.13	0.30	0.41	0.32	0.49	0.40	0.36	0.29	0.32	0.93
K_2O	0.84	0.95	1.18	0.64	0.98	1.18	0.98	0.94	1.06	0.86
P_2O_5	0.73	0.23	0.47	0.05	0.45	0.24	0.09	0.18	0.16	0.17
H_2O-	2.49	3.42	4.10	1.04	3.81	2.43	0.24	3.72	3.02	1.74
LOI	4.09	4.22	5.07	1.51	5.19	3.71	0.43	4.96	4.33	3.16
TOTAL	99.24	98.99	99.92	99.05	99.56	99.08	99.80	100.13	99.79	100.12
Rb	68	50	65	33	41	54	54	42	59	51
Sr	109	42	64	27	68	67	41	44	59	82
Y	25	27	27	26	25	26	28	28	20	25
Zr	215	204	216	226	183	215	234	199	178	170
Nb	7	8	8	8	10	9	11	9	7	8
Cu	46	60	75	62	74	65	68	59	65	69
Ni	109	90	116	90	119	102	106	96	103	86
Zn	58	64	79	51	70	72	70	52	51	59
V	210	250	282	246	360	266	240	253	272	250
Cr	479	436	486	413	454	485	516	401	415	339
Co	43	32	33	32	66	43	54	30	34	37

Sample	Site	Phase
SL114	Doornkop 2530AB5	Lydenburg II
SL105	Langdraai 2530AB24	Langdraai
SL150	Langdraai 2530AB24	Langdraai
SL151	Langdraai 2530AB24	Langdraai
SL187	Langdraai 2530AB24	Langdraai
SL188	Langdraai 2530AB24	Langdraai
SL193	Langdraai 2530AB24	Langdraai
H252	Lydenburg Heads 2530AB4	
H67	Lydenburg Heads 2530AB4	
H72	Lydenburg Heads 2530AB4	

Table A4.6.1. continued.

Sample	H77	H77A	SL178	SL179	SL180	SL181	SL182	SL183	SL184	SL185
SiO_2	56.50	55.98	65.82	52.35	59.51	57.99	59.55	54.95	61.63	65.12
TiO_2	0.96	0.96	0.90	0.93	1.01	0.80	0.89	0.77	1.27	0.87
Al_2O_3	18.52	18.34	12.77	19.11	15.83	14.02	13.98	12.74	15.45	15.02
Fe_2O_3	13.80	13.58	6.50	12.51	9.92	13.05	8.53	13.10	8.83	5.32
MnO	0.46	0.54	0.09	0.33	0.08	0.19	0.04	0.16	0.06	0.03
MgO	1.34	1.11	0.85	1.27	0.94	3.63	0.95	4.61	1.00	0.59
CaO	1.17	1.34	2.05	1.78	0.99	2.48	1.82	2.61	1.73	1.24
Na_2O	0.02	0.06	0.11	0.07	0.17	0.48	0.38	0.34	0.49	0.24
K_2O	1.60	1.66	1.25	1.61	0.78	0.59	0.90	0.43	1.58	0.67
P_2O_5	0.33	0.35	3.08	2.83	0.36	0.86	2.38	0.61	1.87	1.83
H_2O-	1.72	2.01	2.94	2.78	4.67	1.81	4.50	3.74	2.22	3.95
LOI	3.79	4.10	4.37	4.28	5.83	3.28	5.81	5.43	3.53	5.37
TOTAL	100.21	100.03	100.73	99.85	100.09	99.18	99.73	99.49	99.66	100.25
Rb	85	90	43	89	33	23	39	20	61	25
Sr	82	85	173	239	61	106	142	78	168	152
Y	28	32	20	35	25	19	20	16	24	19
Zr	196	213	209	181	212	145	180	131	207	204
Nb	13	15	9	12	10	7	8	7	16	8
Cu	65	64	49	63	64	94	59	81	60	46
Ni	339	348	86	255	146	304	81	347	73	79
Zn	35	33	105	98	56	91	105	97	94	63
V	291	298	160	279	289	270	250	240	211	248
Cr	1419	1396	431	1197	923	1443	638	1557	403	523
Co	112	135	31	108	56	85	34	103	36	29

Sample	Site
H77	Lydenburg Heads 2530AB4
H77A	Lydenburg Heads 2530AB4
SL178	Lydenburg Heads 2530AB4
SL179	Lydenburg Heads 2530AB4
SL180	Lydenburg Heads 2530AB4
SL181	Lydenburg Heads 2530AB4
SL182	Lydenburg Heads 2530AB4
SL183	Lydenburg Heads 2530AB4
SL184	Lydenburg Heads 2530AB4
SL185	Lydenburg Heads 2530AB4

Table A4.6.1. continued.

Sample	SL186	SL189	SL190	SL191	SL192	SL206	SL124	SL125	SL123	SL122
SiO_2	62.03	69.67	51.67	61.18	58.01	63.36	65.88	65.62	63.56	63.87
TiO_2	1.28	0.57	0.91	0.87	0.70	0.84	0.85	0.84	0.59	1.17
Al_2O_3	15.51	10.65	14.32	11.78	13.32	14.60	15.48	15.49	11.06	14.92
Fe_2O_3	8.98	9.95	14.97	12.21	12.33	5.20	4.98	4.88	10.17	10.63
MnO	0.05	0.13	0.11	0.14	0.25	0.04	0.03	0.03	0.11	0.16
MgO	1.00	1.94	0.92	3.28	1.94	0.59	0.67	0.72	3.15	1.03
CaO	1.62	1.23	1.94	2.03	1.84	1.14	1.08	1.01	2.17	1.48
Na_2O	0.47	0.63	0.43	0.50	0.48	0.27	0.25	0.25	0.66	0.26
K_2O	1.61	0.43	0.76	0.79	0.45	0.72	0.75	0.80	0.65	1.37
P_2O_5	1.61	0.54	4.17	1.52	2.01	2.83	0.20	0.12	0.97	0.56
H_2O-	2.44	1.40	4.34	2.00	3.70	4.04	4.03	3.93	2.61	1.20
LOI	3.71	1.97	5.19	3.33	4.45	5.89	5.46	5.94	3.84	2.71
TOTAL	100.31	99.11	99.73	99.63	99.48	99.52	99.66	99.63	99.54	99.36
Rb	61	18	30	24	16	28	29	32	18	55
Sr	149	51	278	127	133	180	69	61	108	86
Y	24	13	25	15	18	19	20	19	16	38
Zr	208	154	158	158	137	190	211	211	147	251
Nb	15	5	10	7	6	7	6	5	3	14
Cu	58	67	89	98	86	69	47	47	81	61
Ni	73	198	152	213	302	92	91	95	228	102
Zn	85	111	204	139	167	97	41	41	109	67
V	213	167	291	228	256	302	284	287	201	261
Cr	416	1010	637	1101	1451	607	632	636	1087	442
Co	36	65	74	65	92	29	16	17	47	44

Sample	Site	Phase
SL186	Lydenburg Heads 2530AB4	
SL189	Lydenburg Heads 2530AB4	
SL190	Lydenburg Heads 2530AB4	
SL191	Lydenburg Heads 2530AB4	
SL192	Lydenburg Heads 2530AB4	
SL206	Lydenburg Heads 2530AB4	
SL124	Lydenburg Heads 2530AB4	Lydenburg I
SL125	Lydenburg Heads 2530AB4	Lydenburg I
SL123	Lydenburg Heads 2530AB4	Lydenburg I
SL122	Lydenburg Heads 2530AB4	Lydenburg II

Table A4.6.1. continued.

Sample	SL126	SL128	SL134	SL129	SL130	SL131	SL177	SL198	SL199	SL200
SiO_2	59.49	53.28	63.64	62.08	55.33	60.28	61.66	57.42	56.96	57.67
TiO_2	0.83	0.96	0.71	0.88	1.58	0.98	1.09	1.10	1.10	1.10
Al_2O_3	14.63	14.05	13.25	17.13	14.18	15.88	16.71	14.53	14.71	14.70
Fe_2O_3	11.53	12.05	12.59	11.35	15.97	10.65	6.46	12.53	12.64	12.75
MnO	0.17	0.06	0.22	0.32	0.13	0.14	0.04	0.04	0.04	0.04
MgO	1.29	1.40	4.89	1.56	2.10	0.55	0.68	0.66	0.62	0.68
CaO	2.06	2.21	2.46	1.11	1.01	0.99	0.66	0.75	0.78	0.73
Na_2O	0.44	0.40	0.87	0.76	0.32	0.12	0.22	0.27	0.27	0.28
K_2O	0.84	0.82	0.33	1.47	0.32	0.79	0.60	1.30	1.29	1.30
P_2O_5	1.42	5.04	0.05	0.45	0.07	2.30	0.60	1.91	1.61	1.20
H_2O-	2.72	4.17	0.20	1.01	4.28	3.37	4.41	4.47	4.28	4.12
LOI	4.30	5.42	0.49	1.59	4.84	3.90	5.82	5.33	5.02	5.26
TOTAL	99.72	99.86	99.70	99.71	100.13	99.95	98.95	100.31	99.32	99.83
Rb	33	32	15	72	18	52	33	76	75	78
Sr	126	237	46	52	39	99	38	80	77	71
Y	28	25	22	33	26	32	23	23	24	23
Zr	178	166	145	173	186	229	208	207	207	203
Nb	9	8	6	11	9	11	8	14	14	14
Cu	79	98	93	131	171	60	67	49	49	47
Ni	152	117	330	161	209	107	88	70	71	72
Zn	104	164	86	104	115	102	63	89	90	93
V	277	341	209	278	393	219	209	253	251	253
Cr	744	583	1658	359	846	543	494	342	331	339
Co	52	40	74	58	69	45	30	58	59	59

Sample	Site	Phase
SL126	Lydenburg Heads 2530AB4	Lydenburg II
SL128	Lydenburg Heads 2530AB4	Lydenburg II
SL134	Lydenburg Heads 2530AB4	Lydenburg II
SL129	Klingbeil	Klingbeil
SL130	Klingbeil	Klingbeil
SL131	Klingbeil	Klingbeil
SL177	Klingbeil	Klingbeil
SL198	Klingbeil	Klingbeil
SL199	Klingbeil	Klingbeil
SL200	Klingbeil	Klingbeil

Table A4.6.1. continued.

Sample	SL201	SL202	SL203	SL204	SL205	SL152	SL153	SL154	SL155	SL156
SiO_2	57.58	59.82	61.20	59.87	55.63	61.90	58.42	59.26	55.62	66.72
TiO_2	1.12	1.05	1.07	1.08	0.89	0.91	0.64	0.80	0.64	1.06
Al_2O_3	14.65	16.05	15.87	16.04	17.05	14.66	14.55	17.78	17.34	17.79
Fe_2O_3	12.52	7.85	7.55	7.76	10.66	8.63	11.78	12.86	14.69	6.77
MnO	0.05	0.03	0.04	0.04	0.22	0.07	0.18	0.12	0.19	0.05
MgO	0.64	0.94	0.91	0.98	1.26	1.26	4.40	3.97	5.83	1.37
CaO	0.73	0.77	0.79	0.81	1.14	2.92	2.51	0.80	0.69	0.86
Na_2O	0.29	0.35	0.32	0.34	0.45	0.45	0.56	0.18	0.13	0.15
K_2O	1.30	1.39	1.40	1.41	1.14	1.47	1.01	1.26	1.08	1.45
P_2O_5	1.37	0.16	0.14	0.10	0.14	1.78	0.29	0.26	0.20	0.37
H_2O-	4.09	4.26	4.07	3.80	5.10	2.31	2.00	0.61	1.26	1.06
LOI	5.22	6.86	6.40	7.27	5.79	3.91	3.64	1.87	2.20	2.20
TOTAL	99.56	99.53	99.76	99.50	99.47	100.27	99.98	99.77	99.87	99.85
Rb	77	76	76	77	55	91	39	72	67	79
Sr	73	55	59	57	50	193	100	49	41	52
Y	23	20	22	21	25	28	20	24	20	26
Zr	204	205	202	206	162	202	122	164	121	234
Nb	14	11	11	11	9	9	5	8	7	11
Cu	50	55	55	54	118	69	72	71	71	53
Ni	73	80	75	78	147	102	223	595	782	210
Zn	106	90	60	105	83	106	95	97	109	74
V	254	243	241	233	302	222	218	263	252	265
Cr	351	415	404	393	356	429	877	2749	3091	1312
Co	57	40	41	40	71	27	58	71	90	27

Sample	Site	Phase
SL201	Klingbeil	Klingbeil
SL202	Klingbeil	Klingbeil
SL203	Klingbeil	Klingbeil
SL204	Klingbeil	Klingbeil
SL205	Klingbeil	Klingbeil
SL152	Klipspruit	Klipspruit
SL153	Klipspruit	Klipspruit
SL154	Klipspruit	Klipspruit
SL155	Klipspruit	Klipspruit
SL156	Klipspruit	Klipspruit

Table A4.6.1. continued.

Sample	SL157	SL158	SL159	SL160	SL161
SiO_2	60.19	60.98	60.47	56.54	61.79
TiO_2	1.60	0.75	0.77	1.18	1.44
Al_2O_3	19.49	18.00	17.92	18.94	20.76
Fe_2O_3	11.02	11.86	11.72	11.59	8.56
MnO	0.07	0.33	0.26	0.13	0.05
MgO	1.59	3.20	3.16	1.59	0.85
CaO	2.28	1.76	1.95	1.10	1.11
Na_2O	0.57	0.61	0.63	0.30	0.35
K_2O	1.17	1.37	1.67	1.88	0.97
P_2O_5	0.19	0.08	0.23	0.32	0.50
H_2O-	0.36	0.21	0.28	2.17	1.07
LOI	1.02	0.60	1.02	3.40	2.49
TOTAL	99.55	99.75	100.08	99.14	99.94
Rb	41	84	92	89	48
Sr	68	76	75	56	67
Y	44	22	24	29	28
Zr	225	137	137	181	226
Nb	12	7	8	11	13
Cu	144	69	78	76	85
Ni	146	154	144	164	144
Zn	111	114	124	109	74
V	284	246	244	306	354
Cr	566	494	484	597	590
Co	40	57	49	74	50

Sample	Site	Phase
SL157	Klipspruit	Klipspruit
SL158	Klipspruit	Klipspruit
SL159	Klipspruit	Klipspruit
SL160	Klipspruit	Klipspruit
SL161	Klipspruit	Klipspruit

Table A4.6.2. Data for the Mokopane sherds.

	vm06	vm07	vm08	vm09	vm10	vm11	vm12	vm13	vm14	vm15
SiO_2	nd	56.75	59.49	73.36	61.71	59.62	57.73	50.53	67.40	55.51
TiO_2	nd	0.83	0.90	0.55	1.05	1.26	0.74	0.33	0.59	0.70
Al_2O_3	nd	17.53	16.25	12.75	17.35	15.24	16.63	22.93	13.17	16.85
Fe_2O_3	nd	9.30	8.43	4.78	11.16	8.94	9.28	6.04	6.39	7.91
MnO	nd	0.07	0.05	0.05	0.11	0.06	0.09	0.11	0.12	0.04
MgO	nd	1.49	1.22	0.49	1.19	0.70	0.64	3.76	1.22	0.42
CaO	nd	1.95	1.18	0.56	1.22	0.78	0.65	9.97	4.22	0.27
Na_2O	nd	0.32	0.30	0.11	0.29	0.19	0.42	1.29	0.38	0.21
K_2O	nd	0.73	1.02	0.68	0.99	1.27	2.90	0.77	1.32	3.54
P_2O_5	nd	0.15	0.37	0.18	0.08	0.08	0.15	0.17	0.18	1.36
H_2O-	nd	3.64	3.57	1.58	1.00	4.31	3.74	0.70	0.97	4.65
LOI	nd	6.28	5.83	3.81	2.44	5.84	5.65	2.15	3.25	7.25
TOTAL	nd	99.04	98.61	98.9	98.59	98.29	98.62	98.75	99.21	98.71
Rb	44	35	55	30	42	52	138	12	61	169
Sr	33	64	57	39	66	71	56	239	100	44
Y	20	14	10	9	20	45	44	2	19	54
Zr	172	170	189	161	216	449	427	63	225	429
Nb	10	6	8	4	9	16	20	5	10	21
Cu	68	69	54	36	75	83	57	29	30	53
Ni	81	88	66	43	80	80	61	82	53	32
Zn	78	68	74	43	79	74	91	43	49	75
V	298	356	284	215	275	298	178	99	133	136
Cr	329	311	252	180	257	171	114	171	158	85
Co	54	52	38	25	45	50	46	35	38	29

vm06	6599 Bokpoort Mokopane
vm07	6599 Bokpoort Mokopane
vm08	6599 Bokpoort Mokopane
vm09	6600 Buffelshoek Mokopane
vm10	6600 Buffelshoek Mokopane
vm11	6597 Bliedensfarm Mokopane
vm12	6597 Bliedensfarm Mokopane
vm13	6597 Bliedensfarm Mokopane
vm14	6597 Bliedensfarm Mokopane
vm15	6598 Holmsleigh, Mokopane

Table A4.6.2. continued.

	vm16	vm17	vm18	vm19	vm20	vm21	vm22
SiO_2	61.96	56.77	54.38	70.95	65.26	56.16	63.6
TiO_2	0.75	0.74	0.82	0.37	0.65	0.84	0.29
Al_2O_3	14.11	16.36	18.12	14.84	18.71	17.48	17.89
Fe_2O_3	6.55	5.16	7.82	2.77	5.78	9.45	3.51
MnO	0.07	0.03	0.04	0.02	0.02	0.06	0.01
MgO	0.59	0.58	1.25	0.16	0.95	1.51	0.25
CaO	1.23	1.56	1.16	0.71	0.52	1.89	0.55
Na_2O	0.94	0.59	2.06	1.53	0.57	0.39	0.30
K_2O	3.36	3.83	5.34	2.80	3.02	0.74	2.77
P_2O_5	1.74	1.62	0.15	1.35	0.65	0.13	0.03
H_2O-	2.88	3.30	2.08	1.36	0.81	3.63	3.99
LOI	4.67	7.58	5.10	2.06	1.78	6.16	5.15
TOTAL	98.85	98.12	98.32	98.92	98.72	98.44	98.34
Rb	150	173	140	127	133	32	129
Sr	221	215	128	111	101	67	51
Y	25	35	31	8	54	18	5
Zr	314	352	321	92	272	174	134
Nb	17	19	16	13	14	7	4
Cu	25	19	12	24	13	70	40
Ni	61	28	42	20	38	88	33
Zn	89	72	51	43	49	67	17
V	77	96	112	51	81	355	50
Cr	210	85	82	78	95	310	104
Co	27	22	26	8	21	44	17

vm16	6598 Holmsleigh, Mokopane
vm17	6598 Holmsleigh, Mokopane
vm18	6598 Holmsleigh, Mokopane
vm19	6598 Holmsleigh, Mokopane
vm20	6598 Holmsleigh, Mokopane
vm21	6599 Holmsleigh, Mokopane
vm22	6602 Mozoto Dam, Zebediela

Table A4.6.3. Data for the Eiland Salt Works site.

Sample	b45	b63	b83	b90	h1	h10	h11	h11A	h2	h2A
SiO_2	51.07	62.49	62.31	64.72	67.62	63.57	67.83	66.78	54.34	54.13
TiO_2	1.28	0.44	0.70	1.09	0.83	1.17	0.63	0.62	1.15	1.07
Al_2O_3	22.68	13.56	22.24	17.73	18.02	16.62	16.04	16.42	18.09	17.47
Fe_2O_3	9.47	7.07	6.15	4.35	4.07	7.52	4.38	4.39	9.03	8.87
MnO	0.09	0.05	0.07	0.05	0.02	0.04	0.01	0.02	0.10	0.11
MgO	0.92	5.72	0.54	0.26	0.06	0.25	0.38	0.35	3.16	2.57
CaO	5.73	1.84	4.19	1.42	1.06	1.25	1.06	1.08	7.12	7.45
Na_2O	0.78	1.36	1.24	2.20	1.88	2.21	1.56	1.66	1.38	1.95
K_2O	0.79	0.77	1.46	2.11	2.72	2.39	1.52	1.65	0.57	0.62
P_2O_5	0.07	0.05	0.06	0.13	0.05	0.06	0.08	0.05	0.12	0.16
H_2O-	1.93	1.94	0.09	1.96	1.09	1.35	1.70	1.82	1.26	0.91
LOI	5.59	4.93	1.10	3.72	2.66	3.71	4.77	5.56	3.56	4.32
TOTAL	100.40	100.22	100.15	99.74	100.08	100.14	99.96	100.40	99.88	99.63
Rb	34	44	52	80	120	98	62	48	27	24
Sr	334	207	168	250	253	301	249	269	262	278
Y	18	6	18	9	14	34	8	12	19	21
Zr	109	113	153	117	176	203	137	149	125	128
Nb	7	2	7	2	9	10	1	5	7	7
Cu	59	25	39	22	16	32	15	12	57	56
Ni	119	484	70	35	21	26	28	28	166	177
Zn	27	31	30	29	26	44	24	24	39	38
V	216	126	104	97	113	192	99	99	201	201
Cr	339	1558	164	74	77	103	96	100	477	477
Co	34	39	27	12	11	11	4	7	29	29

b45	2/74 Eiland Salt Works: EIA
b63	2/74 Eiland Salt Works: EIA H70
b83	2/74 Eiland Salt Works: EIA
b90	2/74 Eiland Salt Works: EIA
h1	4/74 Eiland Salt Works: Letaba style, LIA
h10	4/74 Eiland Salt Works: Letaba style, LIA
h11	4/74 Eiland Salt Works: Letaba style, LIA
h11A	4/74 Eiland Salt Works: Letaba style, LIA
h2	4/74 Eiland Salt Works: Letaba style, LIA
h2A	4/74 Eiland Salt Works: Letaba style, LIA

Table A4.6.3.continued.

Sample	h9	i109	i110	i251	i37	i41	i61	i62	i62A	i65
SiO_2	52.03	66.02	53.18	59.12	63.16	51.44	56.05	56.24	56.41	53.68
TiO_2	1.56	1.12	0.79	0.63	0.94	0.96	1.50	0.94	0.90	1.28
Al_2O_3	20.78	15.16	19.10	19.01	17.03	22.04	18.54	18.40	17.40	18.23
Fe_2O_3	10.24	4.81	8.06	5.78	5.73	7.90	7.69	8.78	9.09	7.79
MnO	0.14	0.02	0.06	0.02	0.03	0.06	0.12	0.05	0.06	0.08
MgO	2.29	0.42	1.60	0.21	0.08	1.01	1.01	0.69	1.19	2.22
CaO	7.77	1.78	4.52	2.17	1.41	4.92	4.52	2.74	2.76	4.19
Na_2O	1.41	0.79	0.38	0.86	0.76	0.49	0.73	0.29	0.20	0.76
K_2O	0.39	2.07	0.90	2.05	1.30	0.60	0.53	1.00	1.00	0.58
P_2O_5	0.07	0.06	0.07	0.04	0.10	0.12	0.08	0.05	0.07	0.09
H_2O-	0.55	3.10	4.45	3.96	3.48	3.95	3.58	4.14	4.20	4.47
LOI	2.46	4.78	6.57	5.99	6.06	6.35	5.51	6.46	7.00	6.54
TOTAL	99.69	100.13	99.68	99.84	100.08	99.84	99.86	99.78	100.28	99.91
Rb	21	74	45	70	60	33	24	48	53	27
Sr	273	230	230	318	93	146	191	181	176	165
Y	18	12	12	14	18	8	25	25	19	26
Zr	109	186	95	137	177	66	181	145	128	177
Nb	8	4	1	4	9	7	9	6	3	8
Cu	74	18	73	28	31	59	42	77	74	50
Ni	135	28	146	51	55	110	101	140	138	80
Zn	40	21	28	27	21	21	26	21	24	31
V	243	172	219	126	179	271	201	265	256	214
Cr	319	107	420	188	161	232	258	336	313	218
Co	49	6	43	14	16	30	43	42	44	26

h9	4/74 Eiland Salt Works: Letaba style LIA
i109	6/74F Eiland Salt Works: phase 1 Silver Leaves style (AD 350-500)
i110	6/74F Eiland Salt Works: phase 1 Silver Leaves style
i251	6/74F Eiland Salt Works: phase 1 Silver Leaves style
i37	6/74E Eiland Salt Works: phase 3 Eiland style (AD 900-1300)
i41	6/74E Eiland Salt Works: phase 3 Eiland style
i61	6/74E Eiland Salt Works: phase 3 Eiland style
i62	6/74F Eiland Salt Works: phase 1 Silver Leaves style
i62A	6/74F Eiland Salt Works: phase 1 Silver Leaves style
i65	6/74E Eiland Salt Works: phase 3 Eiland style

Table A4.6.3.continued.

Sample	i66	i82	i93
SiO_2	55.29	59.67	59.86
TiO_2	0.67	0.66	0.64
Al_2O_3	17.01	19.44	19.56
Fe_2O_3	7.22	5.30	5.40
MnO	0.06	0.02	0.02
MgO	2.72	0.24	0.25
CaO	1.54	1.53	1.85
Na_2O	0.66	1.01	1.25
K_2O	0.99	2.05	1.99
P_2O_5	0.08	0.04	0.04
H_2O-	4.54	3.95	3.47
LOI	8.64	6.07	5.76
TOTAL	99.42	99.98	100.09
Rb	66	69	71
Sr	173	217	254
Y	10	14	15
Zr	107	147	148
Nb	1	5	5
Cu	45	35	35
Ni	290	58	55
Zn	1	26	27
V	160	130	127
Cr	869	220	217
Co	54	16	14

i66	6/74E Eiland Salt Works: phase 3 Eiland style
i82	6/74F Eiland Salt Works: phase 1 Silver Leaves style
i93	6/74F Eiland Salt Works: phase 1 Silver Leaves style

Table A4.6.4. Data for Phalaborwa sherds.

	a24	a25	a26	a27	l103	l99
SiO_2	58.01	63.95	nd	64.59	61.69	53.31
TiO_2	0.85	0.53	nd	0.90	3.28	1.39
Al_2O_3	18.87	17.08	nd	16.53	16.58	15.20
Fe_2O_3	6.88	5.71	nd	8.76	5.63	13.87
MnO	0.07	0.03	nd	0.08	0.08	0.08
MgO	1.31	1.45	nd	1.37	0.43	1.19
CaO	4.00	1.45	nd	2.42	0.09	1.46
Na_2O	1.57	1.66	nd	2.28	0.01	0.38
K_2O	1.14	2.26	nd	2.15	0.57	0.22
P_2O_5	0.09	0.19	nd	0.21	0.10	0.08
H_2O-	1.82	1.96	nd	0.04	4.06	4.24
LOI	5.21	4.14	nd	0.71	7.59	8.61
TOTAL	99.82	100.41	nd	100.04	100.11	100.03
Rb	42	138	77	132	30	12
Sr	181	194	254	159	17	71
Y	14	12	10	43	15	21
Zr	102	171	149	133	322	176
Nb	2	5	6	16	12	9
Cu	49	27	48	52	161	96
Ni	71	149	63	72	59	250
Zn	37	25	40	48	48	30
V	137	85	98	146	695	415
Cr	202	409	190	180	257	1116
Co	25	12	12	24	13	76

a24	14/64 Phalaborwa
a25	14/64 Phalaborwa
a26	14/64: Phalaborwa
a27	14/64 Phalaborwa
l103	K 29/F
l99	K 29/F Silver Leaves

Table A4.7.1. Data for the Type R and other Northern Cape potsherds.

	ak50	ak51	ak52	ak53	ak54	ak55	ak56	ak57	ak58	ak59
SiO_2	69.12	55.27	61.49	66.81	62.44	62.70	63.84	62.20	65.32	60.00
TiO_2	0.66	0.74	1.56	0.79	1.34	1.32	1.33	1.33	0.70	0.82
Al_2O_3	16.13	16.02	18.39	16.31	14.60	27.21	27.59	27.14	15.17	14.71
Fe_2O_3	6.45	12.77	5.17	7.48	15.02	5.69	4.92	2.81	5.57	10.93
MnO	0.10	0.15	0.05	0.23	0.12	0.05	0.07	0.10	0.08	0.13
MgO	1.98	4.55	1.39	2.11	1.09	0.40	0.41	0.53	1.62	5.52
CaO	0.50	1.69	0.65	1.17	1.06	0.34	0.27	0.47	2.28	1.48
Na_2O	0.52	0.16	0.15	0.68	0.15	0.04	0.03	0.06	1.67	0.59
K_2O	3.91	0.82	6.14	2.78	2.51	0.49	0.50	1.27	2.93	2.75
P_2O_5	0.18	1.20	0.10	0.14	0.11	0.20	0.12	0.19	0.11	0.23
H_2O-	0.08	1.53	0.66	0.23	0.42	0.08	0.14	0.42	0.60	0.48
LOI	0.60	4.65	4.00	1.59	1.55	1.21	0.75	3.81	3.80	2.72
TOTAL	100.23	99.55	99.75	100.32	100.41	99.73	99.97	100.33	99.85	100.36
Rb	146	28	196	127	105	23	23	44	119	58
Sr	79	102	102	106	69	153	154	85	231	63
Y	41	23	41	31	53	47	48	31	29	19
Zr	218	179	268	213	244	460	468	331	211	160
Nb	14	12	15	15	14	21	22	20	14	9
Cu	82	113	22	84	219	68	66	60	60	57
Ni	68	271	61	55	88	40	41	69	34	156
Zn	73	70	29	112	109	35	34	41	85	117
V	118	225	244	202	253	180	163	194	114	195
Cr	126	968	180	143	121	193	195	371	83	351
Co	21	40	14	24	46	9	12	13	13	58

ak50	Nokanna south of farmhouse; 18thC Tswana
ak51	Kinderdam west of engravings; ?CLSA/IA
ak52	Tlhame nr farmhouse: ??CLSA/IA
ak53	Loch View near stone walling; CLSA
ak54	Lukas Jantjie Stad; 19thC Tswana
ak55	Lukas Jantjie Stad; 19thC Tswana
ak56	Lukas Jantjie Stad; 19thC Tswana
ak57	Lukas Jantjie Stad; 19thC Tswana
ak58	Rooikop 3022CC; CLSA ?Karoo Herder
ak59	Doornlaagte near engravings; ?Type R

Table A4.7.1 continued.

	A1	A2	A4	A5	A6	A8	A9	A10	A11	A12
SiO_2	61.49	61.42	59.54	61.06	60.11	46.58	63.29	55.36	65.80	67.04
TiO_2	0.86	0.85	0.73	1.58	0.79	0.52	0.78	0.92	0.73	0.78
Al_2O_3	19.60	21.07	15.63	12.58	12.60	13.15	19.89	19.71	13.25	15.93
Fe_2O_3	8.85	9.16	8.05	11.16	7.47	28.79	7.25	12.46	5.91	5.96
MnO	0.26	0.16	0.12	0.15	0.17	0.17	0.07	0.48	0.09	0.08
MgO	1.84	1.86	3.15	2.31	3.03	1.69	1.93	2.19	1.79	1.88
CaO	1.08	1.14	4.17	2.82	4.71	3.80	0.91	2.88	3.02	1.99
Na_2O	0.24	0.62	1.05	1.48	0.83	0.24	0.22	0.16	0.57	0.83
K_2O	2.86	2.40	1.71	1.94	1.43	1.46	3.38	3.09	1.96	2.34
P_2O_5	0.25	0.20	0.16	0.26	0.36	2.08	0.15	1.55	0.31	0.22
H_2O-	0.08	0.08	1.54	0.93	1.63	0.13	0.42	0.11	1.34	0.19
LOI	2.10	0.91	4.24	3.64	6.63	1.28	1.13	0.92	4.78	2.80
TOTAL	99.51	99.87	100.09	99.91	99.76	99.89	99.42	99.83	99.55	100.04
Rb	149	130	82	38	20	81	153	166	71	96
Sr	75	100	162	281	209	151	57	162	185	130
Y	38	48	28	22	14	48	37	55	27	30
Zr	201	205	170	210	157	167	208	167	228	222
Nb	17	18	9	10	3	22	15	21	10	13
Cu	45	49	56	72	52	58	48	56	27	37
Ni	63	49	53	142	56	31	37	56	35	34
Zn	113	121	88	67	57	106	100	136	77	67
V	200	213	168	239	167	229	150	193	130	144
Cr	201	159	212	218	307	99	103	153	132	152
Co	32	35	31	100	65	59	23	36	22	21

A1	Driekopseiland: Type R
A2	Driekopseiland; Type R
A4	Ramah: herder pot with specularite
A5	Moirdale: herder rather than Type R
A6	Moirdale: herder rather than Type R
A8	Klipfontein 4: Type R
A9	Klipfontein 4: Type R
A10	Klipfontein 4: Type R
A11	Klipfontein 4: Type R
A12	Klipfontein 4: Type R

Table A4.7.1 continued.

	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22
SiO_2	61.11	66.59	62.73	63.47	62.76	62.30	61.09	70.01	56.46	78.62
TiO_2	0.64	0.75	0.84	0.91	0.84	0.83	0.92	0.71	0.78	0.58
Al_2O_3	16.04	17.63	14.62	18.23	16.11	16.07	18.12	16.49	16.01	8.84
Fe_2O_3	5.83	6.14	4.50	7.86	7.01	7.17	7.82	6.85	8.82	6.02
MnO	0.11	0.19	0.07	0.16	0.08	0.08	0.14	0.13	0.13	0.05
MgO	1.79	1.57	1.71	2.21	2.46	2.48	3.13	1.68	4.27	0.91
CaO	4.11	0.99	3.88	0.90	4.83	5.00	1.04	1.57	4.81	1.60
Na_2O	0.65	0.66	0.51	0.61	0.59	0.60	0.59	0.77	0.73	0.21
K_2O	2.85	2.84	2.73	3.72	2.30	2.24	4.69	1.39	1.52	0.91
P_2O_5	0.65	0.26	0.42	0.19	0.19	0.20	0.52	0.31	0.23	0.07
H_2O-	0.70	0.15	0.89	0.11	0.13	0.13	0.31	0.27	0.58	0.41
LOI	5.44	1.90	6.76	1.65	2.56	2.73	1.41	0.00	5.50	1.03
TOTAL	99.92	99.67	99.66	100.02	99.86	99.83	99.78	100.18	99.84	99.25
Rb	110	115	86	146	100	98	150	55	65	28
Sr	194	86	140	85	172	172	92	103	176	75
Y	31	30	29	35	30	30	31	29	27	15
Zr	205	207	216	182	212	209	164	205	183	237
Nb	11	14	12	18	15	15	20	13	13	4
Cu	38	22	26	40	33	35	44	43	48	33
Ni	30	71	30	76	38	37	99	62	46	37
Zn	87	93	67	94	70	69	114	97	73	47
V	107	206	145	166	159	163	181	203	160	130
Cr	106	188	142	210	181	186	348	209	202	132
Co	19	27	15	31	21	24	35	23	31	20

A13	Klipfontein 4: Type R
A14	Klipfontein 3: Type R
A15	Klipfontein 3: Type R
A16	Klipfontein 3: Type R
A17	Klipfontein 2: Type R
A18	Klipfontein 2: Type R
A19	Klipfontein 1: Type R
A20	Klipfontein 1: Type R
A21	Klipfontein 1: Type R
A22	Witsand: CLSA, ?HG

Table A4.7.1 continued.

	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32
SiO_2	64.24	64.88	65.67	61.30	54.15	68.26	50.69	54.79	72.08	59.12
TiO_2	0.71	0.71	1.31	1.44	1.70	1.03	1.94	1.26	0.96	1.40
Al_2O_3	14.85	15.05	20.03	26.13	25.33	20.89	16.07	18.47	19.85	31.51
Fe_2O_3	11.45	11.54	6.58	6.68	11.16	2.72	20.45	11.06	2.66	3.98
MnO	0.09	0.11	0.09	0.08	0.07	0.09	0.09	0.07	0.07	0.06
MgO	1.50	1.54	0.40	0.67	0.61	0.20	1.15	0.46	0.45	0.28
CaO	2.08	2.00	0.42	0.46	0.89	0.65	0.82	0.67	0.55	0.62
Na_2O	0.47	0.46	0.20	0.18	0.18	0.04	0.21	0.13	0.07	0.10
K_2O	1.43	1.37	1.20	0.83	3.52	1.33	5.48	2.91	1.47	0.52
P_2O_5	0.15	0.19	0.12	0.08	0.21	0.12	0.10	0.13	0.10	0.17
H_2O-	0.52	0.35	0.46	0.34	0.23	0.65	0.36	0.89	0.04	0.21
LOI	2.37	1.53	3.26	1.77	1.83	3.48	2.51	9.21	1.81	1.77
TOTAL	99.86	99.73	99.74	99.96	99.88	99.46	99.87	100.05	100.11	99.74
Rb	53	56	37	26	145	39	247	120	42	12
Sr	140	124	58	53	76	47	42	49	35	87
Y	24	25	27	34	40	19	35	30	18	26
Zr	237	248	292	383	355	229	246	295	225	433
Nb	9	10	13	16	18	11	18	14	9	15
Cu	43	43	47	52	70	16	161	63	17	26
Ni	85	90	42	38	89	29	143	70	35	27
Zn	35	40	53	54	90	30	139	79	31	26
V	173	181	284	268	253	127	308	192	112	229
Cr	374	405	474	323	281	450	175	256	388	431
Co	44	46	18	27	50	13	55	28	12	14

A23	Witsand: CLSA, ?HG
A24	Witsand: CLSA, ?HG
A25	Meidekop: CLSA, ?HG
A26	Meidekop: CLSA, ?HG
A27	Kathu Nature Reserve: LIA
A28	Kathu Nature Reserve: LIA
A29	Kathu Nature Reserve: LIA
A30	Kathu Nature Reserve: LIA
A31	Kathu Nature Reserve: LIA
A32	Kathu Nature Reserve; LIA

Table A4.7.1 continued.

	A33	A39	A3BIN	A3BUI	A3M	A7	A7BIN	A7BUI	A7M
SiO_2	51.07	66.18	63.89	63.32	62.89	61.48	61.81	61.14	60.33
TiO_2	1.67	0.42	0.91	0.89	0.88	1.09	1.11	1.13	1.09
Al_2O_3	23.13	10.16	16.55	16.42	16.85	19.59	20.06	19.72	19.25
Fe_2O_3	14.09	7.69	9.26	8.85	9.10	8.39	8.76	8.83	8.46
MnO	0.09	0.09	0.23	0.23	0.23	0.08	0.11	0.11	0.10
MgO	0.79	9.50	2.64	2.62	2.59	1.00	1.06	1.21	1.03
CaO	1.38	2.10	1.99	2.04	1.94	0.88	0.92	0.88	0.82
Na_2O	0.16	0.28	0.70	0.72	0.73	0.24	0.27	0.29	0.25
K_2O	3.64	1.95	2.74	2.80	2.71	1.29	1.28	1.45	1.25
P_2O_5	0.12	0.21	0.33	0.35	0.31	0.16	0.24	0.22	0.17
H_2O-	0.39	0.07	0.02	0.05	0.08	0.31	0.06	0.11	0.15
LOI	3.38	1.31	1.61	2.06	1.28	5.77	4.57	5.04	7.00
TOTAL	99.91	99.96	100.87	100.35	99.59	100.28	100.25	100.13	99.90
Rb	163	45	136	135	131	37	46	50	39
Sr	75	72	135	137	136	111	107	117	118
Y	42	14	30	29	31	29	23	23	26
Zr	301	119	223	215	223	250	255	250	265
Nb	17	3	13	13	15	10	8	9	11
Cu	112	26	48	51	52	59	60	62	64
Ni	119	607	72	68	68	32	35	35	34
Zn	108	98	106	106	104	70	70	73	71
V	333	90	172	169	179	212	185	204	217
Cr	297	1376	212	207	214	192	180	179	218
Co	64	55	38	34	34	23	30	33	32

A33	Kathu Nature Reserve; LIA
A39	Dithakong; thick sherd
A3BIN	Driekopseiland; Type R; inner surface of sherd
A3BUI	Driekopseiland; Type R; outer surface of sherd
A3M	Driekopseiland; Type R; centre of sherd
A7	Omdraai; LIA/CLSA; whole sherd
A7BIN	Omdraai; LIA/CLSA; inner surface of sherd
A7BUI	Omdraai; LIA/CLSA; outer surface of sherd
A7M	Omdraai; LIA or CLSA; centre of sherd

Table A4.7.2. Data for various sediments form the Northern Cape.

	A50	A51	A52	A53	A54	ak60	ak61	ak62	ak63	ak64
SiO_2	69.15	68.80	77.97	63.03	49.89	93.53	64.83	77.44	78.58	54.07
TiO_2	0.82	0.61	0.65	0.67	0.52	0.23	0.79	0.70	0.46	0.94
Al_2O_3	9.75	5.78	5.45	13.64	9.84	1.40	14.54	9.87	3.82	14.43
Fe_2O_3	5.23	2.95	3.05	5.44	3.48	0.90	5.50	3.08	3.19	8.95
MnO	0.07	0.07	0.06	0.11	0.07	0.01	0.11	0.05	4.63	0.15
MgO	1.25	3.11	0.49	2.28	6.26	0.07	1.66	0.91	0.81	5.64
CaO	1.89	3.64	1.75	3.07	9.56	0.86	1.93	1.91	0.94	8.15
Na_2O	0.41	0.30	0.45	0.51	0.57	0.01	0.66	1.22	0.01	1.15
K_2O	1.40	1.19	1.20	1.75	1.52	0.40	2.22	1.76	0.61	0.72
P_2O_5	0.10	1.14	0.08	0.19	0.14	0.72	0.12	0.06	0.05	0.11
H_2O-	2.15	2.21	1.55	1.89	2.42	0.45	2.41	1.03	1.80	1.57
LOI	7.39	10.38	7.56	6.98	14.42	0.83	4.69	2.43	5.07	4.06
TOTAL	99.61	100.18	100.26	99.56	98.69	99.41	99.46	100.46	99.97	99.94
Rb	61	38	33	83	65	7	97	62	29	22
Sr	78	245	69	208	475	22	166	167	347	190
Y	16	8	7	27	20	0	28	16	16	19
Zr	300	266	363	214	184	144	236	312	257	126
Nb	7	4	5	11	7	3	14	10	8	11
Cu	31	12	10	30	18	43	75	55	65	95
Ni	35	18	20	34	22	7	45	28	54	81
Zn	51	34	30	76	53	117	90	43	87	70
V	139	113	74	131	73	22	124	84	125	191
Cr	200	107	140	113	89	26	113	86	43	258
Co	20	9	9	19	14	3	21	11	22	30

A50	Klipfontein: anthill near Type R site
A51	Driekopseiland: anthill near Type R site
A52	Opposite Moirdale: anthill near Rd
A53	Driekopseiland, stream bed near Type R site
A54	Driekopseiland, flood silt in Riet River; near engravings
ak60	Nokanna sediment
ak61	Klipfontein sediment
ak62	Klipfontein sediment
ak63	Tlhame sediment
ak64	Loch View sediment

Table A4.7.2 continued.

	ak65	ak66	ak67	ak68	ak69	ak70	ak71	ak72
SiO_2	43.54	70.00	62.06	57.65	90.06	85.46	52.77	85.44
TiO_2	0.25	0.78	0.75	0.69	0.47	0.42	0.92	0.53
Al_2O_3	3.88	12.06	12.64	11.08	5.32	4.47	14.15	5.48
Fe_2O_3	2.46	4.58	7.06	6.47	1.19	2.48	9.88	3.68
MnO	0.10	0.11	0.12	0.10	0.02	0.03	0.19	0.04
MgO	3.92	0.98	2.57	3.36	0.00	0.07	1.73	0.16
CaO	19.56	1.18	2.96	5.70	0.02	0.17	2.19	0.15
Na_2O	0.44	0.58	0.37	0.82	0.06	0.14	0.53	0.19
K_2O	0.45	1.89	1.02	1.51	0.86	0.81	1.18	0.81
P_2O_5	0.14	0.08	0.04	0.13	0.02	0.03	0.12	0.07
H_2O-	3.11	2.60	0.56	2.62	0.55	0.95	7.31	0.58
LOI	22.23	5.49	10.36	9.73	2.45	5.46	9.28	3.11
TOTAL	100.08	100.33	100.51	99.86	101.02	100.49	100.25	100.24
Rb	23	80	44	50	31	31	43	25
Sr	229	114	115	177	22	26	169	33
Y	7	28	22	18	10	6	24	7
Zr	87	315	199	162	320	249	204	243
Nb	6	12	9	10	7	6	11	6
Cu	57	67	52	78	46	50	87	21
Ni	23	48	63	50	20	22	130	30
Zn	38	70	78	76	19	24	90	22
V	39	105	189	150	52	58	199	96
Cr	34	105	253	144	56	60	168	112
Co	10	20	35	17	70	6	58	15

ak65	Ga Mogara River, Lanham: sediment
ak66	Riverton sediment
ak67	Doornlaagte sediment
ak68	Agterplaas, Brak River sediment
ak69	Luka, stream nearr LJS site: sediment
ak70	Gaston farm east of Langeberg sediment
ak71	Taung, Harts River silt
ak72	Kinderdam near engravings: sediment