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Vitrified dung in archaeological contexts: an experimental study on the process of its formation in the Mosu and Bobirwa areas

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Many ancient stock enclosures in Botswana contain a glassy material known as vitrified dung. There are several hypotheses to explain its formation. This study manages to refute some of these and support others. Clearly, extreme heat is required to turn dung into a glassy substance, but how such high temperatures were generated remains an open question. A new and intriguing possibility is raised here: that vitrified dung is from sheep and that sheep urine may be the important factor in its formation.

This study sets out to investigate the processes involved in the formation of vitrified dung in archaeological contexts. The study assumes that the crucial factor responsible for the formation of vitrified dung is the burning of decomposed dung which has accumulated to depths, as a result of prolonged use of the same kraal. As a second hypothesis, it is proposed that vitrified dung in archaeological contexts is not from cattle middens alone.

This study relies primarily on experimental research conducted on various middens in the Mosu area. The experiments are complemented with oral evidence collected in Bobirwa. Middens selected for study were those of small stock and cattle. The burning of livestock middens under controlled circumstances was undertaken to find out whether heat is an essential factor in the formation of vitrified dung.

This study builds on an ethnoarchaeological study of kraal midden formation previously conducted by Noko (1997). There is a need for this kind of experimental research since Noko's work only initiated the process of looking at site formation processes of kraal middens. This study therefore differs from Noko's work in that it examines the process of vitrification of dung deposits in abandoned kraals rather investigating kraal midden formation.

This research was conducted in two different localities, namely the area of Makgadikgadi pans and the Bobirwa area (Fig. 1). This study focused on kraals sampled mainly from Mosu village, its surrounding cattle posts and Mabolwe village. An archaeological site under study by the Human Responses and Contribution to Environmental Change research project (Reid & Segobye, 2000), namely Mmojane site, was also included in the sample. A number of archaeological sites had previously been reported around Mosu village (Main, 1996), mainly situated on the escarpment overlooking the pan itself. Mmojane site extends for more than one and a half kilometers along the river valley. It consists primarily of low, oval stone enclosures around six meters in diameter (Reid & Segobye, 2000). There are four locations where vitrified dung indicates the presence of prehistoric middens of varying sizes.

Today a number of different ethnic communities inhabit the area. The settlement history of the study area suggests that Basarwa communities were the first to settle in the Mosu area. Farming communities that came to settle in this area found indigenous Basarwa communities who led a mobile existence (Gabotlale, 1998; Matshetshe, 1998). According to Gabotlale (1998), Bangwato were the first to turn these areas into cattle posts. Other groups living in the area today, such as the Bakalaka, Bakhurutshe and Baherero, inhabited the area in the 1940's following the resettlement of people from the Boteti river area by

Tshekedi Khama. In retrospect it is not surprising then to find that Basarwa and other recently arrived ethnic communities know little about the formation of vitrified dung and the processes that led to its formation.

Research was also conducted in Gobajango, Mabolwe and Semolale villages in Bobirwa area. These villages are occupied by Babirwa who were originally staying in Bobonong and, following resettlement by Tshekedi Khama, finally inhabited the three villages (informants 18 & 27). Huge concentrations of vitrified dung deposits were encountered in Semolale village. According to informants who positively identified a sample of vitrified dung, it represents burnt sheep dung (informants 19 & 26).

This study has been prompted by an apparent lack of information on the processes involved in the formation of vitrified dung middens despite their abundance in the country. Deposits of porous, slag-like and occasionally partially fused material have been found at several archaeological sites in Botswana. It has been proposed that these are residues from the decomposition or the ignition of kraal manure (Butterworth, 1979). On the same note, van Waarden (1987:108) argues that

If the dung burns, lit on purpose, possibly for health reasons, or accidentally, it burns long and very hot and this may eventually create a lava like substance, called vitrified dung. Much ash is usually associated with this material. Dung deposits which burn insufficiently or decompose in the sun will appear as ash and sometimes as compacted ash called unvitrified dung.

Today, as might have happened in the past, livestock, particularly cattle and small stock, are kept in the kraal overnight and allowed to roam freely during the day. At night livestock accumulate dung in the kraal. Prolonged practice of penning livestock at night and freeing them during the day leads to large accumulations of dung in their enclosures. With the passage of time, as livestock trample and lie on these deposits of dung, they become hard compacted layers of decomposed dung. The assumption is that it is these compacted layers of decomposed dung which melt and later fuse together after ignition to form vitrified dung. This is based on Butterworth's (1979) experimentation with ashed kraal manure which fused at 1000 ° C.

According to Denbow (personal communication), in cases where the dung heaps are not very deep, temperatures do not rise high enough to actually melt the phytoliths. Instead the organic material simply burns to a white, clear ash. Phytoliths, or plant opal, are microscopic silica formations inside plants such as grasses, sedges and herbs which become incorporated in sediments when the plant decays (Huffman, 1993:220). If the dung deposits are deeper, then more heat is generated internally and the vitrification process begins. When deposits are deeper, the vitrification process begins first by producing small granular glassy or vitrified particles. Denbow (1983) further mentions that most sites investigated contained layers of vitrified or semi vitrified material which occurs in layers up to a meter in thickness, showing evidence of having burnt *in situ*.

In an attempt to understand the processes of vitrification, two hypotheses have been advanced by other researchers. Firstly, it is argued that very high temperatures can be achieved by sub-surface burning of organic rich strata confined by thermally insulating layers. Secondly, it has been suggested that ignition and melting could be effected by lightning striking midden deposits (Thy *et al.*, 1995). The occurrence of the majority of reported vitreous slag on hilltops supports the lightning theory. It has been suggested that middens located on low-lying sites will have less chance of being struck by lightning. Field observation (Segobye, 1994) indicates that only rarely do middens located on low-lying areas contain vitreous slag.

In his book on lightning, Viemeister (1972) argued that the earth and its soil are a better conductor of electricity than air, and wet ground is a far better conductor than dry ground. When lightning hits the ground, the flood of electrons spread out radially in all directions. The lightning may follow several paths much like the roots of a tree. Viemeister (1972) further mentions that if lightning strikes sand of proper composition, the high temperatures of circa 50,000 ° C may fuse the sand and convert it to silica glass, producing a fulgurite, called after Fulgur, the Latin word for lightning. The glass lining of a fulgurite is a naturally produced silica glass formed from the fusion of quartz sand at about 1800 ° C (Viemeister, 1972).

It is observed that the theories currently available to explain the formation of vitrified dung are unsatisfactory. More research is needed to explain this archaeological phenomena. Firstly there appear to be no recorded or remembered occurrences of vitrification in historic periods in Botswana, particularly in the east central region of Botswana, where large archaeological deposits of vitrified dung have been found (Denbow, 1983; Segobye, 1994).

That large recorded instances of vitrified dung appear in such a relatively small area, considering the much wider occurrences of livestock middens, is surprising. If this is purely a natural phenomena, unless the lightning is significantly different in the east central region of Botswana, there must be other factors involved. Regarding the lightning theory, can the shift of kraal location practices from relatively high points in the past to more low level areas today account for the reduced role of lightning? However, Moralan site (Reid, 1996), Serowe (Segobye, 1994), Semolale and Kanye site which are low lying sites still exhibit vitrified dung in the archaeological record. There are vitrified dung middens of reasonably large size in Botswana and elsewhere. For instance, there are recorded instances at Mawala hill in Zimbabwe (Robinson, 1968) and Selonskraal site in the Republic of South Africa (Pistorious, 1992), but they are fewer in number. Other recorded occurrences globally are the Deccan Ash Mounds of southern India, where they have been specifically attributed to human intervention, that is the ash mounds formed as a result of deliberate burning of livestock pens by human beings.

There is an assumption that vitrified dung is only from cattle middens. Given the modern day high frequencies of small stock middens in Botswana, and the high level of deposits produced by them, it would seem improper to ignore their investigation. The role of small stock in the past and the rearing practices have to be examined to find out whether they would have produced middens in the archaeological record. Voigt (1986:20) mentions that even a small number of sheep can build up an appreciable layer of dung in a year if they are left penned for part of the day and every night. The inclusion of small stock middens in the experimentation is because they were also viewed as important for comparison with archaeological sites in order to test the hypothesis that vitrified dung may not be from cattle middens alone.

Evidence of domesticated animals in several Late Iron Age sites in Botswana such as Bosutswe, Toutswe, Taukome, Phate Hill and Thatshwane, and thick silicified deposits at these sites indicate long term occupation by pastoralists. Recent studies indicate that the Toutswe tradition, often thought to be dominated by cattle, shows that faunal assemblages actually have equal numbers of cattle and small stock (Reid, 1998). Based on the stratigraphic profiles of the Taukome site excavations, the earliest recorded date for vitrified dung dates back to AD 685 (Denbow, 1983). According to Reid (*et al.*, 1998) the first evidence for livestock in Botswana dates back to around 2000 years ago. Since then the country has witnessed a number of different cultural traditions that were associated to some degree with the keeping of livestock. In the case of the groups like Batswana, cattle became a major source of social as well as economic growth.

Burchard (1993) argued that with expansion of pastoralists and the development of nomadic tendencies in search of new pastures for cattle, goats and sheep, it happened inevitably that stock enclosures within most regions in Africa proliferated century by century. Archaeological surveys are beginning to show parts of Africa littered with stock pen sites of ancient and recent times, and equally with dung deposits. The picture which emerges is one where livestock kraals steadily accumulated depths of trampled dung within their surrounding pens. These were at certain times set on fire (Noko, 1997). The fires would generate considerable heat and in the process the dung would either turn to a powdery ash or fuse, creating at greatest heat a glassy slag called vitrified dung (Allchin, 1963; Butterworth 1979; Thy *et al.*, 1995). Dung deposits, which burn insufficiently will appear as ash and sometimes as compacted ash called unvitrified dung.

Denbow (1983) observed *Cenchrus ciliaris* (buffalo grass) to be one of the first perennial grasses to colonize recently abandoned kraals. It is possible that this species has greater tolerance than other grasses for the high concentration of nitrates and phosphates found in such soils of prehistoric kraals. However, Field (1976) argues that *Cenchrus ciliaris* is not widespread in Botswana, it is seen in some pans around termite hills in the Nata area, northwest district and some other eastern parts, and that it is consumed as valuable palatable pasture grass by livestock. Field (1976) associates the presence of *Cenchrus ciliaris* with particular micro environments.

Burning and vitrified dung

The length of burning dung deposits has been shown to be a problematic issue in the historic past. In his diary of 1865 to 1870, Thomas Leask (Wallis, 1954) brings to our attention the controversy involved in the length of time some cattle middens take to burn

It was Sunday 15th July 1866, Thomas Leask and his team passed an old cattle kraal near Moselekatsi's old Bulawayo. The dung was six feet thick and over fifty yards in diameter. This heap of dung was burning when they passed it. So that evening the topic of conversation was the length of time that some cattle kraals take to burn. Finaughty (one member of the team) told of one midden, which he knew in Cape Town, that burnt for seven years. Hartley, said he knew that one, but it was nothing for there is one in Zwartuggens near Marico that to his certain knowledge burnt for twenty-one years. Hartley stated that the one passed that day was burning when they passed last year, and that it will burn for the next two years. Unfortunately, Inyoka, the guide and guardian of the team who was with Hartley in the same capacity last year, upon being asked for how long the kraal has been burning, Inyoka said it could not be more than a moon, for he passed about "five weeks ago" and it was not on fire then. (Wallis, 1954:72-73)

Originally vitrified dung was thought to be iron slag (Lepionka, 1977). In a quest for the source of vitrified dung, samples were collected during the reconnaissance and submitted to the Geological Surveys Department for chemical analysis. In his report Butterworth (1979) concluded that the vitrified remains found on prehistoric sites in the Toutswe region were undoubtedly produced by burning kraal manure. The general similarity between the samples is strongly indicative of a common source and it seems reasonable to conclude that all the deposits are residual matter from kraal manure, the slight difference being attributable to dietary variations and the fact that the material is an inorganic residue, rather than an assemblage of specific minerals. Although Denbow (1983) and Butterworth (1979) were able to identify vitreous remains as undoubtedly produced from burning kraal manure, they did not mention who or what was responsible for starting the burning and whether it was a deliberate or accidental action.

It is worth noting that exposed deposits of vitrified dung at Toutswemogala occur near to *daga* material which have slagged in the process of heating, producing the same material as iron slag (Reid, 1998). It follows therefore that not only dung vitrifies but also other materials like *daga* vitrify in the process of heating. The only apparent difference between vitrified dung and slagged *daga* was noticed in the colour and weight of the two materials, the former being mostly grey and light.

From the results of a survey conducted in connection with the study of lightning, it has been suggested that the incidence of lightning in Botswana is seasonally dependent because lightning is very much associated with rainfall. According to the survey, targets of lightning strikes include isolated tall objects, such as houses and single trees (Devan & Yeboah-Amankwah, 1984). It is likely that a kraal can be struck by lightning but most probably the trees in the kraal, burning it to below ground and causing a fire which can burn the combustible organic material in the kraal for a long time. The slow burning fire then spreads through the midden causing vitrification. Moreover, there is also a possibility that lightning can also strike wet dung middens hence start the midden burning (Noko, 1997).

Thy (*et al.*, 1995) argues that not all the burning and vitrified deposits found in archaeological contexts can be explained by human agency. The temperatures necessary for vitrification were probably much higher than could be attained from domestic fires and open natural fires. From a study done analysing vitrified dung from sites in the Mokgware hills, Thy (*et al.*, 1995) suggested that the most probable agency is lightning. Thy (*et al.*, 1995) further stresses the importance of the process of thermal insulation, that in order to generate temperatures of around 1000 °C, rather than the average burning dung temperatures of about 450 °C, there has to be some form of covering layer. In the case of many of the sites such as Mmojane, the vitrified dung is present on the surface. Is this exposure after the supposedly hard insulating layer has been removed by wind or rain? What should the layer look like and how thick need it be to afford the due amount of insulation? Butterworth (1979) suggests that only the center of the middens will achieve high enough temperatures to vitrify, therefore one can pose a question as to why do middens at Mmojane, for instance, exhibit a ring of vitrified dung around their outer edge?

Physical and chemical composition of vitrified dung

According to Allchin (1963) the lumps of vitrified dung (biomass slag) are similar in all essential respects. They are whitish or grey with a green tinge, in places black or brown, the internal colour is not infrequently black due to the presence of varying amounts of unburnt organic matter. This tends to suggest that oxygen was insufficient in the center of the slag, while on the outside an excess of air was available.

In an attempt to identify the chemical properties of vitrified dung, Butterworth (1979) conducted a chemical analysis of the vitreous material from one of the Toutswe-type sites. Samples were obtained from two adjacent hilltop sites in Thatswane hills, 25 km north of Palapye village in eastern Botswana. A sample of fresh kraal manure was also obtained for comparison and prepared by drying at 600 °C. The samples were analyzed by conventional chemical methods for silicate rock. The vitreous material was heated to 1100 °C, surface melting began at 1000 °C, while the ashed kraal manure fused at 1000 °C. The fusion of ashed kraal manure at 1000 °C tends to suggest that kraal middens will vitrify when subjected to high temperatures.

Low values for copper and iron oxide exclude the possibility that the vitrified material has been associated with any operations of these metals. The chemical analysis showed high silicon and potassium oxide content. A similar material which is found in large deposits at Selonskraal site, a Sotho Tswana settlement in the Transvaal, was also

chemically analyzed (Pistorius, 1992). A review of the analyses similarly indicated that the slag represents the remains of burnt dung. The analysis of the material showed it has a high concentration of silicon and potassium oxide. According to Pistorius (1992) the high percentage of silicon can be derived from two sources, sand particles or quartz which adhered to the original wet dung collected in cattle kraals, and or silica derived from the cattle's grazing still present as an undigested component in the original dung. The potassium oxide can be attributed to ash derived from wood or charcoal which may contain as much as 30% potassium oxide. A further matter of note is the loss of weight and volume which the burning of dung in mass would entail. In an experiment conducted at the Institute of Archaeology, London, Allchin (1963:156) observed that

As received, fresh dung contained 61 % water, lost on drying at 110 ° celcius. On ignition organic matter and combined water were driven off, the loss in weight amounting to 77.3% of the dry dung. The remaining ash was 22.7%. This was light, bulky and easily blown about. Loss of volume on fusion was very great.

The findings indicate that when subjected to heat, large quantities of dung will lose weight and further weight will be lost upon melting and eventually fusion of ash.

Archaeological occurrences of vitrified dung

Many sites with vitrified dung have been located and mapped over much of eastern Botswana (Denbow, 1983; Segobye, 1994). Some of these sites are hilltop middens with ashy soils covered with *Cenchrus ciliaris*. According to statistics from Denbow's (1983) survey, 168 out of 242 of all sites with Toutswe tradition components located during the reconnaissance contained deposits of vitrified dung, in some cases a meter in depth. Radiocarbon dates from sites in the Toutswe region indicate that Iron Age communities were well established along the fringes of the Kalahari by the 8th century AD. The earliest dates cluster around AD 700 and come from dung deposits in the lowest levels at Taukome site.

Plug (1996) emphasizes that remains of cattle outnumber those of sheep and goats in all phases at Bosutswe. However, this pattern differs from that at Taukome and Limpopo valley sites where small stock generally outnumber cattle. Reid (1998) in his evaluation of the Toutswe-type sites notes that at Toutswe cattle and small stock bones are present in roughly equal proportions. Regarding the issue of herding economies, it has been argued that to date assumptions have been that the rugged inselbergs of the Toutswe - Shoshong region were the western most points of concentration for pre-sixteenth century extensive and intensive herding economies. However, it has been found that the Mosu area, which lies west of Toutswe area in the Makgadikgadi pans, now suggests that more westerly niches were also utilized. The area appears to have had high carrying capacities for livestock. This has been demonstrated by the location of 0.4 m thick deposits of burnt but not vitrified dung at the base of unit C at Kaitshe site at the south end of Sowa Pan (Reid & Segobye, 2000).

Moritshane which lies south of the Toutswe region has an ashy midden and the site dates to the eleventh century. This is probably the most southerly recorded prehistoric kraal in southern Botswana. Evidence of substantial herding in other parts of Botswana have been indicated by the recent discovery of immense deposits of vitrified dung at Kanye village (in a primary school) by members of the Archaeology Club of the University of Botswana. This further demonstrates that the southerly localities were also used for keeping livestock in large numbers in the past. This also applies to the findings of recent archaeological

research at Dimawe site by the Archaeology Division of the National Museum Monuments and Art Gallery. Among other things, survey revealed vitrified dung with a mass of 2 kg on the surface of the site, which indicates that livestock played a vital role in Bakwena economy (Thebe, 1998). These findings tend to suggest that vitrified dung deposits in archaeological contexts are not only concentrated in a relatively small area of eastern Botswana but rather spread throughout the country.

On a comparative basis, Denbow (1983) has shown that large deposits of vitrified dung such as found in the Toutswe region have not been reported from other sites of southern Africa, even though much more research has been undertaken in these areas. However, mention is made of some sites in Zimbabwe and South Africa, but these are few in number. According to Denbow, the absence of vitrified deposits in adjacent areas suggest a number of alternatives. First, that different strategies of animal husbandry were employed in these areas, so that deep deposits of dung were not built up. Second, that perhaps there was less dependence upon domesticated animals. Third, that some deposits of vitrified dung have either been overlooked or misidentified as smelting slag. Fourth, that some as yet undetermined factor is also a necessary condition for the formation of vitrified middens. Denbow further argued that it is unlikely that soil conditions in surrounding regions would affect preservation of vitrified dung. If deposits are deep enough, their burning leaves behind an indestructible rubble of glass.

Modern livestock herding management

A major part of this section of the study is to present a synthesis of modern livestock rearing practices, particularly providing insights into kraal structures, shape, size and function. A sound understanding of the structure and function of present day kraals will be useful in interpreting the kraals of early farming communities (Noko, 1997). The practice of cattle management applies in similar ways to small stock management, but unlike cattle, goats and sheep are penned every night as it is dangerous to leave them unpenned, since they easily fall prey to wild animals and stock thieves.

According to informants in Mosu and the Bobirwa area, the amount of dung accumulated in a kraal depends on how long the livestock is penned. It also depends on the number of livestock that are kept in the kraal. If there is a lot of dung, the practice is not to reduce the dung from the kraal but to abandon the kraal. Ethnographic information from the Mosu area tends to suggest that burning of abandoned livestock middens is not part of their tradition. If a farmer has intentions of moving to a different place, the kraal midden stays as it is until it is reduced to ground level by human or animal action.

Informants further mentioned that the average age of a cattle kraal when it is abandoned is around eight to ten years, while small stock are abandoned around four to six years, the assumption being that cattle and small stock were penned regularly. Foremost among the reasons why livestock owners abandon their livestock kraals is because of deep accumulation of dung in the kraal which leads to the increased risk of hoof borne diseases during the rainy season. In a closer observation, both in the Mosu and Bobirwa areas, kraals are built with trees either inside or at the edges of the kraal to provide shade for the livestock. The shape of the kraal is determined by the owner, while the size of the kraal constructed is determined by the number of livestock, also taking into consideration that the number of livestock is likely to increase with time. On herd management strategies it is important to note that people sometimes hold livestock for their relatives as mafisa, as a result some cattle posts have a lot more livestock than others which could belong to several siblings. Moreover, in most cases herders are not owners of livestock, so herding strategies are often the domain of herders not owners.

Ethnographic evidence from the Bobirwa area suggests that livestock management, particularly small stock, have changed over time. It has been mentioned that in the past, sheep and goats were enclosed in separate kraals, because it was believed that if penned in the same kraal either sheep or goats will breed more than the other. So the purpose of separate kraals was to avoid this perceived problem, known as *go hepa* in Setswana. Today almost every small stock owner encloses sheep and goats in the same kraal. This practice of enclosing sheep and goats in the same kraal has been attributed to drought which drastically reduced the number of livestock in the Bobirwa area. It has been further mentioned that, in the past, kraals were used for many years. This was probably a result of easy access to good pastures for livestock and water sources for both human beings and livestock. Today farmers spend a relatively short period of time at a particular area because of problems of shortage of water and good pastures (informants no. 18 & 19).

Methodology

Oral interviews were conducted during the fieldwork. In undertaking my interviews I had a questionnaire which served as my guide (Peter, 1999:77). Interviews were conducted in Mosu and surrounding cattle posts, such as Nthane, Nokayabokalaka and Iyaga. Interviews were also conducted in Bobirwa area, particularly in Gobajango and Semolale areas. Prior to field work I had knowledge of the existence of vitrified dung in the area. As such I felt it vital to test if people in the area know what factors lead to its formation. Most of the interviewees were aged between 40 and 90 years. The objective of oral interviews was to establish the age of abandoned cattle and small stock middens. Also, interviews were conducted particularly to find out if local people know vitrified dung and the factors that lead to its formation: a sample of vitrified dung was produced by the author in every instance. Finally questions sought to find out the frequency with which people in Mosu and Bobirwa areas burn abandoned livestock middens and under what circumstances. All interviews were conducted in Setswana and later transcribed into English. In administering interviews the study employed open-ended questions.

Test excavations were conducted at the Mmojane site. The purpose of this was to investigate both the archaeological and modern middens. Four archaeological middens with vitrified dung were excavated: units C, E, L and G respectively. The author excavated unit C, a 4 m by 1 m excavation unit. The pit was excavated to the depth of 0.4 m, the excavation unit covered part of the vitrified dung that formed a crust on the surface. Other archaeological units with vitrified dung (units E, G and L) were excavated as part of an ongoing research project conducted by Drs. Reid and Segobye.

Modern burnt middens (cattle and small stock middens) were also excavated. The middens selected for test excavations were already burnt for various reasons. The need for investigating modern middens was basically to study their stratigraphy. Four burnt middens were excavated in Mosu and only one cattle midden at Mmeya cattle post was excavated.

A total of four goat middens and two cattle middens were set alight by the author in Mosu and at surrounding "cattle" posts in an attempt to reproduce modern vitrified dung, as well as to record the temperatures of kraal middens before and as they burn. A type K thermocouple was used for measuring temperatures of burning middens. Various techniques of burning were employed in different middens before setting them on fire to see if there will be any difference in the results. All the plans of the middens set on fire were drawn, likewise the heights of the middens were taken along the North/South axis and East/West axis before setting them on fire, so as to determine the level of reduction after the middens have completed burning. Middens of varying depth were set on fire so as to record the length of burning middens as part of the experimental study and to observe the burning

process. Owners of middens were requested to record the dates when the middens have completed their burning, as this will help the study to determine the length of burning middens, and hence help us to correlate the depth of deposits and length of burning.

A number of difficulties were encountered during the data collection of this study. For instance due to the lack of sufficient equipment in the field, heights of the cattle middens were not recorded. Also due to the length of time it takes for middens to burn, all the middens set on fire were left burning.

Samples of sheep dung were collected in Mabolwe village in the Bobirwa area for burning in a kiln, after a 1 m by 1 m pit was dug in a sheep kraal belonging to Mr Mothele. This was done following information gathered from oral interviews that vitrified dung is burnt sheep dung, so the purpose of burning sheep dung in a kiln was to test the authenticity of this view. Samples of vitrified dung and compact ash from a burnt goat and sheep midden were submitted to the Geology Department for elemental analysis (Peter, 1999:59-61).

Sheep Dung

In Bobirwa, particularly Gobajango and Semolale villages, informants positively identified a sample of vitrified dung as vitrified sheep dung, effected by the process of burning sheep dung *in situ*. All those who identified a sample of vitrified dung have seen it before. According to informants sheep middens were deliberately set on fire to create vitrified dung which was then used for scraping the inside of sheep skins, which were later used as blankets called *mokuru*. When vitrified dung was used for scraping the inside of sheep skins it was called *lengwaelo* or scraper. However, one informant mentioned that vitrified dung was nicely shaped and was used as a body washing stone, this technique was revealed to the informant by her parents (interview with informant no. 21). Informants mentioned that in the past sheep and goats were penned separately, the reason being that people in the past perceived that if sheep and goats were penned in the same kraal one group of livestock will breed more than the other, or in some cases the young ones will die immature. So separate kraals were particularly for equal breeding. Informants further mentioned that the practice of separate small stock enclosures in Bobirwa area was abandoned a long time ago because of decline in livestock population due to drought, which affected the area in the past. As a result, today goats and sheep are penned in the same kraal.

All those interviewed did not know why only burnt sheep dung formed vitrified dung, nevertheless informants observed that sheep urine is thick and oily as compared to goat and cattle urine which is watery. According to informants, when a sheep midden is set on fire, the urine mixed with decomposed sheep dung will melt dung to a molten state, which upon cooling eventually fuses and results in the formation of vitrified dung. One informant said he learned of the process from his parents when he was still a small boy (interview with informant no. 18) and that clear lumps of vitrified dung will be visible after the rains. The informant further stressed that one cannot find vitrified dung anywhere else except where only sheep were enclosed for a considerable length of time and dung had accumulated to depth.

In contrast, interviews from Semolale village tend to suggest that vitrified dung is sheep dung which has naturally vitrified as a result of alternate rainfall and heat on sheep middens. A well known sheep midden with vitrified dung in Semolale village testifies to this. According to the informant Mr Nko Madema, the midden was never set on fire before (interview with informant no. 27). Informants further suggested that maybe the difference in the diet of small stock contributed to the formation of vitrified dung. It has been observed that sheep eat grass and bulbs of certain plants while goats are particularly known for

browsing (interview with informant no. 21). Mention was further made to the effect that the length of time for vitrified dung to form is determined by accumulated dung deposits to burn, melt and eventually fuse. In most cases it takes two to three month for deep deposits to burn.

Excavations

Excavation of several archaeological middens was conducted at Mmojane site. Excavation of modern middens was carried out in Mosu village and the surrounding cattle posts. Four archaeological middens in Mmojane site, which are units C, E, L and G, were excavated. It is worth noting that Mmojane is a nineteenth century stone walled Kalanga settlement.

The purpose of excavating all the units was to look for stratigraphic information which may be relevant to the formation of vitrified dung, as well as to find the depth of vitrified dung in archaeological contexts. The author excavated unit C, a 4 m by 1 m trench at Mmojane site. The trench was excavated down to bedrock up to 0.4 m. One intriguing feature was that exposed deposits of vitrified dung formed a semi-circular ring on the edges of the midden, leaving virtually nothing in the center of the midden. Excavation revealed that the layer of vitrified dung was 0.25 m thick from the surface of both northern and southern sections (Fig. 2). Evidence of burning was shown by ash trapped in between vitrified layers.

Units E and unit L, 2 m by 1 m trenches, were also sunk where vitrified dung was exposed to the surface. Vitrified dung exhibited similar characteristics as in unit C, where there was virtually nothing in the center of the midden. Excavation revealed that the layer of vitrified dung was about 0.35 m thick in unit E, and 0.2 m thick in unit L. All trenches were excavated to 0.4 m. In the majority of cases vitrified dung was underlain by white ash. Unit G, a 1 m by 1 m test pit was located a meter away from unit C. The first 0.1 m of the unit revealed fine, ashy grey loose soil with patches of vitrified dung. At the depth of 0.4 m the ashy grey soil gave way to concentrations of gravel and ultimately bedrock.

Lack of vitrified dung in the center of all the middens at Mmojane site tends to suggest that dung was probably piled on the edges of the middens, and that it is not a chance occurrence. This however does not reflect on the time of burning as it may have happened long after the abandonment of the site. There appeared beneath the soil layer no insulating layer of ash covering the vitrified dung as would be expected from Thy's (*et al.*, 1995) theory of thermal insulation. There was no indication that such a layer had been removed by either wind or rain. Vitrified dung was observed to be sitting on a layer of soil and was surrounded by a layer of merely burnt dung (ash) as would be expected from Butterworth's (1979) theory of burning kraal manure.

In all units investigated, the lumps of vitrified dung were similar, showing whitish with a greenish colour and when broken apart exhibited black colour. Difference in colour of vitrified dung can be attributed to difference in temperatures, which in turn depends upon the thickness of the dung and perhaps its compactness in the midden. From all archaeological middens investigated the depth of vitrification ranged from 20 cm to 35 cm in depth. Variation in terms of depth and thickness of vitrified dung middens in archaeological sites can be attributed to varying length of occupation of different middens in archaeological contexts.

In light of the interpretation of the units excavated at Mmojane site, it was also felt crucial to look at the stratigraphy of other sites with vitrified dung where earlier excavations are sufficiently informative. The study looked at three archaeological sites with vitrified dung where excavations revealed informative profiles. The first is Phate Hill site excavated by Segobye (1994). The calibrated radiocarbon dates obtained from charcoal samples

clustered between the mid 11th century AD and mid 15th century AD. Another site is Taukome excavated by Denbow (1983). The dates indicate that the lower dung deposits included in the excavation levels VII through to X probably built up during a single occupation of the site, occurring around the beginning of the 8th century AD. The third site from which stratigraphic evidence is available is Toutswe site, which was also excavated by Denbow (1983). The sequence of dates recovered indicate that the cultural deposits on Toutswe hill began to accumulate around the beginning of the 7th century AD.

From a comparative study of the profiles from Mmojane site, Taukome, Phate Hill site and Toutswe, the same sequence of dung and midden soils was found in all sites. Thus, in all sites there is evidence of an initial period of livestock occupation, followed by periods of dung accumulation and burning at some time. The predominance of ashy grey soils and carbonized dung in some profiles of the middens testify to the burning hypothesis.

In all the profiles of Taukome and Phate Hill site, vitrified dung deposits were not exposed to the surface. They were found underneath compact layers of ash which might have acted as an insulating layer, while in other sites such as Mmojane and Moralané (Reid, 1996) there is no sign of such an insulating layer. Vitrified dung deposits are exposed on the surface. It can be suggested then that Taukome and Phate Hill sites continued to be occupied for a long time by people maintaining long standing kraals for many years, while at Mmojane and Moralané the sites were occupied for a comparatively short period of time. Or the insulating layer was perhaps removed by rain after the abandonment of these sites.

The need to study modern burnt middens was felt in order to study their stratigraphy and to find out from interviews why the middens were set on fire, as well as to know their length of occupation. In total, three already burnt goat middens of varying diameters, and one cattle midden were excavated in Mosu and surrounding areas. According to the owners of the middens, Mr. Ivanga and Mr. Kopano, the goat middens were burnt for reasons of hygiene, while Mr. Bishop and Mr. Boitshenyó's middens were accidentally set on fire by people dropping burning coal on top of the midden. The middens were used for not more than five years and the length of burning was between one to two months.

The stratigraphy of the burnt middens, particularly small stock, followed the same pattern of clear layers. The surface layer comprised of loose ashy soil between 5-10 cm deep, beneath it was a dark, very compact layer of grey ash about 2-3 cm thick. Immediately below this was a layer of compact yellowish ash with the same thickness as the layer above. This layer seemed to be quite aerated although still robust. It was followed by a thick layer of carbonized dung. It should be mentioned that in some of the middens it was not easy to distinguish different layers, the reason being that some of the middens suffered heavy trampling from livestock and human beings.

Two 1 m by 1 m test pits were laid in a burnt cattle midden. Both pits had the same simple stratigraphy, the top layer comprised of a mixture of burnt dung and soil, followed by a layer of unburnt dung about 3 cm thick. From the stratigraphy revealed in the modern units, the hard compact layer of grey ash is intriguing as it appears to have acted as an insulating layer over the yellow and white ash. Due to aeration it seems to have burnt at a higher temperature. Due to lack of burnt cattle middens in Mosu and the surrounding areas, only one midden was excavated at Mmeya cattle post. The stratigraphy of this midden was less informative. It showed no ash, only carbonized dung and unburnt soil below that.

A sheep midden belonging to Mr Mothele in Mabolwe in the Bobirwa area was excavated. A 1 m by 1 m test pit was sunk in the midden. The purpose of digging the midden was to take samples of different layers of compact decomposed sheep dung which were later to be burnt in a kiln, to test the view that only sheep dung forms vitrified dung, as mentioned by the informants in Bobirwa area. Excavation was done using a hoe and a

shovel in 0.2 m spits. The midden was excavated up to 0.6 m in depth, and excavation revealed that sheep dung was 0.5 m thick (Fig. 3). It has been observed during excavation that a hard layer of crust about 5 cm had formed on the surface of the midden just below the thin sun dried powdery deposits of kraal manure. This was thought to be acting as an insulating layer. It was concluded as such because the goat midden which was joined to the sheep kraal had no hard layer on the surface. According to the owner of the kraal Mr Mothele, the kraal was used for three years and it enclosed 82 sheep. Excavation revealed that the top layer comprised of a thick hard layer of compact decomposed dung. Beneath it was a mixture of sheep droppings and decomposed dung, followed by a thick layer of wet brownish decomposed dung. Immediately below is a thin layer of yellowish decomposed dung, which gave way to a layer of brownish wet compact soil.

Burning middens

Middens selected for experimental study were small stock and cattle middens. A total of four goat middens and two cattle middens were set alight in Mosu village and surrounding cattle posts.

According to the owner, the Mmojane goat midden had been in use for three years and was abandoned for a year by the time it was set on fire. It enclosed about 120 goats. The midden was set alight after the kraal poles were removed at the request of the owner, Mr G. Kasidima. The midden, which was about 18 m in diameter, first had a pile of dung taken from the northeasterly edge and placed about a third of way in from the East. This was done in order to increase the height of the midden at this point and to replicate the piling of dung which was exhibited at units C, E and L at the archaeological site of Mmojane. The pile of dung was about 0.6 m in height and 1.5 m in length. Firewood was spread over the midden and was lit on the 25th of June 1998. After all the wood had burnt away there was a layer of white ash from wood on the surface, but smoke was breaking through from a few small areas on the side of the mound. Yellow and white ash was being produced at the burnt areas. There was no visible fire, only smoke came from the cracks between pieces of compacted, decomposed dung. On the 2nd of July an area just on the west of the mound was scraped clear of the loose, surface, sun dried dung and a fire was lit on the spot in an attempt to start other parts of the midden burning. Temperatures of 408 °C and 550 °C were recorded from the side of the midden where smoke was escaping. The flat surface where there appeared to be just ash gave a reading of 180 °C.

A goat midden belonging to Mr Sebetso was burnt after heights were taken. The midden was about 10 m by 14 m, and was in use for 8 years and was abandoned nine years previously. The first instance for burning was smoke seen rising from cracks in the midden surface, after three days there were no more signs of burning. The midden was re-lit after the area was cleared on the 1st of July 1998. Temperatures between 355 – 500 °C were recorded.

Mr. Abofilwe's goat midden, measuring 5 m by 7 m, was set on fire on the 29th of June 1998. The pen was used for four years. It was located in the Mosu village, and had been abandoned for fourteen years. Before the midden was set on fire, a pit about 30 cm deep was dug in the center of the midden so as to allow hot coals to fall into the more compacted dung layers, heights as well as temperatures were recorded prior to burning. The burning dung and ash gave readings between 205 – 415 °C.

A second goat midden belonging to Mr. Abofilwe was also lit on the same date as the first one, with a similar pit dug in the center as well. The livestock pen had been in use for five years and was abandoned nine years previously. Temperatures were recorded at

various locations of the burning midden (158 – 525 ° C). The midden was re-lit by the owner on the 17th of October 1998 after it was found that it had stopped burning.

Two abandoned cattle middens belonging to Mr. Masokola's cattle were set on fire at Sedibana cattle post, after a pit was dug in the center of both middens. Unfortunately due to time and equipment restrictions, the levels of the middens were not recorded.

From all the middens set on fire in the Mosu area, four goat middens burned satisfactorily and two of these were excavated. These are the Mmojane goat midden and Mr Abofilwe's first goat midden. The other two small stock middens burnt completely but they were not excavated because they were heavily trampled by livestock before they could be excavated. The two cattle middens which were set on fire belonging to Mr Masokola, did not burn at all. Burning was observed to have penetrated less than 2 cm into the dung deposits. As such it was felt unnecessary to excavate these middens.

The goat midden belonging to Mr. Kasidima in Mmojane took four months to burn. An 18 m by 1 m trench was sunk across the eastern to the western side. The midden was excavated down to normal soil. The upper layer comprised of a mixture of loose ashy grey and crumbly aerated ash. Below it was a layer of compacted yellow ash about 25 cm thick. Beneath that was a thin layer of dark grey ash, immediately followed by a layer of compact burnt red soil. The midden was excavated to a depth of 0.5 m. The heights of the midden were recorded so as to determine the level of reduction after burning. The maximum temperature recorded from Mmojane goat midden was 550 ° C. The substance which we got from excavation was not vitrified dung, but compacted ash. It is worth noting that Mmojane midden, like other middens which were selected for study, exhibited localized burning of dung deposits, that is, there was no sign of "flowing" dung after burning.

Mr Abofilwe's first goat midden was excavated on the 11th of October 1998. The midden took three months to burn. A 4 m by 1 m trench was laid along the North-South axis of the midden. Trampling by livestock had broken down the surface of the midden. Excavation revealed similar strata as that exhibited in the Mmojane midden. The midden was excavated up to 0.65 m and excavation revealed that dung deposits were 0.6 m thick (Fig. 4). The maximum temperature recorded from Mr Abofilwe's goat midden was 41.5 ° C. The burnt dung did not show any sign of vitrification. The midden only exhibited localized burning of dung.

Lack of vitrification in all the middens selected for the experiments can be attributed to their not being deep enough to afford the due amount of temperatures produced internally by deep middens (Denbow, 1983). It should be mentioned that in an attempt to accelerate the process of vitrification alternative experiments were employed. The experiment was conducted with water, a shovel full of glowing lumps of ash was emptied into a half full bucket of water. It was thought that perhaps the sudden drop in temperatures would result in glassification of compact ash. This proved to be unsuccessful.

Samples of sheep dung from Mabolwe village in Bobirwa area were burnt in a kiln at the Geological Surveys mineral dressing laboratory in Lobatse on the 26th November 1998. Samples were fired at various temperatures so as to observe the changes and reaction of sheep dung to various temperatures. The first sample was fired at 550 ° C. The sample was allowed to dwell at 550 ° C for three hours so as to give it enough time to heat. It was observed that the burnt dung turned to fragile powdery ash exhibiting black and white colours at various places, and very light in weight as compared to the original sample. These findings correspond to the results that were observed from burning middens in the Mosu area.

The second sample was fired at 850 ° C. It was also allowed to dwell for three hours at the same temperature. The sample turned to hard compacted material but no signs of

vitrification were observed, loss of weight was also noticed in the fired dung. The third sample was fired at 1100 °C. As with the first samples the dung was allowed to dwell at the same temperature for three hours in a kiln. Observation made was that the sample showed some signs of vitrification, this was indicated by small granules with green colours at various spots on the fired sample, loss in weight was evident in the fired dung.

These results tend to suggest that heat is in fact an essential factor in the formation of vitrified dung. It is also worth noting that wet samples of sheep dung burned to fragile lumps of ash while more dry compacted samples of dung, particularly those collected from the top layers of the midden, burned to form a hard solid block of dung as temperatures increased. This, in a way, tends to support the view that age of abandoned middens is one of the fundamental factors in the vitrification process (Denbow, 1983). As such, recently abandoned middens still exhibiting layers of wet decomposed dung will burn to compact white ash.

In an attempt to find the elements which constitute vitrified dung, elemental analysis of vitrified dung was conducted at the Geology Department laboratory of the University of Botswana. Two samples were submitted to the laboratory: a sample of vitrified dung, and a sample of compact ash from a burnt sheep and goat midden. The purpose of conducting the analysis was to identify the various elements which constitute the two samples. The samples were first powdered using powder X-ray diffraction principle. Analysis of the samples indicated that two minerals were identified for vitrified dung and four minerals for burnt compacted ash (Peter, 1999: figs. 14 & 15). From the results of the analysis of both samples, silicon oxide had the highest peak than other elements identified. Since silicon is a chemical element found in sand and many rocks, the predominance of silicon in the two samples analyzed suggests that the two samples had large quantities of sand and that the two samples had nothing to do with iron working (see also Butterworth, 1979).

Summary and conclusion

This study has attempted to isolate some of the processes involved in the formation of vitrified dung. The data from the study suggest that one important variable in the formation of vitrified dung is temperature. The main point here is that for vitrified dung to form you have to have very high temperatures, most likely to be produced in very deep kraal deposits. Ethnographic evidence from Bobirwa, particularly from Gobajango and Semolale villages, suggest that vitrified dung is burnt sheep dung. This information tends to answer the second hypothesis, that vitrified dung is not only from cattle middens as earlier mentioned by other scholars who investigated a similar research theme (Denbow, 1983).

Informants varied in their presentation of information as regards the processes involved in the formation of vitrified dung. In Gobajango village, informants mentioned that vitrified dung is effected by burning deep deposits of sheep dung, while in Semolale village about six kilometers from Gobajango village, informants mentioned that vitrified dung is sheep dung which has formed naturally as a result of heat from the sun and heavy rainfall on abandoned sheep middens.

According to informants, the general lack of modern vitrified dung is because of the practice of enclosing both sheep and goats in the same kraal. If vitrified dung found in archaeological sites is from sheep dung alone, this tends to suggest that prehistoric communities were not entirely dependent on cattle as a source of mainstay, but also that small stock, particularly sheep, played a significant role in the economy of prehistoric communities.

Excavation of archaeological middens showed a lack of vitrified dung in the center of all the middens investigated at Mmojane site: vitrified dung formed a ring on the outer edges

of the midden. It has been suggested that dung was probably piled on the edge of the middens and that it was not a chance occurrence. There appeared beneath the soil layer no insulating layer of ash covering vitrified dung as would be expected from Thy's (*et al.*, 1995) theory of thermal insulation.

Deposits of vitrified dung showed similar characteristics from all the middens investigated, showing white-greenish patches and when broken apart exhibiting black colour. Difference in colour of vitrified dung can be attributed to difference in temperatures. From all archaeological middens excavated, the depth of vitrified dung ranged from 20-30 cm. Variation in terms of depth and thickness of vitrified dung can be attributed to varying length of occupation of different middens.

In an attempt to produce modern vitrified dung, several livestock middens were set on fire and middens selected for study were those of small stock and cattle. From all the middens set on fire it has been observed that burning middens took three to four months to complete burning. It is important to note that length of burning middens is determined by the depth of accumulated dung deposits. However, other factors such as heavy rainfall can interfere with the length of burning middens. Temperature readings were taken at various points of selected middens before and during the process of burning and the maximum temperature recorded was 550 ° C from Mmojane goat midden. Even under such temperatures there was no sign of dung vitrification observed. Excavation revealed only compact ash.

Samples of sheep dung were fired in a kiln at the Geological Surveys laboratories, the samples were fired at various temperatures to observe the changes that will take place. The first sample fired at 550 ° C turned to fragile powdery ash. The second sample was fired at 850 ° C and was allowed to dwell at the same temperature for three hours. It was observed that the burnt dung turned to hard compacted ash but no signs of vitrification were observed. The third sample was fired at 1100 ° C. Like the first samples, the dung was allowed to dwell at the same temperature for three hours. After cooling, it was observed that the dung showed some signs of vitrification. This was indicated by small granules with green colours at various spots of the fired dung. Loss in weight of the fired dung was another characteristic observed. These results suggest that burning is in fact an essential factor in the process of dung vitrification.

Maybe the reason vitrified dung formed in prehistoric times was because prehistoric communities were more closely herding their livestock due to predators or raids and the dung built up more deeply in their kraals. Or perhaps grazing was a little better, allowing them to keep more livestock for longer periods of time in the same place, which resulted in the accumulation of deeper dung deposits. From all livestock middens that were selected for investigation, none of them had dung deposits of about a meter in depth. This phenomenon can be attributed to the fact that today not every livestock owner (particularly cattle) enclose their livestock every day. This results in less accumulation of dung in livestock pens, and less chance of vitrification is expected in modern context because of the nature of shallow deposits. These results indicate to us that livestock middens have to be deep enough, about a meter in depth, to offer suitable conditions for production of vitrified dung.

Research by other scholars has indicated that only rarely do livestock middens located on low-lying areas contain vitreous slag (Segobye, 1994). However, evidence coming out from field work has found vitrified dung in low-lying sites in the Shashe-Limpopo and Bobirwa areas from sites such as Semolale, Mashatu 1 and Pitsane river site. Other sites exhibiting vitrified dung on low-lying sites include Mmojane (Main, 1996), Moralan site (Reid, 1996) and Kanye site. In that light, fieldwork evidence does not support the view that

vitrified dung middens are mostly found on hill tops, because of the incidence of lightning. Other factors may also be responsible.

Large deposits of vitrified dung have not been reported for other parts of southern Africa even though much research has been conducted in these areas (Denbow, 1983). The absence of vitrified dung in adjacent regions can be attributed to little or no archaeological work aimed particularly at investigating and documenting dung related studies. This study has opened up new avenues and many questions as regards dung vitrification mechanisms and livestock herding strategies in the past.

Notes

Mr. Peter is currently a school teacher in Bobonong. His research essay was completed in 1999 under the supervision of Alfred Tsheboeng. The original includes 15 figures, 9 photographs and 6 tables. To save space, the text was heavily pruned and most of the figures, photographs and tables were omitted.

References

Oral interviews

Mosu

1. Tabengwa M., male farmer aged 62, at Mowana 02.06.98
2. Charlie A., male farmer aged 66, at Mosu 02.06.98
3. Kopano M., housewife aged 38, at Mosu 02.06.98
4. Kgwanathe G., male VDC member aged 83, at Mosu 03.06.98
5. Lebopo L., housewife aged 31, at Nthane 03.06.98
6. Nkgasapane S.G., female farmer aged 53, at Nthane 03.06.98
7. Tom U., female farmer aged 40, at Nthane 03.06.98
8. Sebetso G., male farmer aged 49, at Iyaga 06.06.98
9. Rankwane G., male farmer aged 78, at Iyaga 06.06.98
10. Ivanga R., housewife aged 43, at Mosu 07.06.98
11. Kasidima G., male farmer aged 79, at Mmojane 18.06.98
12. Keatshotse B., herder aged 30, at Kutitsha 22.06.98
13. Humeme M., male farmer aged 78, at Sedibana 23.06.98
14. Mangwane D., male farmer aged 72, at Nokayabokalaka 28.06.98
15. Gaisang B., male herder aged 40, at Nokayabokalaka 01.07.98
16. Gakebuesepe G., male herder aged 68, at Nokayabokalaka 01.07.98

Bobirwa

17. Makwati K., male farmer aged 62, at Gobajango 28.07.98
18. Mtlhagodi M., male farmer aged 77, at Gobajango 28.07.98
19. Mokgethi M., male farmer aged 93, at Gobajango 28.07.98
20. Mmaki M., male farmer aged 78, at Gobajango 28.07.98
21. Onneng D., female farmer aged 55, at Setempe 28.07.98
22. Molotlhanyi B., female farmer aged 67, at Setempe 28.07.98
23. Marole D., housewife aged 47, at Semolale 19.09.98
24. Serumola M., housewife aged 78, at Semolale 19.09.98
25. Mabusha T., male farmer aged 68, at Semolale 19.09.98
26. Madema D., housewife aged 69, at Semolale 19.09.98
27. Madema N., male farmer aged 76, at Semolale 19.09.98
28. Mothele K., male farmer aged 72, at Semolale 19.09.98

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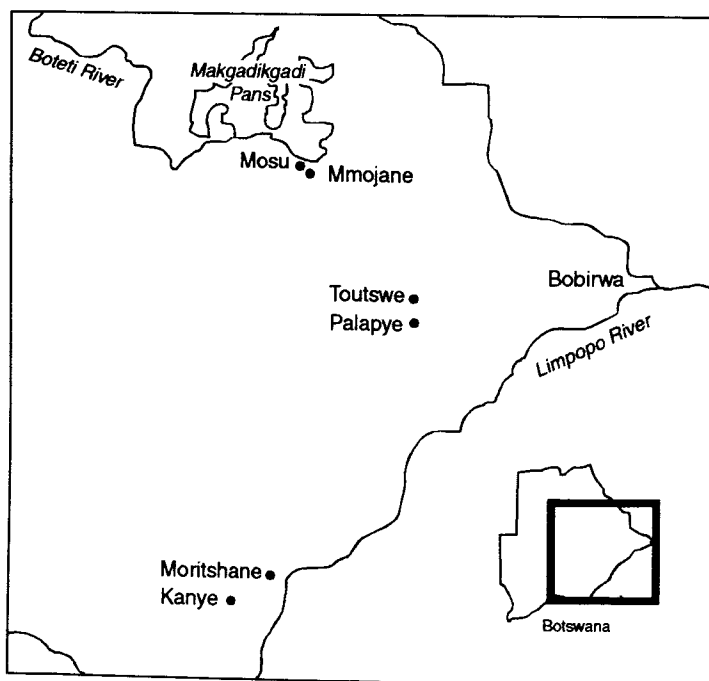


Fig. 1. Some of the places mentioned in the text.

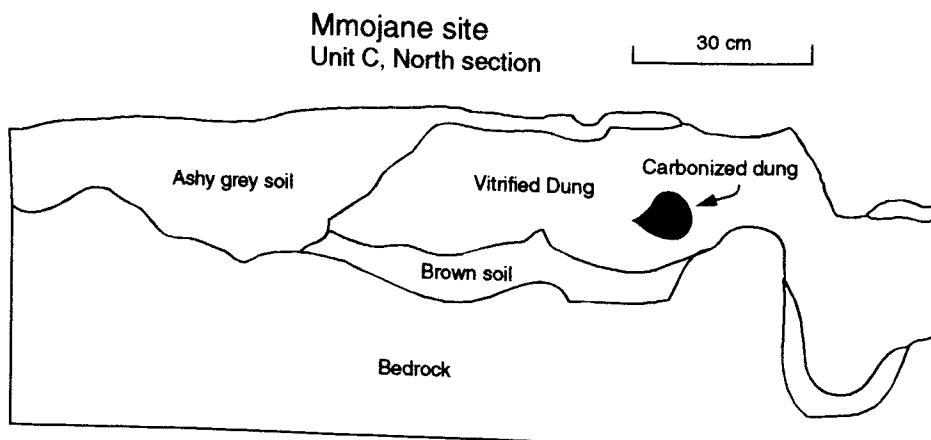


Fig. 2. The excavated section of Unit C at Mmojane site.

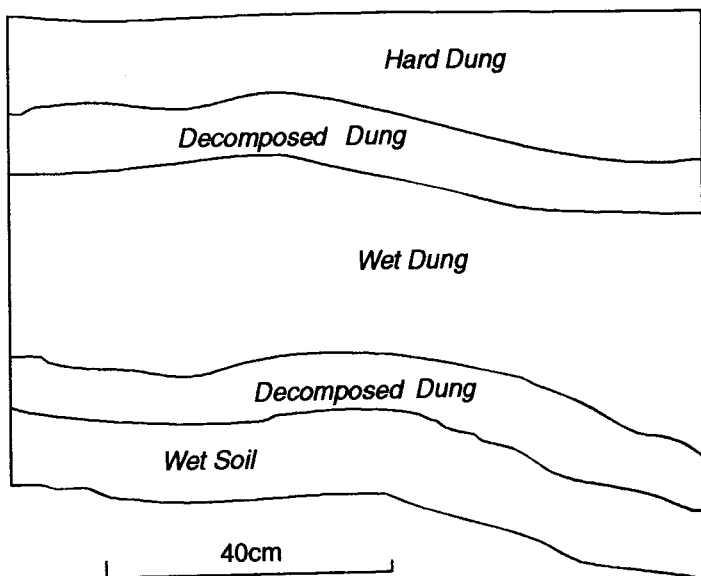


Fig. 3. Section of Mr Mothele's sheep midden.

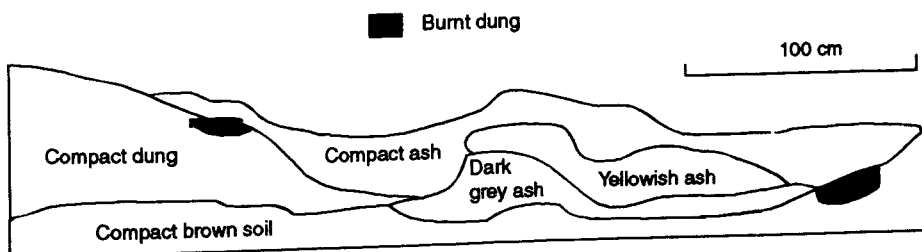


Fig. 4. West section of excavation in Mr Abofilwe's goat midden.