Southern African Field Archaeology 5:36-44. 1996

PRELIMINARY STONE TOOL RESIDUE ANALYSIS FROM ROSE COTTAGE CAVE*

BONNY WILLIAMSON

Department of Archaeology,
University of the Witwatersrand,
P.O. Wits, Johannesburg, 2050

*Accepted for publication April 1996

ABSTRACT

Microscopic screening of a sample of Rose Cottage Cave lithics revealed a variety of residues including a red blood cell. Colourimetric screening has revealed putative blood films and plant remains have also been identified on a number of tools. These results could significantly affect established stone tool classification systems, which rely on inferred function or shape, and could also affect social interpretations.

INTRODUCTION

Until recently, Stone Age archaeologists examining lithic assemblages had to be content with typological classifications and microwear analysis. Typological classification schemes, though valuable, have inherent problems, not least among these is their subjectivity (Kooyman *et al.* 1992).

Microwear analysis also has problems: (i) there is no way of objectively registering and classifying use-wear, (ii) it is often difficult to distinguish use-damage from chipping due to some other causes, (iii) not all polishes are attributable to identifiable causes, (iv) not all types of rock are suitable for microwear studies (Olausson 1990); (v) two researchers may see and interpret the same wear pattern in different ways, and (vi) many of the visual effects seen by microwear analysts may in fact be the result of the cleaning procedure and magnification used (Moss 1986).

Residue analysis overcomes some of the problems associated with microwear studies. The residues are usually microscopic, which means that highly specialised techniques of microscopy and inorganic and biochemical methods have to be used, but the advantages to the archaeologist are almost limitless. Residues can be used to identify animal carcasses processed at a site, to identify traces of vegetal remains (Kòrbe-Grohne 1988), to infer tool use, and to provide genetic information. Residue analysis comprises the following broad means of inquiry: low and high power microscopy and photography for the identification of residues, colourimetric screening, haemoglobin crystallisation, immunological methods, and DNA extraction and sequencing using PCR and other methods. An investigation of stone tool residues needs to be problem-oriented and question-driven, thus the techniques chosen will depend on the level of information required, depositional conditions and available resources. Microscopy and colourimetric screening are a useful first stage of analysis, and both techniques are inexpensive. Where it is desirable to identify the blood residue to the level of genus then immunological methods, haemoglobin crystallisation or DNA sequencing may be used.

The results of blood residue analysis are often met with some scepticism because many people do not believe that proteins can survive for hundreds or thousands of years. It has been argued that the proteins will denature altogether or at least to the extent that they will no longer be recognisable or reactive. This need not happen, however, because it is in the first few hours of drying that a protein is most likely to be altered. On dehydration the protein becomes hydrophobic (water-repellent) on its outer surface. Bonds also form between the rock surface, the molecule and any soil particles, forming a matrix by which the presence of residues is often recognised.

Notwithstanding the scepticism of some researchers there is substantial evidence for the preservation of haemoglobin and other proteinaceous material found in prehistoric sites (Perron 1991; Brown & Brown 1992). Gurfinkel and Franklin (1988) state that while the protein component of blood may degrade with time, the haem component is relatively stable. Sensabaugh *et al.* (1971), however, feel that limited protein degradation occurs in dried blood samples. Kooyman *et al.* (1992) detected blood residues on tools more than 5 600 years old. They found that standard forensic techniques used to identify stains of unknown origin provide reliable means for identifying the animal species on which the tool was used. Loy and Hardy (1992) found evidence for organic residues on tools dated to 90 000 BP. These organic residues include red blood cells, collagen, resin and hair fragments.

Tool use may be inferred from the residues on them. The assumptions made here are that the residues are ancient and that they are related to tool use. These are reasonable assumptions if it can be shown that none of the excavators sustained an injury while removing the artefacts from the deposit, that the artefects were handled with extreme caution and stored properly and that the deposit was undisturbed before the artefacts were removed. Incidental or modern plant residues have a different appearance to those those arising from deliberate tool use. The same applies to animal residues although incidental blood residues cannot be ruled out as blood may have spilled onto a tool lying on the ground during the butchering of an animal. Animal tissue samples may be interpreted as evidence for the processing of animal products although it cannot be said with certainty at this stage whether this was food processing or artefact manufacture. For these purposes microwear studies and species identification of residues are essential; for instance, inedible plant species found on stone tools would most likely signify artefact manufacture. Apart from residues which appear to be modern, most stone tool residues can be related to ancient tool use.

Cattaneo *et al.* (1990) maintain that the extraction of blood proteins of human and animal origin in ancient material will help to reconstruct ritual, dietary and domestic behaviour. They used forensic methods to analyse skeletal remains from Early Saxon and Medieval burial sites in Britain and their results showed that blood protein survives for more than 1 000 years. Hyland *et al.* (1990) used immunological methods to examine stone tool edges for blood-antigen residue. The results they obtained helped them to answer questions about human diet and palaeoclimatic parameters.

Furthermore stone tool residues can yield genetic and hence evolutionary information in the form of DNA fragments (Bahn 1987; Loy *et al.* 1990; Cattaneo *et al.* 1991; Persson 1991:9). Genetic information, both plant and animal, is invaluable, for example in the study of the development and spread of domesticates. Human genetic data could provide information on population distribution and movements. Lawler *et al.* (1988) isolated nuclear genes from 7 500-year-old archaeological remains which facillitated familial typing of individuals and thus population movement and density studies.

Until now no research into stone tool residues has been done in South Africa where the longest stone tool sequences have been found. There is thus a pressing need for expertise and research in residue analysis in this country. My research begins at Rose Cottage Cave.

RESIDUE ANALYSIS AT ROSE COTTAGE CAVE

The Site

Rose Cottage Cave is situated in the eastern Orange Free State about 3 km east of Ladybrand (28.13S, 27.18E, see Fig. 1). The earliest excavations were undertaken by Malan in the 1940s (Wadley 1991) and have been continued for the last five years by Dr Wadley. The six metre deep deposit dates from approximately 100 000 BP to 100 BP, and contains a complex series of Middle and Later Stone Age industries. Most Rose Cottage Cave stone tools are made on fine grained opalines or tuffaceous rocks that originated in the Caledon River, which is about 10 km from Rose Cottage Cave.

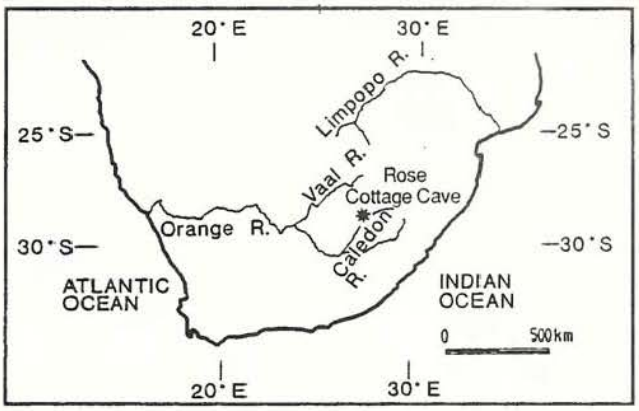

Fig. 1. Geographical location of Rose Cottage Cave.

The lithics for the residue analysis were excavated as outlined in Appendix 1. The 167 artefacts in this study were excavated mainly from square P5 although some samples were also taken from squares Q5, O5 and N5. Table 1 provides a summary of the residues found on the lithics.

I decided to examine every piece of stone, regardless of whether it was a formal tool, an item of waste, a manuport or even a piece of 'puddlestone'. 'Puddlestone' is mudstone formed when pools of mud dry up and solidify (Wadley pers. comm.). The material flakes and crumbles easily and is therefore unsuitable for stone tools. 'Puddlestone' comprised about 12% of the stone sample for this study (data not shown) and a few pieces did carry recognisable residues, mostly of plant orgin.

Most of the lithics were taken from level Pt. This level is dated to 5970 ± 70 BP (Pta 5934) (Wadley pers. comm.). Samples were also taken from level Ja which is undated but should be about 7000 BP. Level Pt contains a Classic Wilton Industry and Ja contains an Oakhurst Industry (Wadley 1991).

The analysis of the Rose Cottage Cave material has comprised mainly microscopy and colourimetric screening. The results are discussed below.

METHODS OF RESIDUE ANALYSIS

Reference Material

A small reference collection was made. Fresh samples of beef, chicken, pork and human blood were smeared on replicated quartzite flakes. The flakes were also used to macerate some of the muscle tissue of the beef, chicken and pork samples, as well as a grass sample and to scrape a twig taken from a coniferous tree. This was a preliminary comparative collection, a more comprehensive one will need to be made for future studies.

Light Microscopy

An Olympus BHS-2UMA binocular microscope with internal incident light was used to examine the lithics. Polarising filters were used to indentify starch grains and possible cellulose fibres, but the degree of polarisation was not measured. 10x Eyepieces with a measuring graticule in one lense were found to be essential for measuring the sizes of starch grains and other residues. Neo-S-Plan objectives of 5x, 10x and 20x and a long-working-distance of 50x were fitted. The long-working-distance objective gave an effective magnification of 500x and it was found to be indispensable because of the high relief surfaces of the stone tools. The surface to be examined needs to lie as parallel as possible to the focal plane of the microscope. Even with repositioning, a short-working-distance objective did not facilitate the examination of some recesses in the surface of the stone, the position where most residues of any value are likely to be found. The positions on the tools where the residues were seen were marked on a rough sketch of the tool. This facilitated later re-examination where necessary.

Residue types

Table 1 gives a summary of the principle types of residue observed on the Rose Cottage Cave lithics. It can be seen that around 50% of the samples had plant residues on them as well as patches of black film. A red blood cell of mammalian origin (annucleated) was seen on only one tool and ochre also had a very low occurrence.

ANIMAL RESIDUES

Blood films

Haemoglobin is anisotropic, *i.e.* it disappears under cross polarised light. Blood stains may either have a black, greasy appearance (Richards 1989:82) (Fig. 2) or be glassy and highly reflective (Fig. 3). On thicker films characteristic 'mud-cracking' (Loy 1993) is evident and the colour can range from black to reddish brown to straw-yellow. About 40 of the Rose Cottage Cave tools had putative blood films identifed by colourimetric screening. They occured primarily on opalines, although there were some positive results from tuffaceous rock types and pieces of 'puddlestone'. Most of these residues seem to have been found on flakes but this may be due to the fact that flakes comprised the largest proportion of the lithic collection. Of equal significance is the presence of putative blood films on lithics normally classified as cores and chunks with a very low occurance on retouched lithics.

Loy (1983) reports definite surface blood deposits on 68% of the artefacts he examined from a variety of sites. In my analysis the percentage of artefacts which tested positive with the Hemastix was only 24.2% (or 40 out of 167). The percentage of tools with clear evidence of blood or animal tissue is around 3% (see Table 1). The low values obtained from the analysis of the Rose Cottage Cave lithics suggest that my sampling strategy may have adversely affected this count. Samples were taken from only three squares and two levels, and not from the entire site. A different area of the site may have yielded a higher frequency of animal residues, so a greater sampling area would have regulated the frequencies. The frequency values are also influenced by the fact that I examined and counted every piece of stone which was excavated instead of selecting those most likely to have residues.

Table 1. The frequencies of principle residue types from Rose Cottage Cave

Plant residues	Starch	80	49%
	Plant Fibre	75	46%
	Plant Tissue	92	56%
	White, sugary deposit	30	18%
Animal residues	Other fibre	4	2%
	Other tissue	6	4%
	Red blood cells	1	1%
Other residues	Black film	83	51%
	Brown film	18	11%
	Coarse sand	55	34%
	Orange sand	31	19%
	Black & white sand	9	5%
	Black & yellow sand	14	9%
	Ochre	13	8%
Usewear	Utilisation/retouch	24	15%
	Worn edges	32	20%
	Polish	20	12%
	Cortex	4	2%
	Scratches	49	30%
Modern residues	Mycohyphae	57	35%
	Rootlets	59	36%
	Metal scratches	5	3%

Fig. 2. A typical black film which gave a positive result with colourimetric testing for haemoglobin.

Animal fibres and tissue

Collagen does not have a bright colour reaction under cross polarised light. Hairs are usually straight and cylindrical with scale patterns and a central medulla (Kòrbe-Grohne 1988). The surface can sometimes be

Fig. 3. A glassy film (possibly blood residue).

Fig. 4. Putative animal tissue residue on an archaeological sample and which closely resembles that on an experimental tool (see Fig. 5).

Fig. 5. A reference sample with macerated beef tissue.

quite eroded. The diagnostic cuticle of the hair is needed for species identification using DNA techniques. This cuticle is often not preserved but other morphological features can sometimes be used (Kòrbe-Grohne 1988:76; Shafer & Holloway 1979:30). Several putative animal fibres were found on Rose Cottage Cave tools, noticeably three opaline flakes and an opaline chunk. One large opaline flake had tissue and fibre residues (Fig. 4) resembling the macerated beef tissue on a reference

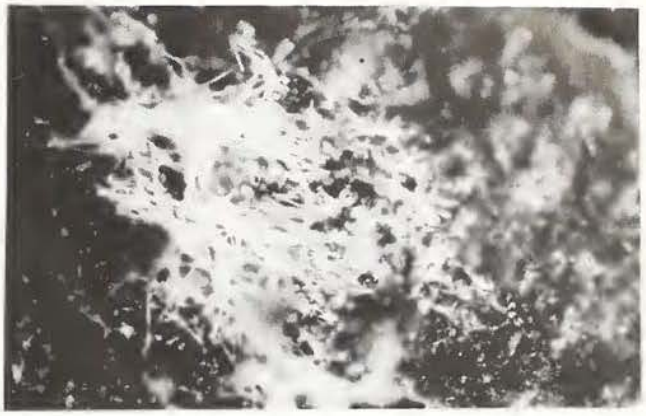

Fig. 6. A clump of wood fibres.

sample (Fig. 5). The Hemastix test on this flake yielded a positive result which reinforces the interpretation of the residue as being of animal origin. Putative tissue samples were observed on a small opaline scraper, an opaline core, three tuff chunks and the large flake already described.

PLANT RESIDUES

Starch

Starch grains are formed in the plant tissue by the addition of concentric spherical layers of starch. Starch grains are birefringent (*i.e.* they have a bright colour reaction under cross polarised light). A characteristic extinction cross is also visible under cross polarised light. Starch grains are ubiquitous throughout the plant but may be stored in greater concentrations in specialised organs such as tubers and corms (Shafer & Holloway 1979:392). Because of the small sample sizes and unknown numbers of possible sources, more research is necessary before the identification of starch grains to species is viable for archaeological soil samples and tool residues (C. Wallace, pers. comm.). Starch grains were found on a wide range of Rose Cottage Cave tools and in the case of 28% of the lithics these grains were found together with the black films and 3% with residues grouped as animal residues.

Plant fibres

Single fibres of wood are sometimes seen but wood residues occur more often in clumps (Fig. 6). Wood can look a lot like hair but it is more 'rumpled' (Kòrbe-Grohne 1988) and it has a bright colour reaction under cross polarised light due to its cellulosic composition. Of the Rose Cottage Cave lithics, about 45% had plant fibres on them. These are distinct from *mycohyphae* described below and may result from plant food processing or artefact manufacture.

Plant tissue

Plant tissue often resembles bricks (Fig. 7), especially the bark of woody species. The cells are usually irregular, elongated and often layered. Yellow/green deposits (Fig. 8) are often chlorophyll and can be tested

Fig. 7. Macerated plant tissue. The cells can still be seen as elongated and irregular.

Fig. 8. Possible deposits of chlorophyll.

with test strips and EDTA (discussed below). Unlike collagen (animal origin), cellulose (plant origin) does have a bright colour reaction under bright field cross polarised light. Shafer and Holloway (1988) found that epidermal cells are the most diagnostic of all plant parts. The presence of macerated plant tissue on 56% of the Rose Cottage Cave lithics (Table 1) is even more convincing evidence of plant working than plant fibres.

Other Residues

Stripes and scratches (Fig. 9) which look chalky under bright field incident light often result from the use of metal forceps and trowels during the excavation and handling of the tools. This feature can be confusing to the untrained eye and should be minimised by using sterilised plastic tweezers and careful excavation techniques when removing samples from the deposit. Only 3% of the Rose Cottage Cave samples appeared to have these marks.

Mineral deposits of manganese dioxide (MnO_2) form by precipitation as black shiny films that are are not unlike blood films. MnO_2 is usually associated with plant residues (Loy, pers. comm.) and is soluble in organic solvents but it is not very soluble in water. I tested a black film on a piece of stone from a different site (supplied by K. Kuman) which I knew to be MnO_2 with the test strips. It yielded a positive result so I checked it

Fig. 9. A chalky-looking scratch on the tool surface caused by the use of metal forceps or trowel during the excavation and handling of the tool.

with EDTA (discussed below) and found that the mineral was chelated which confirmed that the initial reaction was a false positive. The use of the EDTA test for identifying false positives is therefore also justified. Of the Rose Cottage Cave samples, 12 which had black film residues tested negative with the Hemastix. The positive results which were checked with EDTA were found to true positives. This means that even if the black film is not always blood, at least it does not interfere with the Hemastix as a screening procedure.

Colourimetric Screening

Labstix/Hemastix (Fig. 10) are commercially available strips which are usually used for the detection of blood in urine samples. They were found to be a quick and inexpensive means of screening stone tools for possible haemoglobin residues. Hemastix (with a single test pad for haemoglobin) and Labstix (a multiple test strip which includes pH, protein, urobilinogen, nitrite and leukocytes) are both manufactured by Ames, Bayer Diagnostics. The test pads for haemoglobin on each of the strips are identical and are reported to be sensitive to haemoglobin concentrations which fall in the range 150-620 ug/L which is approximately equivalent to five to twenty intact red blood cells per microlitre.

Once an area of interest on the tool surface had been identified by microscopy, 10 ul of ultra-pure water (distilled, deionised and filtered) was applied to the surface of the tool with a variable volume micropipette. A new sterilised disposable nylon tip was used for each sample to avoid cross contamination. The water was then agitated with the tip and allowed to soak for about 60 seconds. The time allowed depended on the porosity and surface nature of the stone. Once the water was withdrawn and placed on the pad of the test strip, the reaction was timed with a stop-watch. (If the residue was found to be relatively insoluble, it was scraped off with a sterile scalpel blade onto a clean microscope slide and then hydrated.) The manufacturers recommend taking the first reading of the strip at one minute. A first conservative reading was taken at 45 seconds, then again

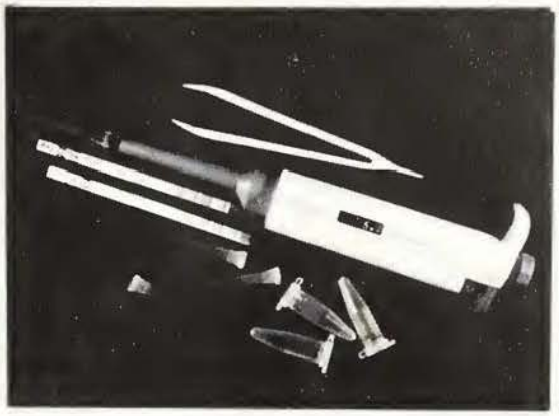

Fig. 10. Equipment used for the colourimetric testing of the residues. Shown here are two of the strips with the haemoglobin test pad at the end of the strip, disposable nylon tips and a micropipette, and some Eppendorf tubes used for hydrating the soil samples.

Fig. 11. Modern contamination in the form of rootlets which grow over and adhere to the surface of the tool. Microscopic root hairs can be seen.

at 60 seconds and the last reading at 120 seconds. Any reaction after two minutes is considered to be auto-oxidation of the test strip in the presence of atmospheric oxygen. For this reason the bottle must be kept tightly capped and a strip tested with pure water before use each time. If there is a colour reaction before five or six minutes then the bottle is discarded. The test pad was also never blotted directly onto the tool surface as the dye may be transferred onto the surface. The colour reaction is roughly quantitative and is given integer values from 0 to +5. A result of zero indicates a negative reaction (no haemoglobin), whereas +5 indicates an instant dark green reaction and a high concentration of haemoglobin. Trace amounts of haemoglobin are recorded as 't' and appear as isolated green spots on the test pad.

The results of colourimetric screening using Hemastix and Labstix test-strips are as follows: 57 of the 167 tools were tested using the Hemastix. Of these, 17 (30%) gave a negative result, 15 (26%) gave a trace amount, 8 (14%) gave +1, 3 (5%) gave +2, 5 (9%) gave +3, 3 (5%) gave +4 and 6 (11%) gave +5 results. Those tools that gave +5 result were put aside for further molecular analysis, probably DNA sequencing, at a later date. Tools which gave lower readings than +5 may be analysed if time allows.

Soils were tested for haemoglobin by placing a small amount of the soil in an Eppendorf tube (see Fig. 10) and hydrating it with approximately 100 ul ultrapure water. The results were all negative except for one sample which was checked using EDTA as described above. The EDTA test result was negative indicating that the initial positive result was false and was due to chlorophyl or mineral contamination. The negative results from testing the soils also indicate that the organic remains which caused the colour reaction on the Hemastix did not originate in the surrounding soils.

The use of Hemastix for the detection of blood residues has been criticised by numerous authors (Custer *et al.* 1988; Gurfinkel & Franklin 1988; Downs & Lowenstein 1995). The criticisms focus on the the non-specificity of the technique in that the psuedoperoxidase reactions can also be induced by certain vegetable and bacterial peroxidases and by chlorophyll (Loy & Hardy 1992). Microscopic screening of the tools to ensure that no algal growth is visible, and the EDTA test described above, can minimise the false positives induced by these agents. However, it was deemed reasonable to use the Hemastix test for the Rose Cottage Cave lithics as the test was only a preliminary means for identifying tools/residues which would be suitable for further analysis. Thus any false positive reactions with the Hemastix would be identified and not lead to further spurious results.

CONTAMINATION

Microscopically Visible Contamination

Rootlets

Modern contamination can be seen in the form of rootlets which grow over and adhere to the surface of the lithics (Fig. 11). Rootlets are clearly different from plant residues which result from the processing of vegetal material as the latter is often macerated. The fine root hairs of the rootlets are usually visible and the rootlets appear to lie on top of any matrix. Rootlets occured on 36% of the Rose Cottage Cave lithics and were not interpreted as evidence for plant working.

Mycohyphae

Other contaminants that are relatively easy to identify are *mycohyphae*, the roots of fungal species. *Mycohyphae* are characterised by right angle joints but their colour may vary (Fig. 12). Ross (1979:9) describes the hyphae as the "apical extension of branching filaments" which are usually single celled (also Webster 1970:60). Webster (1970) states that *hyphae* may differ considerably in morphology. Almost 35% of the Rose Cottage Cave sample examined had evidence of *mycohyphae* which I have classified as 'modern residues' (Table 1) along with rootlets and metal scratches.

Fig. 12. Another form of modern contamination are the roots of fungal species, or *mycohyphae*. Note the right angle joints in the root system. The colour may vary but still gives a characteristic bright colour reaction under cross polarised light.

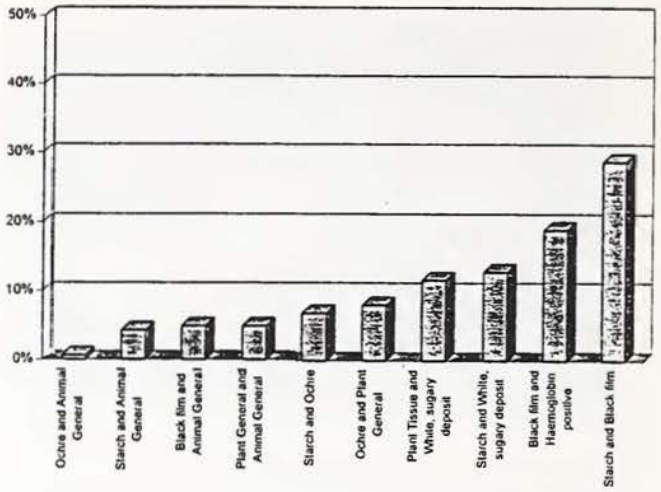

Fig.13. Selected combinations of the residue types found on the Rose Cottage Cave lithics.

DISCUSSION

Residues have been identified on all material types and most tool types of Rose Cottage Cave lithics, except those classified as chips. The analysis shows a low proportion of animal residues, while at least 50% of the Rose Cottage Cave lithics examined here displayed plant residues. The processing of plant food may have been emphasised in Rose Cottage Cave or plant residues may be better preserved. The high frequency of plant residues in the sampled area may be a function of the spatial use of the cave. The manufacture of artefacts such as arrow shafts, bows, digging sticks, baskets and so on, would also be expected to leave plant residues on the stone tools that were used in their manufacture.

This project has shown that flakes and chunks were used as tools because many of them carried residues. There is sufficient evidence to suggest that flakes, cores and chunks were used to process plant and animal materials. Microwear, replication studies and residue analysis should be used in a complementary manner to provide archaeologists with a better understanding of stone tool use and curation. Shafer and Holloway's (1979) study of the lithics from Hind's Cave in south-west Texas, led them to conclude that much of the tool use there was expedient; any sharp flake would do. Retouched or sharpened tools probably reflect long term, complex histories of tool use. This initial study of the Rose Cottage Cave material supports a similar interpretation for the lithics at the site, as well as the possible interpretation that formal tools served some function other than, or in addition to, the processing of food or the manufacture of artefacts. Formal tools may have served a social function, to denote alliances or as exchange items.

Residue studies can enhance information already gleaned from the archaeological record. The combinations of residue types from the Rose Cottage Cave material imply multiple use of tools. Scrapers, for example, may not have been used only for hide working because both plant and animal residues on a single scraper suggest that it was used for processing both vegetables and meat. Such results stress the need for archaeologists to review their assumptions of stone tool functions. Some residue types are related. For example, the anomalous black film, which was found on 50% of the tools, but which tested positive for haemoglobin in only 22% of the cases, has a higher correlation with starch grains (28%) than with other animal residues (3%), such as animal tissues, fibres or red blood cells. This suggests that some of the black residues are perhaps of plant origin. The total absence of a coincidence of ochre and general animal residues suggests that none of the lithics in the analysed sample were used for the joint processing of these materials. This is of interest because ethnographic evidence shows that ochre was sometimes used in the processing of hides (Watts, pers. comm.) and animal fluids are thought to have been mixed with the pigments used in rock art (How 1962:33; Jolly 1986; Lewis-Williams 1986).

Ultimately, stone tool residue analysis may help to change interpretations of the social behaviour of prehistoric societies. Plant working has traditionally been seen as 'women's work' while hunting, butchering and the manufacture of stone tools have been seen as the work of men. The presence of plant and meat residues together on tools implies that behaviour was more flexible than has previously been recognised. Both genders may have performed all tasks, including manufacture of stone tools. Furthermore, the use of a particular tool may not have been exclusive to one gender. The suggestion that there was no gender restriction on the use of stone tools empowers Stone Age women and supports Gero's (1991) contention that women both made and used stone tools. The preliminary results from Rose Cottage Cave clearly show that further residue analysis will be profitable.

FUTURE RESEARCH

The main emphasis of future research will be in the

direction of DNA extraction, amplification and identification. I hope to extract comparative DNA samples from the faunal remains from Rose Cottage Cave, listed by Plug and Engela (1992) for the Late Pleistocene and Holocene periods. Protein residues will be analysed to see how well they correlate with the species mentioned in the list.

A secondary aim will be to build a comparative collection of blood and protein samples. This will involve setting up a data base of blood samples from a wide range of African fauna. I aim to do this in collaboration with the Veterinary Department at Pretoria University and the Johannesburg Zoo. This research will also be of great value to other academic and archaeological institutions in South Africa.

ACKNOWLEDGEMENTS

I would like to thank Dr Lyn Wadley for reading drafts of this paper and for her support, encouragement and help during the project. The Rose Cottage Cave project is funded by the University of the Witwatersrand and the HSRC. I would also like to express my grateful appreciation to Dr Tom Loy for his help and support and for access to his unpublished material. Thanks also to Bruce Hardy for the protocol on excavating and handling of stone tools.

APPENDIX

A feasible sampling strategy for the retrieval of lithics destined for residue analysis needs to be decided upon before sampling begins. A sampling technique should include a spatial spread and as many rock types as possible. Particular attention should be paid to activity areas such as hearths and pits.

Archaeologists need to be made aware of the general problems associated with residue analysis and the precautionary measures that need to be taken. A protocol for the excavation and handling of stone tools for residue analysis is outlined by Hardy *et al.* 1995 (in press). Excessive handling could cause the residue matrix to rub off. It is also important that soil samples are taken (about one tablespoon) from nearby, but not adjacent to, the tool. The background levels of soil organics may be determined from these soil samples and thus used as controls to test for false positive results (Custer *et al.* 1988). Ideally, disposable powder-free surgical gloves should be worn by excavators. Tools may be gently lifted on the tip of a trowel and dropped into clean individual zip-lock plastic bags. (I have found new bank bags useful). Tweezers, preferably plastic (such as contact lens tweezers available from most opticians) can also be used. They should be sterilised in commercially available bleach (jik) and dried thoroughly with a tissue between samples. Excess soil should not be brushed from tools as residue can be lost. Brushes used in excavation should have synthetic bristles.

Common sense and forethought as to the possible sources of contamination will go a long way to ensuring that residues do not become contaminated with modern DNA. It is also strongly advised that the analyst or lab for which the samples are destined be consulted prior to excavation.

REFERENCES

Bahn, P.G. 1987. Getting blood from stone tools. Nature 330:14.

Brown, T.A. & Brown, K.A. 1992. Ancient DNA and the archaeologist. Antiquity 66:10-23.

Cattaneo, C., Gelsthorpe, K., Phillips, P., Sokol, R.J. & Smillie, D. 1991. Identification of ancient blood and tissue - ELISA and DNA analysis. Antiquity 65:878-881.

Cattaneo,C., Gelsthorpe, K., Phillips, P. & Sokol, R.J. 1990. Blood in ancient human bone. Nature 347:339.

Custer, J.F., Igenfritz, J., & Doms, K.R. 1988. A cautionary note on the use of chemstrips for the detection of blood residues on prehistoric stone tools. Journal of Archaeological Science 15:343-345.

Downs, E.F. & Lowenstein, J.M. 1995. Identification of archaeological proteins: a cautionary note. Journal of Archaeological Science 22:11-16.

Gero, J.M. 1991. Gender lithics: women's roles in stone tool production. In: Gero, J.M. and Conkey, W.M. (eds) Engendering Archaeology: women and prehistory. Oxford: Basil/Blackwell Ltd.

Gurfinkel, D.M. & Franklin, U.M. 1988. A study of the feasibility of detecting blood residue on artefacts. Journal of Archaeological Science 15:83-97.

Hardy, B.L., Raman, V. & Raff, R.A. 1996. Recovery of mammalian DNA from Middle Palaeolithic stone tools. (in press)

How, M. 1962. The Mountain Bushmen of Basutoland. Pretoria: Van Schaik.

Hyland, D.C., Tersak, J.M., Advasio, J.M. & Siegel, M.I. 1990. Identification of species of origin of residue blood on lithic material. American Antiquity 55:1.

Jolly, P. 1986. A frist generation descendant of the Transkei San. South African Archaeological Bulletin 41:6-9.

Kòrbe-Grohne, U. 1988. Microscopic methods for identification of plant fibres and animal hairs from the Prince's Tomb of Hochdorf, south-west Germany. Journal of Archaeological Science 15:83-97.

Kooyman, B., Newman, M.E. & Ceri, H. 1992. Verifying the reliability of blood residue analysis on archaeological tools. Journal of Archaeological Science 19:265-269.

Lawler, D.A., Dickel, C.D., Hauswirth, W.W. & Parham, P. 1988. Ancient HLA genes from 7 500 year-old archaeological remains. Nature 349:785-788.

Lewis-Williams, J.D. 1986. The last testament of the Southern San. South African Archaeological Bulletin 41:10-11.

Loy, T.H. 1983. Prehistoric blood residues: detection on tool surfaces and identification of species of origin. Science 220:235-239.

Loy, T.H. 1993. The artefact as site: the biomolecular analysis of organic residues on prehistoric tools. World Archaeology 25(1):44-63.

Loy T.H., Jones, R., Nelson, D.E., Meehan, B., Vogel, J., Southon, J., & Gosgrove, R. 1990. Accelerator radiocarbon dating of human blood protein in pigments from Late Pleistocene art sites in Australia. Antiquity 64:110-116.

Loy, T.H. & Hardy, B.L. 1992. Blood residue analysis of 90 000-year-old stone tools from Tabun Cave, Israel. Antiquity 66:24-35.

Moss, E.H. 1986. What microwear analysts look at. In: Early Man News Vols 9-11. Tubingen: Commision for the palecology of Early Man. pp 91-96.

Olausson, D. 1990. Edge-wear analysis in archaeology: the current state of research. Laborativ Arkeologi 4:5-14.

Persson, P. 1991. Ancient DNA. SAC-News 3.

Plug, I. & Engela, R. 1992. The microfaunal remains from recent excavations at Rose Cottage Cave, Orange Free State. South African Archaeological Bulletin 47:16-25.

Richards, T. 1989. Initial results of blood residue analysis from Thorpe Common rockshelter, south Yorkshire. In: Brooks, I. & Phillips, P. (eds) Breaking the Stony Silence. Papers from the Sheffield Lithics Conference 1988. Oxford: British Archaeological Reports International Series 213.

Ross, I.K. 1979. Biology of the Fungi. USA: McGraw Hill.

Sensabaugh, G.F., Wilson, A.C. & Kirk, P.L. 1971. Protein stability in preserved biological remains. International Journal of Biochemistry 2:558-568.

Shafer, H.J. & Holloway, R.G. 1979. Organic resdiue analysis in determining stone tool function. In: Hayden, B. (ed.) Lithic Use-wear Analysis. New York: Academic Press.

Wadley, L. 1991. Rose Cottage Cave: background and a preliminary report on the recent excavations. South African Archaeological Bulletin 46:125-130.

Webster, J. 1970. Introduction to Fungi (2nd. ed.). Cambridge: Cambridge University Press.