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2009-09-08T12:48:25Z
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TESTING RESIDUES: AN EXPERIMENTAL APPROACH

University of the Witwatersrand

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PhD thesis

In fulfilment of the requirements for the degree Doctor of Philosophy
Submitted to the Faculty of Science,
University of the Witwatersrand
2009

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SUMMARY

I investigate the decay mechanisms for microscopic organic residues. Residue analysis aims to identify microscopic remains or traces that are left on a tool's surface after use. Analysts have identified organic remains such as plant starch grains, fibres, tissue cells, resin; animal blood films and red blood cells, muscle tissue, connective fibres, bone fragments, hairs; fish scales, feathers and shell. Besides organic residues, it is also possible to distinguish inorganic deposits such as ochre and ash. After the processed materials are identified on the artefact, residue analysis can be used, for example, to reconstruct tool use and assess site function.

Preservation of residues on artefacts is a debated topic and I decided to investigate the following issues:

- Non-use-related residues, for example from unintentional handling or sediments, might contaminate artefacts.
- Researchers are unable to describe the mechanism of residue preservation.

My study investigates what research biases might occur from extraneous, or "extra", remains and from deteriorated, or "missing" residues.

I use experimental archaeology and middle-range theory (Binford 1983, Raab and Goodyear 1984, Schiffer 1988, Reynolds 1999, Outram 2008) to bridge the gap between the apparently static archaeological data (what one sees on the tools) to a dynamic reconstruction of past processed materials (what tools were used on and for). The aim of this study is to produce predictions about residue preservation, recognition and possible misinterpretation.

In order to understand the decay of organic residues, I set out experimentally made tools with modern residues at Sterkfontein Caves and Sibudu Cave in South Africa and at Wilhelmina Polder and Zelhem in the Netherlands. The modern flakes were of chert, hornfels and flint respectively and they were used to process muscle tissue, bone, plant tissue, starch rich and plant material. The samples at the sites were subdivided and deposited under different variables; these included time, precipitation, temperature, burial circumstances, sediment pH, sediment constitution, rock type and processed material. Practically this means that part of the sample was deposited inside the caves and the other part outside and that part of the sample was deposited on top of the soil and another part was buried. The sediment pH at Zelhem is low, whereas

the pH at Wilhelmina Polder is high; at Sterkfontein and Sibudu the sediments are neutral; the sediment at Sterkfontein consists of sandy clay, the sediment at Sibudu consists of anthropogenic ash, at Wilhelmina Polder the sediment is clayey and at Zelhem it is sandy. After four weeks I excavated and analysed some of these tools from Sterkfontein and Sibudu. After one year I analysed the remaining set. The Zelhem and Wilhelmima Polder experiments were all collected and analysed after six months. At Zelhem and Wilhelmina Polder the experiments also included sets of sandpaper of different grain sizes and glass slides with modern residues. Part of this sample was buried with the residues facing up and the other part was facing down. This was to test to influence of the raw material surface and microenvironment on residue preservation. All experiments had a set of blank doubles; these are unused flakes, which were deposited in the same settings. These blanks served as control sample and they helped me to study the distribution of contaminants on stone surfaces.

I also analysed ancient samples of stone tools from Sterkfontein and Sibudu. This was to study the possible correlation in preservation between the experimental and ancient residues.

I formulated predictions about the preservation of residues under different circumstances, and in the course of this study I demonstrated that reliable predictions can be made when the taphonomy and curation history of tools and preservation optima of organic remains are carefully studied.

This study clearly demonstrates that all experimental and ancient artefacts contain contaminants. Sediment remains adhere to tools and handling also leaves residues on tools. Not only plant type residues are possible contaminants, I also found contaminant animal type remains, such as connective fibres and muscle tissue. The used samples showed more sediment contamination than the blanks. Because the moist, use-related residues act as an adhesive it is probable that tools with dry residues show less contamination.

It is possible to distinguish use-related residues from contaminants and unintentional residues by quantifying the results and by implementing the contextual approach. Use-related residues are more abundant than contaminants. In addition, use-related residues form coherent distribution patterns with suites of associated residues. For example, processing of animal material leaves deposits of muscle tissue and fat

around the working edge. The distribution and association approach formulated by Lombard and Wadley (Lombard and Wadley 2007, Wadley and Lombard 2007) is a valuable tool in residue analysis.

Different residue types preserve differently. Plant tissue and bone preserve better than muscle tissue, blood and starch grains. Although fat is a tough material, it is often absorbed into the stone material and sediment and therefore lost for analysis. In addition, what is a good environment for one residue can be destructive for another. For example, at Sterkfontein (outside the cave), almost no starch residues were preserved on the starch tools, but at Wilhelmina Polder plenty of starch grains were present and, in addition, many use-related epidermal tissue deposits were also preserved. Another example is muscle tissue, which preserved well inside Sibudu Cave, but preserved badly outside the cave. Outside Sibudu Cave, bone and plant tissue deteriorated less than muscle tissue.

Microbial activity is the main reason for deterioration. From the experiments I gained insight into how the variables time, precipitation, temperature, burial circumstances, sediment pH, sediment constitution, rock type and processed material affect microbial activity. Consequently, precipitation leads to decay and therefore moist, humid and fluctuating environments are bad for preservation. Precipitation also leads to mechanical weathering as residues can be washed off tools. When a soil is rich in nutrients (organic matter) there are more microbes in the sediment and as a result more residue decay. At moderate temperatures less residues are preserved than at low (<5ºC) or high temperatures (>35ºC). However, chemical and mechanical weathering can have a negative effect in more extreme temperatures. Because microbes flourish in environments with a moderate pH (pH 6-7.5), these settings lead to more decay. Residues are better preserved in acidic or alkaline environments, but chemical and mechanical weathering sometimes benefit from more extreme pH values and can then have a negative effect on residue preservation. Medium- and fine-grained rocks are better for preservation than large-grained or glass-like materials. At this point it is unclear if direct burial protects or destroys residues. Direct burial probably promotes preservation if the sediment shields residues from another harmful environment, such a humid atmosphere (potentially the case at Sibudu), or precipitation (as is the case at Wilhemina Polder). Prolonged surface exposure may ensure preservation if it dehydrates the residues and if it keeps residues safe from microbes. Residues always undergo decomposition. Depending on the circumstances,

organic residues either decompose rapidly within a few years or extremely slowly. With rapid decay, no residues are left for analysis even after only one year. With slow decay it appears that residues are permanently preserved. However, chemically and sometimes visually, these residues undergo change. Slow decay can take up to tens of thousands of years, provided that the environments remain stable. In a stable environment, residues preserve better than in an environment that is subjected to reworking and extensive post-depositional processes.

The described results imply the following procedures for residue analysis: tools should be selected from stable sites with low bioactivity. In practice this excludes most open-air sites. Dry and desiccated sites, waterlogged, extremely acidic or alkaline sites and cave sites potentially preserve residues best. On the basis of these results it is possible to make predictions about residue preservation for each site. For example, the prediction made in this study that ancient residues are preserved inside Sibudu Cave proved correct.

Selected artefacts must be handled with care and residue analysis should be the first analysis to be conducted on a tool sample. This means that no lithic or other analysis should take place prior to residue analysis. Sediment samples and blank flakes should be analysed to gain insight into possible contaminants and the raw material.

The selected sample should include a substantial number of artefacts. Because residual decay always occurs, some tools in a sample will not show the expected patterning or preserve residues. To filter out these exceptions, and to ensure that the overall signal becomes clear, more than 30 tools should be analysed. In addition, these should be tools of the same type. It is only possible to recognise and compare distribution patterns when dealing with a uniform sample. For example, possible hafting of scrapers and the accompanying distribution pattern and residue suite is easier to recognise in a scraper-only-sample than in a mixed sample including retouched flakes and points.

The contextual approach should be applied and residues should be quantified. The deductive list, which is discussed in detail in Chapter Six and Seven, is a practical and heuristic device for conducting residue analysis and it follows the contextual approach.

Residues can be representative of past processed materials. However, not all residues on tools are use-related and it essential to differentiate between use-related and post-depositional and unintentional remains.

This study has shown that residue-analysis must be approached with caution. Unfortunately the taphonomy of many sites precludes the preservation of ancient residues. However, with the aid of the predictions regarding circumstances of preservation of residues, the careful selection of sites and samples, and by implementing the contextual approach, I have argued that residue-analysis can be a valuable tool in the reconstruction of processed materials and past activities.