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THE DETECTION OF BLOOD ON PREHISTORIC FLAKE TOOLS

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Within the last fifteen years a great deal of research has been directed toward attempting to ascertain the functions of prehistoric flaked stone tools. In such functional studies most researchers have adopted one or more of the following analytical approaches:

1. correlating tool function with such morphological attributes as tool size, edge angle, edge shape, etc (Morwood, 1974),
2. assigning function by a study of the distribution and form of edge scars and abrasion when viewed at magnification up to X20 (Roe, 1967; Leach, 1979), and
3. determining function through a microscopic study of the various forms of striations, polish and microscarring on the tool working edge employing magnifications in excess of X100 (Keeley, 1980).

All three approaches rely on ethnographic analogy (Gould et al, 1971), and/or tool use replication experiments (Tringham et al, 1974), to enable a comparison between the morphology and use-wear of tools used in known tasks with that of tools in archaeological assemblages. However, ethnographic analogy often assumes uniform tool use in comparing cultures distant in time and space, while use experimentation usually takes place under idealised laboratory conditions which can only be tentatively compared to the prehistoric situation.

Organic residue studies

In recent years a new approach to the functional analysis of flaked stone tools has emerged which circumvents many of the problems associated with more traditional techniques. This involves the identification of microscropic fragments of the worked material which in many cases adhere to the tool surface. There are two means by which such organic residues may be identified:

1. the application of diagnostic chemical indicators, and
2. viewing the residues under high power optical or electron microscopes.

Briuer (1976) employed chemical indicators (phloroglucin and hydrochloric acid, iodine, potassium iodide, and Sudan III) in the identification of plant residues on stone tools excavated from rock shelters. Using a different chemical technique (ascending paper chromatography) Broderick (1979) was able to separate and identify amino acids from residues present on archaeological slate knives. Shafer and Holloway (1979) adopted a microscopic approach in the detection and identifi-

cation of plant remains (fibres, epidermis fragments and phytoliths) and animal hair fragments adhering to a large number of stone tools from a cave site.

In a recent study undertaken by Loy (1983) the focus of investigation was aimed purely at detecting and identifying blood residue. This analysis was designed to identify one functional category of flaked stone tool (i.e. that employed in processing animal flesh) and to determine which specific tools had been employed in processing particular animal species. Flake tools used in the study were of basalt, chert and obsidian and were excavated from midden and forest sites 1000 to 6000 years old (Loy, 1983:1269). Detection of blood residue was achieved using medical test strips sensitive to haemoglobin and by a number of chemical tests for amino acids and protein. Identification to species was achieved by crystallising out the haemoglobin and matching the crystals with those from a reference collection.

Blood residue on New Zealand tools

Following the success achieved by Loy it was decided to test his method of detecting erythrocytes (red blood cells) using obsidian flakes which had been excavated some years previously from the sites at Whakamoenga Cave (N94/7) and Twilight Beach (N1,2/976; see Fig.1). These two sites greatly differ in local environmental conditions: flake tools from Whakamoenga Cave were preserved in relatively stable conditions while those from Twilight Beach were exposed to the effects of sunlight, wind, rain and sea. It was considered that examining material from both a cave and an exposed midden would provide an indication of how well erythrocytes survive in markedly different archaeological contexts.

It is likely at least some of the obsidian flakes from both sites were employed in processing animal flesh. This may be inferred for Whakamoenga Cave by the remains of many bird species in all occupation phases and dog, pig and Norwegian rat from the more recent phases (Leahy, 1976). The Twilight Beach midden revealed the remains of fur seal, whale and a large number of bird and fish species (Taylor, 1984). It was thus thought that erythrocytes, if still intact, should be detectable on at least some of the sample of flakes studied from each site. Owing to limited time only 138 flakes from Whakamoenga Cave and 61 from Twilight Beach were included in the analysis.

Microscopic analysis. The first stage in the search for erythrocytes involved examining each flake under an incident light microscope at between X15 and X50 magnification. A range of residues was readily apparent comprising fibrous material

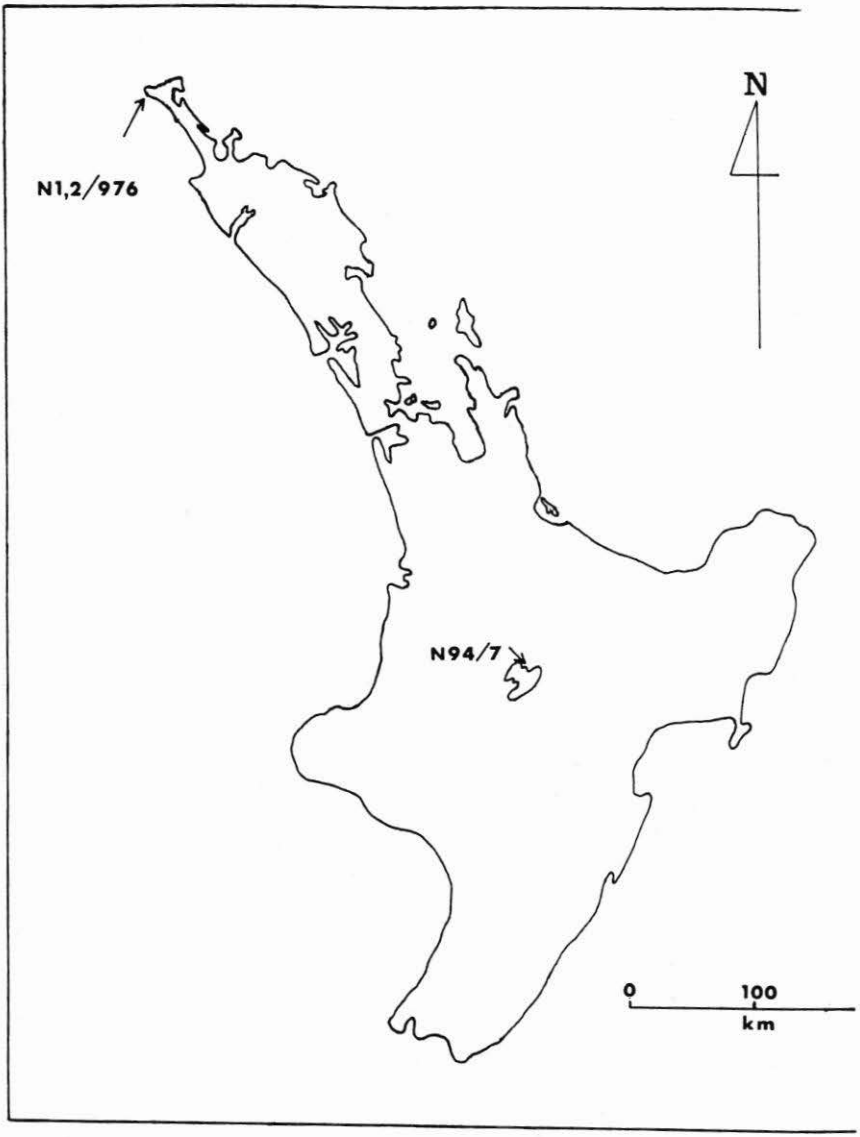

FIGURE 1. Map showing location of Whakamoenga Cave (N94/7) and Twilight Beach (N1-2/976).

embedded in a white 'greasy' matrix; minute red fibres; yellow/brown deposits; and red and brown residues possessing a 'scabby' appearance (Fredericksen, n.d.:Appendices 1 and 2).

However at such low magnifications none of the various residues could be positively identified as blood. The next step therefore involved selecting a number of flakes which possessed residues resembling congealed blood or fatty material and chemically testing them for the presence of erythrocytes and haemoglobin.

Chemical analysis. Five flakes from Whakamoenga Cave possessing red/brown 'scabby' residues and a similar number from Twilight Beach displaying a white 'greasy' patina were tested using Ecur-Test brand medical testing strips (similar to those employed by Loy in his study). The procedure involved simply mixing a small amount of distilled water (no more than one small drop from a pipette) with the residue, waiting 5 to 10 minutes for the blood to dissolve and then applying the test strip. The practical sensitivity limit for Ecur-Test testing strips is very high (five erythrocytes per microlitre of water) but the strips react with chlorophyll as well as haemoglobin. The presence of certain types of plant material in the residue may therefore result in false positive readings of blood.

The results of this chemical test were that none of the residues from either site reacted with the test strips. It was thought this may have been due to one of three factors:
1. none of the residues contained erythrocytes (either the flake tools were not employed in meat processing or the erythrocytes had not survived),
2. human error had occurred in the testing procedure, or
3. the testing strips were no longer viable (they were approaching their recommended expiry date).

In view of these results it was decided to have one of the flakes from Whakamoenga Cave independently tested. The flake chosen (57/3K) was subjected to analysis by Dr Margaret Lawton, a forensic chemist with the Auckland division of the Department of Scientific and Industrial Research. Test strips similar to Ecur-Test were applied to the organic residue on the flake but the result was again negative for the presence of erythrocytes.

In an attempt to visually determine whether erythrocytes were present, Dr Lawton subsequently studied this residue using an electron microscope. During this study structures were observed by Dr Lawton which very closely resembled erythocytes in size and shape. In the light of this promising result it was decided that a larger sample of residue from both sites would be studied under electron microscopy employing the scanning electron microscope (S.E.M.) at Auckland University.

Scanning electron microscope analysis. Unfortunately few of the residues which underwent chemical testing were suitable for electron microscopy as the application of test strips usually resulted in the destruction of the more concentrated residues. It was therefore necessary to select previously untested flakes with obvious residues for the S.E.M. analysis. The residues from eight flakes from Whakamoenga Cave and three flakes from Twilight Beach were subsequently viewed under the S.E.M.

At magnifications of between X500 and X5000 a range of fibres, spores and other plant material was evident interspersed with soil particles (Fredericksen, n.d.:Appendix 1, Plates 10, 11, 21, 22). Identification of these is beyond the scope of this study but given an adequate reference collection it should be possible to determine at least some of the plant species processed by the prehistoric inhabitants of Whakamoenga Cave. (It should be mentioned that no organic material was evident in any of the residues studied from the three Twilight Beach flake tools).

One of the flakes studied (33/3C from Whakamoenga Cave - see Fig. 2) had identifiable blood residue. Erythrocytes were clearly visible and identifiable from their distinctive shape and size of approximately 5 um - (Fig. 3). That only two erythrocytes were observed in the residue (although others may have been overlooked) might explain why the chemical test strip gave a negative indication for the presence of haemoglobin. Although few in number, the erythrocytes identified are remarkable for their state of preservation. A number of factors may contribute to the protection of erythrocytes from decomposition.

The first involves a change in the chemical state of blood. When exposed to air a considerable time the iron atoms in haemoglobin change from a divalent (ferrous) state to a more stable reduced trivalent (ferric) state (Perutz, 1964:65). This oxidation very likely prevents changes in shape from discocyte to echinocyte or stomatocyte observed in cells in solution where pH and other factors have been altered (Weinstein, 1975: 220-222). Thus erythrocytes present on archaeological specimens may also be largely uninfluenced by changes in local environmental conditions.

A second factor in the ability of erythrocytes to survive relatively intact for a long period of time may be found in the fact that soils high in clay mineral content are more retentive of organic matter than those low in clay content (Pinck and Allison, 1951:130). Proteins which become incorporated with montmorillonite (a clay mineral) have proven

to be largely resistant to hydrolysis by enzymes or decomposition by soil microorganisms.

In recent experimental work Mansur-Franchomme (1983) employed flint endscrapers on dry hide and found that skin from the hide had become 'entombed' in a silica gel formed on the edges of the scrapers during use (Mansur-Franchomme, 1983:227). Although it is unlikely this mechanism was responsible for the survival of erythrocytes on the obsidian tools from Whakamoenga Cave, these were clearly within the residues adhering to the surfaces of the two flakes, it does point to the possibility of blood and other organic residues becoming almost permanently fixed to the edges of stone tools.

Summary and implications

The replication and testing of Loy's (1983) technique of employing chemical indicator strips in the detection of blood residue was largely inconclusive. No erythrocytes were chemically detected on any of the residues from the flakes studied. The applicability of employing testing strips and other more sensitive chemical tests, such as the benzidine colour and luminol tests, in the detection of blood on prehistoric tools will only be determined by further experimentation.

That erythrocytes do survive archaeologically, at least in the stable environment of cave sites, was verified using an S.E.M. to observe them at high magnification. Loy's claim that blood residue can remain intact for a very long time and may be detected on prehistoric stone tools was therefore confirmed.

Limited time precluded the testing of Loy's method for identifying species of origin by crystallising out the haemoglobin in the blood residue (Loy, 1983:1269). However, research has indicated that tests which involve the crystallisation of haemoglobin are susceptible to contamination and thus often unreliable (Saferstein, 1977:255). The test commonly employed by forensic scientists in identifying blood to species of origin is the precipitin test. This technique involves mixing antiserum for a variety of species with blood residue. If a particular species' antiserum reacts with the blood residue the blood is identified as originating from that species.

Antiserum is available commercially for humans and a number of animals and is produced by injecting a test animal (usually a rabbit) with a small amount of blood from a chosen animal. This results in the formation of antibodies in the test animal which are recovered by isolating the blood serum (antiserum). This antiserum will contain antibodies that only react with antigens in the blood of the species with which the test animal was injected (Saferstein, 1977:255). It should therefore be

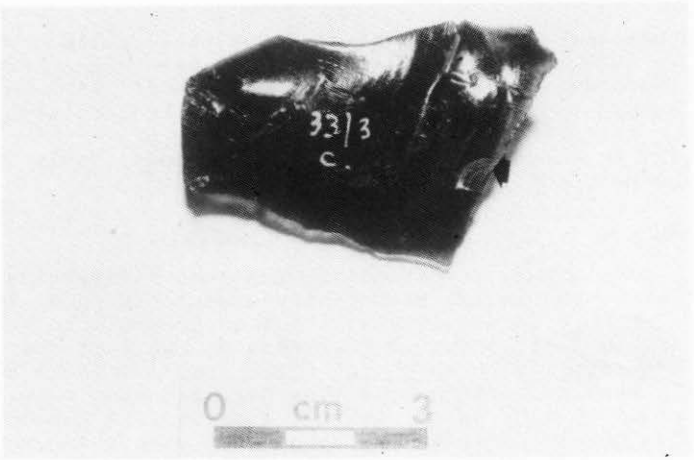

FIGURE 2. Obsidian flake showing position of scanning electron microscope examination.

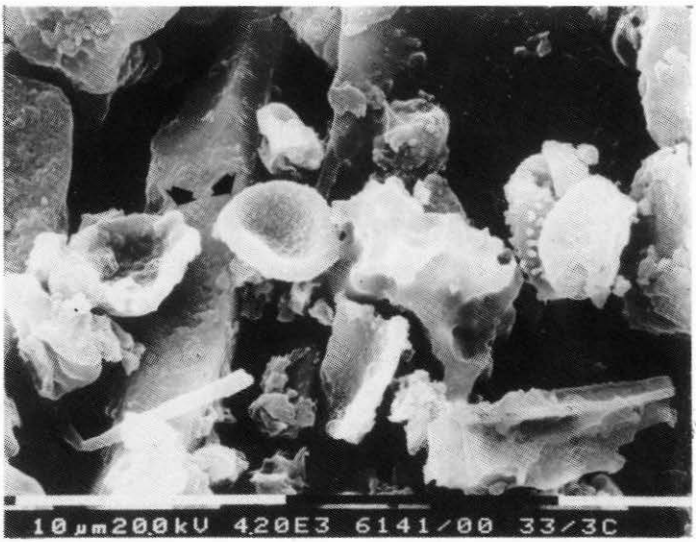

FIGURE 3. Photomicrograph of residue on flake 33/3C. Erythrocytes are the two cup shaped structures (marked by arrows) in the left half of the picture. Scale 10 um intervals.

a relatively straightforward matter to produce antiserum for most indigenous New Zealand animal species.

The precipitin test has given a positive reaction when applied to 4000 to 5000 year old tissue extracts from Egyptian mummies (Saferstein, 1977:256-257). The age of the blood residue should thus pose no problem for New Zealand archaeologists. The precipitin test may therefore prove to be a very useful technique for identifying individual tools used in processing specific animals.

Conclusion

This preliminary investigation has demonstrated that blood residue, and in all probability organic residues in general, can survive relatively intact on prehistoric stone tools. Archaeologists should therefore be aware of the loss of valuable information which may occur when artefacts are needlessly handled, when bagged together, and when they are cleaned prior to storage or use-wear analysis. A number of precautions should therefore be taken when excavating and storing flaked stone tools:

1. direct contact should be avoided with the edges and the area immediately behind the edges where residues could accumulate,
2. flakes should be bagged separately in clean plastic bags without the inclusion of paper forms and labels, and
3. flakes should not be cleaned using water, chemicals, ultra-sonic baths or by any other method. Blood residue is often contained within soil adhering to the flake (Loy, 1983:1270).

If the flake tools are to undergo use-wear analysis a microscopic examination should first be made of the residues. Any flakes possessing fibres, hairs, 'greasy' red/black residue or other potential organic residues, should undergo a more thorough study using both microscopic and chemical techniques.

The application of these procedures should ensure that organic residues on stone tools are not needlessly contaminated or destroyed. The preservation of these diagnostic residues will facilitate the undertaking of more comprehensive analyses of prehistoric flake tool function and thus provide further information on the activities of the first inhabitants of New Zealand.

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