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Blood Protein Residues on Lithic Artifacts from Two Archaeological Sites in the De Long Mountains, Northwestern Alaska

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ABSTRACT. Immunological analysis of blood residues was performed on 25 lithic artifacts from two archaeological sites (DEL-166 and DEL-168) in the De Long Mountains of northwestern Alaska. Blood residues occur on five artifact types: retouched flakes; end scrapers; flake burins; bifaces; and wedge-shaped microblade cores. Fourteen (56%) of the 25 analyzed artifacts react positively to six animal antisera and to human blood. Besides human blood, identified residues include the blood of sturgeon (Acipenseridae), deer (Cervidae), rabbit (Leporidae), bear (*Ursus*), "cat" (Felidae) and "mouse" (Rodentia). Although the application of blood residue analysis to archaeological problems is a relatively new application of an old forensic method, it may provide useful information about artifact function and animal procurement from sites where faunal remains are not preserved.

Key words: Northwest Alaska, De Long Mountains, blood residue analysis, crossover electrophoresis, stone tools, forensics

RÉSUMÉ. On a procédé à une analyse immunologique de résidus sanguins sur 25 artefacts lithiques provenant de deux sites archéologiques (DEL-166 et DEL-168) dans les monts De Long du nord-ouest de l'Alaska. On a trouvé des résidus sanguins sur cinq types d'artefacts: éclats retouchés; grattoirs sur lame; burins faits d'éclats; bifaces; et nucléus microlames cunéiformes. Quatorze (56 p. cent) des 25 artefacts analysés ont réagi positivement à six antisérums de provenance animale et à du sang humain. Outre le sang de provenance humaine, les résidus identifiés comprennent le sang d'esturgeon (Acipenseridae), de chevreuil (Cervidae), de lapin (Leporidae), d'ours (*Ursus*), de «chat» (Felidae) et de «souris» (Rodentia). Bien que l'application de l'analyse de résidus sanguins à des questions d'ordre archéologique soit une application relativement nouvelle d'une ancienne méthode médico-légale, elle peut fournir des renseignements utiles sur la fonction de l'artefact et sur l'approvisionnement en animaux dans les cas de sites où les vestiges de la faune n'ont pas été conservés.

Mots clés: Alaska du Nord-Ouest, monts De Long, analyse de résidus sanguins, électrophorèse croisée, outils de pierre, expertise médico-légale

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INTRODUCTION

The analysis of blood protein residues on prehistoric stone tools continues to be controversial. Although the method is accepted in principle by many forensic scientists, the question of how long and under what conditions blood residues survive and can be accurately identified on stone tools remains open. Studies by Cattaneo et al. (1993), Eisele (1994), and Eisele et al. (1995) are highly critical of the validity and applicability of blood residue analysis; in fact, they deny that immunologically meaningful residues survive the passage of time and that they could be identified accurately even if they did. On the other hand, Newman and colleagues (Newman et al., 1993) argue to the contrary, providing archaeologists with reason to be more optimistic and confident in immunological methods than some believe is warranted.

Few archaeologists are trained in immunology, so it is sometimes difficult to understand the arguments for and against the possibility of using immunological techniques to identify the animals hunted or butchered by prehistoric people. However, the problem of identifying animal procurement and processing is important enough, especially for hunter-gatherer archaeology, that the potential of immunological approaches is worth further examination. Until more controlled experimental research is undertaken, archaeologists should continue to submit specimens for analysis, even while recognizing the need to critically evaluate the results (Cattaneo et al., 1993).

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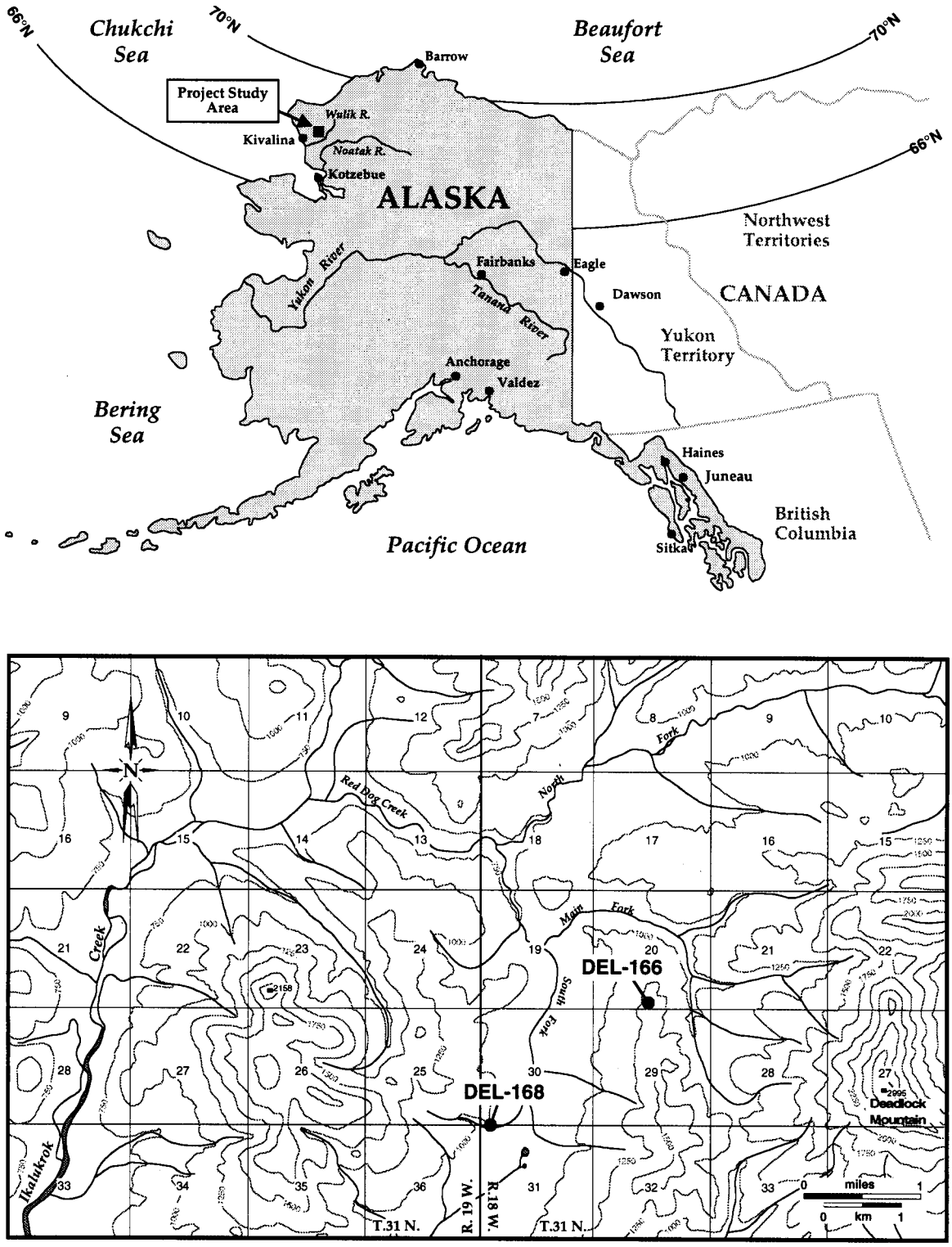

FIG. 1. Location of study area (from USGS Map 1:63 360 De Long Mountains A-2 Quad).

In this study we present the results of an immunological analysis of blood residues on lithic artifacts from two prehistoric archaeological sites in the De Long Mountains of northwestern Alaska (Fig. 1). Analysis of various artifact types from the two sites, including wedge-shaped microblade cores, flake burins, bifaces, and retouched flakes, produced positive results and identified several taxa. Without pushing interpretation too far, we offer this study with the hope that archaeologists and biologists will continue working with immunological and other forensic techniques in the future.

In 1985 Gerlach and Hall (1986, in press) excavated several shallow lithic sites in the De Long Mountains of

northwestern Alaska as part of a larger research project associated with the development of the Red Dog Mine (Tailleur, 1970; Plahuta, 1978). DEL-166 and DEL-168, two of the largest and densest sites in terms of spatial extent and artifact numbers, produced associations of wedge-shaped microblade cores, bifacial tools, and the by-products of core, blade, and biface technology (Gerlach and Hall, in press). Both sites lack stratigraphy, organic materials for dating, and preserved faunal remains. Because of the large number of microblade cores and evidence of both blade and biface technology, we initially assigned both of these sites to some phase of the American Paleo-Arctic tradition as defined by Anderson (1968, 1972). The American Paleo-Arctic tradition, specifically the Akmak and Kobuk complexes, is thought to date between 9570 B.P. and 8000 B.P. (uncalibrated), although the radiocarbon dates and artifactual associations from the Onion Portage site on the Kobuk River lack published stratigraphic coordinates (Anderson, 1968, 1988; Hamilton, 1970; Schweger, 1976, 1985; Gerlach and Mason, 1992). For better or worse, most arctic archaeologists continue to use this temporal framework to date north Alaskan sites with microblade core technology (Ackerman, 1992).

In the early 1980s, we began experimenting with methods that would provide more information about animal procurement and processing from small sites without organic preservation than is possible through the typological or functional analysis of lithic remains alone (Hall and Gal, 1988). In 1986 we undertook a blood residue analysis of excavated soil samples from a reindeer herder's corral and camp complex near Kivalina, Alaska, using the hemoglobin recrystallization method (Loy, 1983; Loy and Hardy, 1992). Because the results obtained were negative, and we were suspicious of the technique used, for a time we felt that blood residue work was unpromising (see Gurfinkel and Franklin, 1988; Smith and Wilson, 1990, 1992).

In 1991 we initiated another study, using the crossover electrophoresis method and samples from the two excavated prehistoric stone tool assemblages described above (Knell, 1992). The blood residue data summarized below for the Red Dog sites are the first positive results we have obtained. Our original intent in conducting this study was simply to see if blood residues are preserved, and if so, whether they can be identified and correlated with mammals living in northwest Alaska today. The artifacts analyzed from the two sites were selected arbitrarily from the collections, since our primary interest was in simply documenting the presence or absence of residual blood residues on stone tools.

Further research will attempt systematically to investigate samples of artifacts from a larger suite of sites, conduct controlled experimental investigations, and attempt to radiocarbon date samples of blood residues preserved on lithic material (Nelson et al., 1986). If the radiocarbon dating proves reliable, it may be one way to radiometrically date lithic material from the numerous shallow or surface sites with microblade core and blade technologies scattered throughout northern Alaska.

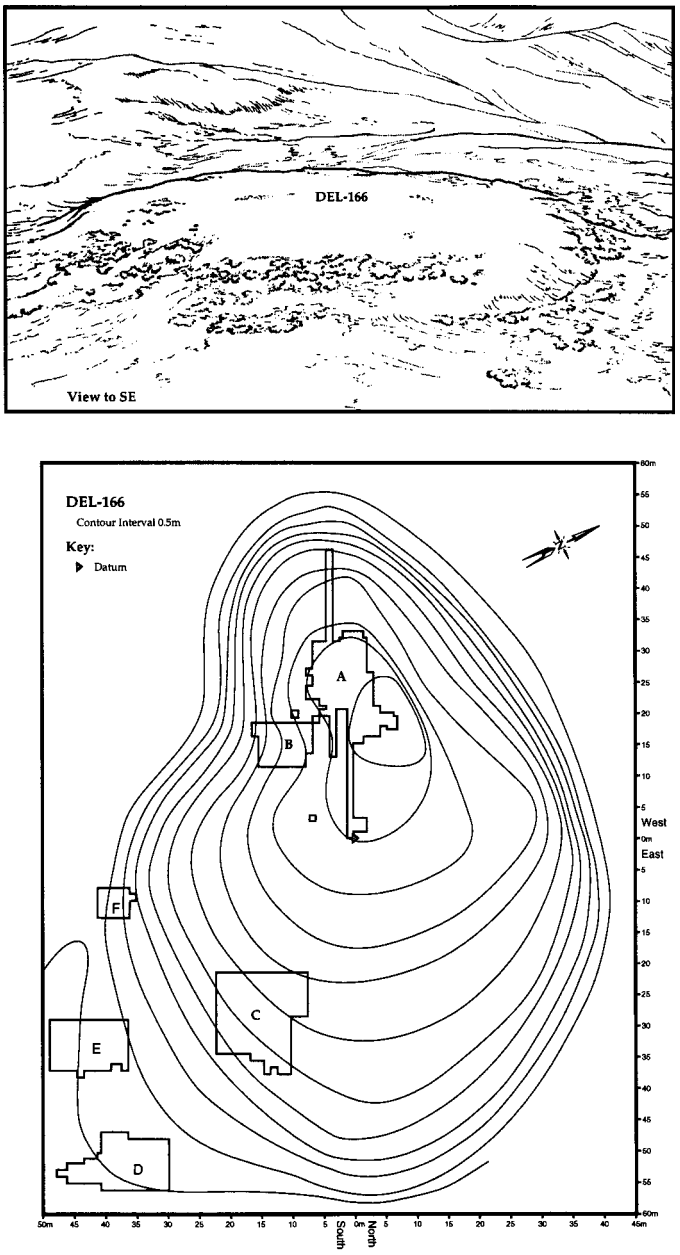

FIG. 2. Oblique view, contour intervals, and excavated localities at DEL-166.

THE STUDY AREA AND SITE LOCATIONS

The study area is located approximately 89 km from the Chukchi Sea east-northeast of Kivalina, and 132 km north of Kotzebue, Alaska. DEL-166 and DEL-168 are on opposite sides of the south fork of Red Dog Creek, which flows into Ikalukrok Creek, an eastern tributary of the Wulik River (Fig. 1). Northwest Alaska has long winters and short summers with generally less than 10 mm of precipitation per year. Geocryological processes and freeze-thaw cycles subject surficial and buried lithic material to considerable disturbance, including but not limited to needle-ice formation, frost-heaving, wind polish, erosion, and various other cold-climate

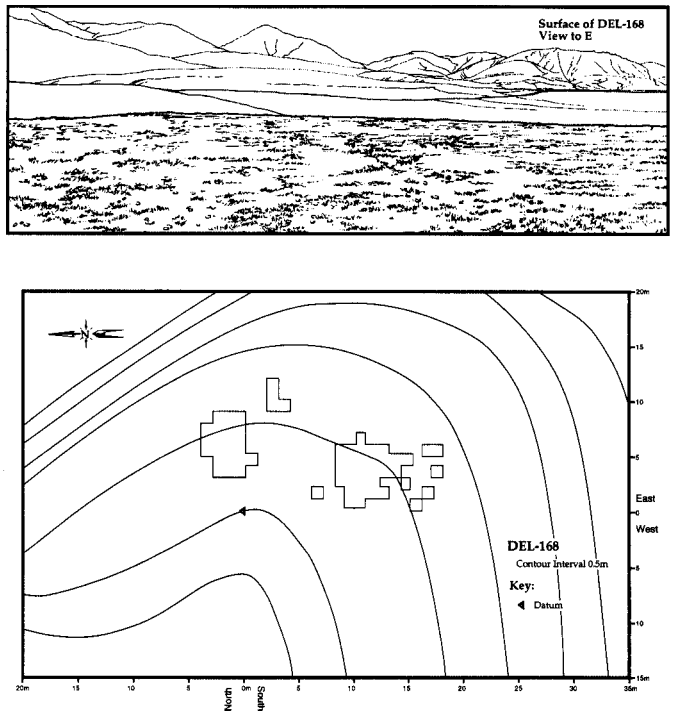

FIG. 3. Oblique view, contour intervals, and excavated localities at DEL-168.

processes (Washburn, 1973; Bowers et al., 1983). Bedrock consists of limestone, sandstone, shale, chert and mafic igneous rocks (Selkregg, 1974). The area is underlain by permafrost, the temperature state of a material remaining below 0°C for a period of two or more years. Soil at temperatures below 0°C is classified as permafrost even though it is structurally similar to unfrozen ground. In general, slopes in this area have silty, mineral soils with some sphagnum peat; the seasonal thaw or active layer may be as much as 3 m deep on exposed hillsides. Both archaeological sites are marked by undulating sand deposits with lenses of deflation-lag gravel.

The sites are located on the west side of Deadlock Mountain and are surrounded on the west and southeast by the foothills of the De Long Mountains, which range in elevation from 243 m to 455 m. DEL-166 contains six loci (A-F) with cultural material recovered from 67 excavated units, each 1 m square, and from 619 m of controlled surface collection (Fig. 2). DEL-168 contains three artifactual loci, with cultural material recovered from the excavation and controlled surface collection of 39 one-metre squares (Fig. 3). No hearths or features were discovered during excavation of either site. Eight of the 25 artifacts analyzed from the two sites were collected from the surface, and 17 were recovered from excavations (Table 1). Twelve of the analyzed specimens, almost 50% of the sample tested, are from DEL-166B. All of the analyzed lithic artifacts from the Red Dog sites are produced from fine-grained, cryptocrystalline cherts (see Mull et al., 1982; Gerlach and Hall, 1986). In Table 1 we identify cherts from which the artifacts were produced by color and by the geologic formation from which they were derived, where this is known with certainty (Lorne Young, pers. comm. 1985).

The association of American Paleo-Arctic tradition artifact types with a predominate Holocene fauna is interesting, especially in light of Mobley's (1989) re-dating of similar artifacts from the Campus site in central Alaska between 4000 and 2500 B.P. (uncalibrated). The continuation of a "post-American Paleo-Arctic tradition," lasting until possibly as late as 2000 or 3000 years ago and manifest in several regionally distinct microblade core technologies, is accepted by some archaeologists (Gal, 1982).

BLOOD RESIDUE ANALYSIS

In spite of experimental evidence to the contrary (Smith and Wilson 1990, 1992; Cattaneo et al., 1993; Eisele, 1994; Eisele et al., 1995), several studies demonstrate that lithic artifacts may retain traces of organic residue from their original use (Briuer, 1976; Broderick, 1979; Shafer and Holloway, 1979; Downs, 1985; Hyland et al., 1990; Yohe et al., 1991; Kooyman et al., 1992; Newman and Julig, 1989; Newman et al., 1993b). Through the application of immunological and biochemical techniques, the animal origin may be identified to at least the taxonomic level of the family, if not more specifically. We need this type of information to know which animals were procured and processed at or from a site, and to identify artifact function or use.

Immunological tests have been used for many years to identify bloodstains in medical and legal work. Since the introduction at the turn of the century of the precipitin test for the medico-legal identification of bloodstains, several new techniques have been introduced and critically reviewed (Culliford, 1964; Gaensslen, 1983). The basis for all tests is still the antigen-antibody reaction first observed in the classic precipitin formulation (Gaensslen, 1983). The successful identification of blood residue is dependent on the amount and condition of antigen retained in the stain. Archaeologists should be encouraged by the fact that blood proteins can withstand harsh treatment and still be identified in most cases, although human handling should be kept to a minimum and artifacts unwashed (Lowenstein, 1992). The sensitivity and specificity of precipitin reactions makes them especially effective for the detection of trace amounts of protein (Kabat and Meyer, 1967:22), regardless of whether they have been washed or not. The artifacts from the Red Dog sites were not washed during any phase of laboratory investigation or analysis.

We conducted an immunological analysis of blood residues on 25 lithic artifacts, 18 from DEL-166 and 7 from DEL-168, using crossover electrophoresis (CIEP) (Newman, 1992). This method is based on the work of Culliford (1964), with modifications in method adopted from the Royal Canadian Mounted Police Serology Laboratory in Ottawa, and the Centre of Forensic Sciences in Toronto. This test is extremely sensitive and can detect 10 to -8 g of protein (Culliford, 1964:1092; see Newman, 1990, for a complete review of this procedure). Crossover electrophoresis is considered by some forensic scientists to be more accurate than Loy's (1983; Loy

TABLE 1. Results of immunological analysis on lithic artifacts from DEL-166 and DEL-168.

Site	Grid square	Quadrant	Level	Depth below datum (cm)	Accession number	Artifact type	Raw material	Result
DEL-166A	4S/25W	SW	Level 1	0–10	UA85-95-0250	Utilized flake	Otuk Chert	Negative
DEL-166A	5N/18W	SW	Level 1	0–10	UA85-95-0883	Biface fragment	Grey Chert	Negative
DEL-166B	10S/15W	SW	Level 3	20–30	UA85-95-0996	Biface	Black Chert	Deer
DEL-166B	10S/15W	SE	Level 1	0–10	UA85-95-1006	Biface fragment	Black Chert	Negative
DEL-166B	10S/14W	SW	Level 3	20–30	UA85-95-1009	Biface	Black Chert	Human
DEL-166B	10S/14W	SW	Level 1	0–10	UA85-95-1014	Retouched flake	Grey Chert	Rabbit
DEL-166B	10S/14W	SW	Level 1	0–10	UA85-95-1018	Microblade core	Grey Chert	Sturgeon
DEL-166B	10S/14W	NW	Level 1	0–10	UA85-95-1024	Biface	Black Chert	Negative
DEL-166B	10S/14W	SE	Level 1	0–10	UA85-95-1025	End scraper	Siksikpuk Chert	Negative
DEL-166B	8S/14W	SW	Level 1	0–10	UA85-95-1028	Biface	Siksikpuk Chert	Human
DEL-166B	10S/14W	SW	Surface		UA85-95-1034	Flake	Siksikpuk Chert	Negative
DEL-166B	10S/14W	SW	Surface		UA85-95-1035	End/Side scraper	Siksikpuk Chert	Deer
DEL-166B	14S/14W	NE	Surface		UA85-95-1040	Retouched flake	Black Chert	Deer
DEL-166B	11S/14W	NE	Level 2	10–20	UA85-95-1069	Biface	Black Chert	Bear, Deer
DEL-166C	21S/29E	NE	Surface		UA85-95-1097	Burin spall	Grey Chert	Negative
DEL-166C	14S/30E	SE	Level 1	0–10	UA85-95-1206	Microblade core	Kogruk Chert	Bear
DEL-166C	11S/30E	SW	Surface		UA85-95-1327	Microblade	Siksikpuk Chert	Negative
DEL-166E	46S/36E	NE	Level 1	0–10	UA85-95-0939	Burinated flake	Siksikpuk Chert	Negative
DEL-168	10S/6E	SW	Level 1	0–10	UA85-96-0001	Unifacially retouched flake	Grey Chert	Negative
DEL-168	10S/6E	SW	Surface		UA85-96-0021	Unifacially retouched flake	Grey Chert	Cat
DEL-168	10S/4E	SW	Surface		UA85-96-0079	Microblade core	Grey Chert	Deer, Rabbit
DEL-168	9S/5E	NW	Level 1	0–10	UA85-96-0156	Biface fragment	Black Chert	Rabbit
DEL-168	10S/6E	NW	Level 1	0–10	UA85-96-0261	Unifacially retouched flake	Grey Chert	Negative
DEL-168	10S/4E	SW	Level 1	0–10	UA85-96-0298	Flake burin	Grey Chert	Deer
DEL-168	115S/4E	NW	Level 1	0–10	UA85-96-0710	Flake burin	Grey White Chert	Mouse

and Hardy, 1992) hemoglobin recrystallization method, because the latter (1) assumes that hemoglobin crystals can be grown from blood residues recovered from the surfaces of prehistoric tools; (2) relies on identifying the animal species from the signature shape of the crystals; and (3) identifies the isoelectric point of the hemoglobin (Nelson et al., 1986; Bahn, 1987; Smith and Wilson, 1992).

METHODS

Possible residues from the artifacts were removed by using a 5% ammonium hydroxide solution. This has repeatedly been shown to be the most effective extractant for old and denatured bloodstains, and does not interfere with subsequent testing (Dorrill and Whitehead, 1979; Kind and Cleevely, 1969). Lithic artifacts were placed in shallow plastic dishes where 0.5 cc of the 5% ammonia solution was applied with syringe and needle. Initial disaggregation of residue was carried out by floating the plastic dish and its contents in an ultrasonic cleaning bath for two to three minutes. Extraction was continued by placing the boat and its contents on a rotating mixer for 30 minutes. The resulting ammonia solution was removed with a pipette, placed in a numbered plastic vial, and refrigerated prior to further testing.

All artifact extracts were first tested against pre-immune serum, which is serum from a non-immunized animal. A positive result against pre-immune serum may arise from a nonspecific protein interaction that is not based on the immunological specificity of the antibody (i.e., non-specific precipitation). However, no positive results were obtained from this test. All extracts were then tested against the antisera shown in Table 2. Duplicate testing was carried out on all positive reacting specimens to insure comparability and accuracy of the results.

Except where noted (Table 2), the animal antisera used in this analysis were obtained from commercial sources developed specifically for use in forensic medicine. These antisera are either polyclonal, or they recognize epitopes shared by closely related species. For example, anti-deer will give positive results with other Cervidae such as moose, caribou and elk, or with pronghorn antelope (Antilocapridae). Two additional antisera, elk and trout, were produced at the University of Calgary. The elk antiserum is species-specific. Trout are polyclonal and will elicit positive reactions with most members of the Salmonidae. Two additional antisera, white sturgeon and shark, were obtained from Dr. Jerold Lowenstein at the University of California at Berkeley.

TABLE 2. Antisera used in analysis.

Antisera	Source
anti-bear	Organon Teknika forensic medicine
anti-bovine	Organon Teknika forensic medicine
anti-cat	Organon Teknika forensic medicine
anti-chicken	Organon Teknika forensic medicine
anti-deer	Organon Teknika forensic medicine
anti-dog	Organon Teknika forensic medicine
anti-guinea pig	Organon Teknika forensic medicine
anti-human	Organon Teknika forensic medicine
anti-mouse	Organon Teknika forensic medicine
anti-rabbit	Organon Teknika forensic medicine
anti-rat	Organon Teknika forensic medicine
anti-sheep	Organon Teknika forensic medicine
anti-duck	Nordic Immunological
anti-elk	University of Calgary
anti-trout	University of Calgary
anti-shark	Lowenstein, UC Berkeley
anti-sturgeon	Lowenstein, UC Berkeley

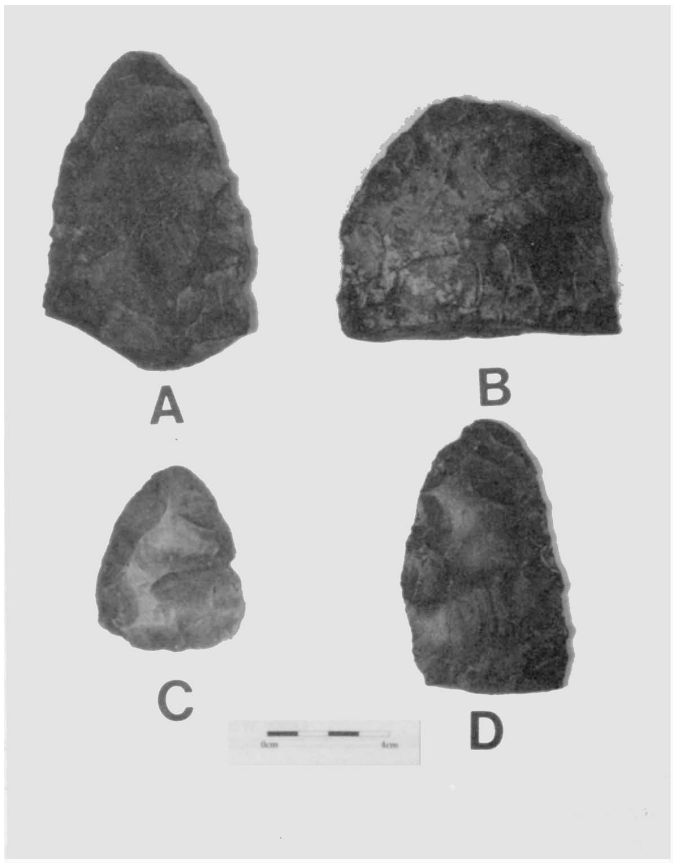

FIG. 4. DEL-166: A) biface (UA85-95-1009); B) biface (UA85-95-0996) C) biface (UA 85-95-1028); D) biface (UA85-95-1069).

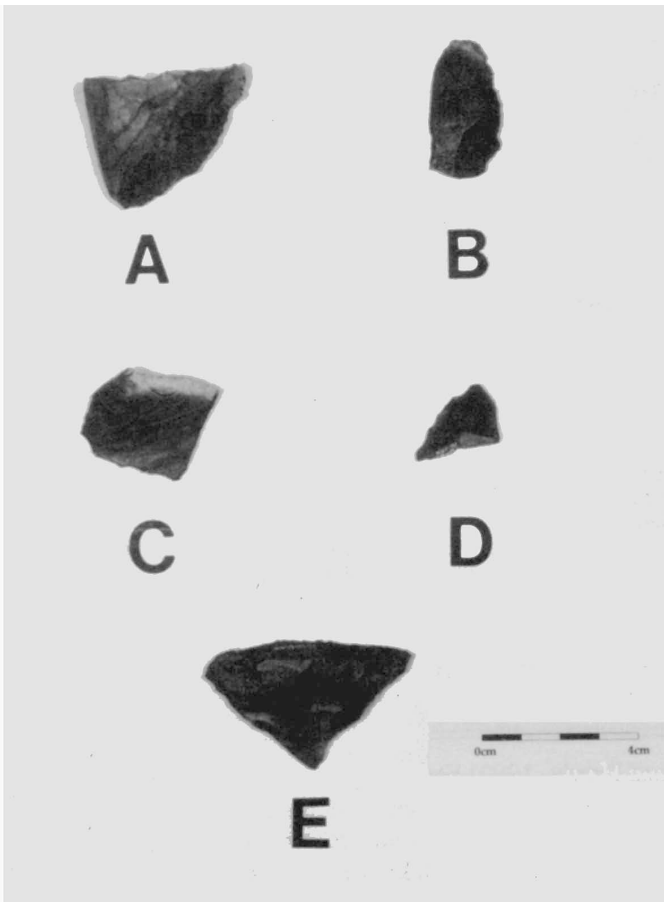

FIG. 5. DEL-168: A) microblade core (UA85-96-0079); B) flake burin (UA85-96-0298); C) flake burin (UA-85-96-0710); D) biface fragment (UA85-96-0156); E) retouched flake (UA85-96-0021).

Although immunological relationships will not necessarily reveal close relationships as reflected in the Linnaean taxonomic system, they generally have done so in comparative studies undertaken so far (Gaensslen, 1983). Identifications based on bloodstains using CIEP analysis are considered accurate to at least the family level, although species identifications may sometimes be circumstantially correlated with animals found in a contemporary study area for added precision.

RESULTS

The identified blood residues for the Red Dog sites are summarized in Table 1 and are discussed by artifact type below. Seven different artifact types were submitted for analysis: retouched flakes (n = 7), end scrapers (n = 2), flake burins (n = 3), bifaces (n = 8), wedge-shaped microblade cores (n = 3), a burin spall (n = 1), and a microblade (n = 1). Blood residues, however, are present on only the first five of the seven types. The typology used here is descriptive and is not based on analysis of artifact function (see Gerlach and Hall, 1986 for detailed descriptions and complete artifact illustrations). Only those artifacts that produced positive results are illustrated here.

Fourteen (56%) of the 25 artifacts, representing five morphological types, have identifiable blood residue. This is a relatively high preservation rate when compared to artifacts from the plains grassland, the northern Ontario boreal forest, and a dry cave, where a 25–30% preservation rate for these combined environments is typical (Kooyman et al., 1992; Newman, 1992). The absence of identifiable proteins on some of the Red Dog artifacts may be due to poor preservation of protein; but it may mean that they were used on species other than those represented by the antisera, or that they were manufactured on site and then discarded unused.

The Artifacts

Bifaces: Five of the eight bifaces and biface fragments analyzed reacted positively to antisera. One (UA85-95-0996; Fig. 4B) reacted to deer; one (UA85-96-0156; Fig. 5D) to rabbit; two from the same site locality (DEL-166B) and in close spatial relationship to one another (UA85-95-1028; Fig. 4C, UA85-95-1009; Fig. 4A) reacted to human blood; and one specimen (UA85-95-1069; Fig. 4D) reacted positively to both bear and deer.

End/Side Scrapers: Only one (UA85-95-1035; Fig. 6D) of the two end scrapers analyzed reacted positively to deer antisera. The second scraper (UA85-95-1025) reacted negatively to all animal antisera against which it was tested.

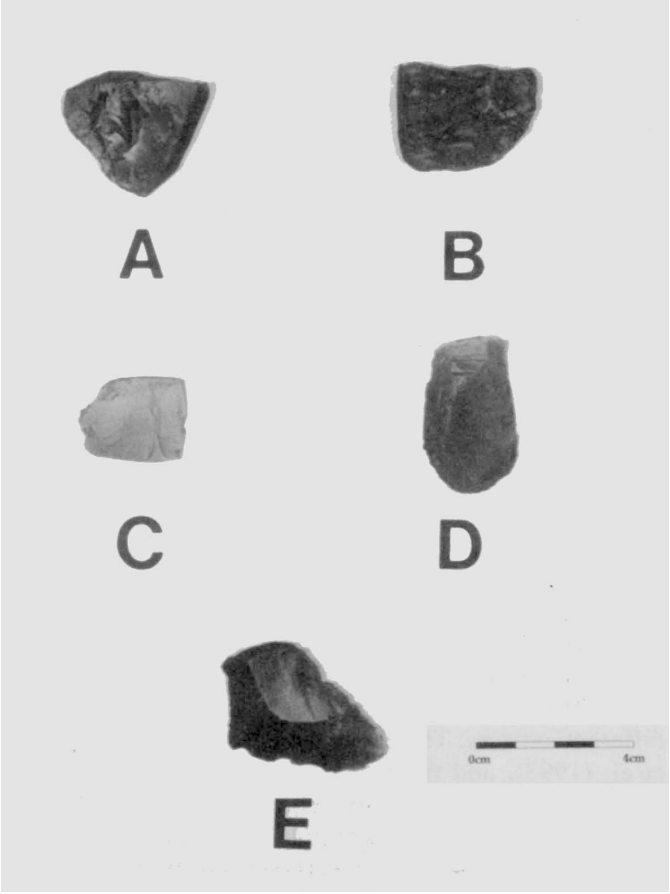

FIG. 6. DEL-166: A) microblade core (UA85-95-1206); B) microblade core (UA85-95-1018); C) retouched flake (UA85-95-1040); D) end/side scraper (UA85-95-1035); E) retouched flake (UA85-95-1014).

Flake Burins: Two flake burins from the same site reacted positively to antisera. One (UA85-96-0710; Fig. 5C) to mouse, and the other (UA85-96-0298; Fig. 5B) to deer. Negative results were obtained for a burinated flake (UA85-95-0939) and a burin spall (UA85-95-1097).

Microblade Cores: All three microblade cores from DEL-166B reacted positively to antisera, although each specimen reacted to a different taxonomic family. One microblade core (UA85-95-1018; Fig. 6B) reacted to sturgeon, one (UA85-95-1206; Fig. 6A) to bear, and one (UA85-96-0079; Fig. 5A) to both deer and rabbit. A microblade (UA85-95-1327) from DEL-166C was analyzed with negative results.

Retouched Flakes: Three of the seven retouched flakes submitted reacted positively to antisera. One (UA85-95-1040; Fig. 6C) reacted to deer, one (UA85-95-1014; Fig. 6E) to rabbit, and one (UA-85-96-0021; Fig. 5E) to cat.

DISCUSSION

While few solid conclusions can be drawn on the basis of this limited sample, we still note the presence of residual blood residue and the representation of diverse species. A minimum of six taxonomic families are identified by blood residues on five artifact types from the combined Red Dog site samples. The results obtained from the blood residue analysis of artifacts from DEL-166 and DEL-168 are interesting because they indicate late Holocene taxa from artifacts considered by many archaeologists to be late Pleistocene or early Holocene in age. The Holocene assessment is tentative, however, since these species were present in the Pleistocene as well. The most that we can do here is document the absence of blood residues from animals that were clearly and exclusively members of the Pleistocene faunal community in Beringia (see Guthrie, 1990).

In the first systematic study of blood residues preserved on lithic material from arctic sites, E. James Dixon and Tom Loy analyzed a series of fluted points from northern Alaska using the hemoglobin recrystallization method and identified mammoth, bison, sheep, bear, caribou, and musk-oxen (Dixon, 1993; Table 9.1). In contrast to the artifact samples analyzed in our study, the archaeological specimens that Dixon and Loy were forced to rely on (1) were collected over a considerable period of time, some systematically and some unsystematically; (2) were collected with no thought of blood residue studies; (3) were in museum collections, and thus were handled in various ways by numerous people; and (4) were generally from surface collections or lacked provenience data. Our samples from the De Long Mountain sites are well provenienced (Table 1), were collected with blood residue analysis in mind and, while not washed, were still handled as a result of normal curatorial activities.

The positive reaction to cat antiserum on the one unifacially retouched flake from DEL-168 indicates protein from a member of the Felidae. Cross-reactions with other families do not generally occur. Lynx (*Lynx canadensis*) is the most likely candidate, as this species is found along forested river bottoms in northwest Alaska today.

Deer proteins were identified on six artifacts: a retouched flake, two bifaces, and an end/side scraper from DEL-166 and a flake burin and microblade core from DEL-168. A positive reaction to deer antiserum is obtained with all members of the Cervidae. However, negative results to elk antiserum were obtained on all of these artifacts, thus eliminating elk from the list of possible candidates. Elk (*Cervus canadensis*) were present in Beringia during the Pleistocene and very early Holocene (Guthrie, 1990), but disappear in the mid- to late Holocene faunal record in Alaska; elk are not present in northwest Alaska today. The most probable association is with caribou (*Rangifer tarandus*), since the Western Arctic Herd regularly uses northwestern Alaska as part of its seasonal migration pattern and appears to have done so throughout the historic period at least (Skoog, 1968; Burch, 1972; Gerlach, 1989). Cross-reactions with families other than those discussed do not generally occur.

Bear proteins were identified on a biface and a microblade core from DEL-166. The microblade core, as described above, also reacted with deer antiserum. These results may indicate any member of the Ursidae, including grizzly (*Ursus horribilis*) or black bear (*Ursus americanus*), or may indicate

multiple uses for the tool. Cross-reactions to other families are not known to occur.

Positive reactions to rabbit (*Lagomorpha*) antiserum were obtained on a retouched flake from DEL-166 and a microblade core and biface fragment from DEL-168. The microblade core also reacted with deer antiserum. Other members of the Order Lagomorpha (such as hares, or pikas) may be indicated, but cross-reactions with other orders are not known to occur. Hares (*Lepus*) occur in northwest Alaska today, but it is impossible to be more specific than to state that Lagomorpha is represented by the identified blood residue.

One positive reaction to mouse (Rodentia) antiserum was obtained on a flake burin from DEL-168. Other members of the Order Rodentia, such as ground squirrel (*Spermophilus parryii*), marmot (*Marmota*), or beaver (Castoridae), may be indicated. Cross-reactions with members of other orders do not generally occur. Beavers (*Castor canadensis*) occur in northwest Alaska in limited numbers today, and marmot and ground squirrels are represented at both Pleistocene and Holocene localities in Alaska (Guthrie, 1990).

A positive reaction to sturgeon antiserum was obtained on one microblade core from DEL-166. Although sturgeon are not known to have been used in this far northern region in either the Pleistocene or the Holocene, positive reaction to sturgeon antiserum will occur with any member of the Salmonidae. The sturgeon antiserum did give a weak positive reaction to trout. Although these are different families, there are still epitopes that are common to both, a fact reflecting an immunological relationship between the two. Such an immunological relationship is distinct from the Linnaean classification. The negative relationship to trout antiserum may also indicate that insufficient epitopes were preserved or that a related family is indicated. Salmon occur throughout Kotzebue Sound, and are present in many of the major rivers in the general region. Arctic char (*Salvelinus alpinus*) are also common, occurring in large numbers seasonally in the Wulik River to the west of the Red Dog area. Lake trout (*Salvelinus namaycush*) and several species of whitefish (*Coregonus*) are present in many of the inland lakes and rivers.

Positive reactions to human antiserum were obtained on two bifaces from DEL-166B. Positive reactions to this antiserum are obtained only with humans and apes. Unless the results represent prehistoric feuds, the most likely explanation is accidental cuts during use or manufacture of these artifacts. Although skin oils or perspiration from recent handling may be responsible for the positive results, it is likely that more positive results on a wider variety of artifact types would be obtained if this were the case.

The artifactual data from the Red Dog sites suggest that, at minimum, six families of animals and fish were utilized, representing a fairly wide range of regionally or locally available resources. However, not all families represented by blood residues on the Red Dog artifacts were necessarily procured in the region, as some believe that bloodstains may adhere to tools for up to 90 000 years (Loy and Hardy, 1992). This makes it difficult to state precisely that an animal was procured in the area where a tool was discarded. In other words, a tool containing blood residue may have remained in use throughout an annual round and then been discarded in a different locality from that in which it was used. Artifacts or lithic raw materials may also have been commodities in broad exchange networks. Thus, some other form of evidence, such as use-wear, faunal analysis, or the presence of exotic raw materials, may be necessary before solid conclusions about procurement, processing, or artifact function are drawn.

Limitation of the Study

While blood residue analysis provides interesting results from DEL-166 and 168, residual blood stain analysis as currently applied still has a number of technical problems. For example, Downs et al. (1992; see also Lowenstein, 1992) tested the comparability of three separate techniques in a three-way blind test. For the known modern blood samples, the test results were comparable; for the unknowns they were not, reflecting, perhaps, the use of different identification procedures as well as the use of different antisera. The experimental research of Cattaneo et al. (1993), and the experimental and immunological work of Eisele (1994; Eisele et al., 1995) raise questions about the validity of any attempts to apply immunological techniques to stone tool analysis (see however, Newman et al., 1995). Although Eisele (1994; Eisele et al., 1995) treats important issues about blood residue analysis in a systematic way, negative results produced by one researcher using one analytical technique do not necessarily negate the work of others, nor do they invalidate the results produced by different analytical techniques. Clearly, more work needs to be conducted with archaeological samples and well-documented control cases. We are currently conducting experimental studies of manufactured stone tools soaked in blood of known species and buried in loess or exposed on the University of Alaska Fairbanks campus. These specimens will be subjected to a series of blind identification tests after recovery.

One problem with the blood residue study of the Red Dog sites is that no soil samples were submitted with the artifacts. This is necessary for a soil background check and to help identify any soil contaminants that might yield false positive results. However, Kooyman et al. (1992) show that false positives from soil contaminants are rare.

Blood residue analysis is experimental, but additional research with archaeological samples is encouraged. In contrast to faunal analysis, which provides an indirect linkage based on associations of bones with other categories of material culture, blood residues on stone tools provide a more direct indication of procurement and processing activities from archaeological sites. This is the kind of "middle-range" analytical technique that is potentially useful for understanding the subsistence resources used by prehistoric people.

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REFERENCES

ACKERMAN, R. 1992. Earliest stone industries on the north Pacific coast of North America. Arctic Anthropology 29(2):18–27.

ANDERSON, D.D. 1968. A stone age campsite at the gateway to America. Scientific American 218:24–33.

———. 1972. An archaeological survey of the Noatak drainage, Alaska. Arctic Anthropology 9(1):66–117.

———. 1988. Onion Portage: The archaeology of a stratified site from the Kobuk River, Northwest Alaska. Anthropological Papers of the University of Alaska 22(1–2).

BAHN, P.G. 1987. Getting blood from stone tools. Nature 350:14.

BOWERS, P.M., BONNICHSEN, R., and HOCH, D.M. 1983. Flake dispersal experiments: Noncultural transformation of the archaeological record. American Antiquity 48(3):553–572.

BRIUER, F.L. 1976. New clues to stone tool function: Plant and animal residues. American Antiquity 41(4):478–484.

BRODERICK, M. 1979. Ascending paper chromatographic technique in archaeology. In: Hayden, B., ed. Lithic use-wear analysis. New York: Academic Press. 375–383.

BURCH, E.S., Jr. 1972. The caribou/wild reindeer as a human resource. American Antiquity 37(3):339–368.

CATTANEO, C.K., GELSTHORPE, K., PHILLIPS, P., and SOKOL, R.J. 1993. Blood residues on stone tools: Indoor and outdoor experiments. World Archaeology 25(1):29–42.

CULLIFORD, B.J. 1964. Precipitin reactions in forensic problems. Nature 201:1092–1094.

DIXON, E.J. 1993 Quest for the origins of the first Americans. Albuquerque, New Mexico: University of New Mexico Press.

DORRILL, M., and WHITEHEAD, P.H. 1979. The species identification of very old human bloodstains. Forensic Science International 13:111–116.

DOWNS, E.F. 1985. An approach to detecting and identifying blood residues on archaeological stone artifacts: A feasibility study. Manuscript on file, Center for Materials Research in Archaeology and Ethnology, Massachusetts Institute of Technology, Cambridge, Massachusetts.

DOWNS, E.F., LOWENSTEIN, J.M., and NEWMAN, M.E. 1992. Issues of comparability in results between different blood residue identification techniques (a 3-way blind study). Paper presented at the 158th National Meetings of the American Association for the Advancement of Science. 6–11 February, Chicago, Illinois.

EISELE, J. 1994. Survival and detection of blood residues on stone tools. Department of Anthropology Technical Report 94-1. University of Nevada, Reno.

EISELE, J.A., FOWLER, D.D., HAYNES, G., and LEWIS, R.A. 1995. Survival and detection of blood residues on stone tools. Antiquity 69:36–46.

GAENSSLEN, R.E. 1983. Sourcebook in forensic serology, immunology, and biochemistry. Washington, D.C.: U.S. Department of Justice.

GAL, R. 1982. Excavation of the Tunalik site, Northwestern National Petroleum Reserve in Alaska. Anthropological Papers of the University of Alaska 20(1-2):61–78.

GERLACH, S.C. 1989. Models of caribou exploitation, butchery and processing at the Croxton site, Tukuto Lake, Alaska. Ph.D. dissertation, University of Alaska Fairbanks.

GERLACH, S.C., and HALL, E.S., Jr. 1986. The view from the hinterland: Cultural resource site mitigation in association with development and operation of the Red Dog Mine, northwestern Alaska. Edwin Hall and Associates Technical Memorandum #24. Manuscript on file, Elmer E. Rasmuson Library, University of Alaska Fairbanks.

———. In press. Northwest Alaska: The Red Dog sites. In: West, F.H., ed. American beginnings. Vol.1. The Archaeology of Alaska and Yukon Territory.

GERLACH, S.C., and MASON, O.K. 1992. Calibrated radiocarbon dates and cultural interaction in the western arctic. Arctic Anthropology 29(1):54–81.

GURFINKEL, D.M., and FRANKLIN, U.M. 1988. The study of the feasibility of detecting blood residue on artifacts. Journal of Archaeological Science 15:83–97.

GUTHRIE, D. 1990. Frozen fauna of the mammoth steppe. Chicago: University of Chicago Press.

HALL, E.S., and GAL, R. 1988. Geology and exploration of the National Petroleum Reserve in Alaska, 1974–1982. Gryc, G., ed. U.S. Geological Survey Professional Paper 1399. Washington, D.C.: U.S. Government Printing Office.

HAMILTON, T.D. 1970. Geological relations of the Akmak assemblage, Onion Portage, Alaska. In: Anderson, D.D., main author. Akmak, an early archaeological assemblage from Onion Portage, northwest Alaska. Acta Arctica. Copenhagen: Munksgaard. 71–78.

HYLAND, D.C., TERSAK, J.M., ADOVASIO, J.M., and SIEGEL, M.I. 1990. Identification of the species of origin of residual blood on lithic material. American Antiquity 55(1):104–112.

KABAT, E.A., and MEYER, M.M. 1967. Experimental immunochemistry. Springfield, Illinois: Thomas.

KIND, S.S., and CLEEVELY, R.M. 1969. The use of ammoniacal bloodstain extracts in ABO groupings. Journal of Forensic Sciences 15:131–134.

KNELL, E.J. 1992. Blood residue on lithic artifacts from northwestern Alaska. Final summary and financial report prepared for the 1992 Geist Fund committee. Unpubl. ms. on file at the University of Alaska Museum, 907 Yukon Drive, Fairbanks, Alaska 99775, U.S.A.

KOOYMAN, B., NEWMAN, M., and CERI, H. 1992. Verifying the reliability of blood residue analysis on archaeological tools. Journal of Archaeological Science 19:265–269.

LOWENSTEIN, J.M. 1992. Prehistoric bloodstains. Pacific Discovery 2:46–47.

LOY, T.H. 1983. Prehistoric blood residues: Detection on tool surfaces and identification of species of origin. Science 220:1269–1271.

LOY, T.H., and HARDY, B.L. 1992. Blood residue analysis of 90 000-year-old stone tools from Tabun Cave, Israel. Antiquity 66:24–35.

MOBLEY, C.M. 1989. The Campus Site, a prehistoric camp at Fairbanks, Alaska. Fairbanks: University of Alaska Press.

MULL, C.G., TAILLEUR, I.L., MAYFIELD, C.F., ELLERSIECK, I., and CURTIS, S. 1982. New upper paleozoic and lower mesozoic stratigraphic units, central and western Brooks Range, Alaska. American Association of Petroleum Geologists Bulletin 66(3):348–362.

NELSON, D.E., LOY, T.H., VOGEL, J.S., and SOUTHON, J.R. 1986. Radiocarbon dating of blood residues on prehistoric stone tools. Radiocarbon 28:170–174.

NEWMAN, M. 1990. The hidden evidence from Hidden Cave, Nevada: An application of immunological techniques to the analysis of archeological materials. Ph.D. dissertation, University of Toronto, Ontario.

———. 1992. Immunological analysis of artifacts from sites in the Brooks Range, northwestern Alaska. Unpubl. ms. Available from the author at the Department of Archaeology, The University of Calgary, 2500 University Dr. N.W., Calgary, Alberta T2N 1N4, Canada.

NEWMAN, M.E., YOHE, R.M., CERI, H. and SUTTON, M.Q. 1993. Immunological protein residue analysis of nonlithic archaeological materials. Journal of Archaeological Science 20:93–100.

NEWMAN, M.E., CERI, H., and KOOYMAN, B. 1995. The use of immunological methods to detect archaeological resources: A reply to Eisele. Unpubl. ms. on file at the Department of Archaeology, The University of Calgary, 2500 University Dr. N.W., Calgary, Alberta T2N 1N4, Canada.

PLAHUTA, J.T. 1978. Geologic map and cross sections of the Red Dog prospect, De Long Mountains, northwestern Alaska. U.S. Department of the Interior, Bureau of Mines Open File Report No. 65-78.

SCHWEGER, C.E. 1976. Late quaternary paleoecology of the Onion Portage region, northwestern Alaska. Ph.D dissertation, University of Alberta, Edmonton.

_____. 1985. Geoarchaeology of northern regions: Lessons from cryoturbation at Onion Portage, Alaska. In: Stein, J.K., and Farrand, W.R., eds. Archaeological sediments in context. Peopling of the Americas, Vol. 1. Orono: Center for the Study of Early Man, Institute for Quaternary Studies, University of Maine. 127–142.

SELKREGG, L.L. 1974. Alaska regional profiles. Northwest Region. Anchorage, Alaska: University of Alaska Environmental Information and Data Center.

SHAFER, H.J., and HOLLOWAY, R.G. 1979. Organic residue analysis in determining stone tool function. Hayden, B., ed. Lithic use-wear analysis. New York: Academic Press: 385–399.

SKOOG, R. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D dissertation, University of California.

SMITH, P.R., and WILSON, M.T. 1990. Detection of haemoglobin in human skeletal remains by ELISA. Journal of Archaeological Science 17:255–268.

SMITH, P.R., and WILSON, M.T. 1992. Blood residues on ancient-tool surfaces: A cautionary note. Journal of Archaeological Science 19:237–241.

TAILLEUR, I.L. 1970. Lead-, zinc-, and barite-bearing samples from the western Brooks Range, Alaska. U.S. Geological Survey Open File Report No. 445.

WASHBURN, A.L. 1973. Periglacial processes and environments. New York: St. Martin's Press.

YOHE, R.M., II, NEWMAN, M.E., and SCHNEIDER, J.S. 1991. Immunological identification of small-mammal proteins on aboriginal milling equipment. American Antiquity 56(4):659–666.