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ARCHAEOLOGICAL SURVEY
OF CANADA
PAPER No. 94

COMMISSION ARCHÉOLOGIQUE
DU CANADA
DOSSIER No. 94

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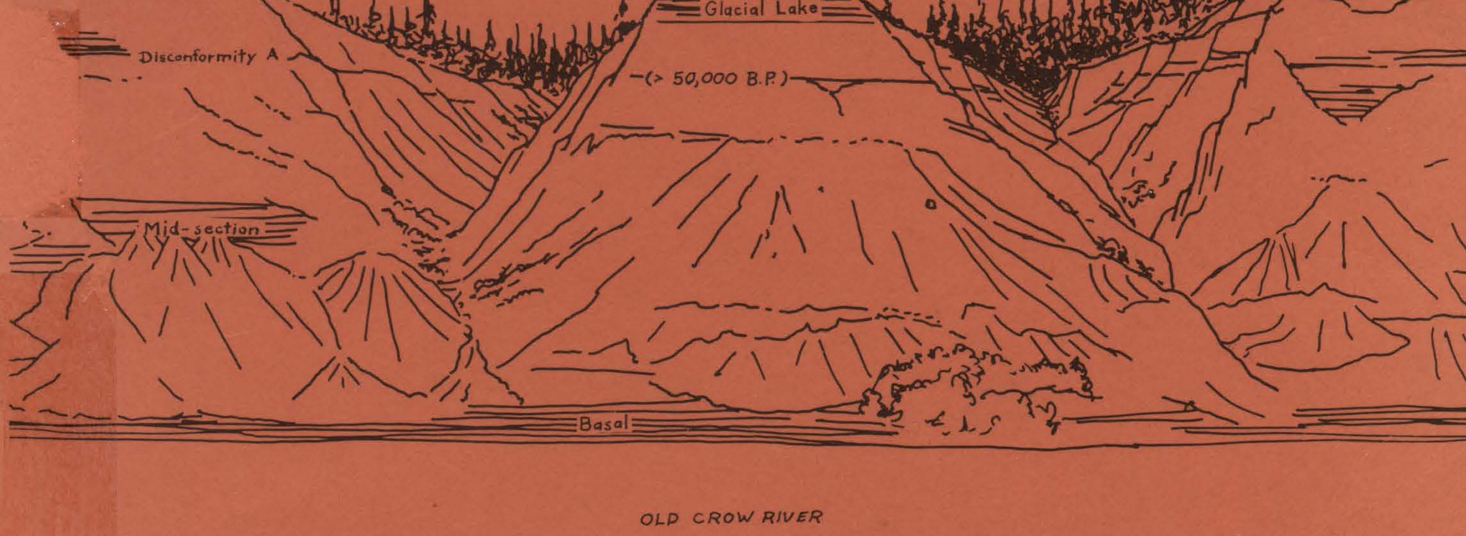
RICHARD E. MORLAN



NATIONAL MUSEUMS OF CANADA

MUSÉES NATIONAUX DU CANADA

OTTAWA 1980

NATIONAL MUSEUM
OF MAN
MERCURY SERIES

MUSÉE NATIONAL
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ISSN 0316-1854

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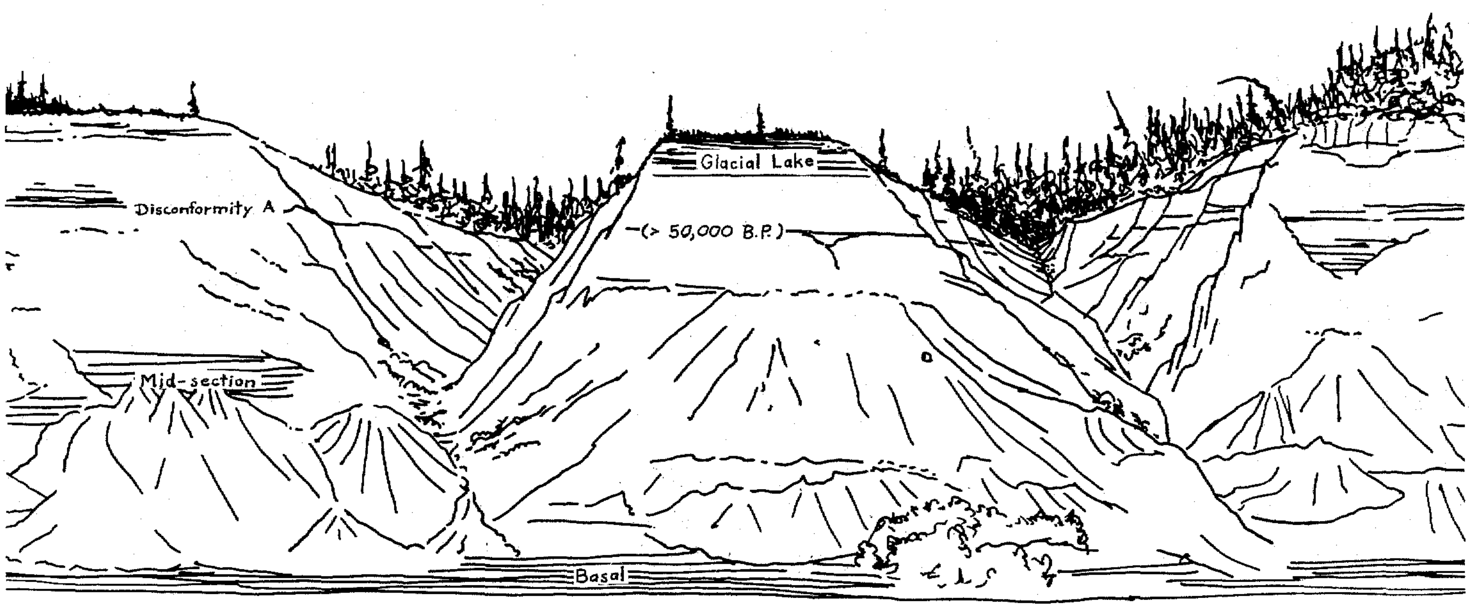

OLD CROW RIVER

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ABSTRACT

Beringia, long heralded as the route of entry for mankind into the New World, has only slowly yielded evidence of ancient human activity. Recently, several areas of Beringia have produced fossilized vertebrate remains which are wonderful for their paleontological significance and both perplexing and promising for their archaeological potential. Some of these pieces have been known for more than 40 years but were difficult to evaluate due to poorly understood stratigraphic contexts and poorly developed analogues for the interpretation of bone, antler, and ivory alterations. During the past 14 years, Old Crow Flats and several other areas of the Yukon Territory have gradually provided tens of thousands of Upper Pleistocene vertebrate fossils among which there are enough artificially modified specimens to increase the archaeological record by a hundred fold. These discoveries have prompted a series of field and laboratory studies specifically designed to improve our analogues for interpreting bone, antler, tusk, and tooth specimens which have been altered by both natural and artificial agencies.

Another recent development is the importation of the concept of taphonomy, originally defined 40 years ago, to the field of archaeology. This integrative concept encourages the view that human activity is but one of many factors which can influence the condition of bone and the composition of bone assemblages between the time of death of an animal and the moment of the recovery of its fossilized remains from the sedimentary contexts in which they have been preserved. This view makes explicit the need to develop carefully documented interpretive analogues with which to improve the assignment of meaning to the alterations of bones and the assemblages in which they occur. One purpose of this report is to review the current status of several aspects of our knowledge of bone alterations and to make recommendations as to how our analogues can be enlarged and improved.

Yet another theme in early man studies during the past decade has been the explicit pronouncement of "standards for evidence" with which to judge purported ancient indicators of human occupation. These so-called standards have been defined in response to the plethora of poorly substantiated claims, the poor quality and quantity of published reports of both fact and fiction in the early man field, and a pervasive feeling of frustration which has arisen from scores of failed promises and from the difficulties encountered by anyone who attempts to decipher the awesome record of confused stratigraphy, unexpected (or undocumented) "dates," and sometimes dubious artifact identifications. There is no doubt that standards of some kind are needed, that we must at least know what our units of analysis should be, but we have gone too far in our definition of "standards." We have forgotten (perhaps forsaken) the fact that archaeologists usually study the results of human behaviour which happen to be preserved in geological deposits. There are only two fundamental assumptions required in this study: (1) that human behaviour can be understood by studying the material results of that behaviour; and (2) that the results of human behaviour are always (or at least usually) separable from the results of various other natural processes. But a third criterion has been forced into the issue, viz., that these presumably interpretable

results of human behaviour must occur in an "archaeological site" where the predominant (if not the only) attributes are attributable to human activity. Hence we are in danger of overlooking (or even omitting by definition) a substantial amount of archaeological information simply because it does not meet standards which have been defined in a very arbitrary way.

In this report I have tried to bring these themes together by examining several collections of Pleistocene vertebrate fossils from the northern Yukon Territory among which an archaeological record can be defined on the basis of a growing series of field observations and experimental studies. Some of these collections can be related to a stratigraphic framework which suggests that human occupation began in the Yukon Territory more than 50,000 years ago -- an age unprecedented in previous data-based reports. The larger significance of this record is not yet clear. For example, the evolutionary status of these early eastern Beringians is unknown, and we know very little about the cultural adaptive capabilities and particular sequence of paleo-environmental changes which permitted or encouraged the appearance of human societies in North America at this time.

None of the indicators of this remarkable archaeological record has been found in an undisturbed "archaeological site," and each specimen has been interpreted in terms of a large series of analogues which are useful regardless of the geological contexts in which the individual specimens and assemblages occur. Many of these analogues deserve a considerable amount of additional study in both the field and the laboratory, and I have indicated in this report where the major weaknesses may lie and how the archaeological interpretation might be successfully challenged. I have also shown that the search for undisturbed archaeological deposits has been systematically narrowed. Current plans for field and laboratory work include comprehensive surveys of the most promising stratigraphic units in the northern Yukon and further studies of many forms of bone, antler, tooth, and tusk alteration which could be misinterpreted and incorrectly attributed to natural or artificial causes.

RESUME

La Béringie, considérée depuis longtemps comme le passage qui a permis à l'homme de pénétrer dans le Nouveau Monde, n'a révélé que lentement les preuves d'une activité humaine ancienne. Dernièrement, on a découvert dans plusieurs régions de la Béringie des restes de vertébrés fossilisés d'une importance considérable pour la paléontologie, et offrant à l'archéologie des perspectives aussi déroutantes que prometteuses. Certains de ces spécimens, connus depuis de 40 ans, étaient néanmoins très difficiles à étudier jusqu'ici en raison de contextes stratigraphiques mal compris et du peu de cas analogues permettant d'interpréter les modifications de l'os, de l'andouiller et de l'ivoire. Au cours des quatorze dernières années, la région de Old Crow Flats et plusieurs autres régions du Yukon ont graduellement révélé des dizaines de milliers de vertébrés fossilisés du Pléistocène supérieur, parmi lesquels se trouvent assez de spécimens aménages pour centupler la documentation archéologique existante. Ces découvertes ont donné lieu à une série d'études en laboratoire et sur le terrain, destinées expressément à améliorer les analogues dont nous disposons pour l'interprétation des spécimens d'os, d'andouillers, de défenses et de dents modifiés

par des agents naturels ou artificiels.

Citons un autre progrès important, à savoir l'application des principes de la taphonomie, définis il y a 40 ans, au domaine de l'archéologie. Ce concept part du point de vie que l'activité humaine n'est qu'un des facteurs qui peuvent influencer l'état des os et la composition des assemblages entre la date de la mort de l'animal et le moment où l'on recueille les restes fossilisés des milieux sédimentaires qui les ont préservés. Ce principe explique la nécessité de développer des analogues d'interprétation bien documentés, afin de pouvoir préciser davantage le sens des transformations subies par les assemblages d'ossements ainsi que par les pièces osseuses individuelles. L'un des buts du présent rapport est de passer en revue, sous divers aspects, l'état actuel de nos connaissances sur les transformations des os, et de formuler des recommandations sur les moyens d'augmenter et d'améliorer nos analogues d'interprétation.

Au cours des dix dernières années, un autre thème dans l'étude des paléo-amérindiens a été l'élaboration explicite de normes, destinées à évaluer les indices possibles d'activité humaine. Ces prétendues normes ont été définies en réponse à une prolifération d'affirmations sans fondement, de la mauvaise qualité des rares rapports portant sur ce sujet, qu'ils s'appuient sur des faits ou des hypothèses, et d'un sentiment de frustration constante causé par des dizaines de fausses promesses et par les difficultés que rencontrent tous ceux qui tentent de déchiffrer la somme imposante de documents stratigraphiques confus, de "dates" inattendues (ou mal documentées) et d'identifications souvent douteuses d'objets. S'il ne fait aucun doute que certaines normes sont nécessaires, et que nous devrions au moins savoir en quoi doivent consister nos unités d'analyse, nous sommes cependant allés trop loin dans la définition de "normes". Nous avons oublié (consciemment ou non) que les archéologues étudient des témoignages d'activité humaine qui se trouvent par hasard préservés dans des dépôts géologiques. Cette démarche ne sous-entend que deux prémisses: (1) on peut étudier l'activité humaine à partir de ses résultats matériels; et (2) ces résultats sont toujours (ou souvent) indépendants de ceux d'autres processus naturels. Cependent, on a cru devoir ajouter un troisième critère, selon lequel ces résultats de l'activité humaine, vraisemblablement interprétables, doivent être trouvés dans des "sites archéologiques" dont l'ensemble des données ne serait imputable qu'a l'activité humaine. Par conséquent, nous courons le risque de négliger (ou d'omettre par définition) une grande quantité d'information archéologique, tout simplement parce qu'elle ne se conforme pas à des normes établies de façon très arbitraire.

Dans ce rapport, j'ai tenté de rassembler ces thèmes en examinant plusieurs collections de fossiles de vertébrés du Pléistocène provenant du Yukon septentrional, et à l'aide desquels on peut établir une documentation archéologique fondée sur un nombre croissant d'observations sur le terrain et d'études expérimentales. Certaines de ces collections peuvent être rattachées à cadre stratigraphique qui ferait remonter à 50,000 ans la présence de l'homme dans le Yukon -- date sans précédent dans un rapport basé sur de données. Or, on ne connaît pas encore la portée de cette documentation dans toute son étendue. On ignore par exemple le degré d'évolution de ces premiers habitants de la Béringie orientale, et on connaît fort peu de choses sur le potentiel culturel d'adaptation et sur la séquence particulière de transformations du paleo-milieu qui ont permis ou incité l'établissement de sociétés humaines en Amérique du Nord à cette époque.

Aucun des indices de cette documentation remarquable ne provient d'un "site archéologique" intact, et chaque spécimen a été interprété en fonction d'un grand nombre d'analogues dont l'utilité est sans égard au contexte géologique des spécimens ou de leurs assemblages. Nombre de ces analogues demandent encore une étude complémentaire poussée, tant sur le terrain qu'en laboratoire; dans ce rapport, j'ai indiqué où peuvent se trouver les principaux points faibles, et comment l'interprétation archéologique pourrait être contestée avec succès. J'ai aussi expliqué dans quelle mesure la recherche de dépôts archéologiques intacts devient de plus en plus serrée. Parmi les projets actuels de recherche en laboratoire et sur le terrain, mentionnons l'étude des unités stratigraphiques les plu prometteuses du nord du Yukon et l'étude approfondie de certaines modifications des os, des andouillers, des dents et des défenses qui peuvent être mal interprétées et attribuées par erreur à des agents naturels ou artificiels.

Le personnes désireuses de recevoir en français de plus amples renseignements sur cette publication sont priées d'adresser leurs demandes à:

Commission archéologique du Canada
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Musées nationaux du Canada
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PREFACE

Background

Beringia is a physiographic and biogeographic province of continental proportions which has had a profound influence on both terrestrial and marine life, on climate in the Northern Hemisphere, and on the peopling of the New World. In the broadest sense, with reference to phytogeography, it stretches from the Taimyr Peninsula and Khatanga River on the west to the Boothia Peninsula and Parry Islands on the east, and it reaches southward to include the Kamchatka Peninsula, the Aleutian Islands and Lake Athabaska (Yurtsev 1974). Much of this enormous area remained unglaciated during the Pleistocene and therefore comprised a significant refuge for the survival of plant and animal species which could disperse into newly deglaciated areas at the close of each glacial maximum (Hultén 1937, 1968; Gressitt 1963; Hopkins 1967a; Sher 1974; Kontrimavichus 1976; Harington 1978). It is this unglaciated portion of Alaska and the Yukon which is called "eastern Beringia" in this report. Near the center of Beringia an area of shallow seas covering broad continental shelves as much as 1000 miles (1600 km) from north to south has alternately been exposed as land and drowned beneath the Chukchi and Bering Seas (Hopkins 1973). When exposed, as during some glacial periods, this area, known as the Bering Land Bridge, permitted faunal exchanges between Siberia and Alaska/Yukon, and when the continental shelves became flooded by marine waters during interglacial and interstadials, faunal exchanges could occur between the Arctic and Pacific Oceans.

Beringia is not merely an avenue for faunal exchanges, however, for it has also been a center for evolution of many forms, and it has sometimes been characterized by very distinctive, even unique, biotic and climatic characteristics (e.g., Barry 1979; Gal-Chen 1979; Guthrie 1979; Matthews 1979; Ritchie and Cwynar 1979; Young 1979). Of the many mammal species which crossed the Bering Strait area and adapted to the evolving ecosystem of Beringia, one of the most interesting is our own species. Since man did not evolve in the Western Hemisphere, the search for a route from the Old World to the New has included many suggestions as to the paths which might have been followed, but the Bering Land Bridge nearly always stands out as the most likely route since so many other mammal species are thought to have reached the Nearctic by this means. Nonetheless Beringia has yielded actual evidence of early human occupation only recently. Only during the past decade has there been a significant increase in archaeological research dedicated to this relatively little known region, and many large scale projects, some of them stimulated by proposed land development, have been fielded in Siberia, Alaska, (e.g. Cook 1970, 1977) and the Yukon and Northwest Territories (Cinq-Mars 1973, 1974, 1975). Many of these projects have included specific attention to the peopling of the New World. Mochanov's work in the Lena Basin began in the 1960's but has been published in detail only during the last decade, and it has included a specific focus on the relevance of new finds to the problems of New World origins (Mochanov 1977, 1978a, 1978b); several of Mochanov's colleagues have likewise demonstrated a keen interest in this problem (Abramova 1973; Dikov 1978; Derevianko 1978).

The North American contributions of the last decade can be divided into two major categories: (1) final Wisconsinan and early Holocene sites, some of which are stratified and some of which can be related to the new Siberian evidence; and (2) poorly stratified and redeposited fossil vertebrate remains which are altered in various ways more or less suggestive of human activity. Important new or recently reported sites of the first kind include Akmak (Anderson 1970), Healy Lake (Cook and McKennan 1968, 1970, 1971; McKennan and Cook 1968), Putu (Alexander 1974), Gallagher Flint Station (Dixon 1975), Girl's Hill (Gal 1976), Batza Tena (Clark and Clark 1975), Dry Creek (Thorson and Hamilton 1977; Powers and Hamilton 1978), Kikavichik Ridge and Dog Creek north of Old Crow Flats (Irving and Cinq-Mars 1974; Cinq-Mars 1978, pers. com. in 1979), Bluefish Cave (Cinq-Mars 1979), and various sites which form the basis for defining the Ugashik Narrows phase and Koggiung Complex on the Alaska Peninsula (Dumond, *et al.* 1976) and the Denali complex on the north side of the Alaska Range (West 1967, 1976). This short list comprises a wealth of data when compared with the scanty information available to Laughlin (1967), Müller-Beck (1967), and Hopkins (1967b) when *The Bering Land Bridge* was published.

This report is devoted primarily to the second category of evidence which has been derived from the study of altered bones preserved as fossils in various contexts in Alaska and the Yukon Territory. Appropriate citations will be mentioned later in the report, and here I wish to outline some of the concepts which stimulated this work and some of the historical background from which my research developed.

Altered bones comprise a very complex kind of record which has a significant bearing upon paleontology, paleoecology, and archaeology. The announcement that altered bones from the Yukon provide New World evidence of human occupation of unprecedented antiquity was greeted with mixed reactions from the archaeological community at large. For several reasons, this mixed reaction is not surprising. Some of the reactions were in line with expectations and represented little more than prejudice. So much of early man research is unpublished that an archaeological oral tradition is often the daily guide for interpretation, and many archaeologists are firmly committed to a particular view of New World origins or to a particular date for the time of man's arrival in the Western Hemisphere. Thus it was to be expected that a radically new kind of evidence for early human occupation would be entertained enthusiastically in some quarters, with a grain of salt in others, and not at all in a few. Scepticism has arisen because of the apparent age of the evidence, because it involves bone alterations rather than lithic craftsmanship, because it has been recovered from reworked deposits rather than from "archaeological sites," and because of a number of other considerations which will be discussed at length in this report.

Not all of the reactions have been sceptical, and some of them have even been too enthusiastic and are marred by too little critical appraisal. Many archaeologists have made very useful suggestions and constructive criticisms, and one purpose of this report is to show how these probes have been useful in stimulating a more holistic view of the vertebrate collections.

This is the third monograph on these collections. Harington's (1977) dissertation on the paleontology of the vertebrates from Old Crow and Dawson has been an invaluable work in understanding the possible role of man in relation to the many taxa which have been recovered from these regions. Bonnichsen's (1979) analysis of artifacts collected as of 1973 has been a fundamental point of departure and an immeasurable valuable aid in organizing the collections and interpreting individual specimens. In this report I have attempted to strengthen the already substantial contributions of both of these earlier monographs by covering new ground which is relevant simultanously to both paleontological and archaeological goals. Harington's study focussed primarily on the classification of cranial material and of the biogeography of each identified taxon, and Bonnichsen's analysis necessarily dealt with a selection of specimens thought to be attributable to artificial interaction with the megafauna of eastern Beringia. In this report I have attempted to elucidate the entire complex suite of alterations which are visible on these fossils and thereby provide a more comprehensive explanation for the many processes which have acted upon individual bones and bone assemblages between the time the animals died and the time we collected their fossilized remains. I did not assume that man was involved in this series of alterations, and only a year ago I still believed (and even hoped) that the entire record could be explained without postulating the presence of humans in the Old Crow basin. In the final analysis I have identified a possible time of arrival for human groups in the northern Yukon Territory, and I have indicated how little we know of these early people. I have not found it possible to account for the evidence afforded by some of these fossils without supposing that artificial activities were among the altering processes which produced visible and preservable marks of the bones.

When the Old Crow region is mentioned in the early man literature it is usually with reference to bones, and there seems to be a growing misconception that the evidence from the northern Yukon Territory supports the old idea (e.g., Menghin 1963) that early societies made their artifacts almost exclusively from bone and only later began to make many of their tools from stone. This is emphatically not the case, and I wish to make it clear at the outset that the existing archaeological record shows already that a significant (but poorly known) lithic industry was associated with the fossils (Chapter 8; Morlan 1980). A second misconception is that one can refer to the "site of Old Crow" (Davies 1979:34) as the source of the material to be discussed in this report; the "site of Old Crow" is a Kutchin Indian village on the north bank of the Porcupine River just below the mouth of the Old Crow River, and the sources of the fossil materials include nearly 200 localities not a single one of which can be shown to be an "archaeological site."

Narrative

I was introduced to the Old Crow region in 1967 when Jacques Cinq-Mars and I worked as field assistants for W.N. Irving, then employed as Head of the Western Section in the Archaeology Division, National Museum of Man, Ottawa. I was looking for a topic on which to write a PhD dissertation, and I asked Irving if some aspect of the exciting but scarcely glimpsed record of human alterations on the Pleistocene fossils could not be isolated for that purpose. Irving replied that it would not be wise to select an early man topic such as that one for a dissertation, because there was too much danger of failing to find a definable archaeological problem even after several years of work. Now, of course, I could not agree more.

In 1969, Irving moved to the University of Toronto, and I was hired by the National Museum of Man to assume the responsibilities of Yukon Archaeologist. In the first year in Ottawa I proposed to organize a

"Northwestern Refugium Biological Survey" which would embrace a wide range of disciplines including archaeology with the goal of searching for early human occupation as well as enlarging the fossil record to supplement biogeographic concepts centered on the unglaciated areas of Beringia. Funding could not be secured at that time, and the proposal was filed with little hope that it could be resurrected.

George F. MacDonald, then Chief, Archaeological Survey of Canada, National Museum of Man, attended the 1973 INQUA conference in Christchurch, New Zealand, and he was alarmed to note that North America was one of the few continents very poorly represented in the sessions on early human occupation. MacDonald returned to suggest that we explore the possibility of launching a more deliberate search for early man in Canada, and I wrote a proposal for the Yukon Refugium Project which passed through the usual budgetary classifications and emerged for funding in the 1975 field season. Meanwhile Robson Bonnichsen had been working on the Yukon collections amassed as of 1973, and his headquarters in Ottawa permitted us to work together on the concept of the new project. Soon thereafter Bonnichsen moved to the University of Maine, Orono, and began the development of a series of early man studies as well as the completion of his monograph on the Yukon collections (Bonnichsen 1979).

I made up lists of general topics which should be embraced by the Yukon Refugium Project, and each list was accompanied by a list of scholars who might be interested in undertaking a portion of the work. From the outset, however, I had planned that each participant, regardless of his specific training, should agree to work with the others in the field. Too often the multi-disciplinary framework has been beautifully defined on paper but has collapsed in the field as each specialist followed his own nose to the "best" exposure for his needs. I was reminded of the enthusiasm with which Johnson and Raup (1964:3-4) wrote of their collaborative work in the 1940's in southwest Yukon: Johnson, the archaeologist, assisting Raup in the collection of plants or coring of trees, and Raup, the botanist, excavating with Johnson on an archaeological site, and all the while the enlightening and stimulating discussion of the past expressed in terms of common problems which are larger than our disciplinary boundaries. I explained these thoughts to each person I called upon for possible participation in the Yukon Refugium Project, and each of them agreed that the framework sounded interesting and useful. It was clearly stated that none of the other disciplines would be seen in a service role with respect to archaeology and that each participant would be responsible for defining his own special research problems and for identifying ways in which his specific talents could contribute to the larger integrative problem of reconstructing Pleistocene paleoenvironments in the unglaciated areas of the Yukon Territory.

I was quite fortunate to find each of the people I called both available to join the project and enthusiastic about its rationale. Owen L. Hughes, Geological Survey of Canada, agree to conduct his continuing work on the stratigraphy of the northern Yukon as the central point of reference in the Yukon Refugium Project. C.R. Harington, National Museum of Natural Sciences, likewise agreed to align his continuing work on vertebrate paleontology with the larger framework provided by the new project. John V. Matthews, Jr., Geological Survey of Canada, had already completed the analysis of insects and plant macrofossils from some of Hughes' samples, and he eagerly accepted this opportunity to conduct field work in the region. Charles Schweger, University of Alberta, was nearing the completion of his palynological work on the Koyukuk drainage in Alaska, and he was anxious to embark upon a comparable study in localities similar to those of north-central Alaska, N.W. Rutter, University of Alberta, was establishing a new laboratory for amino acid racemization analysis, and this project offered opportunities to test a wide variety of sample materials from a long sequence of correlatable deposits. Each of us brought financial and laboratory support from his institution so that the Yukon Refugium Project has been co-sponsored by the National Museum of Man, the National Museum of Natural Sciences, the Geological Survey of Canada, and the University of Alberta.

In the fall of 1974, as these plans were being formulated, I learned of a proposal by W.N. Irving and J. Cinq-Mars to organize the Northern Yukon Research Programme at the University of Toronto. We met to explore the many ways in which the two projects could collaborate in both the field and laboratory aspects of the work and soon discovered that the two projects were defined quite differently although both of them were planned as large scale multidisciplinary studies. The Northern Yukon Research Programme was conceived as a means of examining all aspects of the prehistoric sequence in the Old Crow region of the northern Yukon including the Upper Pleistocene fossils, the Holocene archaeological record, and various ethnographic aspects most relevant to these archaeological problems. The Yukon Refugium Project, on the other hand, was specifically focussed upon the Pleistocene record of all areas of the Yukon Territory which were in or near the unglaciated refugium; although the Holocene would not be steadfastly ignored, it would not be deliberately or systematically studied as a part of the project except to recover reference materials (e.g., modern pollen rain, modern plants and insects, modern detritus samples) which could be used as analogues for the interpretation of the Pleistocene samples. We realized that the two projects together created a better opportunity than either of them singly to discover significant materials for the elucidation of early archaeological manifestations in the Yukon and that the area of overlap in the Pleistocene of the Old Crow region would provide a common reference point for integrating the results of both projects.

Further details concerning the actual field work conducted during each year of the project will be provided elsewhere (Hughes, *et al.* 1980), but some aspects of this history of research are relevant to this report and will be summarized briefly. In 1975, we spent a few days on the Stewart River and in the Dawson area and devoted the balance of one month of field work to the Old Crow region. This included a familiarization tour to exposures in the Bell, Bluefish, and Old Crow basin, and one locality on the Rat River east of McDougall Pass. Many of these localities had been visited previously only by Hughes, and the rapid pace of helicopter-supported one day visits to these enormous profiles of sediment was one of the most exciting but sometimes bewildering experiences I have ever had. Quite often we landed the helicopter near the base of the exposure where we would soon begin to find interesting stratigraphic problems and productive fossil deposits, and by the end of the day we had seldom scaled the entire exposure and usually had little knowledge of the upper part of the profile. From the standpoint of archaeological reconnaissance this procedure may have been somewhat unfortunate, because it now appears that the upper part of the profile is the best place to look for undisturbed archaeological remains. It is important to understand that the Old Crow region offers an embarrassment of riches to the stratigrapher, and we were already aware of the fact that we were searching for an archaeological needle in an enormous sedimentary haystack. We now realize that it is not surprising that we did not find archaeological evidence in the units we examined in 1975, and we were encouraged to climb higher on the bluffs in later years.

In 1976, Hughes, Schweger and I spent three weeks in the Bonnet Plume basin with productive results in terms of stratigraphy and paleoecology but completely negative results with respect to archaeology. Hughes and I visited the Old Crow region briefly near the end of our field season, and Rutter began intensive collecting there for his amino acid work while we discussed stratigraphic problems with John Westgate and W.N. Irving.

In 1977, we sampled at Silver Creek in southwest Yukon (Schweger and Janssens n.d.), returned to the Stewart River exposures, and spent most of the field season in the Old Crow region. By searching the middle and upper portions of several exposures we discovered a major floodplain on which archaeological remains represent the oldest evidence of human activity which we have been able to date in this area. The ensuing analysis of these materials encouraged us to return to this stratigraphic unit in 1978 when we found additional archaeological evidence apparently in point bar deposits associated with the floodplain. We also made a number of scattered finds in other stratigraphic contexts in these exposures, but I now believe that we must search intensively a five meter thick zone of the profile above the ancient floodplain but below a glacial lake deposit which forms a widespread stratigraphic marker in all the basins of the northern Yukon. Hence our field work thus far has improved our understanding of the stratigraphic haystack and narrowed the search for the archaeological needle. We have found solid evidence of human activity in some very ancient stratigraphic contexts, but we have not yet found an undisturbed archaeological site which could provide a better understanding of human adaptation to the ancient environments of eastern Beringia. A systematic search for such a site will begin in 1980.

My 1979 field season was devoted to travel in Europe where I participated in Burg Wartenstein Symposium No. 81 on "Paleoecology of the Arctic Steppe-Mammoth Biome," to a one week trip to Old Crow for the filming of a segment of "Seeking the First Americans" (Chedd 1980), and to analysis and writing on the data collected thusfar. This report is Contribution No. 58 of the Yukon Refugium Project.

Acknowledgements

During five years of multi-disciplinary work I have received invaluable assistance from many colleagues, friends, and institutions. My project co-workers, Harington, Hughes, Matthews, Rutter, and Schweger, have provided me with field and laboratory experience which amounts to post-doctoral training in stratigraphy, paleontology, and paleoecology, and I thank them for permanently altering my view of archaeology and equipping me to take a more holistic approach to the study of paleoenvironments. I am especially indebted to Dick Harington who, assisted by G.R. Fitzgerald, Peter Lord, and

Charlie Thomas, has collected the majority of the specimens described in Chapter 4 and who has generously transferred nearly all archaeologically significant pieces to the collections of the Archaeological Survey of Canada, National Museum of Man. The study of bone alterations, which is the major focus of this report, was undertaken "from scratch" in recent years and could not have advanced quickly enough to produce this report without the assistance and encouragement of Robson Bonnichsen, Jacques Cinq-Mars, Gary Haynes, and Dennis Stanford.

Associates during field work, in addition to the project personnel, provided many stimulating avenues of research which were not specifically mentioned above, and I thank each of them: Miguel Bombin (opal phytoliths), Steve Chatwin (soils), Steve Hopkins (Tertiary pollen), Jan Janssens (sub-fossil bryophytes), Rob Roughley (modern insects), and Pamela Waters (Glacial lake stratigraphy). I was very ably assisted in the field by Heather Morlan, David Parama, Anna Sawicki, Robert Vance and Keary Walde. Invaluable assistance was also provided by several residents of Old Crow -- Alfred Charlie, Kenny Charlie, David Lord, and Charlie Thomas -- and I wish to express my thanks in general to the Old Crow band for the understanding and interest they have shown in this work. Several visitors to the field both broke the monotony of camp life and contributed to our work through advice and encouragement: David M. Hopkins, Linda Johnson, Roger Marois, Edo Nyland, and Lee Ann Porter.

Other visitors assisted by carrying stories on our work to the public by means of the print and electronic media: David Cummings and Walter Wicks (CBC:"Science Magazine"), Tom Canby and Kerby Smith (National Geographic Magazine), Max Fraser (Whitehorse Star), and Graham Chedd, Peter Hoving, Colin MacNab, and Marian White (PBS: "Odyssey"). I am grateful for the interest shown by these and many other media people who perceive the popular appeal of early man research and have often taken great pains to ensure that the message was delivered with accuracy and balance.

During laboratory work on the collections and samples I have been greatly assisted by Catherine Craig, Jean Langdon, and Anna Sawicki. Special problems with particular specimens have been solved by C.R. Harington and G. R. Fitzgerald, Paleobiology Division, National Museum of Natural Sciences (NMNS); by David Campbell and Stan van Zyll de Jong, Mammalogy Division, NMNS; by Joel Grimes, Minerology Division, NMNS; by David Walker, Geological Survey of Canada; by John E. Guilday, Carnegie Institute; and by Lawrence Angel and Clayton Ray, Smithsonian Institution, and Richard Tedford, American Museum of Natural History. The staff of the National Museums library, especially including Jean-Guy Brisson, Lorna Kibbee, Bill McLennan, and Tina Mathiison, exceeded the call of duty by supplying my hundreds of requests for articles and books including many references in the medical literature which were obtained on inter-library loan.

In addition to members of the Yukon Refugium Project, a number of colleagues have exerted important influences on this work through conversations and correspondence: L.R. Binford, R. Bonnichsen, François Bordes, Alan L. Bryan, J. Cinq-Mars, R. Dale Guthrie, C. Vance Haynes, Gary A. Haynes, W.N. Irving, Don L. Johnson, Richard G. Klein, George F. MacDonald, Paul Martin, D. Stanford, James V. Wright, and Masakazu Yoshizaki. During travels in Siberia and European Russia I was graciously aided by Z.A. Abramova, A.P. Derevianko, IU A. Mochanov, E.A. Okladnikova, A.P. Okladnikov, S.I. Tseitlin, R.S. Vassilievsky, and N.K. Vereschagin. In Czechoslovakia, I was welcomed by B. Klíma and K. Valoch, and in Germany by Gerd Albrecht, Joachim Hahn, Martin Jaguttis-Emden, and Karl Rieder. I greatly appreciate the two-week tour of sites and museums provided by Hansjürgen Müller-Beck whose knowledge and friendship have been very stimulating for a dozen years. The opportunity to travel in Europe was provided not only by the National Museum of Man but also by the Wenner-Gren Foundation for Anthropological Research which supported the symposium at Burg Wartenstein, and I wish to express special thanks to Lita Osmundsen and her staff for one of the most inspiring weeks of my life in that venerable castle in Austria.

This manuscript has occupied nearly all my attention for more than a year. It has been completely reorganized several times, and each draft has been improved through the advice and critical appraisals of Robson Bonnichsen, Jacques Cinq-Mars, George F. MacDonald, and John V. Matthews, Jr. I have been in almost daily contact with Cinq-Mars and Matthews, neighbours and friends, who might justifiably claim co-authorship for portions of this report but have perhaps wisely refrained from doing so until it is reviewed. In addition to the usual disclaimer as to their lack of responsibility for errors which I may have committed in this study, it is appropriate to note that there are several minor substantive points on which we do not entirely agree; obviously, in such cases, I have presented my own views as they will do in turn.

The physical appearance of the report has been given careful attention with many hours having been devoted to photography and drafting. Although I organized the manuscript, exposed the film, and typed the tables, the final appearance of the illustrations is a credit to the drafting skills of David W. Laverie and the darkroom abilities of Sterling Presley. The cover illustration and remarkable sketch of an Old Crow River bluff which appears in Chapter 6 were provided by the pen of Keary Walde who also supplied several beautiful and humorous drawings which could not be incorporated in this publication but will likely be seen in slide shows on the Old Crow materials. The text was typed by Barbara von Briesen.

In the final analysis, my greatest debt is to my wife, Heather, who assisted in the field as excavator, cataloguer, note-taker, cook, quartermistress, companion, and entertainer. At home she patiently endured a year of manuscript widow-hood while I transformed our basement into an office and laboratory cluttered with piles of reprints and books and the esoteric debris of microscopic sample preparation. She cheerfully hosted a one-week encampment of elephant butchers and a ten-day workshop of the Yukon Refugium Project and merely asked that we help with the dishes.

This report is dedicated to my grandmother, Edna Eugenia Morlan, who introduced me to the wonders of the natural world and a sense of ecological relationships and who nursed me through my first bad case of poison ivy.

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CHAPTER 1. INTRODUCTION

A Climate of Controversy

One of the most frequently and vigorously reviewed subjects in New World archaeology is the initial colonization of the Western Hemisphere. A climate of controversy seems always to have surrounded the subject. The controversy was started early in this century by uncritical claims for great antiquity based on flimsy or even fraudulent evidence. Such claims accumulated to form a supposed sequence which Wilmsen (1965) has called the "long chronology" spanning between 10,000 and 100,000 years in North America. The controversy continues to be fueled by poorly documented claims, reluctance or failure to publish important evidence, a tendency on the part of many workers to advocate a position on the subject (Lorenzo 1978; Alexander 1978), and the need for better criteria with which to recognize artificially modified stones, bones, and assemblages (Stanford 1979a). A number of recent reviews of early man "sites" in North and South America bear little resemblance either to one another (cf. Lynch 1974, 1978a; MacNeish 1976, 1978; Rouse 1976; Bryan 1973, 1978a; Griffin 1979), or to summaries in more popular media (e.g., Canby 1979; Davies 1979; Chedd 1980)) and the appearance of replies and rejoinders to such reviews seems to be gaining momentum (e.g., Haynes 1974; Bryan 1975; Lynch 1978b).

Several themes are shared by many of these and other early man reviews. The supposed route of entry into the New World is consistently believed to have lain in the Bering Strait area between Alaska and Siberia, but there has been until recently a frustrating lack of early archaeological evidence on both sides of Bering Strait. The route through Beringia was selected logically on the basis of its feasibility and its known role in the dispersal of other vertebrates (Harington 1978).

Many expectations concerning the time of human settlement in the New World have been phrased strictly in terms of two major "valves" which supposedly would have blocked or permitted movements of people and other animals from Northeast Asia through Beringia to central North America. These valves are known as the Bering Land Bridge and the Ice-Free Corridor, and geological evidence for their emergence and closure, respectively, has been highly prized and hotly debated in the archaeological literature. During the past decade, these valves have been declared essentially irrelevant as physical barriers (Johnson 1970; Irving 1971; Reeves 1973), and interest has shifted to their possible implications as ecological filter barriers which could have limited dispersal, human communication, and gene flow. "The Bering Strait area was probably a filter barrier of this type prior to 25,000 years ago and again after 14,000 years ago" (Hopkins 1979:35) with the intervening period offering a bridge of land connecting Siberia with Alaska (see also Hopkins 1973 for this and earlier periods).

The situation in the Ice-Free Corridor is somewhat more ambiguous with data of surficial geology suggesting a significant coalescence of Laurentide and Cordilleran ice between 55° and 60° N. lat. during the climax of the classical Wisconsinan (Rutter 1978; Mathews 1978). On the other hand, radiocarbon dates from a lake core taken within the southern edge of this zone imply ice-free conditions during this same interval (White, *et al.* 1979). In any case even near coalescence must have produced very severe local conditions for most life forms (Morlan 1977a:100; Stalker 1978:21), but we have very little real information from the fossil record to assist efforts to interpret the paleoecology of the corridor area during the late Wisconsinan (Ritchie 1978).

Just as the dimensions of time and space have been subjects for extended theorizing, the content of early human cultural assemblages has been repeatedly "described" despite the general lack of empirical evidence which could supply guidance to the exercise (e.g., Bryan 1978a:307; 1978b: 339). The complex history of discredited and controversial early or putatively early sites has led to some acceptance of certain standards for evidence regarding early man in the New World.

Standards for Evidence

The minimally acceptable site must provide undisturbed horizontal patterns of readily recognizable artifacts in datable stratigraphic contexts, preferably associated with faunal remains and other paleoenvironmental indicators. Jennings (1974:76) apparently expects the regional geological picture to be reconstructed in advance since the "stratum of occurrence should be identifiable as a part of, or related to, geologically understood phenomena over a reasonably wide area," and he also ("with luck") wants "one or more distinctive artifact types represented in the collection [to serve as] 'index fossils'" In addition to these, Griffin (1979:44) wants definable activity areas, pollen and macrobotanical materials, human skeletal remains, radiocarbon dates cross-checked by other dating techniques, and agreement among all lines of evidence as to age, season, environment, and "cultural level of the occupants of the site." Satisfaction of these criteria would make a site "readily acceptable to most archaeologists," and failure to meet these criteria makes any discovery "open to question, rejection, or suspended judgement" (Griffin 1979:44) So pervasive is our paranoia over "equivocal" evidence that even the champions of deliberate searches for more ancient sites have fallen prey to the sceptics by specifying that only undisturbed stratified sites can be considered as evidence (Bryan 1979; Drew 1979:270).

If these are indeed our standards for acceptable evidence we may long await the resolution of the problems pertaining to early man in the New World. When Griffin (1979:44) points to the Eastern Hemisphere for examples of continents on which these criteria have been satisfied, he ignores the fact that several phases of early Old World archaeology, particularly in Europe and Southeast Asia, would evaporate if judged by these standards. Certainly the ideal site would make a valuable contribution to our understanding, but I believe that we must be willing to give serious credence to the careful study of ostensibly less compelling evidence if only to alert ourselves to the kinds of material which should be sought in undisturbed, well preserved contexts. If paleontologists were expected to work only with articulated skeletons found in association with large numbers of like specimens representing the same environment and temporal position we would know precious little about the evolution of most organisms. If geologists were required to trace every formation over distances matching the scale of geological processes we would know very little about the evolution of the earth's surface.

Much of the material to be presented in this paper departs in several respects from the kinds of "acceptable" evidence described above. We will examine a body of archaeological evidence which is only dimly perceived in stratigraphic context, which is very poorly dated, which is based largely upon bone alterations which are often very difficult to interpret and from which our evidence for contemporaneous lithic artifacts must be inferred. We will examine a large collection of permineralized vertebrate fossils among which are numerous specimens modified by man, mostly during the late Pleistocene, when the bone was fresh or green. Modifications thought to have been produced by natural agencies will be defined and subtracted from the total collection in order to illuminate the artificially induced patterns of alterations which provide our earliest dated evidence for human occupation in the New World. Most of these specimens have been collected from secondary deposits totally divorced from their original stratigraphic positions, but a small body of material can be placed in stratigraphic contexts for which a general idea of chronology can be derived. Indirect but conclusive evidence for the contemporaneous existence of lithic tools will be derived from the study of the fossilized bone and antler pieces, but the precise nature of the lithic tools cannot be inferred at the present time (Morlan 1980). The resolution of many aspects of this evidence must await the discovery of undisturbed habitation sites, but the basic outline of a prehistoric picture can be perceived through the data already at hand.

In this paper we will outline evidence from the Porcupine drainage of the northern Yukon Territory (Northeastern Beringia) where it can be demonstrated that human groups were present much earlier than has been shown farther south in the Western Hemisphere. This new-found temporal priority does not automatically solve many of our problems in reconstructing the peopling of the New World. Our evidence has not yet been obtained in the form of demonstrable assemblages which would permit a reconstruction of cultural patterns belonging to a single historical group of people. Opportunities to cite useful comparisons with other areas, either in Eurasia or in the New World, are very limited outside Beringia, because relatively few altered bones have been reported in the literature except for those which are shaped by cutting to form finished tools of comprehensible function or artistic expressions which can take a wide variety of forms (e.g., Abramova 1967). For many of the specimens which I have advanced as artifacts in this report, I have little or no understanding of why they were modified although I can make very specific statements about how they were modified. This fact highlights a major theoretical and methodological issue which pertains to the development of suitable analogues and control samples to support the interpretation of altered bone.

Development of Analogues

There is nothing new about the idea that cultural information can be extracted from fragmentary bone remains, and there is very little new among the numerous cautionary notes which must be carefully considered in such an analysis.

> In conclusion, it is necessary to refer to a certain class of other phenomena observed occasionally in connection with human and especially animal bones, and sometimes brought

> forward as proofs of man's antiquity. This applies to the split or splintered bones and to those that show various scratches, striae, cut, or perforations, which appear to be due possibly to human agency. ...So far as the writer has been able to learn and so far as he can conceive, there is no safe means of distinguishing between the fracture effect of a blow by man on bone recent or ancient and that of a stroke on such bone by the hoof of an animal or by impact of falling stone or earth, fragmentation by the teeth of large carnivores, or, in the case of buried skeletal remains, crushing by the weight and movements of the earth. ...As to scratched, striated, incised, or perforated bones, it is sufficient to call attention to the fact that a sharp edge or point driven by force of any kind may produce simple effects similar to those due to an implement wielded by the human hand (Hrdlička 1912:7-8).

Hrdlička (1912:8-9) goes no to describe various effects of carnivore teeth, insects, worms, and roots, and the difficulty of distinguishing between deliberate and natural fires in evaluating burned bone. His conclusion is quite pessimistic as to the likelihood of successfully eliminating all other agencies which might have modified bones, and he implies that the bones must occur in a context which is otherwise recognizable as an archaeological site before they can be admitted as evidence for human activity. Similar opinions were expressed by Merriam (1906:224-225) who made the doubtful suggestion that the percentage of suspect pieces in a collection was an important criterion in evaluating the presence of man, and Holmes (1919:21-24) summarized a variety of such studies.

This practice of identifying and interpreting the remains of human activity on the basis of context is a two-edged sword which can lead to both errors of omission and errors of commission. Specimens not found in the context of an "archaeological site" have been dismissed as indicators of former human activity while, on the other hand, the entire contents of some archaeological sites have been forced into interpretive frameworks designed to explain every object recovered in excavation as the result of human activity. Martin (1907-1910:Vol. I) presented a monumental study of the bone industry represented at La Quina, but he felt it necessary to infer the Paleolithic domestication of dogs as an explanation for the undeniable evidence that carnivores had gnawed on some of the bones (Martin 1906). Breuil (1939) opened his analysis of the Choukoutien bone and antler "industry" with a summary of "the action of natural agencies on bones" and then proceeded to describe a mixture of possible and dubious artifacts from various localities of Choukoutien. Meanwhile Pei (1938) published an analysis of the role of animals and other natural causes in modifying the Choukoutien fossils, and it is not entirely clear whether Breuil and Pei were referring to precisely the same bones. It is highly regrettable that this potentially valuable collection of faunal remains was among the losses suffered during the war.

What was needed (and what was lacking) in these efforts to interpret bone alterations was a set of analogues based upon both field observations and laboratory experiments by means of which morphological characters could be linked with the processes and agencies which alter bone and other such materials. Despite increasing attention to these needs, we still lack an adequate body of "baseline data" for such inferences (Stanford 1979a), but continuing work in this vein is gradually indicating some of the limits which can be placed on our ability to recognize the more or less distinctive results of the many processes which alter individual bones and bone assemblages. The enumeration of *possible* explanations for patterning in the vertebrate faunal record is not a sufficient response to this kind of interpretive problem. There is little point in citing an ethnographically documented human practice as an explanation of archaeological patterns unless the ethnographic document includes an adequate description of the patterned results of the practice (cf. Binford 1978:9-11). Likewise Hrdlička's (1912:7-9) citations of various *possible* natural causes of bone alteration cannot be taken as a barrier to the search for explanations, but they should be viewed as a stimulus to research designed to investigate the causes of naturally induced patterning in the record of vertebrate remains.

The history of research into the causes of bone alteration has been marred not only by the lack of suitable analogues but also by several studies in which the basis for interpretation was little more than fantasy. Perhaps the most famous effort to derive cultural information from fragmentary bone is the lengthy study by Raymond Dart on the Makapansgat fauna of South Africa (Dart 1949, 1957, 1962, with references: Dart and Kitching 1958) for which the term "osteodontokeratic" (bone-tooth-horn) was devised. One very good outcome of this work was the first description of experimental efforts to produce comparable materials by breaking fresh bones (Dart 1959a:80; 1959b: 89-90). A very unfortunate development, however, resulted from the simplistic form-function hypothesis which guided much of the classification used to characterize the "tools"; many researchers lost interest in the entire subject or became unduly critical of later attempts to evaluate fractured bone (Frison 1974:51-52). In fact these studies gave bone alteration analysis such a "bad press" that one recent reviewer of the subject (Binford n.d.) reckons that many of his colleagues who are interested in bone are little more than latter-day "osteodontokeraticists"!

Confusion has resulted largely from the failure to separate conceptually two very different kinds of studies: formal and surficial alterations of individual bone fragments, and analysis of the composition and structure of bone fragment assemblages. Except for general references to animal chewing on bones (e.g., Dart 1957:2-9; 1958), most of Dart's writing and that of his supporters and critics (Brain 1967a, 1969, 1975, 1976; Washburn 1957; Hughes 1954; Wolberg 1970; Read-Martin and Read 1975, 1976; Shipman and Phillips 1976; Binford and Bertram 1977:144-148) has referred to bone survivorship and accumulation frequencies as observed in natural and artificial situations. Important exceptions include Brain's observation on carnivore activity (Brain 1970) and the influence of trampling in sandy deposits (Brain 1967b); Kitching's (1963) recognition of bone erosion, gnawing, splitting, charring, "rotational scarring," and abrasion; and Bonnichsen's (1975) call for detailed observations of morphology as a preliminary step toward assemblage frequency interpretations. Shipman and Phillips (1976:171) concluded that "Since tool making by australopithecines at Makapan cannot be demonstrated on the basis of breakage patterns, we suggest that only an examination of the collection for evidence of microwear will settle the question." I will show in this report how breakage patterns might still be used in this kind of analysis, but the fact remains that we still do not know the frequency with which various forms of alterations occur at Makapansgat or in the other sites which have been examined for their "osteodontokeratic potential" (e.g., Kitching 1963; Dart 1967; Read-Martin and Read 1975).

Organization and Purpose of this Report

Most of this report is concerned with bones, teeth, tusks, and antlers which have been collected from various areas of the Old Crow region of the northern Yukon Territory. Each of these individual specimens represents a fact which can be used to explore the past by scientific methods, but the facts must be interpreted -- they must be given meaning.

> Facts form the raw material of science -- the bricks from which our model of the universe must be built -- and we are rightly taught to search for sound and solid facts, for strong and heavy bricks that will serve us well in building foundations, for clean and polished bricks that will fit neatly into ornamental towers. But while accumulating the bricks may be a contribution to science, we must take care that the pile does not become a hopelessly discouraging jumble. For science itself is not brickmaking -- it is, at the workaday and technical level, bricklaying; and at the creative and artistic level, architecture, the designing of an edifice that will utilize all the bricks to the very best advantage (Bates 1949:1).

The bricks represented by bones and similar materials have been underutilized in some studies and over-utilized in others so that incomplete structures have been created, on the one hand, and flimsy ones, on the other hand. Bones constitute many kinds of bricks, and some of them are appropriate for use in one kind of structure while others are completely inappropriate for that structure and constitute flaws if incorporated incorrectly. Much of this report is devoted to the sorting of bones into various piles to show which ones can contribute to archaeological reconstructions and which ones are appropriate for use in understanding other aspects of paleoenvironments. Some of these will represent new bricks for the archaeologist, and others will be less clearly suited to the archaeologist's needs. We are not yet ready to lay bricks to represent the Old Crow Pleistocene, but we can start now to sort them and to identify their potential for later construction.

In Chapter 2, I will outline the background of the collections and provide the geographic and stratigraphic framework which is needed to understand the sedimentary history and chronology of the specimens. The distribution and geomorphology of the collecting localities will be enumerated along with a description of the ways in which the collections have been influenced by the interests of the investigators and the somewhat difficult logistics of this rather remote region.

In Chapter 3, I will review some general considerations regarding bones and other such materials, and I will present the view that a taphonomic analysis is the most suitable approach to an understanding of the archaeological content of the collections. A general taphonomic model, borrowed from the paleontological literature, will be presented as a framework for organizing the very complex set of data which has been generated from the Old Crow collections. A review of bone altering agencies and processes will be conducted with reference to the taphonomic model and will be used to derive a series of hypotheses which will guide the interpretation of selected specimens as artifacts.

Chapter 4 will be devoted to an examination of all the artificially modified bones, teeth, tusks, and antlers which have been collected from reworked deposits in the Old Crow region and which are housed in the collections of the National Museum of Man, National Museums of Canada, Ottawa. This presentation will provide an overview of the variety of technological procedures which are manifest in the Old Crow specimens, but the selected nature of these collections will preclude both an explication of the full range of taphonomic considerations and the view of the materials as an historically integral assemblage.

In Chapter 5, I will summarize a redeposited collection from a bar on Johnson Creek, a tributary of the Old Crow River, where every visible specimen was picked up and brought back to the laboratory. This non-selective collecting procedure permits us to examine a larger range of taphonomic factors which are pertinent to the history of both individual specimens and the collection as a whole. These factors will be used as a basis for depicting portions of the "taphonomic pathways" which have led from living animal communities to the fossil accumulation on the Johnson Creek bar, but the depiction will be constrained by the possibility of recent admixture of materials which post-date the Pleistocene record in the Old Crow basin.

Three samples of vertebrate fossils from Pleistocene stratigraphic contexts at one locality on the Old Crow River will provide the contents of Chapter 6. With these three samples we are able to look beyond Holocene redeposition and to come closer to an understanding of the elements which may have belonged together in more ancient times. However, it will be shown that these samples have also been redeposited in the past, and the manner of their redeposition has strongly influenced their contents. Nonetheless a view of these excavated samples from the standpoint of the general taphonomic model suggests that an archaeological component can be factored out of the larger suite of bone alterations which are represented by morphological features on the specimens. The data will again be organized in terms of taphonomic pathways which can be partially reconstructed to account for these three samples of fossils.

Chapter 7 will be devoted to a brief review of specimens which have been obtained through excavation at other localities and in various stratigraphic contexts elsewhere in the Old Crow and neighbouring basins. Chapter 8 will contain a summary of all stone artifacts and all indirect evidence of the use of stone artifacts which has been obtained from the Old Crow valley.

In Chapter 9, I will present an overview of this complex record and suggest both an interpretation of the existing collections and a forecast as to the best approach to the search for undisturbed Pleistocene archaeological sites in the Old Crow valley. A brief review of other Beringian and extra-Beringian evidence will be presented along with a discussion of future research which is needed to improve our interpretive framework for vertebrate remains.

It is my hope that this monograph will demonstrate that a reliable and interesting record of past human behaviour can be gleaned from the careful study of bone and bones; that the bones need not be found in the context of "archaeological sites" in order to be suitable for archaeological analysis; that there are specific directions which should be taken in future research to improve our interpretive analogues; and that the concept of taphonomy is a powerful tool for organizing complex data sets and procedures for archaeological reconnaissance and interpretation. I do not expect to provide more than a glimpse of the peopling of the New World, but I believe that it can be demonstrated on the basis of existing collections that people lived in eastern Beringia a long time ago even if these collections can tell us relatively little at the present time about what those people did, how they lived, where they came from, or where they went.

CHAPTER 2. GEOLOGY AND CHRONOLOGY

Background

It is now more than a century since the first recorded Pleistocene vertebrate materials were collected in the Porcupine drainage of the northern Yukon Territory, and four U.S. scientists made fossil collections in the Old Crow area between 1904 and 1952 (Harington 1977:29-35). Elsewhere in the Yukon the first mammoth remains seem to have been reported by Robert Campbell in the mid-19th century, and fossil finds near Dawson city were made regularly following the discovery of gold in the region (Harington 1977:37-47). Not all these discoveries were accidental, but the deliberate quests were directed toward relatively intact specimens of paleontological significance. Fragmentary materials which might have been of archaeological importance are generally absent from these early collections, and it is somewhat ironical to realize that Pleistocene artifacts may well have been encountered (but not recognized) in the Yukon more than 50 years before the Folsom discovery finally opened the way for serious contemplation of early man in the New World. On the other hand, I have found no published indication that such specimens were collected, and none is listed in Geist's unpublished journal and catalogue (Geist 1952-53).

Harington (1978:63ff.) has summarized the history of paleontological investigations in Alaska where fossil bone, antler, and ivory artifacts, as well as a few of stone, were recognized beginning in 1933 (Rainey 1939, 1940; Hibben 1943; Bonnichsen 1979:178, Table 30). Unfortunately the stratigraphic associations and chronology of these finds could not be known in detail at the time of discovery, and only now are we able to appreciate the likely antiquity of some of these materials. Most of the fossil artifacts were recovered from Pleistocene mucks in the Fairbanks area, but other discoveries have been made more recently at Trail Creek caves (Larsen 1968), Lost Chicken Creek (Foster 1969; Porter 1978; Bonnichsen 1979), and at Jack Wade Creek (Porter 1978).

In the Yukon Territory, Pleistocene paleontology has been intensively investigated by C.R. Harington and G.R. Fitzgerald, National Museum of Natural Sciences, Ottawa, since 1966 (Harington 1970, 1971, 1974, 1977, 1978; Harington and Clulow 1973; Crossman and Harington 1970; McAllister and Harington 1969; Fitzgerald 1978, n.d.). In his first season in Old Crow Flats, northern Yukon, Harington recognized the archaeological significance of a fractured and whittled caribou tibia which was diagnosed as a fleshing tool and brought to the attention of W.N. Irving, then with the National Museum of Man, Ottawa. Returning to the site of discovery in late summer 1966, Harington and Irving collected samples for radiocarbon dating as well as other fossil specimens among which were several mammoth long bone fragments which appeared to have been modified by artificial flaking techniques (Harington and Irving 1967; Irving 1968, 1971). Most of the fleshing tool and two large pieces of mammoth or mastodon long bone were sacrificed for radiocarbon dates which, based upon the apatite fraction of the bones, were between 25,000 and 29,000 years old (Irving and Harington 1973). That these finds were recovered from secondary alluvial deposits laid down in Holocene times soon became apparent from further geological study, and the radiocarbon dates obtained on plant remains (41,280 ± 1600 B.P.: GSC-730-1; 14,390 ± 140 B.P.: GSC-730-2) indicated clearly that materials of a wide variety of different ages were contained together in the deposits.

These discoveries stimulated intensive field and laboratory work in many disciplines. Irving devoted the summers of 1967 and 1970 to further searches for Pleistocene archaeological materials (Irving 1971; Irving and Cinq-Mars 1974), and Harington (1977:48-84) began annual trips to the Yukon almost with the regularity of migratory waterfowl. By the end of the 1973 field season over 14,000 fossil specimens had been collected, primarily from the Old Crow basin, and a detailed analysis of the archaeological significance of these pieces has recently been completed by Bonnichsen (1979).

The Old Crow region also attracted scientists in other fields of study. O.L Hughes, Geological Survey of Canada, conducted an extensive survey of the surficial geology and Pleistocene geomorphology of the northern Yukon and western District of Mackenzie in 1962, and he returned to the Old Crow region as well as other areas to complete the mapping of glacial and other surficial deposits (Hughes 1963, 1969, 1970, 1972). Samples collected by Hughes were studied and reported by specialists in palynology, plant macrofossils, and invertebrate paleontology (Delorme 1968; Lichti-Federovich 1973, 1974; Matthews 1975). Biological surveys included attention to birds, mammals, and fishes (Irving 1960; Youngman 1975; Steigenberger, *et al.* 1975). The proposal for an alternate route of the Mackenzie gas pipeline through the Old Crow region stimulated a variety of studies in archaeology and biology (e.g., Cinq-Mars 1973, 1974, 1975; Surrendi and DeBock 1976; Walton-Rankin 1977).

In 1974, two major multi-disciplinary projects were organized to coordinate the ongoing research of scientists in many disciplines and in order to improve logistic support and intellectual feedback among all our efforts to study the Pleistocene. One of these projects, the Northern Yukon Research Programme (NYRP), was organized by W.N. Irving and J. Cinq-Mars at the University of Toronto (Irving 1978a), and its principal investigators in various fields have included B.F. Beebe, C.S. Churcher, A.V. Jopling, J.C. Ritchie, H. Savage, and J.A. Westgate, with additional support from many students and professional consultants. This programme was designed to study the stratigraphy, paleocology, and archaeology of the northern Yukon Territory beginning with the numerous Pleistocene exposures and extending through the entire Holocene record to the late prehistoric archaeology of the Old Crow region.

I organized the other project, called the Yukon Refugium Project (YRP), with the support from the National Museums of Canada, the Geological Survey of Canada, and the University of Alberta (Morlan 1977b). The purpose of this project is to study the evolution of Pleistocene ecosystems in all areas of the unglaciated Yukon interior, called the Yukon Refugium in the project title (see Preface). By integrating the field work of such a variety of investigators we have been able to coordinate our sampling and stratigraphic interpretations at the time of primary data collection as well as later in analysis. An outline of some of our results has already been presented (Morlan and Matthews 1978; Morlan 1978a, 1979a, 1979b), and a detailed report is in preparation (Hughes, *et al.* 1980).

Until 1977, we were frustrated by our inability to trace the paleontological remains into the primary stratigraphic record of the Old Crow basin. All the archaeologically significant material, including the large collection analyzed by Bonnichsen (1979), had been recovered from secondary deposits and could afford nothing more than a basis for technological description and experimentation in agencies of bone alteration (Harington, *et al.* 1975; Irving 1978b; Morlan and Bonnichsen 1975; Morlan 1976a, 1977b; Bonnichsen 1978). Irving's parties made some truly spectacular discoveries in reworked surficial point-bar deposits where a human mandible and at least one domestic dog mandible were recovered (Irving, *et al.* 1977; Beebe 1978). The 1977 field season introduced a new dimension to the study when we encountered artificially modified bones on an ancient eroded surface (Disconformity A) seen at several exposures near Johnson Creek along the Old Crow valley (Morlan 1978a, 1979a; Morlan and Matthews 1978).

Tens of thousands of vertebrate fossils have been collected in Old Crow Flats during the past fourteen years, and the collecting procedures adopted by various investigators have differed in accord with their primary objectives and logistic limitations. It is of some importance to this analysis to summarize the characteristics of these collections in order to examine the extent to which their contents are comparable. The status of published reporting will also be referenced so that available literature can be seen in its proper perspective.

1. National Museum of Natural Sciences, Ottawa. This collection has been compiled by C.R. Harington and G.R. Fitzgerald during the past fourteen years and comprises a very large series of excellent specimens collected primarily for paleontological study. Harington is an unusual paleontologist, however, in that he developed a keen interest in archaeology during his first field season in Old Crow Flats and has therefore collected numerous specimens of dubious paleontological value, many of which have proven to be of archaeological importance. The cranial material (and a few post-cranial elements) in this collection was the subject of Harington's monumental dissertation in 1977 which covered specimens collected between 1966 and 1975. This work has also been summarized elsewhere (Harington 1978). In addition, all archaeologically important specimens collected as of 1973 were included in Bonnichsen's (1979) analysis.

2. University of Toronto. The bulk of this collection has been amassed since the inauguration of the Northern Yukon Research Programme (NYRP) in 1975 and comes primarily from a modern point bar known as Loc. 11A (Bonnichsen's Loc. 89: 1979). In addition, the 1977, 1978 and 1979 field seasons produced materials from known stratigraphic contexts, although these have not yet been reported in detail. Collections resulting from Irving's 1970 field season, prior to the beginning of NYRP, are also housed at the University of Toronto and were included in the study by Bonnichsen (1979).

3. National Museum of Man, Ottawa. This collection includes: (a) material gathered in 1967 by W.N. Irving during his tenure at the National Museum of Man; (b) artifacts transferred by C.R. Harington from the National Museum of Natural Sciences; and (c) specimens collected by the Yukon Refugium Project (YRP) since its inauguration in 1975. The two principal components of the YRP collection are excavated materials from a high bluff (three stratigraphic levels, see Chapter 6) and specimens gathered from one modern point bar which was completely cleaned of bone in 1977, 1978, and 1979 (see Chapter 5). A number of archaeologically important specimens from sources (a) and (b) were studied by Bonnichsen (1978, 1979), and selected pieces from source (c) have been described and illustrated (Morlan 1978a, 1979a).

Nearly all the collected specimens have been obtained from secondary deposits which include buried layers in Holocene terraces, modern point bars and stream banks, and masses of slumped material on higher river banks. Exceptions include Harington's samples from basal deposits at Locs. 44, 45 and 64 (Harington 1977) which are believed to date to early Sangamon Interglacial times; Irving's recently excavated materials; the three levels at Loc. 15 (Chapter 6) and a few other *in situ* finds (Chapter 7) excavated by YRP. Furthermore, many of the secondary deposits have been selectively collected with thousands of fossils having been abandoned in the field due to their apparently undiagnostic character and the enormous cost of shipping them nearly all the way across the northern half of North America. As a result, the existing collections from reworked deposits can be used to gain insight into the general range of bone modifications and forms of archaeologically significant objects, but they cannot be used either for internal statistical manipulations of "samples" or for external comparisons between localities or for comprehensive studies of "taphonomic" factors which have produced the distributions of specimens now found in the Old Crow basin. An effort along the last-named line has been attempted with the YRP sample from Loc. 71, a modern stream bar, which is reported in Chapter 5.

A Stratigraphic Framework

For many years the Quaternary stratigraphy of the Old Crow region has been understood in terms of a broad outline presented by Hughes (1969, 1970, 1972). Unfortunately it was not possible to place the vertebrate fossils in that outline because of the difficulty of finding them in secure stratigraphic context. Their recent recovery in several levels of the exposed sections has resulted from intensive studies of the stratigraphy on the basis of which certain details can now be added to Hughes' outline. In order to delineate the nature of our work in the area it will be useful to mention some general limitations which affect the recovery of both fossils and stratigraphic information.

Three large basins are found in northern Yukon Territory of which the Old Crow basin is the largest and best studied. As will be explained below, these basins have undergone extensive filling during the Upper Pleistocene, and Holocene downcutting has created numerous exposures which permit the study of the formation and chronology of the basin fill.

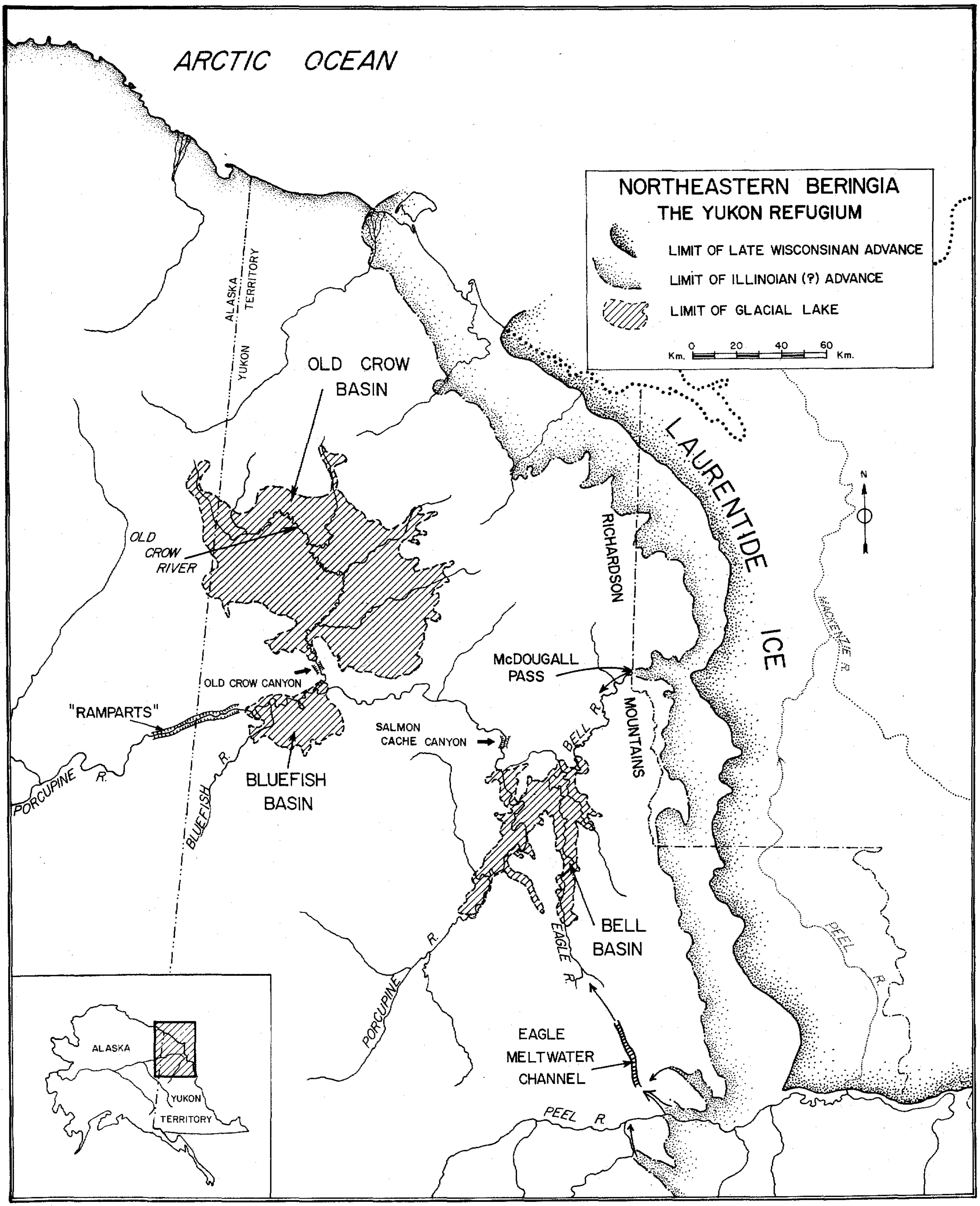


Fig. 2.1. Map of Northeastern Beringia: the Yukon Refugium.

In the Old Crow basin there are about 25 left bank and 35 right bank exposures totalling, respectively, about 19 km and 28 km in length along a river valley which is nearly 300 km long (Morlan 1978b). Portions of each exposure are obscured by encroaching vegetation, while other portions are kept free of vegetation by active erosion at the base followed by large scale mass wasting of the upper layers. As a result there are relatively few localities which are suitable for study, and those which are satisfactory for stratigraphic analysis are relatively active in terms of downslope movement which constantly renews the exposed profiles. In such circumstances large vertebrate materials very readily move down slope and become divorced from their stratigraphic contexts. Excavation of undisturbed sediments is usually limited to the outer meter or less of the sediment, beyond which permafrost is encountered. As will be seen below, the sedimentary layers which contain archaeological materials are too deeply buried to be reached by excavation from the upland surface, so the river banks provide the only access to primary deposits which, once exposed, are subject to rapid destruction. These processes have retarded our discovery of primary stratigraphic associations, but they have produced the enormous wealth of redeposited fossils which tend to become concentrated in secondary terrace and point bar deposits. The transportation of these fossils, including many very fragile ones, with very little breakage and rounding is possible only because large size lithic material (larger than fine gravel) is extremely rare in most areas of Old Crow Flats. In fact, in most circumstances, the vertebrate fossils are among the largest particles transported by the Old Crow River and its tributaries.

Our stratigraphic framework has been given preliminary description elsewhere (Morlan 1978a, 1979a; Morlan and Matthews 1978), and a detailed report is in preparation (Hughes, *et al.* 1980). The most important and conspicuous time-stratigraphic markers consist of two thick and massive layers of glacio-lacustrine clay which were deposited during maximum advances of the Laurentide glacier system (Hughes 1972). These advances dammed the ancestral Porcupine River which flowed through McDougall Pass to the Mackenzie Delta region and which had its headwaters in the Keele Range, the Ogilvie Mountains, and the Old Crow basin. Likewise the Peel River and its tributaries were diverted to the north through the Eagle meltwater channel. These drainage systems, which together drained nearly half of interior unglaciated Yukon Territory, were augmented by meltwater from the Laurentide glacial front, and they raised large lakes in the interior basins of the northern Yukon (Fig. 2.1). On the basis of evidence summarized elsewhere (Matthews 1975; Morlan and Matthews 1978; Hughes, *et al.* 1980). we believe that the earlier of these two lakes was filled during Illinoian times, and the later one represents the late or "classical" Wisconsinan advance. During the intervening period, presumably the Sangamon Interglacial and early to mid-Wisconsinan, the drainageways of the Porcupine and the Peel Rivers may have been restored to their former valleys, although the Porcupine River might already have established a westward flow at a higher base level than that of today (see Hughes, *et al.* 1980). The basins continued to aggrade through the action of coalescent alluvial fans which grew outward from the surrounding mountains.

In some exposures which we have been able to study in the Old Crow

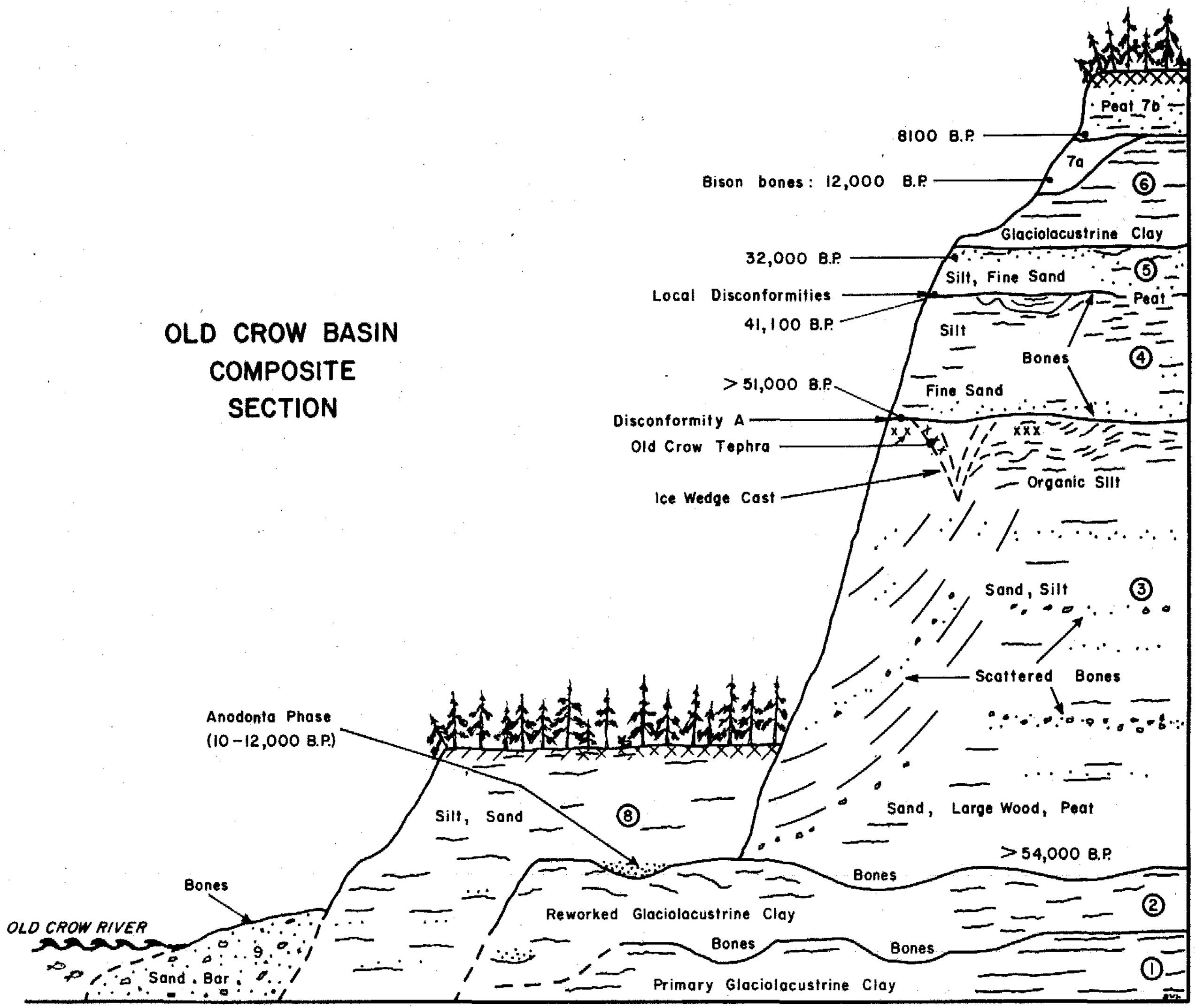


Fig. 2.2. Gross stratigraphy of the Old Crow basin, northern Yukon Territory, based on several high bluffs recently studied along the Old Crow valley. Modified after Morlan and Matthews (1978:2).

basin, this gradual accumulation of alluvium, as well as local lacustrine and back-water facies, was a fairly continuous process from the time the early lake drained until the later one filled. Other exposures, however, reveal that the alluvial fill was locally cut and redeposited in a meandering river system characterized by point bar growth and large scale floodplain development. In fact, this river system may well have been as large as the Old Crow system of the present time. The existence of such a stream has been inferred from the observation of dipping suites of sedimentary layers which have a total vertical relief of more than 10 meters in some exposures.

The recognition of such large scale cut and fill structures is a warning that some exposures contain less complete sedimentary records than others. In some exposures it can be shown that large temporal hiatuses must exist in the profile, while at others a more complete and less disturbed record of sediment accumulation may be found. At the present time we are unable to define these potentialities for most of our sections, because it is possible that some of the apparently undisturbed profiles in fact expose cut and fill structures in longitudinal sections which would be very difficult to recognize in the limited exposures with which we often must work. Thus we are uncertain that the Sangamon Interglacial is represented at all sections.

The filling of glacial lakes in late Wisconsinan times must have been accompanied by sufficient downcutting at the outlet through the "Ramparts" of the Porcupine into Alaska that the eastward flow of the Porcupine could not be reestablished when deglaciation occurred. Although the Peel River resumed its former course to the Mackenzie Delta, the Porcupine continued its westward flow and reached a new base level well below that of Pleistocene times. As a result the fine sediment fill of the northern Yukon basins was deeply dissected by the Porcupine River and its tributaries, and it has provided geologists, paleontologists, and archaeologists with unusual opportunities for the study of the Upper Pleistocene in eastern Beringia.

The major stratigraphic units presently exposed in the Old Crow basin include the following (see Fig. 2.2; cf. Hughes 1969, 1972; Hughes, *et al.* 1980; Lichti-Federovich 1973, 1974; Harington 1977:115ff; Morlan 1979a; Morlan and Matthews 1978):

Unit 1. Primary glacio-lacustrine clay exposed at some but not all sections at lowest water levels in late summer. This massive clay is sometimes seen to be oxidized in vertical joints, implying that its surface was once exposed to a certain amount of drying and aerobic weathering. Thusfar it has produced no fossil material of any kind, but it is thought to be of Illinoian age.

Unit 2. Reworked glacio-lacustrine clay apparently represents a period of downcutting and erosion of the lake bed in late Illinoian or early Sangamon times. Small channels at the contact between primary and reworked clay sometimes contain concentrations of fossil bone, and vertebrate fossils have likewise been found higher in the reworked unit as well as at the contact with the overlying alluvium. None of the vertebrate fossils from Unit 2 is altered in such a way as to suggest human activity.

Unit 3. Most of the thickness of the exposed sections is comprised of bedded sands, silts, and clays in which lateral facies changes are quite rapid and sometimes abrupt while vertical changes likewise are frequent. In some exposures this unit reveals large cut and fill structures in which bone concentrations occur along with abundant plant and invertebrate fossils. These channels are thought to date to Sangamon Interglacial and early Wisconsinan times on the basis of paleoecological data. Coarser granule layers occur in some of these channels and contain abundant microtine remains as well as larger bones and fragments. There appear to be no widely recognizable disconformities in this unit, but its upper boundary has been placed at a disconformity which appears to be of regional importance. Presumably Unit 3 contains a record not only of the Sangamon Interglacial but also of the early Wisconsinan, but a boundary between definable units thought to represent these time-stratigraphic concepts has not been identified in the field. Although some evidence on the Yukon Arctic coastal plain (Rampton n.d.) is at variance with this interpretation, we believe that the Old Crow region was not inundated by glacial meltwater in early Wisconsinan times. Presumably early Wisconsinan ice did not advance far enough westward to divert the regional drainage systems.

Unit 4. Silts and fine sands characterize Unit 4 in which beautifully cross-bedded layers represent fluctuating streams and backwater deposits interspersed with local ponds and colluvial facies. For our purposes the lower contact of Unit 4 is of special significance, because it represents the oldest stable habitable surface yet identified in the Wisconsinan portion of the profile. This contact, provisionally called Disconformity A, is generally characterized by colluvial clayey silts overlain by cross-bedded silts and fine sands, but the contact also provides evidence of subaerial weathering and local erosion as well as indicators of a climatic oscillation during an interval of non-deposition and peat and soil formation. Cryoturbation structures are relatively common and are often truncated by erosion at the contact. Less common but even more significant are ice-wedge pseudomorphs which were formed initially in cold climate but were later melted and refilled by sediment during a warmer period. Our efforts to trace this contact from one section to another are aided by the occurrence of a volcanic ash which is situated only a few tens of centimeters below the disconformity in the upper part of Unit 3. That the ice wedges were thawed out during the time of non-deposition and erosion represented by the disconformity is implied by the occurrence of slumped pods of the volcanic ash in the pseudomorphs. Fractured and cut bones which can be attributed to human activity have been recovered from Disconformity A and from a deeper deposit in Unit 3 where the bones appear to occur in an ancient channel.

Unit 5. The sediments of Unit 5 are so similar to those of Unit 4 that they can be separated only locally on the basis of disconformable contacts. Such contacts can be recognized in several exposures by the occurrence of truncated cryoturbation structures as well as the growth of peat on a stable surface. The designation "Unconformity B" has previously been assigned to several of these local contacts (Morlan and Matthews 1978: Fig. 1; Morlan 1979a:Fig. 2) which have produced artificially fractured bones as well as autochthonous peats for radiocarbon dating, but we have not recognized a single contact which can be confidently correlated among several exposures. Many of the characteristics of Unit 5 may represent thawing and sedimentation during the transgressive phase which includes the deposition of Unit 6.

Unit 6. The classical Wisconsinan advance is thought to have diverted regional drainages into these basins for a second time to elevate large lakes in which the glacio-lacustrine clays of Unit 6 were deposited. These clays occur near the top of all our intact sections although they have been extensively scalloped by retrogressive thaw flow slides which develop as the ice-rich clays become exposed. The clays are not at all fossiliferous and in fact have not even produced an ostracod assemblage. We have never seen a vertebrate fossil in this part of the profile, and we doubt that the clays comprise a significant source of fossil bones.

Unit 7. Drainage of the glacial lake seems to have begun around 12,000 years ago, and the earliest stages of downcutting are represented at one exposure by a silt- and sand-filled channel in which the remains of *Bison crassicornis* have been found. These bison bones exhibit no indications of a human association with their demise, but they have provided invaluable radiocarbon dates for understanding the time of lake drainage and modern valley formation. During the following two millennia peat formation began all over the basin, and thick accumulations of peat and thaw lake sediments underlie the modern surface in most areas of the basin.

Unit 8. By 10,700 years ago, the modern Old Crow River had cut down through this entire profile to form a floodplain very near the level of the modern valley floor. For an apparently brief period this floodplain was inhabited by a mollusc, *Anodonta beringiana*, which does not live in the northern Yukon today (Harington 1977:141). Apparently conditions on the floodplain soon became unsuitable for this large bivalve, and its remains, often found with both valves articulated in growth position, can now be used as markers for the identification of earliest Holocene terrace sediments. During the downcutting of the valley thousands of fossil vertebrates and other materials were exhumed from the fossiliferous units we have just reviewed, and these materials were concentrated and redeposited in the terraces which were gradually constructed along the valley walls. Thus we find vertebrate fossils of all ages associated with *Anodonta beringiana* on former floodplain surfaces 10,000-12,000 years old, and I shall refer to such finds as fossils found in association with the *Anodonta* phase. Vertebrate fossils are also concentrated in later terrace deposits and can be found, for example, in the truncated scars of former ox-bow lakes which are perched on terrace surfaces several meters above the modern river level (Morlan 1978b). These terraces are still being built and destroyed, and they contain many finds of fossils among which are large and small pieces of recycled wood which can give misleading radiocarbon dates implying considerable antiquity (see GSC-730-1 and GSC-730-2, Irving and Harington 1973:Table 1).

Unit 9. The formation of floodplain deposits continues today and includes numerous sand and silt bars in which fine gravel sometimes occurs but is relatively rare. Such bars provide excellent opportunities for paleontological and archaeological prospecting since vertebrate fossils have been concentrated in incredible numbers in some such localities. A few stone and many bone artifacts have been recovered from the banks and bars, but their original provenience cannot be reconstructed because of the numerous primary sediment sources which have contributed to their contents.

Chronology and Paleoecology

In the light of this stratigraphic sequence, our current understanding of chronology and paleoecology can be reviewed. These two aspects of our study will be considered together since our chronological ideas concerning the earliest portions of the sequence stem primarily from paleoenvironmental evidence. As mentioned above, we believe that the lower glacio-lacustrine clay represents an Illinoian advance of Laurentide ice. It is possible that this unit was deposited during an early Wisconsinan glaciation, but we doubt such a late date because of our fossil evidence from the overlying alluvium of Unit 3. The large channel deposits and associated sediments in the lower layers of Unit 3 have produced spruce tree trunks more than 28 cm in diameter, at least one vertebrate species, several invertebrate species, and several plants which imply conditions warmer than those of the present day (Matthews 1975; Harington 1977: 130-137). We believe that the warm climate of an interglacial (Sangamon?) could account for this fossil evidence but it is not out of the question that an early Wisconsin interstadial could supply the elevated mean annual temperatures which would seem to be necessary to permit these species to live in Old Crow flats (Matthews 1980). For example, one of the best preserved deposits of large spruce trunks is found at one of our most northerly sections where the ecotone between boreal forest and tundra is now found on the general surface of Old Crow Flats. In that same deposit are remains of the spotted skunk (*Spilogale* sp.) which today reaches its northern limit at Alta Lake, British Columbia, about 100 km north of Vancouver (Harington 1977:471). A ground beetle from that deposit, *Notiophilus sylvaticus*, today occurs along the coast of British Columbia and Alaska but is not found in the northern interior (Matthews 1976a). As an aside, I would like to mention a cautionary note which must be borne in mind as reconstructions of this kind are made. Until recently we believed that an aquatic plant called *Najas flexilis* was yet another indicator of interglacial conditions in these deposits since its known distribution did not extend north of Alberta (Matthews 1975), but presumed modern seeds of this species, which is not readily collected in many surveys, have since been found in dredge samples from lakes as far north as the Sans Sault Rapids area of the Mackenzie Valley (L.D. Delorme and J.V. Matthews, pers. com. in 1977) and it may well live today in Old Crow Flats. This emphasizes the importance of continuing to study the distribution and ecology of modern forms which are represented in the fossil record.

The paleontological evidence implying a Sangamon Interglacial age for the base of Unit 3 is permitted but not necessarily implied by existing radiocarbon dates on this unit, all of which are beyond the range of the radiocarbon method and one of which is >54,000 B.P. (GSC-2066; Harington 1977: Table 7). In passing, I should acknowledge that we have about two dozen spirally fractured bones from these Sangamon deposits, but I am not convinced that they are artificially fractured. Of all our samples, this small series of spirally fractured long bones is the most heavily scarred by the chewing of carnivores, and none of the specimens is larger than bones known to have been broken by carnivore gnawing and crunching; mammoth and mastodon bones are not included in this series.

Although samples are available and are currently being processed, we have not yet derived a paleoenvironmental record for the middle and upper portions of Unit 3 in which the shift from Sangamon to early Wisconsinan conditions must be represented. Accordingly, I shall move directly to Disconformity A at the contact between Units 3 and 4. Here we find the sediment structures which represent cold climate (ice-wedges and cryoturbation) apparently followed by a warming trend when the ice-wedges melted and were refilled. Since ice-wedges are active today in the Old Crow basin, the evidence that they were thawed on Disconformity A implies a climate warmer than that of the present time (Matthews 1980). By the time deposition resumed,and probably earlier as well, spruce was growing in the area as shown by the occurrence of spruce needles and cones in the cross-bedded silts and sands which immediately overlie the contact. Many of the fossil beetles represent species which occur in both tundra and forest sites, but the majority of those identifiable to species represent obligate tundra forms and imply that the environment may have been characterized by the sorts of forest and tundra mosaic which are found in the region today.

A different picture seems to prevail at the various local contacts recognized between Units 4 and 5. Cryoturbation represents a relatively cold climate form of weathering, but there is no clear evidence of a warming trend and forest indicators are absent from the fossil record. The ice-wedge pseudomorphs appear to have filled through sagging of the overlying sediment, and the ice may have been melted as a result of the formation of the glacial lake rather than by climatic warming. It is likely that the cool climate suggested by fossils and sedimentary features in these units represents the onset of classical Wisconsinan conditions which culminated in the elevation of the glacial lake to deposit Unit 6 and that the filling of the glacial lake brought about the melting of the ice-wedges, as it most certainly would have degraded permafrost in the basin.

A number of radiocarbon dates are available for Units 4 and 5. Of two samples older than the limits of the radiocarbon method, one of them (>41,300 B.P.: GSC-199) probably belongs to the upper part of Unit 3 but cannot be precisely correlated with these units as defined here, while the other is believed to be a piece of redeposited wood (>37,000 B.P.: GSC-958) since it was associated with a finite date on small mollusc shells of 32,400 ± 770 B.P. (GSC-952; Harington 1977: Table 7). A third "greater than" date (>51,000 B.P.: GSC-2559-2) cannot be so easily dismissed since it was obtained on autochthonous peat only 85 cm below the base of the upper glacio-lacustrine deposit on a contact thought to represent Disconformity A (Matthews, pers. com. in 1977). Four finite dates (GSC-1191, GSC-2756, GSC-2507, GSC-2574) are available from Units 4 and 5 at various exposures, and they range between 31,300 and 41,100 years ago. We cannot yet match the 31,300 date with a specific position on our composite profile (Fig. 2.2), but the 41,100 B.P. date was obtained on peat which forms a local "Unconformity B." These dates indicate that Disconformity A is older than the range of conventional radiocarbon dating and that the upper glacial lake began to

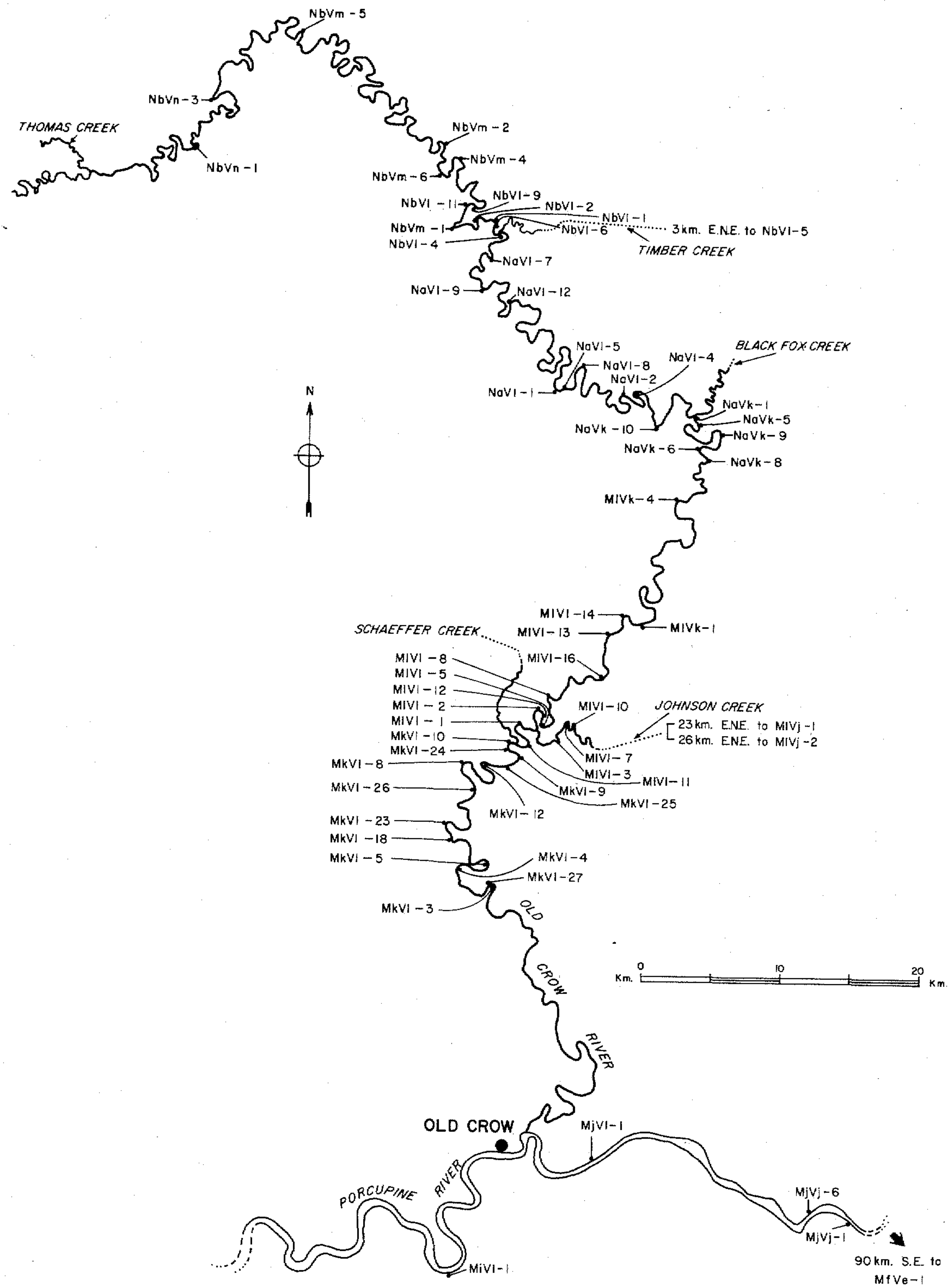


Fig. 2.3. Map of collecting localities in the Old Crow basin, northern Yukon Territory. Km to distant localities are based on straight line measurements.

fill some time after 30,000 years ago.

A maximum age for Disconformity A has been derived from a fission track estimate on the volcanic ash layer located 30-50 cm below the disconformity. This ash was laboriously studied by Nancy Briggs at the University of Toronto, and her analysis suggests that the ash is not more than 80,000 years old (Briggs and Westgate 1978; Westgate, *et al.* 1978).

Since I believe that our oldest artificially modified bones occur on Disconformity A and in point bar deposits associated with it, our archaeological record is bracketed between 80,000 years ago and the time of inundation by glacial lake Old Crow. For purposes of discussion, I have adopted the round-number age of 60,000 years for Disconformity A, and an indication of the age of the glacial lake can be obtained by examining dates on the vertebrate fossils themselves. For reasons to be discussed in the final chapter of this report, radiocarbon dates on bone from Old Crow Flats should be based on their collagen fraction rather than their apatite components. Until recently, all available dates on artificially modified bones had been based upon apatite, but there are 17 collagen-based dates of more than 20,000 years old on bones from the secondary deposits which occur along the floor of the Old Crow valley. Three of these dates are "infinite," but the remaining 14 can be viewed as a small sample of the level of radioactivity observed in vertebrate fossils occurring in the Old Crow River system. When these dates are plotted in the form of a single histogram (Fig. 9.3), a significant peak appears between 27,000 and 29,000 years ago. If we adopt the seemingly reasonable assumption that *most* of these vertebrates did not live in the Old Crow basin when the glacial lake was there (we have never found their bones in the glaciolacustrine clays), we can use the 27,000 to 29,000 year peak as an indication that the upper glacial lake filled around 27,000 years ago. The few apparently more recent animals might have died by falling through the ice on the glacial lake with their bones having been preserved initially in the lake clays. Only one of the dated bones in question was artificially modified when it was green, but this series of dates may point the way to an understanding of the younger limit which we can expect to place on the mid-Wisconsinan portion of archaeological record by virtue of the fact that all lowland areas below an elevation of 1200 feet (365m; O.L. Hughes, pers. com. in 1980) were inundated by glacial meltwater in classical Wisconsinan times. That younger limit appears to be approximately 27,000 years ago.

Site Designations and Other Conventions

In Chapters 4-8, vertebrate specimens and stone artifacts from 58 collecting localities in the Old Crow and Porcupine valleys will be described. Many years of independent work by geological and paleontological parties in this region have resulted in a proliferation of site designation systems, and for a given locality there now exists as many as six or eight designations all of which are approximately equivalent to one another. Since the National Museum of Man utilizes the so-called Borden system (Borden 1952) for its cataloguing and storage purposes, designations from that system have been overlaid upon the schemes already in place. Yet another approach was used by Bonnichsen (1979) who chose to renumber all the localities from the upstream to downstream end. A computer would be

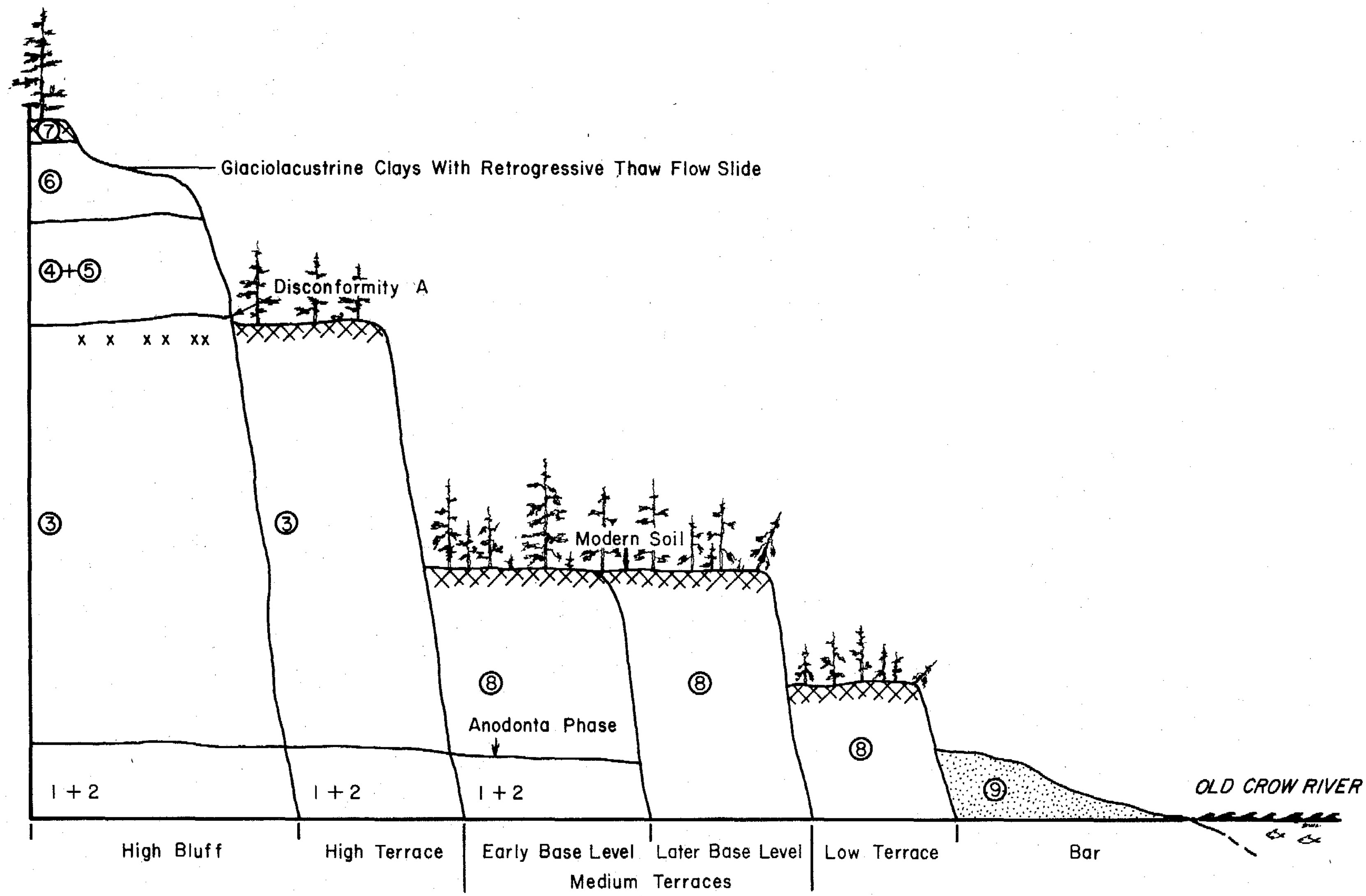


Fig. 2.4. Schematic drawing of major geomorphological units in the Old Crow valley, northern Yukon Territory, as named in Table 2.1. Relative heights of the three terrace levels are variable, and the high terraces may be degraded through differing amounts of the overall stratigraphic sequence.

most helpful in keeping straight the equivalencies among all these schemes.

In this report I have elected to use the Borden designations so that the artifact descriptions and interpretations can be readily compared with the specimens themselves in the National Museum of Man. In a forthcoming report on stratigraphy, paleoecology, and archaeology (Hughes, *et al.* 1980), many of the same localities will be presented under other designations, because the relevant stratigraphic notes and samples are recorded and filed in the Geological Survey of Canada by means of official labels such as "HH-" for O.L. Hughes. Thus many of our study localities are known, for example, as HH68-9 or HH69-21 because Hughes first examined the exposures in 1968 and 1969, respectively. Vertebrate paleontological data at the National Museum of Natural Sciences is filed with reference to Harington's locality numbers. Bonnichsen's renumbering of the localities was done strictly for the purpose of his own study, but equivalents to his numbers are needed in order to retrieve specimens from storage for comparison with his text or illustrations. These needs are met in Table 2.1 which provides all Borden designations for localities discussed in this report along with numbers which have been assigned by Harington, Bonnichsen, and Hughes. Other designations which have been assigned by S. Lichti-Federovich (1973, 1974), W.N. Irving, and R.E. Morlan are also listed.

Location is generally indicated in Table 2.1 (see also Fig. 2.3) by the name of the stream or, in the case of sites along the Old Crow River, the distance from the river mouth in kilometers along the left (L) or right (R) bank (named when facing downstream). The column in Table 2.1 labelled "land form" gives an approximate indication of the geomorphological setting of each locality. The categories were defined during a preliminary terrace classification based upon air photo analysis (Morlan 1978b), and they are shown schematically in Fig. 2.4. A high bluff is the most complete exposure of Quaternary sediments to be found along these streams, and some of the bluffs were degraded to a level well above the existing river to form the high terraces in early Holocene times. Thus the high terraces represent truncated high bluffs in which ancient deposits comprise most of the exposure with at most a thin Holocene cap. The medium and low terraces are very different land forms. They are believed to be aggradational terraces rebuilt as alluvial levees by overbank sedimentation and point bar growth during the Holocene. A considerable investment of field work would be needed to make full use of these terrace structures in the study of the Pleistocene fossils. Portions of them have been rebuilt from an early Holocene base level in which the lower glacio-lacustrine clays (Units 1 and 2) form the base, and in these portions it is possible to find concentrations of vertebrate fossils in association with the articulated valves of *Anodonta beringiana*. Such concentrations are thought to have been created between 10,000 and 12,000 years ago, and their final Wisconsinan and earliest Holocene contents are completely "swamped" by earlier fossils because of the rapidity with which the downcutting of the basin was accomplished. In general we may use such fossil concentrations as indicators of the fauna and the kinds of artifacts which were originally deposited below the upper glacio-lacustrine unit in pre-classical Wisconsinan times. Although many of the terraces may already have yielded concentrations of this kind, my personal knowledge of them permits me to identify these assemblages at only three of our localities, and these have been marked with an asterisk at the left-hand margin in Table 2.1. In subsequent tables, asterisks will be

Table 2.1. Designations, location data, geomorphology, and text references for localities discussed in this report. CRH, C.R. Harington; RB, R. Bonnichsen; SL-F, S. Lichti-Federovich; WNI, W.N. Irving; REM, R.E. Morlan; stream numbers refer to distance above the mouth of Old Crow River on left (L) or right (R) bank. See text for other explanations.

Borden	CRH	RB	Hughes	Other	Stream	Land form	Text References
MfVe-1					Porcupine	High bluff	Chapter 7
MiVl-1	100	109	62-228	SL-F	Porcupine	High bluff	Tables B1, B4-5, B16-18
MjVj-1		110			Porcupine	Med. ter.	Tables B1, B16
MjVj-6		114			Porcupine	Low ter.	Table B18
MjVl-1		115			Porcupine	Med. ter.	Table B18
MkVl-3	3	105			36.4 R	Bar	Table B1
MkVl-4		103		WNI 3B	40.5 L	Bar	Tables B1, B6-7, B10
MkVl-5	4	101			43.4 R	Bar	Tables B1, B16, Chapter 8
MkVl-8	42	91			57.3 R	High bluff	Tables B1-5, B11-12, B15
MkVl-9	11	86	75-10	SL-F OC 6	64.9 L	High bluff	Tables B1, B6-7, B17, Chapter 7
MkVl-10	12	83			66.8 R	High bluff	Tables B4-5, B8-9, Chapter 7
MkVl-12	11A	89			61.9 L	Bar	Tables B11-12, B19, Chapter 8
MkVl-18	10	98			48.1 R	High ter.	Tables B13-14
MkVl-23	9	97			49.2 R	Med. ter.	Table B1
MkVl-24	12E	84			66.0 R	Low ter.	Tables B6-7, B11
MkVl-25			68-8		63.7 L	Low ter.	Table B12
MkVl-26	74	92			54.8 R	Low ter.	Tables B8-9, B12
MkVl-27				WNI 3A	36.6 L	Low ter.	Table B1
MlVj-1			75-25		Johnson Cr.	High bluff	Chapter 7
MlVj-2				REM78-5	Johnson Cr.	Bar	Table B1
MlVk-1	16	73	104Ramp.		92.5 L	Low ter.	Tables B1, B17
MlVk-4	96	68	69-23		112.1 R	High bluff	Table B1
*MlVl-1	14N	80			70.5 R	Low ter.	Tables B1-3, B8-14, B16-17, B19
MlVl-2	15	75	68-9	SL-F OC 5	78.8 R	High bluff	Tables B1-3, Chapter 6
MlVl-3	70	76			Johnson Cr.	High bluff	Table B17, Chapter 7
MlVl-5	69	74			75.1 R	Bar	Tables B1-5, B8-9, B11-14, B16-17, B19
MlVl-7	71	77			Johnson Cr.	Bar	Tables B1, B4-7, B10-11, B13-15, B17

Table 2.1 (Continued).

Borden	CRH	RB	Hughes	Other	Stream	Land form	Text References
M1V1-10					Johnson Cr.	Med. ter.	Tables B1, B6-7
M1V1-11	13	82			68.5 L	High ter.	Table B1
*M1V1-12					74.1 R	Med. ter.	Tables B1-3, B6-7
M1V1-13			69-21		88.3 R	High bluff	Tables B1, B8-9, B15, B17, Chapter 7
M1V1-14				REM78-1	90.6 R	High bluff	Table B1
M1V1-16					84.4 R	Bar	Tables B13-14
NaVk-1	66	58			130.8 L	Bar	Tables B1-3, B8-11
NaVk-5	22	60			130.1 L	Med. ter.	Tables B1-3, B5-10, B13-17, Chapter 8
NaVk-6	20	64			121.5 R	Med. ter.	Tables B1-3, B8-9, B11, B13-14, B17, Chap. 8
NaVk-8	19	66			120.3 L	Low ter.	Table B11
NaVk-9	68	63			124.1 L	Med. ter.	Tables B2-3
NaVk-10	151				139.9 R	High bluff	Table B11
NaV1-1	32	42	75-32	SL-F OC 4	161.5 R	High bluff	Table B11
NaV1-2	142	51		WNI 50	147.3 L	High bluff	Chapter 8
NaV1-4	65	52			143.8 R	Low ter.	Tables B1, B13-14
NaV1-5	32E	43			160.7 L	Med. ter.	Chapter 8
NaV1-7	87	36			195.4 L	Low ter.	Tables B6-7
NaV1-8	93	46			158.2 L	High bluff	Tables B1-3, B17
NaV1-9	138				190.2 R	Low ter.	Chapter 8
NaV1-12	79	38			182.4 L	Low ter.	Tables B2-3, B17
NbV1-1	28	31			199.8 L	Med. ter.	Tables B11, B13-14, B17
*NbV1-2	29	29			201.6 L	Low ter.	Tables B1, B10-11, B17, B19, Chapter 8
NbV1-4	27W	32			199.5 R	Low ter.	Chapter 8
NbV1-5					Timber Cr.	Bar	Table B1
NbV1-6	27	33			199.3 L	Med. ter.	Tables B13-14
NbV1-9	136				206.5 L	Low ter.	Tables B6-7
NbV1-11	84	27	69-31		205.9 R	High bluff	Tables B8-9

Table 2.1 (Continued).

Borden	CRH	RB	Hughes	Other	Stream	Land form	Text References
NbVm-1	64	28			204.4 R	High bluff	Table B15
NbVm-2	45	24		WNI 52	220.8 L	High bluff	Tables B1, B11
NbVm-4	44	26	69-30	SL-F OC 2	214.6 L	High bluff	Tables B1, B12
NbVm-5	60	17			264.8 L	Med. ter.	Tables B1, B6-7, B11
NbVm-6	85	25			217.4 R	Low ter.	Table B11
NbVn-1	57	12			298.0 R	Low ter.	Table B17
NbVn-3	109				284.5 L	Med. ter.	Table B15
XI-B					Johnson Cr.	Bar	Table B1

* with catalogue number identifies sites preserving *Anodonta* phase

used to identify individual specimens which have been recovered from these final Wisconsinan contexts (the *Anodonta* phase).

Other medium and low terraces have been built since the Old Crow River began to dissect the lower glacio-lacustrine unit. *Anodonta* shells are never seen in growth position in these terrace deposits, because the mollusc was apparently extinct in the basin by the time the dissection of the lower clay had occurred (in fact the change in the stream bed brought about by the dissection of the clay may have eliminated the mollusc from the basin, but this remains to be determined). Unfortunately the recognition of terraces based on different base levels cannot be accomplished entirely by means of air photo analysis, and plans for future field work include an effort to map the distribution of these different terrace forms.

The last land form mentioned in Table 2.1 is the bar on which many fossils have been found merely by inspecting the surface. It should be emphasized, however, that the land form classification is not always indicative of the context in which fossils have been found. It is quite possible to find fossil concentrations on the modern river bank at the base of a high bluff or terrace, and most of the specimens reported here as artifacts have been recovered in that way. Indeed there is often a difficult observational problem involved in determining whether a specimen is in place at the foot of a high bluff, because a vertebrate fossil can be introduced to the exposure in any layer which is below the seasonal high water mark. For example, a fossil bone lying on the surface of the bluff can be covered by slumped sediments which can then be reworked by the high water in the spring and redeposited on the fossil to give the appearance of *in situ* occurrence. It is necessary to establish that a given stratigraphic unit actually encloses the specimen and belongs in the lower part of the sequence, and this must be done by tracing the unit laterally along the face of the bluff and into the sedimentary profile behind the face (Fig. 2.5).

The last column in Table 2.1 provides references to tables and chapters in the text where specimens from each locality are described. Most of the localities are treated only in Chapter 4 and Appendix B for which table references have been provided.

Much of Chapter 4 is devoted to a selection of altered bones which can be identified to Order Proboscidea but which cannot be securely assigned a generic or specific name. Several species of mammoths as well as the American mastodon have been recognized in the Old Crow basin on the basis of their teeth (Harington 1977), but most of the post-cranial material, particularly specimens which are relevant to this report, is too fragmentary to identify with confidence. The teeth of the woolly mammoth (*Mammuthus primigenius* Blumenbach) outnumber all other proboscidean taxa by several fold in the redeposited samples, suggesting that a given proboscidean long bone fragment or other post-cranial element can be viewed as more likely belonging to that species than to any other. Therefore, while I want to emphasize that the specimens have not been identified as mammoth bones, I will adopt the convention of using the word "mammoth" in discussions of these remains. Tabular presentations will include the convention "cf. *Mammuthus* sp." while "mammoth" will be used in more conversational modes.

Fig. 2.5 Mammoth (cf. *Mammuthus* sp.) long bone fragment (MlVl-2: 134) shown in its position of discovery just above the contact (trowel tip) of the detrital organic sands (Unit 3) and the reworked lower glaciolacustrine clay (Unit 2). Such specimens near the exposed face of the bluff cannot always be demonstrated to belong to the layers in which they appear to have occurred, because these lower units are flooded annually(?) and can be disturbed by ice-rafting. This bone is probably an example of this process. Small air pockets and a thin slurry of fine sediment were seen beneath the specimen when it was removed.

In a number of preliminary reports on our excavated samples from MlVl-2 (Morlan 1978a, 1979a, 1979b; Morlan and Matthews 1978) we have used the term "Unconformity A" to designate the contact of Units 3 and 4. Strictly speaking, the term "unconformity" is not appropriate for this contact since the amount of time it represents is quite small in geological terms. Therefore we have now adopted the term "disconformity" as a more precise indication that we can demonstrate the existence of a temporal hiatus of unknown duration at this contact, and "Disconformity A" as used in this report is equivalent to our earlier usage of "Unconformity A."

CHAPTER 3. TAPHONOMY AND ARCHAEOLOGY

Taphonomy

One of the most obvious characteristics of paleontological and archaeological bones is that they differ from the bones of living animals. Individual bones and assemblages of bones undergo numerous changes from the time an animal dies until the time the remains are collected for study. Another characteristic which is perhaps less obvious but no less important is that "bones are not necessarily buried where an animal dies, and they are even less likely to be buried where the animal lived" (Behrensmeyer 1975a:36). Many factors are associated with changes in individual bones and bone assemblages beginning with the decomposition and disarticulation of the skeleton and extending through a variety of forces which lead to differential transportation and preservation of skeletal elements.

These factors have been subsumed under the label of "taphonomy" which was defined by Efremov (1940:95) as the "science of the laws of embedding." Recent usage of this term has included all considerations bearing upon the passage of organic material from the biosphere to the lithosphere, and it is in this broader sense that I shall refer to taphonomy in this report. It is increasingly clear that taphonomic considerations are vital prerequisites for reliable reconstructions of paleoecology, and I will try to show in this report that such studies are essential to an understanding of the archaeological meaning of bones and other organic materials.

Taphonomy has been given considerable attention by paleontologists working on pre-Quaternary fossils (e.g. Olson 1962; Clark and Kietzke 1967; Voorhies 1969), and Quaternary microvertebrate assemblages, which are so often used as paleoenvironmental proxy data, have been extensively studied with respect to their various modes of origin (Mellet 1974; Mayhew 1977; Dodson and Wexlar 1979; Korth 1979). General models of various assemblage types have been proposed on the basis of taphonomic analysis (Johnson 1960), and the awareness of information losses through differential preservation in the fossil record is enabling investigators to define suitable constraints for paleoenvironmental analysis (Guthrie 1967; Lawrence 1968).

During the past decade there has been a tremendous acceleration of research oriented toward the taphonomy of early Hominid assemblages in East Africa. Some of these studies have been devoted to the paleoecology of Hominids themselves (Behrensmeyer 1975a, 1975b; Boaz and Behrensmeyer 1976); others have developed modern observational data on carnivore scavenging and ancient fossil assemblages which could be compared with early South African deposits such as Makapansgat (Klein 1975; Shipman and Phillips 1976; Shipman and Phillips-Conroy 1977); and recently abandoned sites have been examined for their implications concerning archaeological site formation processes (e.g. Gifford and Behrensmeyer 1977; Gifford 1978; Robertshaw 1978). Large areas of Africa offer opportunities for examining fossils weathering on the surface (Behrensmeyer 1978), and the existence of large and complex ungulate communities in association with a variety of carnivores permits the observation of processes very similar to those of the Pleistocene. Recent detailed studies of the natural history of large carnivores such as the lion (Schaller 1972) and the hyena (Kruuk 1972)

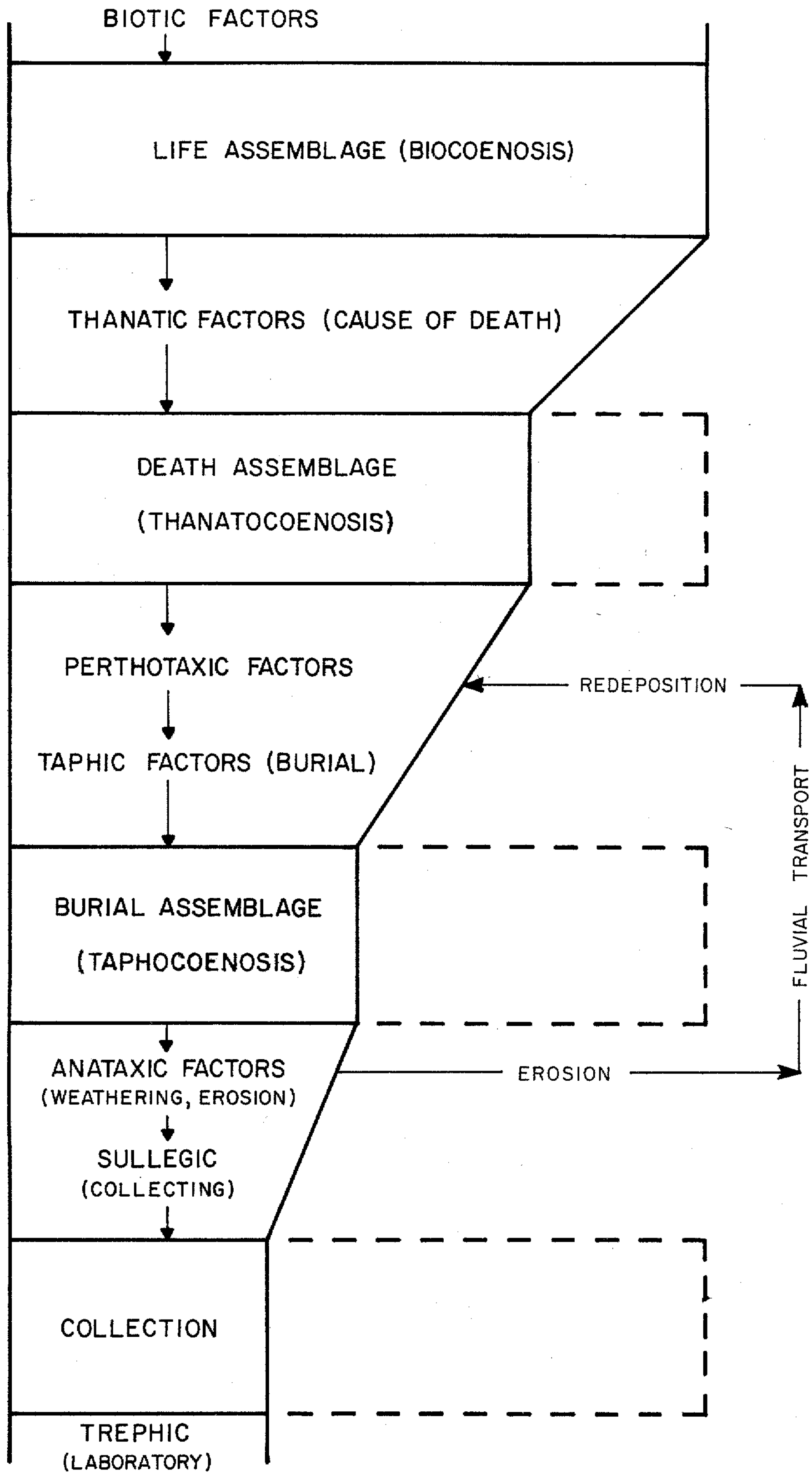


Fig. 3.1. Model of factors and assemblages pertaining to the taphonomic history of vertebrate fossils to be considered in this report (modified after Clark and Kietzke 1967:Fig. 53).

have supplied a framework for interpreting observations of predation and scavenging on animal carcasses from which data on individual bone alterations and on disarticulation sequences can be recovered (Crader 1974; Hill 1976, 1979a, 1979b; Shipman and Phillips-Conroy 1977). Other studies have discussed the effects of drought on the development of fossil assemblages (Shipman 1975) and the decomposition of elephant carcasses with and without the effects of large scavengers (Coe 1978).

Similar studies have been undertaken in other areas of the world with the purpose of the work primarily oriented toward better paleoecological reconstructions or the development of recognition criteria which can be used to separate cultural and natural alterations of bones and bone assemblages (Thomas 1971; Meadow 1976; Yesner 1978; Bonnichsen and Will n.d.). The development of criteria for recognizing artificial bone alterations will be a major focus in this report, and I shall attempt to identify these criteria against the background of a wide variety of alterations some of which are demonstrably attributable to natural agencies. Since we will refer repeatedly to a complex suite of variables and biases which affect the fossil record, I have elected to present a general model of taphonomic factors which should simplify the discussion. Clark and Kietzke (1967) have provided such a model as well as an excellent discussion of some of its components, and I have modified it for use in this report (Fig. 3.1).

Clark and Kietzke (1967:115) note that a living assemblage of organisms (a biocoenosis) is shaped by many biotic factors among which they identify the total range and population density of a species, the ecological niche and competition from other species, the "osteological construction" which refers to the fragility of the remains, and the body (hence bone) size of the species. The implications of the last two factors for fossil assemblages have been discussed by Guthrie (1967), Thomas (1969), Payne (1972a, 1972b) and Watson (1972) among others.

Variables pertaining to the death of an animal are called thanatic factors -- the cause of death, the locus of death, and the age at death -- all of which influence the potential of an animal to become preserved in the fossil record (Clark and Kietzke 1967:115-117). These factors may cause admixture of different habitat indicators as when as upland species faces starvation due to drought and dies in a lowland area while seeking water. Thus the thanatic factors may modify the biocoenoses to produce death assemblages or thanatocoenoses.

Following or accompanying death and prior to burial or destruction of the remains, a variety of "perthotaxic" factors come into play. These include the initial weathering phenomena as well as predation and scavenging pressures which remove flesh from a carcass, contribute to its disarticulation, and inaugurate processes of bone alteration (Clark and Kietzke 1967:117). Undoubtedly these factors exclude many carcasses and elements from the burial environment by completely destroying them or by moving them away from suitable burial habitats, and human activity may play a major role at this stage in the history of many animals (cf. Noe-Nygaard 1977).

Even after the perthotaxic factors have done their work the remains still must be buried in order to be preserved as fossils in most environments, and their burial potential is now determined by taphic factors among which Clark and Kietzke (1967:117-118) list: (1) time interval between episodes of sedimentation; (2) thickness of sedimentary increments; (3) velocity of depositional current in contact with bone or corpse; (4) nature of sediment; (5) post-depositional action of roots and burrowing animals; and (6) permeability of compacted sediment and nature of permeating solutions. These were the factors of interest to Efremov (1940) in his definition of "taphonomy." The taphic factors, along with all previously mentioned factors, determine the nature of the burial assemblage or taphocoenosis.

The initial burial assemblage is the total potential fossil record, and various subtractive processes act upon it both before and after its discovery and excavation. Prior to its discovery the fossil record may be reduced by weathering *in situ*, exposure by erosion, and weathering and transportation after exposure. These anataxic factors operate to expose and destroy fossils, but scientists often depend upon these factors to enable discovery of fossil deposits (Clark and Kietzke 1967:118).

Collecting and curating factors, called sullegic and trephic, respectively, further reduce the fossil assemblage to the final form of the paleontological collection (Clark and Kietzke 1967:118-120). Collecting factors include such biases as screen-mesh size and personal interest, while factors operating in the laboratory include the identifiability of various fragmentary remains which may depend in part of the quality of reference collections and the skill of the analyst (Casteel 1972; Payne 1972a, 1972b; Wolff 1975).

All these factors may interact to produce a complex network of influences on the carcass and individual skeletal elements of a single animal and in turn on the assemblage of specimens which is taken to the laboratory for study. Much of this network probably cannot be reconstructed, but its components must be carefully considered before the paleoecological or archaeological significance of a collection of fossils can be realistically appraised.

In the following discussion I will enumerate some of the taphonomic factors which are specifically relevant to this study. Some of these factors are physical and chemical responses to abiotic influences and others result from interaction between bones and various elements of the ongoing biological community. Of special interest is the phenomenon of green bone fracture which is quite importatnt in the evaluation of archaeological material. These topics will be discussed in terms of the influences on single bones after which we will briefly examine factors which alter the composition of bone assemblages.

Physical and Chemical Factors

A wide variety of physical and chemical changes can occur in bone following the death of an animal. Bonnichsen (1979:Chapter III) has summarized some of these alterations, and a review of these factors is required in this discussion. Temperature, moisture, geochemical, and hydrodynamic factors are the principal agencies which alter bone in the absence of biological organisms (Bonnichsen 1979:26-30). Repeated changes in these variables accelerate their effects on bone so that fluctuations in temperature or moisture, for example, promote bone alteration more readily than most steady conditions. It has long been known that bone develops split lines which can be induced in fresh bone (Tappen 1964, with references), but these features eluded explanation until recently when it was shown by Ruangwit (1967:321) that "the single morphologic feature which seems to be correlated with the occurrence (or lack) of split-lines in cortical bone is the arrangement of bundles of collagen fibers." In an apparently independent study (he does not cite Ruangwit), Tappen (1969:191) showed that "any process which shrinks bone will produce cracks with the same orientation as split-lines," a result which suggests that weathering cracks occurring naturally in drying bones are equivalent to experimentally induced split lines (see also Tappen 1971, 1976; Tappen and Peske 1970). As Tappen (1969:192-193) notes, this observation should open up a new area for the study of archaeological and paleontological specimens. Bones can shrink as much as 30% through the loss of water and organic material (Berg 1963:235), and such shrinkage should be expected to cause failure in the bone wall.

While this process still is not understood in detail and is undoubtedly the result of complex multiple factors which cannot be fully reconstructed by the analysts of fossil bones, some studies have been completed on the effects on natural weathering in desert environments. Miller (1975) has studied carcasses in the Colorado Desert of California where the time of death could be determined for each animal. He has shown that longitudinal weathering cracks appear "shortly after the bones become exposed" but that transverse cracks are not apparent until two years later (Miller 1975:217). These cracks extend through the bone wall *at right angles to its outer surface* and range from small shallow openings to complete separations reaching all the way to the marrow cavity.

An additional form of deterioration, called exfoliation (Pl. 3.1), was observed to begin four years after the exposure of the bone (Miller 1975:218). This process occurs at right angles to the longitudinal and transverse cracks and consists of the progressive removal of the circumferential lamellae which form the outer layers of the bone wall (Fig. A2). I have also observed exfoliation of such lamellae adjacent to the marrow cavities of intensely weathered bones. Cracking and exfoliation can be exaggerated or even produced by minerals such as gypsum and montmorillinite which have large expansion capabilities when wetted (Bonnichsen 1979:27).

A characteristic of long bone fracture which has often been cited as indicative of human activity is the spiral form which the fracture assumes as it travels around the bone shaft (see discussion below). Hill (1976) has remarked that spiral fractures can occur as a result of natural weathering, particularly in bones such as the humerus and tibia which are subjected to torsional stress during the life of the animal. "Similarly, in bones where the stresses are mainly compressional, such as bovid metacarpals, breaks occur parallel to and perpendicular to the long axis of the bone" (Hill 1976:335). Hill is concerned that such weathering patterns might be mistaken for artificial fractures, and I would agree that such errors might be made in the interpretation of small fragments. On the other hand, such natural weathering along the split lines of long bones will not result in the features which I have identified as indicative of impact-induced fractures (see below; Pl. 3.4). At least two studies have suggested that prompt burial of bones tends to prevent the formation of split lines (Peske and Tappen 1970; Gifford 1978:91).

Pitting and rounding of bone surfaces can result from the attack of acids carried by ground water (Pei 1938:12), and the vagaries of bone preservation seem generally to depend on the pH of the burial environment. In most environments other than extremely dry or cold areas little or no preservation of bone can be expected unless burial occurs soon after the death of an animal (cf. Matthews 1962:7ff.).

The burial environment must be capable of retarding decay either through freezing, through maintainence of anaerobic conditions, or through mineral deposits and substitutions. Bones may become permineralized as a result of the filling of pores and open spaces by mineral-bearing ground water at the time of burial, following burial and during the weathering of enclosing sediments (Matthews 1962:17). Some bones undergo total replacement by minerals and are then referred to as mineralized (Matthews 1962:18). These changes are time dependent, but they may begin very soon after the bone enters the burial environment (Cook 1951; Hassan and Ortner 1977; Hassan, *et al.* 1977). Bones may undergo either depletion or accumulation of materials (Cook, *et al.* 1961; Stout 1978). Whereas the bone apatite crystal can freely exchange phosphate and carbonate ions with the burial environment, bone collagen does not seem to exchange carbon to the same extent. On the other hand, there seems to be a net loss of organic materials through time (Cook and Heizer 1952), and various humic acids, amino acids, and trace elements can be introduced to or leached from buried bone by ground water or through the percolation of water through soil (e.g., King and Bada 1979; Wessen, *et al.* 1977).

Accumulation of sediment to great thickness above the burial site of a bone can produce tremendous static loads which in extreme cases can crush the specimen. These effects could be exaggerated in situations involving freeze-thaw or wet-dry cycles or in the presence of minerals which expand when wetted.

All of the foregoing agencies can act upon a bone even if it is never moved from its original site of deposition. New factors come into play if the bone is redeposited one or more times. In streams which carry large stones, bones can be comminuted very quickly, and even in streams with smaller sediment sizes pronounced rounding and pitting can occur (Pl. 3.5). Apparently the effects of wind-bourne sand on bone are to etch its surface rather than to smooth and polish it as occurs with stone ventifacts (Brain 1967b:99), but more study is needed to confirm the condition of ventifacted bones. Polishing is often seen on bones, and it may result from long-term subaqueous solution and abrasion, from movement within a sandy matrix, and perhaps from the abrasive effects of moving ice as in the spring break-up of northern rivers. Slumping of sediments can produce fractures even on large bones, and it would be useful to know what kinds of fracture patterns would result from sediment bodies slumping past a bone which is partially frozen into a position just behind the slump. There are no doubt many other physical and chemical processes which alter bones in various burial environments, but the ones identified above are probably the most relevant to this report.

Biological Factors

Studies of carrion decomposition have shown that bacteria, fungi, and insects play very important roles in the reduction of carcasses and the recycling of nutrients (Payne 1965; Payne, *et al.* 1968; Dodson 1973; Coe 1978). Bones become exposed quite rapidly under the influence of a complex carrion fauna involving hundreds of species. Coe (1978) provides a detailed description of the seral phases of decomposition in three elephant carcasses in the Tsavo National Park of Kenya. Partly due to the action of vertebrate scavengers, the left radius and ulna were completely exposed on the carcass of a large male after only 12 days. By Day 20 the right limb bones were exposed under a layer of dry skin, and the rump had been partly eaten away to expose the pelvis. Exfoliation and "extensive longitudinal cracks" in the bones were observed on Day 231 after a long period during which no observations were made, and on Day 549 the bones were observed to be greatly bleached with most of the outer surface lost to exfoliation while ants were seen carrying away bone "flakes" (Coe 1978: 76). Visits to the site 2½ and 4 years after the death of the elephant revealed that the exposed bones were still losing material through exfoliation of their outer surfaces while some of the smaller bones were nearly buried (Coe 1978:76).

Plants effect bones in several ways. Plants may entrap bones and prevent their movement by streams (Behrensmeyer 1975b:Pl. 3), and in certain circumstances this could promote burial. In the burial environment plant roots and rootlets seem to seek out bones as nutrient sources. I have excavated caribou long bones from recent sites in which roots had grown through the marrow cavity and split the bone longitudinally. Many bones seem to be attacked by rootlets which leave distinctive etching patterns on their cortical surfaces (Pl. 3.2). The causes and mechanisms of etching seem not to be clearly understood. Bonnichsen (1979:26) reports that carbolic acids are produced by the plant roots so as to metabolize bone, but other possibilities include a wide variety of exudates which are produced at the root tip as well as the complex relationships between roots and microorganisms which might be able to dissolve bone or collagen or apatite (Bokhari, *et al.* 1979; Strang 1979). Very small pits (called "Type BF pitting" in this report) may result from end-on contact of root tips on a bone surface.

Bone chewing is undoubtedly a major factor in the destruction of individual bones and carcasses. Chewing by rodents can open small holes or "windows" in bone walls (Singer 1956), and some rodents are capable of producing incisions which might be mistaken for human butchering marks (Pl. 3.6); G.A. Haynes 1978; Pei 1938: 4 ff.; Wood 1952). Even the desert tortoise (*Gopherus agassizi*) is known to leave chewing marks on bones (Miller 1975:213). Ungulate "osteophagia" has been a subject of much discussion in recent years and appears to be nutritionally important in some seasons of the year. Cervids commonly chew antlers (Fish 1950; Gordon 1976) and even bones (Sutcliffe 1973, 1977), sheep are known to chew bone (Brothwell 1976), and some ungulates even ingest small mammals (Teagle 1963) or bones (Anderson 1974). In Rhodesia, bone seems to comprise an essential source of calcium for griffon vultures who suffer malnutrition when adequate supplies are not available (Mundy and Ledger 1976). Several erroneous artifact identifications are now attributed to ungulate chewing of bone and antler (e.g., Tokunaga 1936; Kuss 1969). None of these animals is definitely known to fracture bones while chewing them.

Carnivore chewing can alter bones in several ways (Pei 1938:8ff; Miller 1969a; G. Haynes 1978, n.d.), and Bonnichsen's (1979:18-24) summary of the literature includes references to circular punch marks or perforations made by the canine teeth (Pl.3.7), crunching and splintering of the bone walls, rotational scarring (Pl. 3.8), and scooping of epiphyses (Pl. 3.9), as patterns which have been attributed to carnivore bone gnawing. In general, carnivores attack the ends of long bones where a relatively thin outer table encloses spongy, blood-rich cancellous tissue, but fractures of limb bone shafts do occur with some regularity depending upon the size of the carnivore, the nutritional state and satedness of the carnivore, and the size of the prey skeletal material.

Long Bone Fracture

Before discussing the causes of mid-shaft fractures in long bones, it is important to consider the mechanism of such fractures in order to identify the significance of various fracture attributes which will be used in this analysis. In Appendix A I have presented background information on bone as a material and on the biomechanical properties of bone. There I have arrived at the conclusion that long bone fracture is not readily explanable in terms of the molecular, cellular, or microstructural components of bone, and I will take the position here that long bone fracture is best explained at the macrostructural level of analysis.

Although there are numerous flanges, ridges, and other surface features which significantly influence the propogation of fractures, it is possible to envision long bones as cylinders or tubes and to use analogues based on other cylindrical or tubular materials to explain the fracture properties of long bones. Bonnichsen (1973; Bonnichsen and Will n.d.) has conducted fracture experiments with glass tubes and has shown that the resulting fragments closely resemble the bone fragments which commonly occur in archaeological sites and as a result of experimental bone fracturing. These similarities occur despite the isotropic structure of glass as compared with the anisotropic structure of bone, and it would seem to be the brittle character and tubular form of the two materials which are responsible for their similar fracture properties. Apparently cracks are propogated just outside the impact area, and they may run in any direction from that point. Those which travel transversely around the tube intersect one another first while others travelling along diagonal orientations are carried by the cylindrical shape of the tube into helical or spiral forms. The intersection of these running cracks either causes the bone to fracture or it may induce the cracks to change direction. Both glass tubes and long bones exhibit fracture patterns which seem to be explained in this way, but in the case of bone fracture the resulting pieces seem generally to be longer in relation to the tube diameter presumably because of the influence of longitudinally oriented Haversian systems which would provide added resistance to the tendency for the cracks to travel in spirals (Bonnichsen and Will n.d.).

The position in which the tube is held or stabilized seems to influence the fracture pattern by predetermining where compressive and tensile forces will occur. If the tube is loaded as a simple beam with its ends supported, an impact in the center of the span will create compressive force on the top of the tube and tensile force on the bottom. Tensile forces also occur just outside the impact area and cause local deformation of the tube wall. We will look for these deformations as indicators of the size and position of point loading in this analysis. On the other hand, by placing the tube on a centered anvil support and impacting the tube directly above the anvil, compressive forces are created on opposite sides of the tube while maximum tensile force occurs 90° around the tube in both directions (local deformation due to tensile forces around the anvil and around the loading point can also be observed).

A major difference between glass tubes and long bones is seen at the ends of the tubes. Whereas glass tubes have open ends which do not appreciably influence the fracture front, long bone ends are not only closed but are filled with cancellous trabeculae. These internal structures tend to absorb much of the energy required to propogate a running crack, but some of the energy is reflected in the form of elastic waves which enable the crack to turn away from the epiphysis of the bone and travel in a spiral pattern around the shaft (see Bonnichsen 1973; 1979:43-44).

Very complex fracture patterns can result from multiple impacts on a single long bone. A bone may not completely fail as a result of the first impact, but relatively little additional energy must be supplied to accomplish failure due to the rapidly decreasing cross-sectional area remaining to resist an applied force. Multiple impacts at opposite ends of the bone shaft will result in intersections of fracture fronts advancing from both ends, and long slender fragments of bone can be obtained from this procedure. The recognition of such pieces is sometimes made possible by the existence of micro-relief features on the fracture surfaces - features which are similar to those seen in other brittle materials such as stone (see Gash 1971). These features enable the analyst to determine the direction in which the fracture front advanced even if the precise point of loading is not observed on the specimen.

Spiral fractures in long bones have been attributed to human activity for more than 70 years (Martin 1907-1910: Vol. I, pp. 293 ff.). Apparently it was the spiral form of long bone fractures that prompted Dart (1959b: 91; and, later, Sadek-Kooros 1972:Figs. 1-3) to advance the crack-and-twist concept. According to this view the long bone is cracked by an impact, and the final form of the spiral fracture is produced by twisting the ends of the bone in opposite directions. Spiral fractures can be induced entirely by means of torsional loading (Evans 1952; Pederson, *et al.* 1949), but the amount of force required to fracture even the relatively slender limb bones of humans appears to be an order of magnitude greater than human twisting strength. Such fractures result when skiers fall after trapping the ski tip, but in these cases the length of the ski provides the added leverage needed to deliver more force than the bone can bear. In other animals the combination of torsional force and the axial compression provided by the weight of the victim seem to be critical prerequisites for the production of such fractures in life (Rooney 1969: 110-113). Thus, in the experiments by Dart and others it is likely that the spiral fracture was produced by the impact and that the twisting of the bone merely completed the separation of the pieces which may have been held together by the surrounding periosteum (Morlan 1978a:82; Bonnichsen 1978:108).

The limited available data suggest that bone samples taken from various animals may differ in their ultimate strengths in tension and compression; that the strength of bone increases upon drying (Table A2); and that ultimate strength is strongly influenced by histological factors (Evans and Bang 1966; Evans and Vincentelli 1974). In whole bones the amount of force required to produce spiral fractures is a complex function of bone strength and size, holding position, and force concentration. Many, although not all, artificially induced spiral fractures depend upon the bending resistance of the bone which has been shown to increase by the third power of the bone diameter (Preuschoft and Weinmann 1973). Bending and torsional strength are also complex functions of bone length, bone wall thickness, cross-sectional area, and cross-sectional shape (Lovejoy, *et al.* 1976; Jurist and Foltz 1977). Obviously these relationships are not well understood with respect to most specific instances of bone fracture, but it is possible to generalize about the prerequisites for systematic artificial fracture of large bones. In order for human to induce spiral fractures in a large bone, a well aimed high velocity impact must be delivered to the bone shaft with a rounded impactor such as a hammerstone which concentrates the force in a relatively small area. Such properties permit ordinary mortals to overcome even the massive and very strong long bones of modern elephants (Stanford, *et al.* 1980). The impact area frequently exhibits distinctive negative flake scars which result from local tensile fracture of the bone wall. Often a small flake of bone is driven into the medullary cavity and has even been preserved in place on a few archaeological examples (Pl.3.3).

Obviously the complex relationships among the impact velocity, size of impactor, and size and condition of bone are fundamental determinants of fracture patterns. A needle or nail can be driven into a bone wall without producing a fracture involving the whole bone shaft, and a very large impactor could so completely overcome the target that fractures of the shaft could not ramify in spiral patterns. Ballistics studies may be helpful in defining the minimum contact area required to involve a whole bone shaft in spiral fracture at various velocities (e.g., Huelke, *et al.* 1967), but I have not yet examined this area of research in sufficient detail to provide comment.

The foregoing discussion has highlighted the manner in which bones can be deliberately and systematically fractured by man. That human groups undertake such practices has been shown by means of ethnographic observations

(Zierhut 1967: Bonnichsen 1973; Binford 1978, n.d.) and through the concentrations of bone fragments which commonly form a large part of the archaeological record wherever bone is preserved (e.g., Noe-Nygaard 1977). There are many other agencies which fracture bones, however, and some of them produce fracture patterns which are difficult to separate from the results of human activity.

Many of the fragments produced by carnivores could be mistaken for segments of artificially broken bones, and some of the former even exhibit small flake scars which could be mistaken for negative impact scars resulting from hammerstone use (Pl. 3.10). The relative sizes of chewer and chewed are critical factors, and hyenas seem to be the champions since they can overcome very large bones including those of baby hippopotamus and baby elephant (Sutcliffe 1970:1111), although presumably not those of the adults (Kruuk 1972:116). "Not only are hyenas able to splinter and eat even the largest bones of widebeest and zebra, but they are also able to digest them completely" (Kruuk 1972:107-108). Hyenas can swallow remarkably large pieces of bone which become rounded, perforated, and even inserted into one another in the animal's digestive tracts (Sutcliffe 1970: Fig. 5; Schaller 1972:384). Hyenas seem to be a special case with regard to their bone crushing abilities (Buckland-Wright 1969; Schmid 1976), and there is no known comparable animal in the modern or fossil biota of the New World (except possibly in Middle Pleistocene times). Even the very large hyena of the European Pleistocene (*Crocuta crocuta spelaea* Goldfuss: Kurtén 1968:71) seems not to have broken mammoth limb bones in mid-shaft. One extensively chewed mammoth femur from a cave hyena occupation level at Hohlefels am Schambach in Bavaria has been reduced to less than two-thirds of its original length by gnawing at both ends, but the shaft was not fractured until much later when mineralization of the bone was well advanced (Pl. 3.11).

There is probably an upper limit to the fracture capabilities of a given species of carnivore, but such a limit has never been clearly defined. For example, it is not known whether North American Pleistocene carnivores could have fractured the shafts of large extinct bison species or the several large species of horses. In some cases it seems possible to make an evaluation of large pieces of fractured bones, but small fragments cannot be interpreted reliably. The only taxa which appear to be immune from such a confusing record are in the Order Proboscidea since even the large Pleistocene hyenas seem not to have created mid-shaft fractures in the long bones of adult mammoths and mastodons. Therefore proboscidean limb bone fragments on which signs of intersecting fracture fronts indicate multiple impacts seem to constitute evidence of artificial bone fracture, and such specimens should be sought as indicators of the likely presence of human hunters and scavengers.

Studies of bone chewing (Sutcliffe 1977; G.A. Haynes 1978, 1980; Binford n.d.) are still underway and include field observations as well as zoo studies. Continued experiments with bone fracture include those by Zierhut (1967), Sadek-Kooros (1972, 1975), Bonnichsen (1973), Frison (1974, 1978: Chapter 8), Harington, Bonnichsen and Morlan (1975), and Stanford, Bonnichsen and Morlan (1980).

Accidental injuries during life can cause spiral fractures in many animals, but such fractures have rarely been documented except for those in humans (e.g., Herrmann and Liebowitz 1972:819) and horses (Rooney 1969: Chapter 10). A number of writers have mentioned the possibility that animals can break their limbs by violently thrashing about after becoming mired (e.g., Lemon and Churcher 1961:421-422; Bryan 1973:251; Drew 1979: 278). Most such cases appear to lack discrete points of impact, and the spirals usually ramify in one direction rather than intersecting from clockwise and counter-clockwise fracture fronts. Careful inspection of the numerous elephant carcass photographs published by Beard (1977) reveals that fractures of limb bones are very rare, even when the elephant has met a violent death (see also Coe 1978).

Animal trampling on bones lying on or near the surface probably causes a wide variety of fractures including spiral forms, and high frequencies of fractured bones are known to occur near water holes in Africa (G.A. Haynes, pers. com. in 1979). In a very important study of horse and camel bones from six paleontological localities ranging in age from the Miocene to the Pleistocene in Nebraska, Myers, Voorhies, and Corner (n.d.) have found abundant oblique fractures which they have classified as spiral forms and provisionally attributed primarily to trampling. Since their only classificatory criteria are evidence of rounding, comparisons of surface colours, and gross geometry of the fracture, these specimens should be reexamined in the light of a larger set of attributes which I will specify below.

Elephants are known to pick up the bones of dead elephants, "twiddle" them, toss them aside, and carry them about, and in one published illustration an elephant appears to be holding a spirally fractured femur in its trunk (Douglas-Hamilton and Douglas-Hamilton 1978:237-239, plates). Most of this behaviour appears to be quite reverential and is poorly understood; the elephants are usually excited when they "handle" such bones, but they rarely handle them so roughly as to fracture them (R.C.D. Olivier, pers. com. in 1979).

Clearly there are numerous agencies which alter bone following the death of an animal and both before and after burial of the carcass or individual bone. Most of these agencies have been only casually studied with respect to the fracture patterns and other alterations which they induce on bone, and there are many instances in which it is simply not known whether bone fractures are produced which could be confused with a genuine archaeological record.

The studies mentioned above by no means exhaust the list of possible bone alterations, but they are helpful in defining special attributes and limits for some of these phenomena. I believe that we can demonstrate results which surpass Hrdlička's (1912) expectations, and many of Binford's (n.d.) concerns have already been laid to rest.

Cultural Factors and Assemblage Studies

All of the foregoing physical, chemical, and biological factors have been discussed in terms of their influences on single bones. Many of these factors are also associated with changes in bone assemblages. Carnivores, for example, have a significant influence on the rate and manner of skeletal disarticulation (Toots 1965; Hill 1979a, 1979b), and many kinds of rodents can introduce themselves to bone assemblages either before or after burial (Thomas 1971). Human hunters selectively disarticulate and transport elements of the skeleton (Frison 1978; Klein 1976a; Lyman 1978; Binford 1978), and differential destruction of bone elements results from tool making, grease manufacture, the use of bone as a fuel or dog food, and a variety of ritual disposal observances (e.g., Leechman 1951; Lyon 1970; Casteel 1971; Vehik 1977; Brumley 1973; Binford and Bertram 1977; Yesner and Bonnichsen 1979; Bonnichsen and Sanger 1977).

Individual skeletal elements respond differently to hydrodynamic processes, and flume studies have been conducted to determine such differences so that bone assemblages which have been transported in fluvial systems can be evaluated accordingly (Voorhies 1969; Dodson 1973; Boaz and Behrensmeyer 1976; Bailey and Lundy 1977). Behrensmeyer (1975b) has attempted to relate skeletal elements to quartz grains of various diameters, and Parama (1978) has inaugurated a long term experiment in which the Old Crow River of northern Yukon will transport colour-coded horse bones.

The major conclusion which seems to emerge from most of these studies is that more of this kind of work must be done before a clear understanding of fossil assemblages can be achieved, but at the very least it is possible to determine whether a bone assemblage is autochthonous ("not transported from the environment of disarticulation") or allochthonous ("transported and probably foreign to the environment of deposition") (Behrensmeyer 1975a: 36), or whether the assemblage contains a mixture of "proximal" and more distant elements (Shotwell 1955; Thomas 1971; cf. Hoffman 1979). These considerations also highlight the many activities and processes which took place on "archaeological sites" in addition to the activities of ancient humans (cf. Daly 1969).

Taphonomic Factors and Archaeological Criteria

One reason for my adoption of a taphonomic approach to the Old Crow fossils is that their information content is much greater than the rather narrow range of alterations which have been regarded as archaeologically relevant. It is my belief that we can take advantage of this additional information to improve our understanding of the many processes which have influenced both individual bones and bone assemblages in the Old Crow basin and neighbouring areas. This information should prove to be consistent with the sedimentary and geomorphological evidence with which various burial environments can be characterized, and departures from expected distributions of observable bone alterations might assist the definition of that portion of the vertebrate record which has experienced human interaction in the past. I did not assume, however, that human activity had taken place in the Pleistocene of the Old Crow region. In fact I was uneasy about previous reports on the Old Crow fossils (e.g., Morlan 1978a, 1979a, 1979b; Bonnichsen 1978, 1979) primarily because they had presented a *selection* of specimens thought to have been artificially modified but they had neglected to account for the many other specimens which were found in secondary associations with the artifacts. Bonnichsen's study included a tabulation of animal alterations (Bonnichsen 1979:Appendix F), but there are many other factors which have not been previously considered in detail with respect to these fossil collections.

Between the time when Bonnichsen's observations on the fossils were completed (1974) and the several years during which I have studied these materials (1977-present), we have had several important opportunities to learn more about the capabilities of carnivores in altering bones. We now realize that carnivore crunching and splintering abilities are somewhat greater than had been supposed, and it is also clear that some carnivores can chip back the broken edges of a bone shaft to produce a flaked appearance which might be mistaken for artificial core reduction. Therefore I began to suspect that many of the specimens we had interpreted as artifacts could be accounted for in terms of carnivore activities, and my suspicions grew to embrace more and more pieces until I wondered whether an archaeological record could in fact be demonstrated among the Old Crow fossils. Thus the ultimate motivation for adopting the taphonomic approach used in this study was the realization that I might account for all of the alterations visible on these specimens without involking human activity and presenting an archaeological interpretation. I have challenged every form of alteration visible on the pieces from the Old Crow region from the standpoint of finding alternatives to the concept of human intervention in the Pleistocene, and many of the pieces have either been rejected or have been placed in a sort of limbo until further research clarifies their status. What remains is a somewhat smaller nucleus of materials for which I have been unable to find an explanation without supposing that human activities were involved in producing their present forms. The taphonomic factors which have been considered in this analysis will now be summarized to show how each of them contributes to an understanding of the history of the fossils, and recognition criteria will be defined for the identification of archaeological materials.

Permineralization and Staining

For several reasons it is important to establish whether the preservation of the fossils is due to freezing, deposition in anaerobic environments, permineralization or a combination of these processes. It is also important to determine the significance of colour variations among the bones. To a limited extent the degree of permineralization and staining can be used to estimate gross age categories for individual specimens although this approach cannot be refined beyond distinctions between pre- and post-late Wisconsinan (Harington 1977:Appendix II). More importantly for our purposes, the recognition of permineralization and micro-cracking processes aids in the understanding of fracture patterns, and staining appears to bear some approximate relationship to the permineralization process.

In using Munsell colour charts as a means of standardizing colour observations on these bones, I have found that one must be careful to distinguish the general ground colour from local patches of mineral accumulation or other differential staining characteristics. Bones found today lying on the upland surface in the Old Crow basin have a bleached appearance, very little red in hue, high value, and relatively low chroma (e.g. 5Y8/3).

Reddish hues appear wherever the bone is in contact with mineral soil, and chroma increases abruptly as value decreases (e.g. 10YR7/6). In late Holocene archaeological sites such as Klo-kut on the Porcupine River (Morlan 1973), bones which have been buried in alluvium for 100 to 1200 years have quite variable red-yellow hues even within one specimen, but the value is usually around 5-6 and the chroma in the range of 4-8. These trends are continued in a series of *Bison crassicornis* bones recovered from a late glacial context in Old Crow Flats and dated to about 12,000 years B.P. The majority of the fossils found on the banks and bars of the Old Crow River and in the sedimentary deposits at MlVl-2 are quite dark in colour with hues between 2.5YR and 7.5YR, low values (2-3) and low chromas (0-2). Typical examples are dusky red, dark brown, and black (2.5YR3/2, 7.5YR3/2, and 5YR2/1, respectively).

There are many exceptions to these patterms, however, and some of the variations are seen among a selection of 63 proboscidean limb bone fragments (Table 3.1) from the reworked deposits. Colours range into the 10YR hue, and values and chromas are as high as six. A general trend is noticeable whereby the redder the colour the lower the value and chroma, and this trend may reflect the staining properites associated with iron and manganese enrichment. Regardless of the exact mechanism of colour change, it should be clear that no simple relationship is uniformly applicable to the fossils from Old Crow, and the use of staining characteristics as an aging criteria is probably not warranted. On the other hand, the few very light-stained mammoth or mastodon bones might have been reworked from sediments overlying the upper glacial lake in which case their relarively light colours could be construed as a true reflection of their recent deposition.

Bonnichsen (1978:Table 2), working with P. Tymchuck at the National Research Council of Canada, has shown on the basis of a limited spectographic analysis that the darkening of the bones through time is associated with an increase in iron content from a few tenths of a percent in late Holocene specimens to five or more percent in bones more than 33,000 years old. Using neutron activation analysis, Farquhar and his associates at the University of Toronto have shown that the mineral enrichment of fossil bones from Old Crow Flats is a complex process in which minute cracks and voids may contribute to a general set of time-dependent and depth-dependent transfers of trace elements (Farquhar, *et al.* 1978; Farquhar and Badone 1979). Bonnichsen (1978:Fig. 5; 1979:Pl. IV-4) has found that natural passages such as the Haversian canals are important sites for mineral enrichment and for the development of micro-cracks which influence the structural integrity of the bones and their susceptibility to fracture. These finds are consistent with those of other workers (e.g., Cook 1951; Hassan and Ortner 1977).

These studies show that the bones from Old Crow Flats are permineralized to various degrees and that they have not been preserved simply by burial in permafrost conditions. In fact the fossils have probably undergone several cycles of freezing and thawing among which the most notable period of thawed conditions was the long time during which the upper glacial lake, represented by Unit 6 (Fig 2.2), was at highstand. Earlier permafrost degradation could have resulted from migrations of meander loops in streams which drained the basin during early and mid-Wisconsinan times. Such degradation of permafrost is associated with high ground water pressures (Crampton 1979) which might promote the permineralization of buried bones. The mineral-rich waters of the glacial lake must have supplied ample materials for permineralization in later times as well.

Fracture Patterns

Attributes of bone fracture surfaces, some of which have been understood since the beginning of this century (Martin: 1907-1910, Vol. 1:295; Nelson 1928), have played a major role in all evaluations of the archaeological significance of Old Crow fossils. One of the first critical responses to the announcement that artifacts were to be found among the Pleistocene fossils from the Old Crow area was the possibility that recent bone had become darkly stained or that fossil bone from the Old Crow valley could have been worked by people in Holocene times (Haynes 1971:4). The permineralization of the bones has been demonstrated (see above), and other studies have been conducted to determine whether such permineralized material can be fractured and otherwise worked in a manner suitable for artifact production and use.

C.R. Harington kindly contributed pristine paleontological specimens for controlled experiments in which the fracture patterns of the fossils were compared with those of fresh or green bones. These experiments have been described elsewhere (Harington, *et al.* 1975; Bonnichsen 1978, 1979), and the results are summarized in Table 3.2. Continued experiments of this kind are made whenever a bone is to be submitted for radiocarbon dating (Pls. 4.1-4.2). It should be obvious that a bone does not suddenly change with respect to its fracture properties, and we believe that the gradual decay of collagen fibers, the gradual proliferation and enlargement of micro-cracks and macro-cracks, and the shrinkage which accompanies dessication and loss of organic matter or alternate wet/dry and freeze/thaw conditions are responsible for the changes in bone structure which result in changing fracture attributes.

The attributes listed in Table 3.2 permit the reliable and verifiable sorting of fractured fossil and sub-fossil bones, and I believe that these observations provide a good and sufficient response to the questions raised by Haynes (1971:4). These observations do not, however, contain a demonstration of the agencies which can and do produce green bone fractures of various kinds. This subject was discussed at some length above, and here we will reiterate only those aspects of the problem that shed some light on Pleistocene Beringia. For example, we have already established that some (but not all) carnivores can produce green fractures on some (but not all) bones.

The largest carnivores known from the Beringian Pleistocene include the scimiter cat (*Homotherium serum*), the American lion (*Panthera leo atrox*), and the short-faced bear (*Arctodus simus yukonensis*) (Harington 1977). I have found very little information on the bone altering capabilities of these predators. Miller (1969b:11) attributes certain forms of tooth wear in *Smilodon californicus* to bone gnawing; Harington (1977:515)

Table 3.1 Munsell colour readings for 63 mammoth limb bone fragments from reworked deposits in the Old Crow valley, northern Yukon Territory.

Hue:	2.5YR			5YR				7.5YR							10YR				
Chroma:	0	1	2	0	1	2	3	0	1	2	3	4	5	6	0	1	2	3	4
Value 6																			1
5												2		1				1	1
4					1	1				1		3							
3	5		6		4	12	4			3									
2	1	1	6		3	5		1											

Table 3.2. Fracture patterns induced in green and permineralized bones from northern Yukon Territory (after Bonnichsen 1979:Table 3, and personal observations).

Attribute	Green bone (Pl. 4.1)	Permineralized bone (Pl. 4.2)
Negative impact scars (loading points)	Present	Absent
Texture of fracture surface	Smooth	Rough ("pebbly")
Angle of fracture surface with outer surface of bone	Acute, obtuse, or right	Right
Termination of fracture at epiphyses	At or prior to epiphyses	May cross-cut epiphyses
Colour of fracture surface	Same as outer surface	Often contrasts with outer surface
Outline form of fracture	Straight, diagonal, curved, spiral, generally smooth	Usually straight, transverse, or longitudinal; can be curved, rarely spiral, often perturbed by "jogs" or off-sets

mentioned the efficient crushing teeth of *Panthera leo atrox*; Miller (1969a) and G. Haynes (1978) have documented the extensive damage caused by modern *Panthera leo* on the bones of *Bos* and *Equus*. Evidence concerning bone alteration by bears is very limited, but such alteration is known to occur (G. Haynes 1978), especially among the strongly carnivorous bears which would include *Arctodus simus* (Kurtén 1967:50). None of these animals seems definitely to have been *known* to produce green bone fractures which might be mistaken for artificial bone alteration.

Although most of the fractures induced by carnivores are made by crunching, splintering, and levering pieces from the ends of the bone, other behaviours may occasionally occur. Gary Haynes (pers. com. in 1979) has recently made the following observations at the National Zoological Park in Washington, D.C. A female Kodiak brown bear (*Ursus arctos middendorffi*) was fed her first-ever meal of beef bones in addition to her usual diet of plants, fruits, and fish. In order to strip the soft tissue from the bone, she placed a fore-paw on the center of the shaft and pulled upward with her teeth. On several occasions the tissue came away suddenly so that the bone was forcefully slammed against the hard surface of her enclosure, and a crack formed in the bone wall. After several such "blows" the marrow chamber was opened, and she was able to obtain pieces of marrow by inserting her long claws into the medullary cavity. Although I have not yet seen the resulting bone fragments, I suspect that they include pieces which would be difficult to distinguish from artificially induced fragments.

On the basis of his studies of tiger and wolf at the Alberta Game Farm, Bonnichsen (1973) concluded that deer, caribou, sheep, and immature bison and moose comprise the upper end of the size range which can be reduced to splinters by these two species of carnivores. He infers that "it is improbable that limb bones from adult moose, bison or larger animals will be modified by crunching and splintering" (Bonnichsen 1979:23). I agree with this observation in general but would observe that the ends of adult moose bones can be fully opened by wolves, and the largest bone I know to be damaged in this way is a humerus of *Arctodus simus yukonensis* from the Dawson area of central Yukon (Pl. 3.9). The smaller herbivores such as caribou are regularly attacked by wolves today (Binford 1978, n.d.), and the limb bones can be fractured by wolves in mid-shaft with resulting fractures which are virtually indistinguishable from those produced by man (Pl. 3.10). Furthermore the distinctive scoring marks made on the bone surface by carnivore teeth are not always present on such specimens. Investigations are currently underway to determine whether there is an upper limit to the range of bone sizes and shapes which are susceptible to this kind of misinterpretation, and at the present time it is possible to conclude that proboscidean bones seem to lie entirely outside the scope of such carnivore alterations. As mentioned earlier, even the Pleistocene cave hyena (*Crocuta crocuta spelaea*) seems not to have been capable of fracturing adult mammoth limb bones in mid-shaft (Pl. 3.11). Green bone fractures with well defined points of impact and/or evidence of intersecting fracture fronts on proboscidean bones seem to constitute secure evidence of human presence even in the absence of other kinds of artifacts.

In order to indicate some of the relative weights assigned to the fracture attributes in Table 3.2, many of the attributes have been rearranged

Table 3.3. A proposed key for the interpretation of bone fracture (see also Table 3.2).

1.	Fracture surface has contrasting colour	Recent damage
	Fracture surface has same colour as outer surface	2
2.	Fracture surface has rough texture, and all angles with outer surface are right	Post-dessication fracture
	Fracture surface has smooth texture	3
3.	Angle of fracture surface with outer surface is everywhere right and fracture(s) is (are) parallel and(or) perpendicular to natural split lines	Weathering
	Angle of fracture surface with outer surface is somewhere acute or obtuse and fracture(s) cross(es) split line orientations at various angles (green bone fracture)	4
4.	Proboscidean long bones fractured when green	Artificially induced fractures
	Bones of smaller animals	5
5.	Point of loading absent	6
	Point of loading present	7
6.	Small fragments possibly outside loading point	Not interpretable
	Large fragments on which fracture was formed in a single direction (often a spiral)	Accidental fractures during life
7.	Pitting, scoring, and chipping features represent carnivore gnawing	Possible carnivore-induced fractures
	Such features absent	8
8.	Loading point diameter within size range of carnivore tooth contact areas	Possible carnivore-induced fractures
	Loading point diameter greater than any carnivore tooth contact area	Artificially induced fractures

Note: The term "point of loading" or "loading point" is substituted for "point of impact" since fractures can be induced by either static or dynamic point loading.

in the form of a key (Table 3.3), a procedure suggested to me by Bonnichsen (pers. com. in 1979). Although I have found this key to be a manageable one in assessing bone fracture, I do not usually classify specimens quite as systematically as the key would imply. Instead my approach is more of a "gestalt" in which numerous observations are made simultaneously with one observation able to influence another. Several features are readily apparent from the key and deserve special mention. The colour and texture of the fracture surface are outstandingly powerful attributes for initial sorting of highly stained fossil and subfossil bones. When the angle formed by the fracture surface and the outer surface of the bone is added to the observations, all non-green bone fractures are isolated from green bone fractures. Thereafter the key indicates that various agencies of green bone fracture are difficult to separate and that successful partitioning of fracture agency depends upon the preservation of distinctive features in the area in which the bone was loaded. This area is commonly called the "point of impact," but I have substituted the terms "point of loading" and "loading point" in order to accommodate the kinds of static loading which can induce fractures. The pressure concentrated by a carnivore's jaws, for example, is much closer to a static load than is the impact of a hammerstone which is clearly a dynamic load. It is important to determine whether a fracture was induced by point loading or by a more general load which caused the bone to fail by exceeding its overall bending strength. It is known that horses can break one another's leg bones by kicking, and this is clearly a case of dynamic loading. The dynamic load in such cases is probably not concentrated in a single small area, however, because the muscle bundles and other tissues which surround the bone would cause the force to be dissipated over a larger area. Likewise the static loading which could be applied by the step of a large animal on a bone would be distributed over an area slightly larger than the contact area of the foot, and in most cases it would not constitute point loading. I am well aware that animal trampling is probably not always a form of static loading, but these terms are used here in a relative sense. The Nebraskan collections studied by Myers, *et al.* (n.d.) should be reexamined to test some of these propositions.

A very important point which emerges from the fracture key (Table 3.3) is that *the famous spiral form of the fracture is not a required attribute for recognizing fractures made when a bone was green.* In fact I have found the spiral form to be a very unreliable criterion in that some permineralized long bones are preserved in such a manner that they continue to fracture as tubes (Fig. 3.2). Large portions of the fracture surfaces on these bones may form spirals around the long axis of the shaft, but the surfaces exhibit rough texture, form right angles with the outer wall, frequently are displaced by preexisting split line features, and often exhibit colours which contrast with the unmodified outer surface of the bone. All of these attributes are visible on the specimen illustrated in Fig 3.2.

Three major hypotheses emerge from these considerations and form the basis for all my assignments of green bone fracture to artificial causes:

1. The two most common (but not the only, e.g., cave roof fall) agencies of point loading frequently involved in green bone fracture in the natural world are carnivore jaws and artificial hammerstones and other such devices.

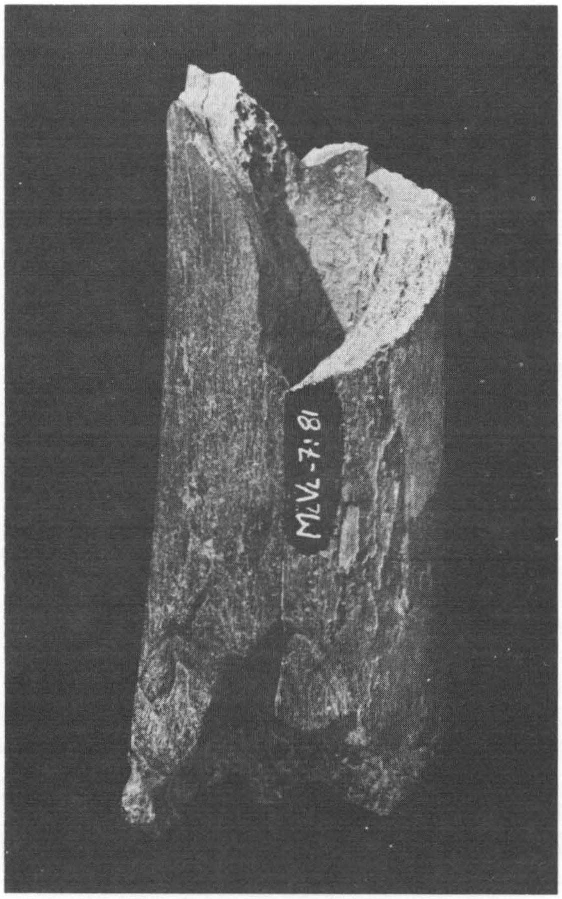


Fig. 3.2. Fracture with spiral form naturally induced on permineralized bone (MlVl-7:81) from Johnson Creek, Old Crow basin, northern Yukon Territory. Note rough surface texture and right angles formed with outer surface.

2. The diameter of the loading point is a useful attribute for separating these two agencies of fracture, and the upper limit of carnivore tooth contact area is smaller than the upper limit of hammerstone contact area.

Since I have not yet undertaken an exhaustive study of carnivore tooth diameters, I am unable to quantify the limits required to evaluate loading point diameters preserved on long bones. Measurements of loading points preserved on the Old Crow fossils have been included in the data in Appendix B to permit additional interpretations once such studies have been completed. At the present time I am prepared to evaluate a few specimens qualitatively, and there are some from the Old Crow valley which preserve such large contact area diameters that they can be confidently attributed to artificial fracture (e.g., Morlan 1978a:Fig. 3).

The third hypothesis arises from various considerations pertaining specifically to proboscidean limb bones. We have already seen that carnivore-induced fractures of such bones have not been identified and that accidental fractures during life or at the time of death are either rare or do not occur at all. Trampling and bone "handling" by proboscideans might induce fractures in fresh limb bones, but these would not entail point loading.

3. Green bone fractures in adult proboscidean limb bones are indicative of artificial fracture techniques, particularly if point loading can be demonstrated.

On the basis of this hypothesis I have listed in Chapter 4 and Appendix B, 104 green fractured mammoth bone fragments as results of artificial fractures, and other examples will be described in later chapters. I have omitted from this list the dozens of green fractured bones which represent smaller mammals such as horses, bison, wapiti, and caribou (cf. Bonnichsen 1979:Table 8). Many of these specimens may have been broken by man, but we cannot yet eliminate the possibility that carnivores induced such fractures. Relatively few of these bones happen to preserve the loading point attributes which might suggest the use of a hammerstone, and I have not found it possible to erect a single simple testable hypothesis which can accommodate the wide variations in size and shape observed among these specimens. In omitting these pieces from this report, however, I have probably reduced the "artifact count" below its real level, and it will be important in the future to reevaluate these specimens as new information on both human and carnivore fracture patterns becomes available.

Bone Flaking

Once a bone has been divided into two or more pieces by primary fracturing, the pieces may be further reduced by flaking techniques similar to those employed in the shaping and reduction of stone. Although they have approached the problem from different theoretical standpoints, both J.G.D. Clark (1972:10-11) and Bonnichsen (1979:188-192) have shown explicitly that some of the techniques and rules of lithic fracture can be transferred to bone, and such concepts are implicit in many archaeological writings. In addition to Breuil's (1939) pioneering effort with the Choukoutien materials, there are many early references to flaked bone artifacts which are scattered through the literature on the European Paleolithic (Breuil 1924:540; Begouen and Begouen 1936; Veyreier and Combier 1952; Bordes 1954:Fig. 17, no. 4), and examples which have long gathered dust in museums have occasionally been described in more recent publications (e.g., Pelosse and Kraatz 1976-77; Bordes 1961:Pl. 108 no. 4). The earliest published reference I have seen to a formal definition of a relatively common bone tool type formed primarily by flaking techniques is Clark's (1954:163-164) description of skin-working tools made on the femora of *Bos primigenius*. Semenov's classic treatise on prehistoric technology, originally published in 1957, includes only a brief reference to "methods of working bone by striking (flaking, notching, and chiselling)" (Semenov 1964:147-151). Having recently been able to examine a number of Paleolithic collections in central and eastern Europe, I am confident that flaked bone tools are much more abundant than the literature would indicate. They seem not to have been mentioned more often either because they were not recognized as tools or because they were so commonplace that their presence went unreported; after all, the investigators had plenty of stone tools to describe, and these have been allowed to carry the entire burden of prehistoric reconstruction. Freeman (1978:33) has made the important observation that many flaked bone tools are directly analogous to elements of lithic flake-tool inventories but that "it would be inadvisable to attempt any major extension of the stone-tool terminology to embrace the bone pieces." Nonetheless some borrowing of this kind seems both appropriate and inevitable.

The most abundant general category of artifacts in the Old Crow fossil collections consists of bone cores and flakes. The majority of these artifacts are made on the massive fragments of mammoth or mastodon limb bones which are emminently suitable for percussion flaking. Even though bone is a multi-phase material (Currey 1964), it can be made to produce conchoidal flakes very similar to those which come from cherty or glassy stones. Experiments by Bonnichsen (1979:51ff) have shown that green bone is more suitable for flaking than dry bone, and I have found it very difficult to obtain conchoidal fractures from permineralized bones found in Old Crow Flats. The few that have approximated this fracture type had such brittle edges that they were useless for any purpose but a demonstration that fresh or green bone is required to make useful tools. Experimental studies are continuing with both fresh and dry elephant bone (Stanford, *et al.* 1980), as well as with various kinds of fresh, dry, sub-fossil, and fossil bone which is more readily obtainable.

Although it can be demonstrated experimentally that people can flake bone systematically to produce well designed cores and useful bone flakes, there are other agencies which can detach flakes from bone and which must be considered in evaluating flaked bones. Some bones, due to their shapes, are susceptible to rotation about a central axis during transport in a stream. Notable examples which have been observed in the Old Crow valley are the huge scapulae of mammoths which can be tumbled either clockwise or counterclockwise about the long axis with flakes being detached from both borders of the blade as well as from the spine. Other bone fragments show similar patterns with flake scars occurring on opposite faces of opposite margins as if the specimens had been turned and struck repeatedly in one direction. One of the salient characteristics of the cores and flakes regarded as artifacts in this report is their clear axial orientation (Morlan 1978a:87), and both Bonnichsen (1979) and I (Chapter 4) have used this attribute in our classifications of bone core types.

A second major agency which could confound the archaeologist is the chipping and splintering of bones by carnivores. Fairly large flakes can be levered from a bone shaft when a carnivore hooks its canine or its carnassial teeth over the broken end of a bone and uses the opposite jaw as a fulcrum for prying against the edge. The result may be somewhat similar to that produced by pressure flaking, because the loading of the "platform" is nearly static and is not likely to induce the kinds of morphological features (e.g. ribs, hackle marks) which if prominently developed are indicative of dynamic loading. Carnivores may also detach flakes from bones by crunching a broken end between the carnassial teeth in the molar/premolar row. Such flakes are apt to be short and often terminate in hinged distal ends. In order for carnivores to exert sufficient force to detach flakes from bones, they often (always?) establish repeated and forceful tooth contact with the bone wall. Their teeth make many kinds of marks on bones, and these have been characterized with such terms as pitting, scoring, rotational scarring, puncturing, etc. When such features are observed on a flaked bone one must wonder whether the flaking was accomplished by carnivores or whether a bone flaked by other agencies was also gnawed by carnivores at some other time. Myers, *et al.* (n.d.) have attributed similar edge chipping to trampling of the bones. It is unavoidable that many specimens cannot be interpreted with confidence because of these possibilities and our imcomplete understanding of carnivore capabilities and the effects of trampling.

The flakes which are described as artifacts in this report have been selected on the basis of their sizes or on the basis of special attributes. Flakes can be generally characterized with terms borrowed from lithic technology (see Crabtree 1972), but bone flakes do not always exhibit the many attributes commonly seen on stone flakes. Bulbs of force are seldom well defined, and hackle marks and ribs are relatively rare on bone flakes. Platforms may be fashioned through accumulated hinge and step fractures, or the unmodified surface of a bone may be used to receive the impact. Flakes commonly bear the dorsal traces of previous flake removals, and cores frequently exhibit both nested and laterally accumulating flake scars. Flake shape is quite variable and is apparently dependent upon many factors, including orientation in relation to bone microstructure, but typical distal end morphologies -- feathered, stepped, hinged, jagged -- are familiar to lithic analysts. These attributes, when combined to aid the interpretation of an individual flake, comprise a powerful set of tools for discriminating between carnivore-induced and artificially produced flakes, but it is unlikely that every specimen can be accurately classified in this way. Evidence of heavy dynamic loading and retouched platform remnants are very important in recognizing artificially struck flakes, and none of the flakes reported here as artifacts exhibits signs of carnivore tooth contact.

The majority of the cores and flakes which I have classified as artifacts are made on mammoth bones, but a few examples represent smaller (but still large) mammals such as horse, bison, and caribou. I have presented specific arguments for interpreting such pieces as artifacts (Appendix B), and one series of flakes and flaked pieces has been described as if it were artificially produced although I believe that carnivores could have been responsible for the flaking (Chapter 6, Appendix C).

Cut and Polished Bones and Antlers

Dozens of fossil bones with polished facets have been found in Old Crow Flats, and most of them are rather difficult to interpret. In most cases they are readily distinguishable from water-rounded bones, although I suspect that a larger series will eventually exhibit gradational variations of several kinds. For example, a few specimens exhibit lineal striae or scratches without high gloss polished areas while others have very glossy facets with or without striae. Some specimens are polished on more than one facet, and multiple facets may be aligned in the same or different planes. Some polished facets are flat and others are convex with either rounded or bivectoral outlines. A few specimens were clearly polished after permineralization of the bone was well advanced since a rind of mineral staining is well defined on all edges of the facet. It seems most likely that such pieces were naturally facetted during transportation by the Old Crow River and its tributaries. Perhaps these specimens were entrapped in river ice and became abraded against bottom sediment during spring breakup. I have reproduced such facets by placing Old Crow fossils on a lapidary wheel with a mixture of particle sizes in the abrasive grit.

Differential staining can occur on a bone surface which was modified when the bone was fresh. In a few cases it appears that a scratched or polished surface responded to staining processes in a different fashion than the unmodified portions of the same bone. Such modifications must alter the physical and/or chemical nature of the bone, but these alterations are poorly understood. Usually it is not difficult to separate bones which were altered and then stained from those which were stained and then altered.

The classification of cut and polished pieces in this report is based on three forms of surface incision and two kinds of surface reduction (see Chapter 4), and two major criteria have been used in judging whether alterations of these kinds were produced naturally or artificially: (1) their complexity; and (2) their truncations of or by other kinds of bone alteration. A few simple scratches, scrapes, or polished high spots can hardly be cited as indicators of artificial bone modification when one is dealing with specimens known to have been transported in a fluvial system. Some polished facets may be quite complex geometrically and still be attributable to natural causes because their form merely mirrors the original morphology of the bone. Thus I have looked for multiple orientations or facets as appropriate indications of the kinds of complexity which would suggest artificial production as an explanation.

Likewise we can frequently find polished facets which have penetrated and exposed a pre-existing rind of permineralization and staining, and these must be supposed to have been produced relatively recently by natural causes. This is not to say, however, that all dark stained polished facets are *a priori* evidence of artificial alteration, because a bone may have been polished by natural processes prior to its permineralization and staining. A scratch or scrape or polished facet which truncates such features as rootlet etching and exfoliation scars would indicate that the altering agency acted upon the bone after its introduction to the burial environment or after a period of weathering, and such a specimen would not likely be an artifact. If the rootlet etching or a flake scar or a green-bone fracture can be shown to truncate a scratch, scrape or polished facet, however, it is more likely that the alteration was accomplished while the bone was fresh and therefore during a period in the history of the specimen when man would most likely have modified the bone.

Additional criteria have been used to separate carnivore alterations from cuts thought to have been made by stone tools (cf. Walker and Long 1977; Binford n.d.). Carnivores may produce elongate marks on bones, and these are usually transverse or oblique to the longitudinal axis of long bones. The initial contact of bone and carnivore tooth may merely "bruise" the bone surface, but more intensive gnawing soon develops into scoring and furrowing (rotational scarring) which may even break through the bone wall to form perforations or deep pits. Some of these elongate marks might be confused with stone tool cut marks were it not for differing morphology. Carnivore scoring is often broader than deep and has ragged edges which result from the increasing resistance of deeper bone lamellae to the action of a relatively blunt tooth. Stone tool cut marks may be quite deep and narrow, usually have U- or V-shaped cross-sections depending upon the precise width and sharpness of the cutting edge, and are characterized by sharply defined rather than ragged edges.

A very important attribute for separating carnivore scoring from stone tool cutting is the relationship betweeen the depth of the mark and the natural contour of the bone surface. Carnivore scoring generally maintains a uniform depth regardless of the bone contour whereas stone tool cut marks are deeper on convexities and shallower on concavities within the length of a single cut.

Finally the placement of the marks may provide important clues. Most, but probably not all stone tool cuts can be interpreted in relation to a specific task which the butcher or artisan was performing. Carnivore scoring may appear on many areas of a bone, and its degree of development may vary considerably depending upon its placement with the greatest intensity of scoring, leading to furrowing, always found near the ends of long bones and at the relatively soft edges of scapulae and innominates.

There is little need in this report to itemize the kinds of damage on various anatomical elements which have been carefully studied by other writers (e.g. Martin 1907-1910; Guilday, *et al.* 1962; Frison, *et al.* 1976; Wheat 1979:Chapter 7; Binford n.d.), because cuts thought to be related to butchering are relatively rare in the collections from the Old Crow basin.

Other Forms of Alteration

The foregoing types of bone alteration, fracturing, flaking, cutting, and polishing, are the major factors which have been considered in evaluating most of the redeposited fossils from the Old Crow basin. Since most of these specimens represent selection in the field, a more thorough analysis seems to me to be pointless, because there is no way of knowing what kinds of alteration characterized the specimens which were left behind at each of the collecting localities. In this respect the samples from MlVl-7 and MlVl-2 (Chapter 5-6) are of some interest because they afford an opportunity to examine a larger range of bone altering phenomena. Additional attributes which have been considered for these samples include sample size, specimen size, degree of rounding, exfoliation, split lines, etching, pitting, and secondary mineral formation.

Sample and specimen sizes are quite variable in these collections, and these variables have a profound influence on the observation of some of the other features. Specimen size has been indicated in terms of linear and weight measurements as described in Appendix B. I attempted to measure the volume of some of the larger specimens in order to calculate their density, but the state of preservation of these fossils precludes re-wetting them after they have become dry. Re-wetting causes the specimens to crack and exfoliate at an alarming rate and in several cases has been seen to "explode" the bones. Thus my attempts to measure volume were made with sieved sand which was weighed before and after displacement by each bone. Unfortunately I was unable to obtain verifiable results by this method.

Two secondary minerals have been recognized with regularity on the Old Crow fossils, although I have not had either of them precisely identified. Vivianite is an iron-phosphate compound ($Fe_3(PO_4)_2 \cdot 8H_2O$) which is well known for its property of colouring fossil bones and teeth on which it is called odontolite (Palache, *et al.* 1951:741-746). It is colourless and transparent when fresh and unaltered, but it readily oxidizes to a range of blue, greenish blue, and indigo blue colours. The mechanism of vivianite oxidation has not been established, but vivianite is one member of a series of hydrated iron phosphates which range from the octohydrated vivianite and metavivianite to the anhydrous scarcopside with the extent of hydration being temperature dependent (Ritz, *et al.* 1974). There may also be a natural chemical reaction which can alter vivianite to the reddish brown and yellowish brown compounds which I have lumped together as hematite in my observations (the yellow colour probably being a result of hydration, e.g. $Fe_2O_3 \cdot H_2O$). I do not know how to interpret the frequency of vivianite, but I have recorded its occurrence on the fossils to indicate the extent of variation among the samples. The hematite frequencies are probably related to the variable periods of time during which the fossils were exposed to aerobic weathering, and the vivianite may reflect anaerobic weathering. I have classified the secondary mineral frequencies as anataxic factors with respect to our taphonomic model (Fig. 3.1), but they might be regarded as taphic factors under some circumstances.

The degree of rounding was recorded for each specimen according to a series of definitions which I have explained in Chapter 5. Rounding may be related to the distance a specimen has been transported by a stream or to the number of times the specimen has entered the fluvial environment. It has been classified as an anataxic factor. The influence of ice may be a major factor in the development of rounding, but its influence is not known in detail. Flume studies and other methods of determining the hydrological properties of bones (e.g., Bailey and Lundy 1977; Behrensmeyer 1975b; Voorhies 1969) have not included ice as a variable because the studies have focussed on sub-tropical and/or Pliocene environments.

Exfoliation and split lines were described above as indicators of sub-aerial weathering, and I have classified them as perthotaxic factors. Caution is urged in the interpretation of their frequencies since exfoliation may occur both before and after permineralization while split line formation becomes less readily observable as the fossils become subdivided through post-permineralization fractures.

Pitting was subdivided into three categories on the basis of criteria described in Chapter 5. These pitting types constitute examples of the need for better analogue development in that I have merely made an educated guess as to their significance. A form of pitting (Type A) which I have attributed to acid attack and classified as a taphic factor seems not to be related to the secondary burial environments from which we excavated the MlVl-2 samples (see Chapter 6), and I have no data to show whether a better relationship would obtain between such pitting and a primary burial environment. It is possible that this pitting form is due to one or more other agencies of bone alteration. Type BF pitting is attributed to the action of plant rootlets because of its frequent association with etching on these fossils (see below). Type BC pitting is under somewhat better control since we have numerous examples of this pitting form on documented reference specimens known to have been gnawed by carnivores. All Type BC pitting is attributed to such gnawing, and it is classified as a perthotaxic factor.

Etching refers to a distinctive dendritic pattern seen on many bones, and it is thought to be a result of plant rootlet attack. The patterns result from growth of the rootlets in contact with the surface of a bone so that the rootlet lies in a groove which presumably was formed by its exudates or by the microorganisms associated with rootlet metabolism (Strang 1979). Although it is not entirely clear why or how plant rootlets etch bones, we can suppose that the plants derive metabolic materials from the bone organic and/or mineral contents. If the organic contents are the target, we might expect that etching would occur only when the bone is fresh. Most of the etched bones are evenly stained on etched and non-etched surfaces, and the occurrence of etching on fracture surfaces is always associated with the attributes of green bone fracture. On the other hand, I have seen a few specimens which exhibit lighter staining in the etch marks than on the surrounding surfaces suggesting that the etching has penetrated a pre-existing permineralization rind and implying that a permineralized bone can attract at least some types of plant rootlets to its surface. Laboratory studies of rootlet-bone chemical reactions are needed to clarify these relationships, but the frequency of etching can be interpreted as a reflection of the portion of a redeposited sample which has demonstrably been buried in a stable plant-supporting deposit. Therefore I have classified etching as a taphic factor.

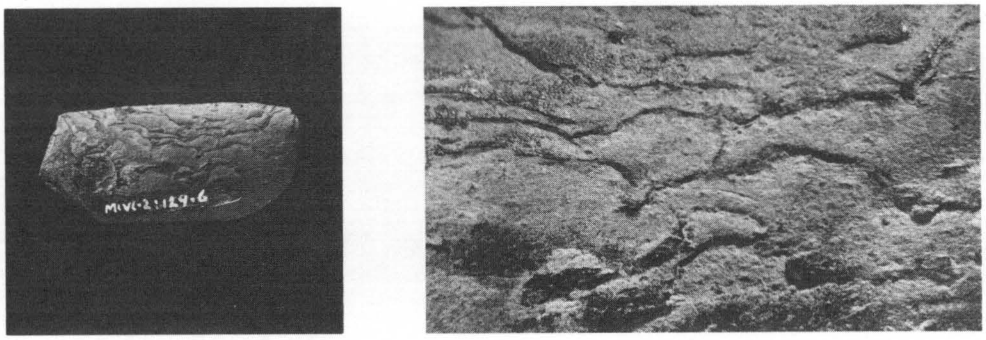
Recognition criteria for distinguishing green bone fractures and post-permineralization fractures were provided in a lengthy discussion above. All green bone fractures, regardless of their origin from carnivore or human activities, are classified as perthotaxic factors in this report. Obviously some kinds of green bone fractures which occur accidentally and are severe enough to lead directly to the death of an animal could be regarded as thanatic factors, but examples of such fractures have not been recognized among the collections reported here. Post-permineralization fractures are more difficult to classify with respect to our taphonomic model because such fractures can occur in the primary burial environment or during subsequent weathering, erosion, and redeposition. Therefore I have listed these fractures as both taphic and anataxic factors.

All artificial alterations reported here have been classified as perthotaxic factors. There are numerous examples in Beringia of fossil mammoth ivory and teeth (but apparently not bones) being utilized during very recent times in a variety of ways (Giddings 1952:69, Pl 42; 1964:65, 94; 1967:20, 270) and this is the kind of reuse which Haynes (1971:4) suggested might explain some of the Old Crow fossils. Such reuse of fossil materials might be regarded as an additional anataxic factor, but I have argued above that it is very unlikely that the Old Crow fossils could be altered after permineralization in such a way that the time of alteration could not be determined.

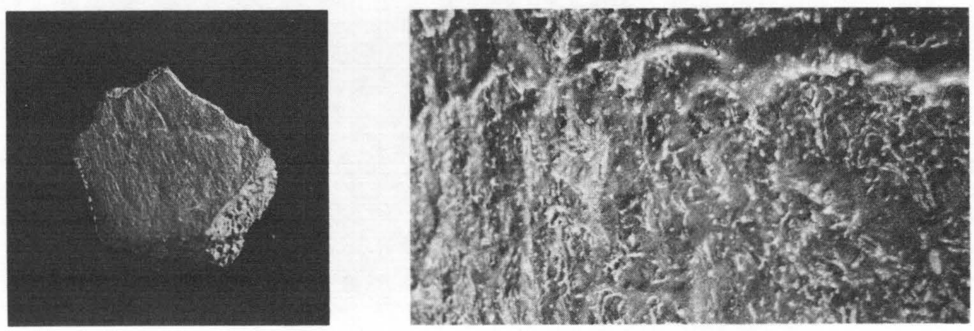
A rather large number of the Old Crow fossils have been placed in a category called "natural or artificial," because I can find no means of deciding what produced the alterations in question. Most of these belong in the perthotaxic category, and the uncertainty revolves primarily around the question of carnivore versus human activity. Some of them, however, are possibly a result of fluvial transport, and these specimens belong to the anataxic portion of the taphonomic model.

The Ginsberg Experiment

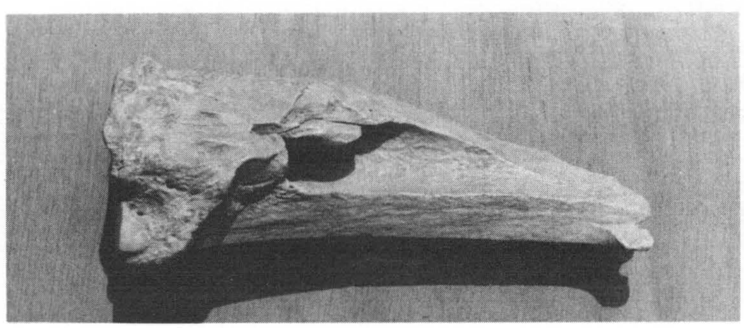
The carcass of an elephant named Ginsberg was the subject of extensive experimental work which was carried out in two phases in March 1978 and March 1979, respectively. A preliminary report on some aspects of this experiment has been published elsewhere (Stanford, *et al.* 1980), and a more extensive report is planned. Therefore I will not describe the experiment in detail except to say that it included many opportunities to study stone tool use and wear, elephant bone fracturing and flaking, periosteum removal techniques and purposes, and bone flake use for cutting various kinds of tissue. I shall have occasion to cite this experiment several times because of the insights which it provided for the interpretation of some of the Old Crow materials; such citations will be made to the preliminary report or simply to the Ginsberg experiment. This is only one of several elephant butchering experiments which have been conducted recently (Huckell 1979; Rippeteau 1979), and it is clear that such experiments provide our only means of developing certain kinds of analogues for the interpretation of prehistoric materials.



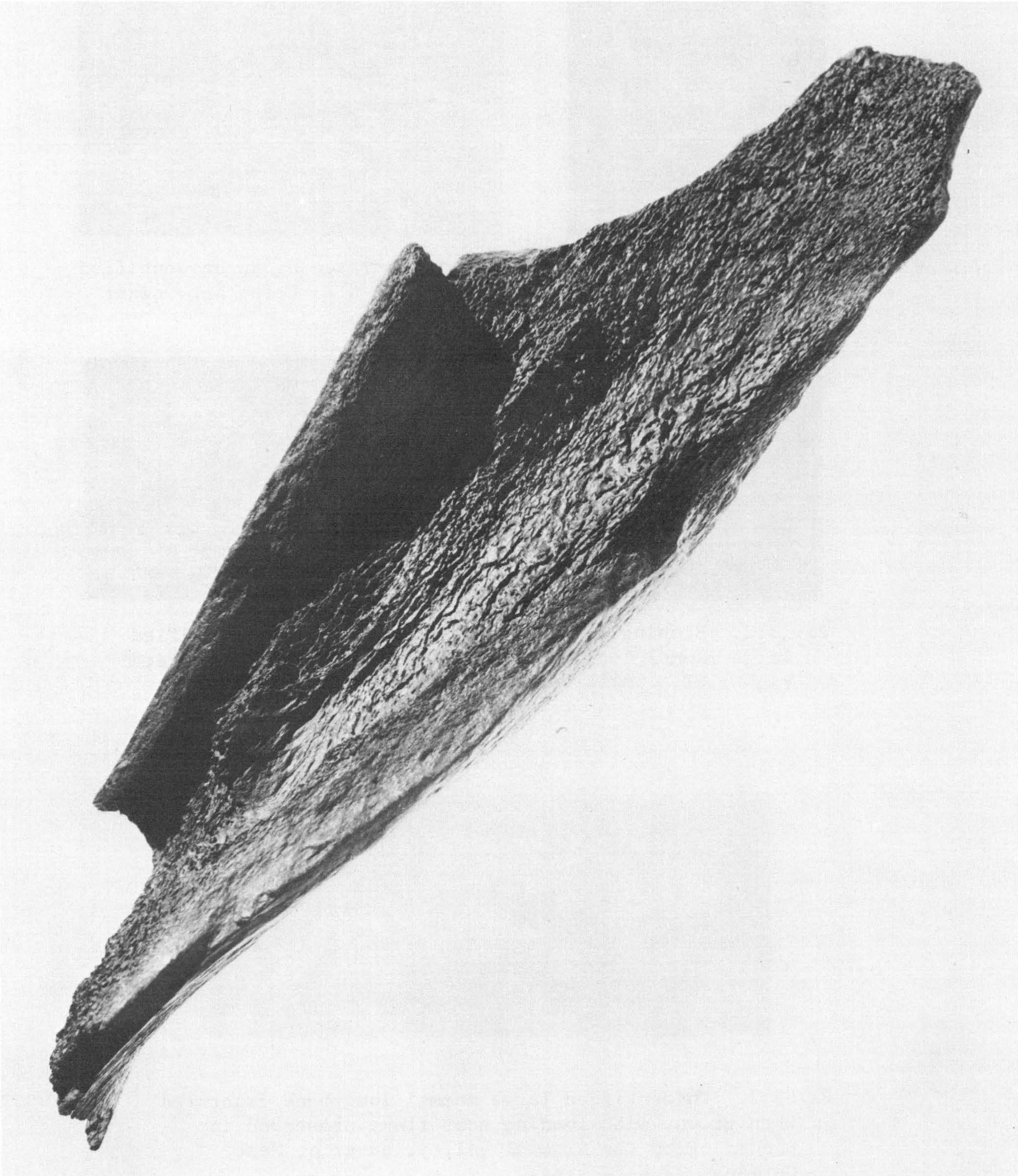
Pl. 3.1. Exfoliation on the outer surface of an unidentified large mammal long bone (M1V1-2:129-6). Left: Nat. size; right: 5X.



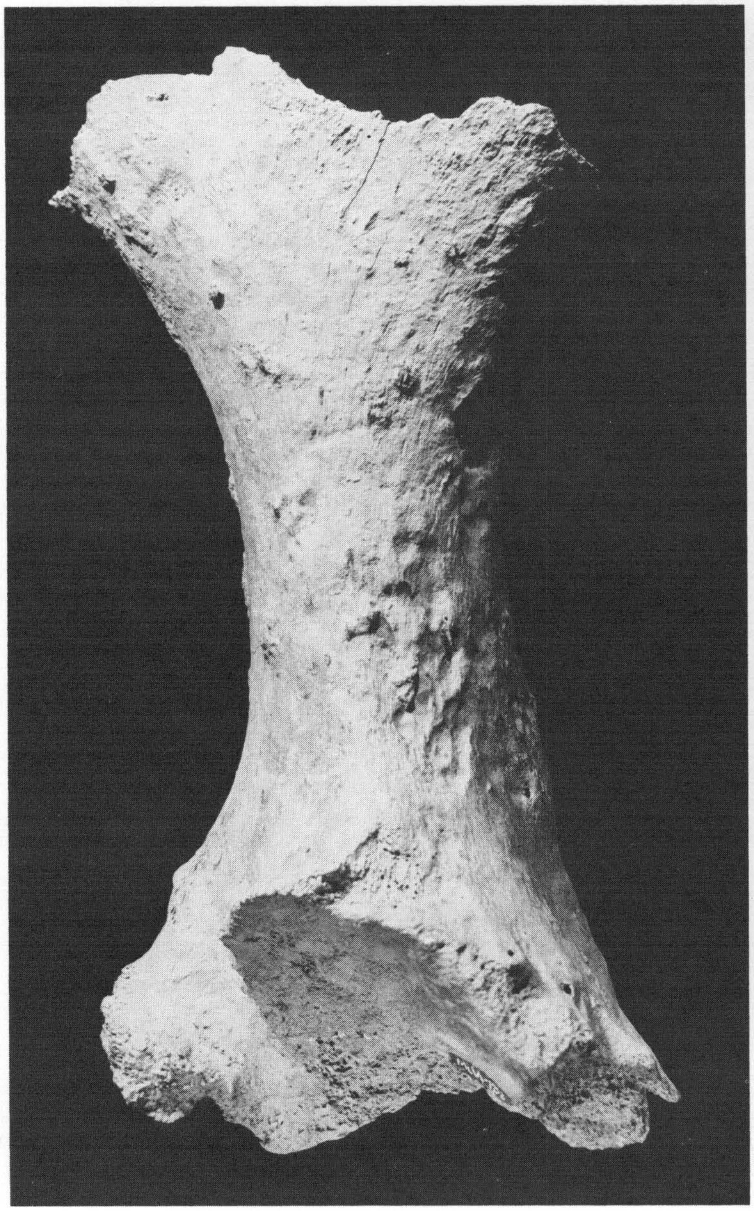
Pl. 3.2. Etching on the outer surface of an unidentified large mammal long bone (M1V1-2:37). Left: Nat. size; right: 6X. Small dots represent Type BF pitting.

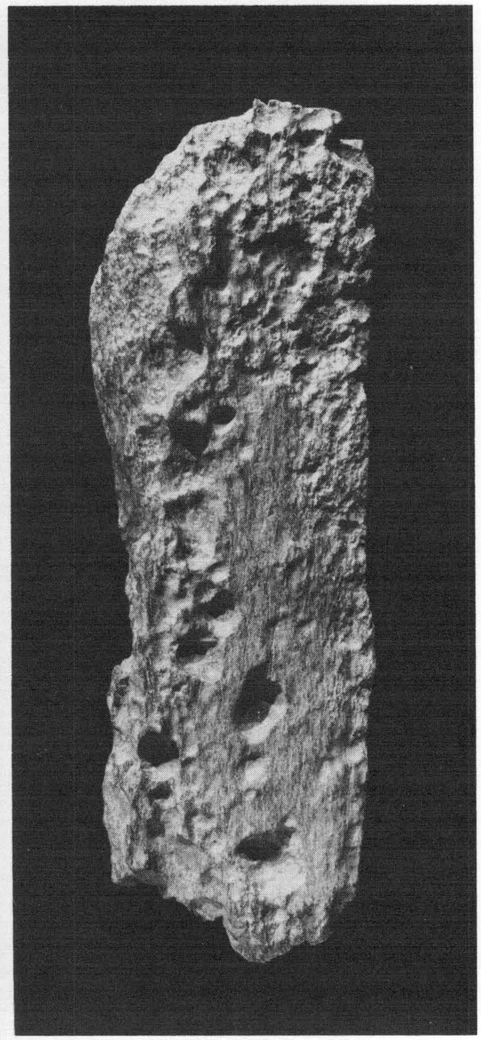


Pl. 3.3. Unidentified large mammal long bone fractured when green, with loading scar flake preserved in place. From the Altmuhl Valley, Bavaria, West Germany. $\frac{1}{2}$ Nat. size.

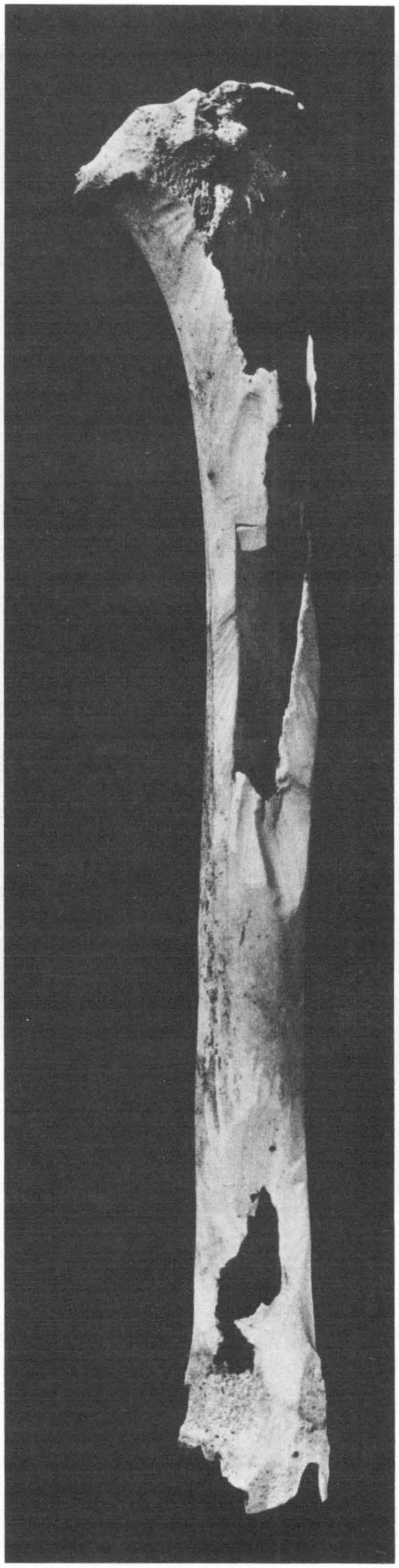


Pl. 3.4. Mammoth (cf. *Mammuthus* sp.) long bone fragmented by weathering and split line separation. The fracture surfaces have a spiral form, but they form right angles with the outer surface of the bone (MkV1-3:1). ½ Nat. size.

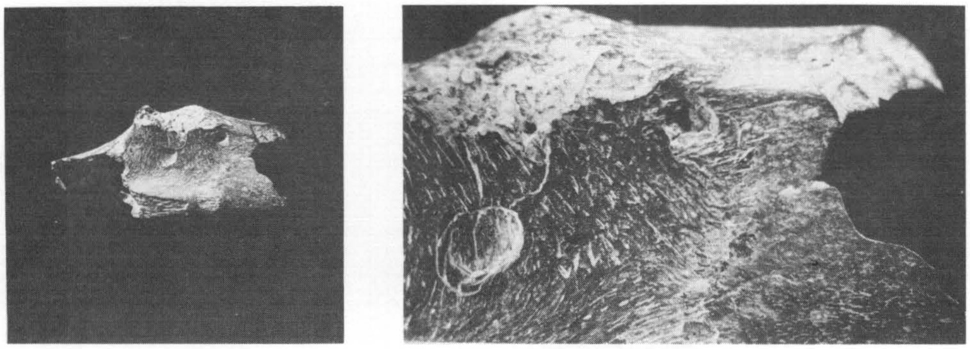




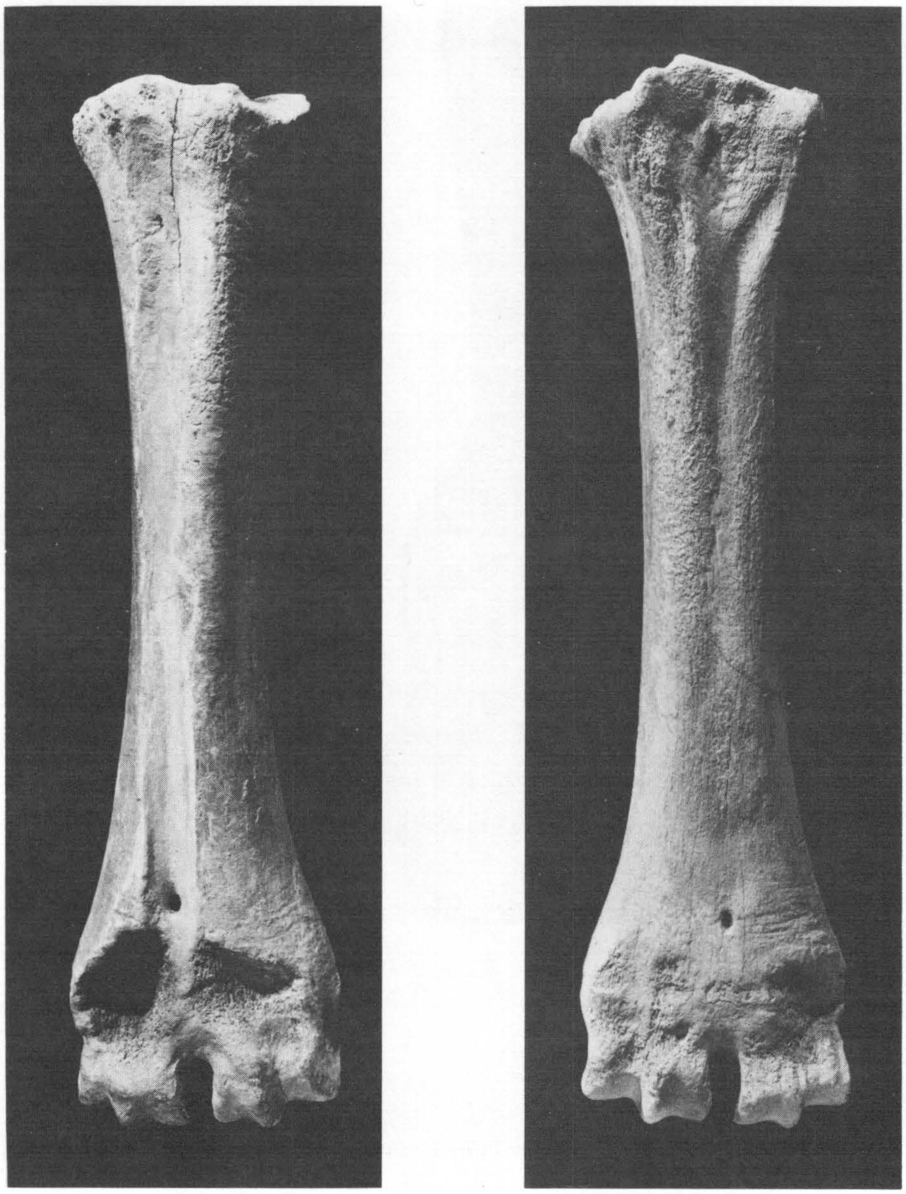
Pl. 3.5. Advanced pitting (Type A) and rounding on a mammoth (cf. *Mammuthus* sp.) right ischium (left) and long bone fragment (right) (MlVl-12:3 and MkVl-24:2, respectively). Type A pitting refers to the reduction of the surface except for high spots (see left example). The deep pits on the right may be due to scouring in a stream or wind-induced erosion (ventifacting). ½ Nat. size.



Pl. 3.6. White-tailed deer (*Odocoileus virginianus*) tibia from the Ottawa Valley, Ontario, showing extensive rodent gnawing marks. Note the window-like openings in the bone wall. 3/4 Nat. size.



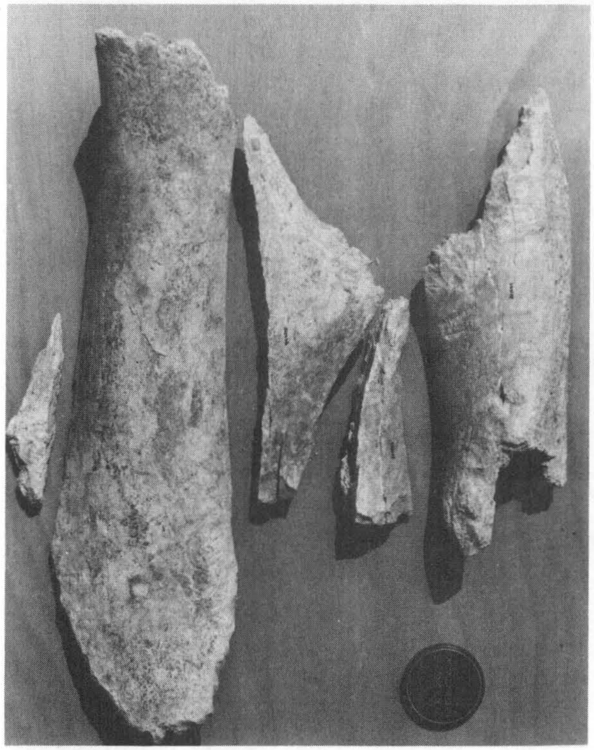
Pl. 3.7. Carnivore-induced perforations on an Arctic hare (*Lepus arcticus*) innominate (M1V1-2:123-5). Left: nat. size; right: 4X.

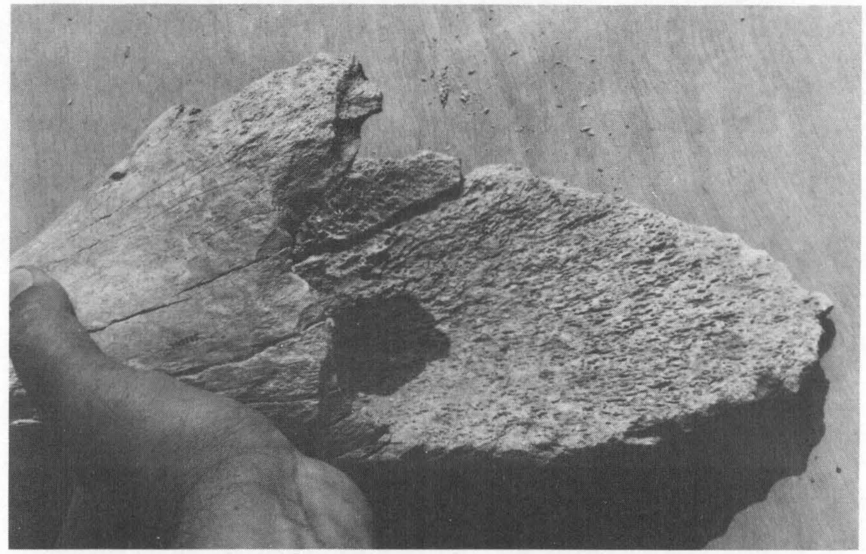


Pl. 3.8. Carnivore-induced furrowing and scooping on a bison (*Bison* sp.) right metatarsal (M1V1-8:10). ½ Nat. size.

Pl. 3.9. Carnivore induced splintering, chipping, and epiphyseal scooping on a short-faced bear (*Arctodus simus*) humerus from the Dawson area, central Yukon. View on left 1/3 nat. size, proximal end enlarged on right.

Pl. 3.10. Caribou (*Rangifer tarandus*) tibia with wolf-induced mid-shaft green fracture, from Porcupine Valley, northern Yukon Territory. Note scar resembling a point of impact at the distal end. Nat. size.





Pl. 3.11. Hyena chewed mammoth (cf. *Mammuthus* sp.) humerus from the Hohlefels site, Bavaria, West Germany. Left: five fragments separated after intensive weathering shown in exploded view. Upper right: chewed proximal end. Lower right: chewed distal end.

CHAPTER 4. ARCHAEOLOGICAL SPECIMENS FROM REWORKED DEPOSITS IN THE OLD CROW REGION

Introduction

Since the majority of the artificially modified bone, tusk, and antler specimens from the Old Crow region have been recovered from undatable secondary contexts, it is through the examination of redeposited materials that we can acquire an overview of the range of human technology expressed in the Pleistocene fossils. Bonnichsen (1979) has recently reported on all such materials collected as of 1973 and housed in the National Museum of Man, the National Museum of Natural Sciences, and the University of Toronto. In this chapter and in Appendix B I shall present a selection of the redeposited specimens now housed in the National Museum of Man, and the selection will include many items already reported by Bonnichsen as well as all artifacts and probable artifacts collected from redeposited contexts since 1973. It was with some hesitation that I decided to allow this report to overlap Bonnichsen's to such an extent, and I have done so for several reasons. The available sample of specimens collected since 1973 is relatively small and does not include certain important features which are represented in the pre-1973 collection. For purposes of comparing other samples (in Chapters 5 and 6) I need to include all available materials whether or not some of them have been previously reported. Finally, there are several ways in which my approach differs from Bonnichsen's, and it seems expedient, if only for the sake of clarity, to present all the materials in terms of a framework with which I feel most comfortable. In some specific instances I do not agree with Bonnichsen's attribution of artificial alterations (I will both add to it and subtract from it), and Bonnichsen (pers. com. in 1980) agrees that his treatment of the polished and cut bones requires revision.

Before presenting the redeposited specimens from the Old Crow region, some general considerations are pertinent to their evaluation. The majority of the pieces comes from the Old Crow valley with a small minority having been found along the Porcupine River. To a small extent this difference is a reflection of where we have spent our time in the field. To a much larger extent it reflects several natural processes. The Porcupine River is a much larger stream than its tributary, the Old Crow, and it carries a much coarser bed load. Bars composed of pebble, cobble and boulder size stones are common along the Porcupine, and fossil bones introduced to such a fluvial system are quickly reduced to unrecognizable splinters. In contrast, the Old Crow River flows almost entirely through valley walls composed of fine sediment in which fine gravel is usually the largest particle size class. A portion of the lower 30 km of the Old Crow River occupies a narrow canyon area with outcropping bedrock in which the current is faster and the bed load much coarser, and we have found very few interpretable fossil bones along this part of the river. Above the canyon area on the Old Crow River the stream meanders across a valley floor as much as one kilometer wide. The broad meander loops are the sites of point bar growth and channel cutting with the point bars and sloping banks on the insides of the bends and steeper erosional faces on the outsides. The steep erosional face may be located at a lateral-most valley wall in which case a high bluff is being eroded to expose a potentially complete profile of Upper Pleistocene and Holocene stratigraphy. In other cases the erosional face is exposing earlier point bars and terraces all of which have developed since the incision of the valley in early Holocene times. Largely because of the very low gradient of the stream (ca. 1:15,000, A.V. Jopling, pers. com. in 1978), but also because of the near absence of large stones, a fossil bone can be reworked in this fluvial system repeatedly without damaging it beyond recognition.

Imagine that a bone was deposited in early Sangamon Interglacial time near the base of Unit 3 (see Fig. 2.2). The bone could be eroded from a high bluff today and redeposited on a modern bank or bar. The same bone might have been eroded and retransported during the initial downcutting of the valley, and it could be redeposited on the same modern bank or bar. In the meantime it could have gone through several intermediate stages of redeposition and erosion in the Holocene terraces which have been built by overbank sedimentation and point bar growth along the valley walls (Fig. 2.4). Furthermore the bone may have been redeposited in earlier times as well, for example, by the fluvial system which is believed to have existed in the Old Crow basin in early Wisconsinan time. To complicate matters even further, the bone may have been redeposited into the early Sangamon context in which we originally postulated its presence, and its age could be very much greater than the Upper Pleistocene.

It is important to realize that very ancient fossils can occur in redeposited contexts in the Old Crow valley. The basin is rimmed by Paleozoic and Mesozoic rocks, and Tertiary outcrops occur in several localities (Norris, *et al.* 1963). Although pre-Quaternary vertebrate fossils have not been reported from Old Crow Flats, redeposited palynomorphs of probable Tertiary and Cretaceous age occur in the pollen samples taken from Upper Pleistocene alluvium (Lichti-Federovich 1973). Among the vertebrate fossils from the modern banks and bars of the Old Crow River are a number of forms which Harington (1977:991) regards as Early and Middle Pleistocene indicators, and such specimens must have been redeposited repeatedly in Upper Pleistocene and Holocene times in order to appear on the modern valley floor. Other vertebrates almost certainly represent virtually every period of the Upper Pleistocene, and an admixture of Holocene specimens can be shown by radiocarbon dating and other observations to have been introduced to this confusing record. The redepostion loop depicted in our taphonomic model (Fig. 3.1) may have been followed many times by a given fossil.

Three major approaches have been taken to the problem of isolating those specimens which might belong together in a time-stratigraphic context. The first is the general vertebrate paleontological biogeographic approach in which certain forms are elsewhere found to typify a certain period of the past. This is the sort of argument which Harington (1977) has used to identify Early and Middle as well as Upper Pleistocene faunal elements in the Old Crow basin. A corollary of this approach is the identification of extinct taxa for which the time of disappearance is generally known. On this basis we can be confident that many of our specimens date at least to the Upper Pleistocene, and we can note in passing that many of the artificially modified bones to be described below represent extinct taxa but that none of them has been attributed to Middle or Early Pleistocene forms.

A second approach is experimental and will be reported in a thesis by Mr. David Parama, a graduate student at the University of Alberta. Parama introduced to the banks and bars of the Old Crow River some 400 modern horse bones which had been painted bright red and yellow and which were further coded by means of notches filed in the bone wall. The downstream and downslope progress of these bones has been monitored annually since 1977 and will eventually form a basis for making generalizations about the fluvial transport of large bones in the Old Crow valley. In conjunction with this work, measurements of volume, wet weight, and orientation of thousands of fossils have provided a data base for assessing some of the hydrodynamic characteristics of the redeposited specimens. Further discussion of this study must await the completion of Parama's thesis.

A third approach has been based upon the degree of staining and apparent permineralization of the fossils. Since these are factors which significantly influence the fracture properties of bone, they have been discussed at some length in Chapter 3. Other taphonomic factors, such as degree of rounding, exfoliation and split line formation, etching and pitting will not be discussed comprehensively for the redeposited specimens because of the several kinds of selection which lie behind their collection in the field and presentation in this chapter. These factors will be described for other samples which were obtained under somewhat more controlled conditions.

Classificatory Procedures

The classification used in this report begins with the same major criteria which were used by Bonnichsen (1979) in his analysis of the Old Crow materials: raw material and altering mechanism (Bonnichsen's "technological patterns"). Four major raw material categories are recognized: bone, ivory, tooth, and antler. Four major altering mechanisms are distinguished: fracturing, flaking, surface reduction, and surface incision. The raw material categories are further subdivided in terms of major biological taxonomic groupings, and the altering mechanisms can be split into a number of more specific techniques of material alteration. The general outline of this classification is shown in Table 4.1 where an "x" has been entered to show the actual occurrence of each possible category in the sample to be described in this chapter.

The sequence of presentation in this chapter has been organized primarily in terms of the altering mechanisms with subdivisions of the raw material categories appearing within this framework. Fracturing and flaking are presented first, but not all possible cells of the classification are included. The reason for this partial treatment of the subject is illustrated in Table 4.2 where the subdivided raw material categories are arrayed against the altering mechanisms. In Chapter 3 I presented hypotheses which state that green fractured

Table 4.1. Classification of fossil specimens based upon raw material and altering mechanism. "x" marks occurrence in this sample.

Raw Material:	Bone	Ivory	Tooth	Antler
Altering Mechanism				
Fracturing	x	x		
Flaking	x	x		
Surface reduction	x	x		x
Surface incision	x		x	x

Table 4.2. Classification of fractured and flaked specimens in relation to raw material and biological taxa. "x" marks categories presented in this chapter.

Raw Material:	Bone		Ivory
Taxonomic Group:	Mammoth	Large Mammal*	Mammoth
Altering Mechanism			
Fracturing	x		x
Flaking	x	x	x

* refers to large mammals smaller than mammoths

mammoth bones are attributable to the activities of man. Therefore such bones comprise our first major category of specimens to be described, and these will be followed by flaked mammoth bones (both cores and flakes, the "negative and positive aspects" of this altering mechanism; Bonnichsen 1979:93). Flaked and fractured mammoth ivory specimens have been presented under a single heading because of the small size of the sample, and these are followed by flaked bones of large mammals smaller than mammoths. The missing category in this presentation is the class of fractured bones which represent large mammals smaller than mammoths, and they have been omitted from this study because of uncertainty concerning the influence of carnivores (see Chapter 3).

The extent to which I have been selective in presenting specimens varies among the major categories in this chapter. In the discussion of fracturing and flaking I have presented only those pieces which I believe were artificially modified when the bone or other raw material was fresh. There are many other specimens in the collection which may have been artificially modified when the material was fresh but which might have been altered by some other agency. These specimens have been placed "in limbo" in this study and their alterations are classified as either natural or artificial. The selection of specimens was guided by the discussion and hypotheses which were presented in Chapter 3.

The large group of specimens which were altered by surface reduction and incision is less easily sorted by means of simply stated hypotheses, because the development of suitable analogues for interpreting such specimens is much less advanced than those for the fracturing and flaking of bone. Both field observations and laboratory experiments are needed to improve our understanding of these altering mechanisms, and I have elected to present a relatively large number of questionable pieces in this report. Those which I have omitted can be characterized in terms of reasonably simple statements as to their likely origin as naturally induced altered forms, and the others (which are described in detail) have been classified in terms of five interpretive categories which represent my opinions concerning their origins: natural, probably natural, natural or artificial (in limbo), probably artificial, artificial.

More specific definitions of the altering mechanisms will be presented as needed during this chapter, and the surface reduction and incision categories will likewise be defined below.

Mammoth Bone Fracture

Descriptions of 104 green fractured mammoth limb bones are presented in Appendix B (Table B1), and four examples are illustrated at the end of this chapter (Pls. 4.3-4.6). If we were dealing here with a demonstrable assemblage of fossilized bones, it would be worthwhile to consider other aspects of the breakage patterns which could be deduced from the attributes under discussion. Since all these bones have been recovered from reworked deposits, however, such an exercise would be meaningless in that we would have to assume that the pieces might reasonably belong together historically. As we will see later in this report, it is possible that as much as 30,000 years of prehistory is represented by these specimens, and any thorough analysis of them as an assemblage would be misleading. They have been presented here for the purpose of displaying those attributes which can be used to identify the past occurrence of human activity, but they cannot be used to explicate the cultural practices of a particular group of prehistoric people. These redeposited specimens will also be used for comparison with the excavated samples to be presented in Chapter 6, and it is only for the purposes of such a comparison that means and standard deviations have been calculated for Table B1. Although these calculations are sample statistics, our geological data indicate that the "sample" lacks historical integrity.

Presumably many of these bones were broken in order to obtain marrow which has long been known as an important energy source for northern peoples whose diets are often deficient in fat. Some of the fractures may have been made to secure raw material for bone flaking (see below), and others could have been produced merely for the purpose of removing segments of the large mammoth legs during butchering and dismemberment (Schroedl 1973; Lyman 1978; cf. Binford n.d.).

Mammoth Bone Cores and Flakes

Classification

Bonnichsen's (1979) analysis of cores from Old Crow Flats was summarized in terms of four categories:

1. Bone cores with flakes removed from the cortical dorsal face. These cores are characterized by nested and/or laterally accumulated flake scars which are floored with compact bone and therefore do not extend through the bone wall to the marrow cavity. The flakes were removed by forces which parallel the long axis and therefore, generally, the Haversian system of the bone (Bonnichsen 1979:101).

2. Bone cores with flakes detached longitudinally from their lateral edges. These cores are not flaked facially, but flake detachment parallels the long axis of the bone (as well as the Haversian system). Presumably the ridges which characterize core edges were instrumental in guiding the propogation of the flakes. This technique produces a flake form which Bonnichsen calls "edge spalls," and it is roughly analogous to burin techniques in lithic technology. This form of core reduction is especially suited to the relatively thin-walled bones of large mammals smaller than mammoths and mastodons (Bonnichsen 1979:113).

3. Bone cores with flakes detached traversely from their lateral edges. In these cases, the axis of detachment is perpendicular to the long axis (and Haversian system) of the cores, and the effect of their removal is to thin, and often to straighten, the core edge. The technique may prove to be a shaping procedure rather than a means of obtaining useful flakes (Bonnichsen 1979:117,124).

4. Bone cores with trimmed distal ends. This category was isolated by Bonnichsen to account for a few specimens which appeared to have been shaped as tools by means of flaking on their presumed working edges (Bonnichsen 1979:127).

Along with flakes, these four "technological classes" formed a concept which Bonnichsen (1979:93-95) labelled a "technological pattern," viz. the flaking of bone and ivory. Elsewhere (Morlan 1979b) I have endeavoured to use these categories in my own analysis of cores and flakes from the Old Crow basin, but I have finally encountered enough difficulties with this classification that I must propose my own approach. The difficulties arise first from the frequent occurrence of both facial and edge flake removal on the same specimen; thus some specimens appear to belong simultaneously to classes 1 and 2. The same problem occasionally occurs in separating class 3 from the first two in that a core may be flaked both longitudinally and transversely. Finally, I regard class four as a different kind of category than the other three classes, because "The flaked edge of the implement is regarded as a working edge" (Bonnichsen 1979:127) rather than simply a raw material (i.e., flake) source.

Another point which must be stressed in this analysis is that no grouping of specimens from the reworked deposits in the Old Crow valley can be assumed to mirror the technological concepts of a particular prehistoric culture. It is conceivable that every core and flake we are about to describe originated in a different archaeological site in the Old Crow basin. Therefore they must not be treated as components or assemblages in any historical sense, and the only justification for grouping them together at all is to simplify the presentation of their respective attributes.

With these limitations in mind, I examined a number of possible criteria which might prove to be useful in classifying the bone cores from the Old Crow region. For example, I looked at the distribution of skeletal elements to see how much variation could be found in the collection of cores, and I found that with only a few exceptions the cores are made on limb bone fragments. Therefore only a small part of the variance could be accommodated in a classification based on this criterion, and most of the non-limb bone fragments could be described with much the same terminology as that used for the limb bones.

It soon became apparent that the orientation of flaking is an important criterion because it has a profound influence on the shapes and sizes of flakes which are detached from the bones (see below). This criterion was adopted as a major classificatory device despite the occurrence of a few specimens on which both longitudinal and transverse flaking is exhibited. The specimens showing combinations of flake scar orientations were assigned to their classes on the basis of the most prominent orientation since this is the one which contains the greatest information content. A few examples of diagonal flaking can also be found because of the spiral forms of some of the green bone fractures which cross-cut the Haversian systems at angles of approximately 45^{o}; these have been grouped with the transversely oriented flake scars.

A second criterion was selected simply as a heuristic device. This is the state of preservation of the core platform which has a marked influence on our understanding of how the bone was manipulated during flaking. Cores which lack preserved platforms tell us very little about flaking procedures since we cannot determine whether the core has been rotated about the platform edge or whether its flaking angles have been adjusted. Many cores are flaked simply by delivering force to the edge of a green fracture surface, and in these cases it is possible to generalize about the range of suitable platform angles which are associated with flake detachment. Other cores have retouched platforms which may reflect deliberate alterations of the platform angles or efforts to strengthen the platform area through the removal of small irregularities and overhanging edges. Cores with retouched platforms also demonstrate that the specimens have been rotated and have been stabilized in more than one position.

The classification of mammoth bone cores based upon these two major criteria is shown in Table 4.3. It is noteworthy that a significant amount of variation occurs in the platform condition of the longitudinal cores and that a very slight amount of variation is seen in this criterion among the transversely flaked cores. In order to simplify the presentation, I have grouped all the transversely flaked cores together rather than presenting separate sections for the few transversely flaked cores which lack preserved platforms or have retouched platforms.

A final note concerning this classification is that it is not adequate to cover every flaked specimen. There are four core fragments with rather confusing features which I have not been able to assign to these categories because they lack the orientation features and definable platform areas which would point to their placements in Table 4.3. In addition there are two flaked specimens which are made on the proximal ends of mammoth radii and which could be described as traversely flaked or longitudinally flaked cores were it not for the fact that their primary fracture has produced cylinders instead of fragments. These have been treated separately as miscellaneous "cores."

Flakes are viewed as the positive counterparts of negative flake scars on the cores, and they are recognized by their conchoidal fracture characteristics as well as some of the fracture attributes which were discussed in Chapter 3. The orientation of flakes in relation to the long axis and Haversian systems of their parent cores is usually readily discernible and can be used to classify them. Other attributes used in this analysis concern the condition of the platform remnants and the morphology of the distal terminations of the flakes, but I have not endeavoured to construct a classification of the flakes beyond the observation of their orientations with respect to bone structure.

Summary

The mammoth bone cores and flakes have been described in detail in Appendix B, and here the results will simply be summarized (see references to tables of data and illustrations in Table 4.4).

Table 4.3. Classification of mammoth bone cores based upon predominant flaking orientation and state of platform preservation.

Flaking orientation:	Longitudinal	Transverse	Both*
Platform condition			
No preserved platform	15(1*)	2	1
Unmodified green fracture surface	9(1*)	9(2*)	3
Retouched surface	12(2*)	1	2

* Cores with both longitudinal and transverse flaking were assigned to the predominant category as indicated in parentheses.

Table 4.4. Distribution of mammoth bone cores and flakes from the reworked deposits in the Old Crow region, northern Yukon Territory.

Category	N	Appendix B	Illustrations
Longitudinally flaked cores without preserved platforms	15	Tables B2-3	Pl. 4.7-4.8
Longitudinally flaked cores with unmodified green fracture surface platforms	9	Tables B4-5	Pl. 4.9-4.10
Longitudinally flaked cores with retouched platforms	12	Tables B6-7	Pl. 4.11-4.14, 5.3
Transversely flaked cores	12	Tables B8-9	Pl. 4.15-4.16
Core fragments with confusing features and miscellaneous "cores"	6	Table B10	Pl. 5.4
Flakes	28	Table B11	Pl. 4.17-4.19, 5.5

In summarizing the characteristics of mammoth bone cores and flakes, I wish to reiterate that the collection cannot be construed as an assemblage and that cultural historical concepts cannot be derived from the data. There are several kinds of observations which can be made, however, concerning the metric and non-metric data presented in Appendix B. We can examine, for instance, the distribution of specimen sizes for non-flaked green fractured bones and that for cores to see whether flake detachment has the effect of reducing specimen size, but it would not be appropriate to reduce the data to technological concepts such as core reduction "strategies" which are peculiar to specific prehistoric cultures. We can demonstrate that the shapes of longitudinally struck flakes, as reflected in their length:width ratios, are less influenced by bone structure than are the shapes of transversely struck flakes, but we cannot generate concepts of "desirable" flake size and shape on the basis of this collection. Hopefully we can synthesize some general concepts concerning the flaking of mammoth bones which will be useful criteria for evaluation primary archaeological assemblages of such material.

Metric data for all green fractured mammoth bones and bone cores have been summarized in Table 4.5 For most measurements there is substantial overlap in the variance of all categories, and it would not appear that flake detachment significantly reduced the size of green fractured mammoth bone fragments. Perhaps this indicates that most bone cores were discarded after a single episode of flake removal, and this is the kind of pattern which should be sought with primary assemblage data.

In Table 4.6, some non-metric observations have been summarized for the same green-fractured bones and cores. The loading point observations have been summed in order to indicate the relative rarity of identifiable loading point preservation. This fact reduces the diagnostic value of green-fractured bones smaller than those of mammoths and mastodons and will place severe constraints on the interpretation of the excavated samples in Chapter 6. The fracture codes have been combined to show that the amount of the specimen perimeter which was fractured when green is much greater for the cores than for the green-fractured bones which were not flaked. At first glance this difference might seem to be a simple matter of recognition, but it is just as easy to recognize the distal ends of flake scars on extensively damaged bones as it is on specimens recovered in good condition. I believe that this difference in the frequency of green-fractured margins results from the reduction in bone cross-section, although not necessarily in size, which accompanies the flaking of bone fragments. Since all bones are subject to considerable stress from shrinkage leading to the formation of split lines, the amount of cross-section still remaining intact when a bone enters a fluvial environment will significantly influence its susceptibility to fracture by natural causes. Those bones which have already been flaked following primary fracture will be less likely to suffer further attrition in the sedimentary environment. A vague reflection of this relationship may be seen in the perimeter measurements (Table 4.5) for all categories of cores except the transversely flaked ones. No doubt this reflection is blurred by the variations in original size among the bones in these categories, and I have not thought it worthwhile to attempt to standardize the data for the purpose of a better measurement of this effect. Perhaps such an effort should be made with primary archaeological material which could be subject to

Table 4.5. Summary of metric data for green-fractured mammoth bones and bone cores from the reworked deposits in the Old Crow region, northern Yukon Territory (measurements influenced by recent and post-permineralization fractures have been excluded).

Category		Length	Chord	Perim.	Weight	Wall Thickness Min.	Wall Thickness Max.	Loading Point Diam.
Green fracture only (not flaked) Table B1	N	44	37	36	103	100	100	16
	Mean	151.4	73.2	95.0	291.6	16.1	23.3	13.9
	S.D.	79.0	19.3	46.0	362.6	6.6	6.8	6.3
Cores lacking platforms (green fracture attributes) Table B2	N	12	10	10	15	14	14	5
	Mean	163.6	63.6	78.8	238.1	15.4	22.7	17.5
	S.D.	40.3	16.9	20.7	118.6	6.3	6.7	9.1
Cores with unmodified platforms (green fracture attributes) Table B4	N	7	7	7	9	9	9	
	Mean	130.9	67.3	89.6	228.6	15.4	20.1	
	S.D.	35.7	30.1	47.1	170.9	7.2	6.9	
Cores with retouched platforms (green fracture attributes) Table B6	N	7	7	7	12	12	12	2
	Mean	163.3	81.3	94.7	354.9	15.7	28.1	17.6
	S.D.	35.3	25.4	34.5	257.3	7.3	13.7	1.8
Cores with transverse flaking (green fracture attributes) Table B8	N	7	8	8	11	12	12	4
	Mean	205.7	82.1	107.9	496.7	17.8	27.6	12.6
	S.D.	79.1	18.9	42.3	329.4	4.5	7.9	4.3
All green fractured mammoth bones and cores (except fragments and misc. "cores")	N	77	69	68	150	147	147	27
	Mean	157.4	73.0	93.6	302.6	16.1	23.8	14.6
	S.D.	69.1	21.1	41.4	330.0	6.5	7.8	6.4

Table 4.6. Summary of non-metric data for green-fractured mammoth bones and cores from the reworked deposits in the Old Crow region, northern Yukon Territory.

Category	Fracture code			Totals	Loading Points	
	$x/y < \frac{1}{2}$	$\frac{1}{2} \leq x/y < 1$	$x/y = 1$		Cones	Scars
Cores lacking platforms, Table B2	2	6	7	15	1	4
Cores with unmodified platforms, Table B4	1	2	6	9		1
Cores with retouched platforms, Table B6	3	4	5	12		2
Transversely flaked cores, Table B8		9	3	12	1	3
Core fragments, Table B10		2	2	4	1	
All cores and fragments	6	23	23	52	3	9

Category	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Totals	Cones	Scars
All cores and fragments	6	14	23	22	23	16	52		
Green fracture only (not flaked) Table B1	36	28	42	43	25	32	103	6	19
Totals	42		65		48		155	9	28

$\chi^2 = 11.5$; df $= 2$; P $= 0.997$ that χ^2 will not be exceeded

Table 4.7. Summary of metric data for flake scars and flakes on mammoth bones from the reworked deposits in the Old Crow region, northern Yukon Territory (measurements influenced by recent and post-permineralization fractures have been excluded).

Category		Length	Chord	Perim.	Thickness	Weight
Category						
Flakes struck longitudinally,	N	20	23	23	23	23
Table B11	Mean	106.0	54.5	58.6	18.1	111.9
	S.D.	52.1	21.4	28.5	8.9	170.6
Flakes struck transversely,	N	5	5	5	5	5
Table B11	Mean	68.8	95.0	92.8	26.1	72.5
	S.D.	34.2	33.4	38.2	25.4	49.9
Flake scars on longitudinal	N	14	15			
cores lacking platforms,	Mean	58.2	35.0			
Table B3	S.D.	23.6	13.6			
Flake scars on longitudinal	N	10	11			
cores with unmodified	Mean	66.0	29.9			
platforms, Table B5	S.D.	32.0	9.8			
Flake scars on longitudinal	N	15	17			
cores with retouched	Mean	54.9	38.7			
platforms, Table B7	S.D.	32.3	16.0			
Flake scars on transverse	N	14	15			
cores, Table B9	Mean	22.5	61.0			
	S.D.	11.2	28.0			
All longitudinal flake scars	N	41	45			
(including two from text	Mean	57.0	34.4			
descriptions)	S.D.	29.5	14.2			
All transverse flake scars	N	17	18			
(including three from text	Mean	21.3	56.7			
descriptions)	S.D.	10.6	27.6			

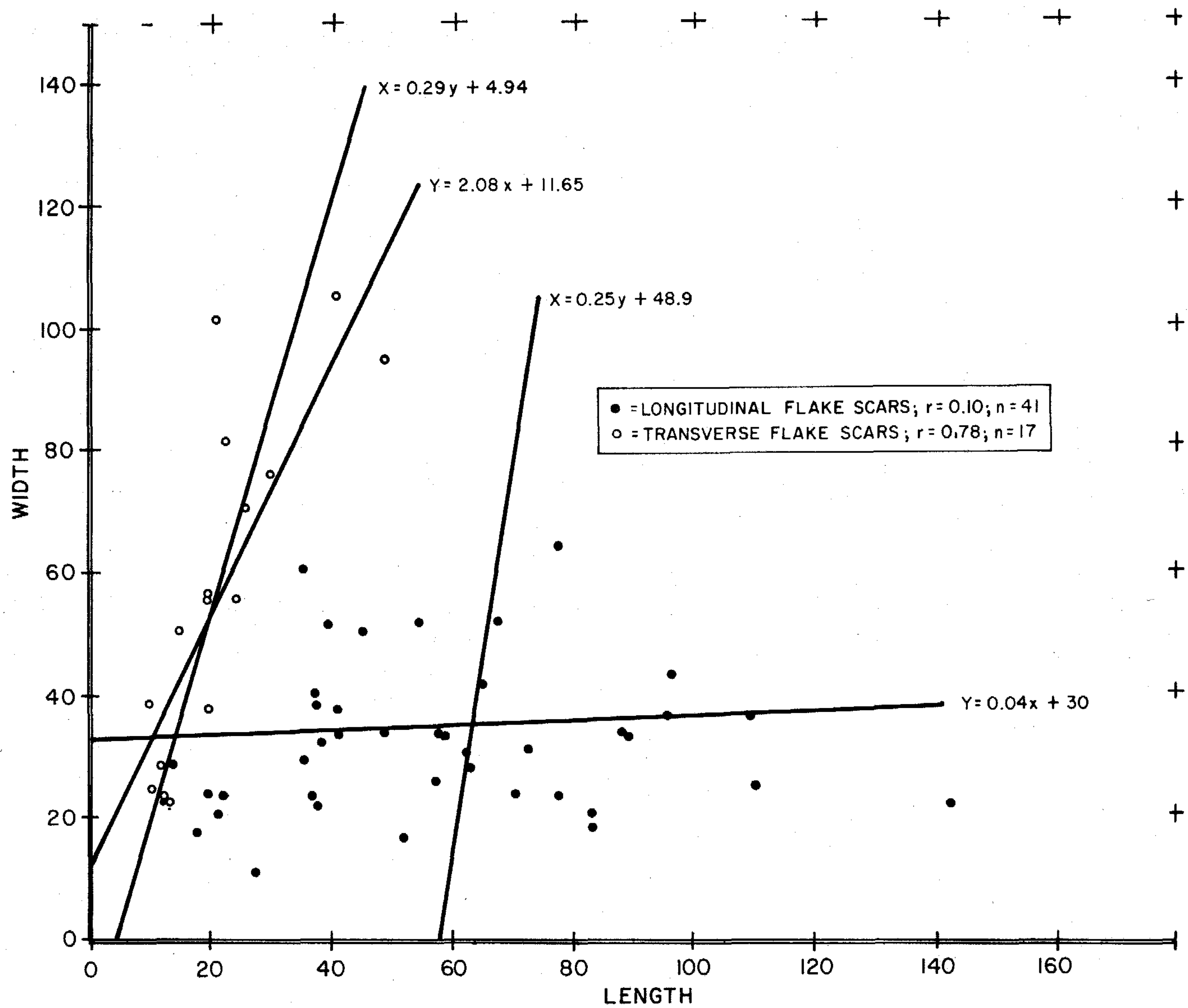


Fig. 4.1. Scattergram of length and width of flake scars on cores. Note high correlation for transverse flake scars and low correlation for longitudinal flake scars.

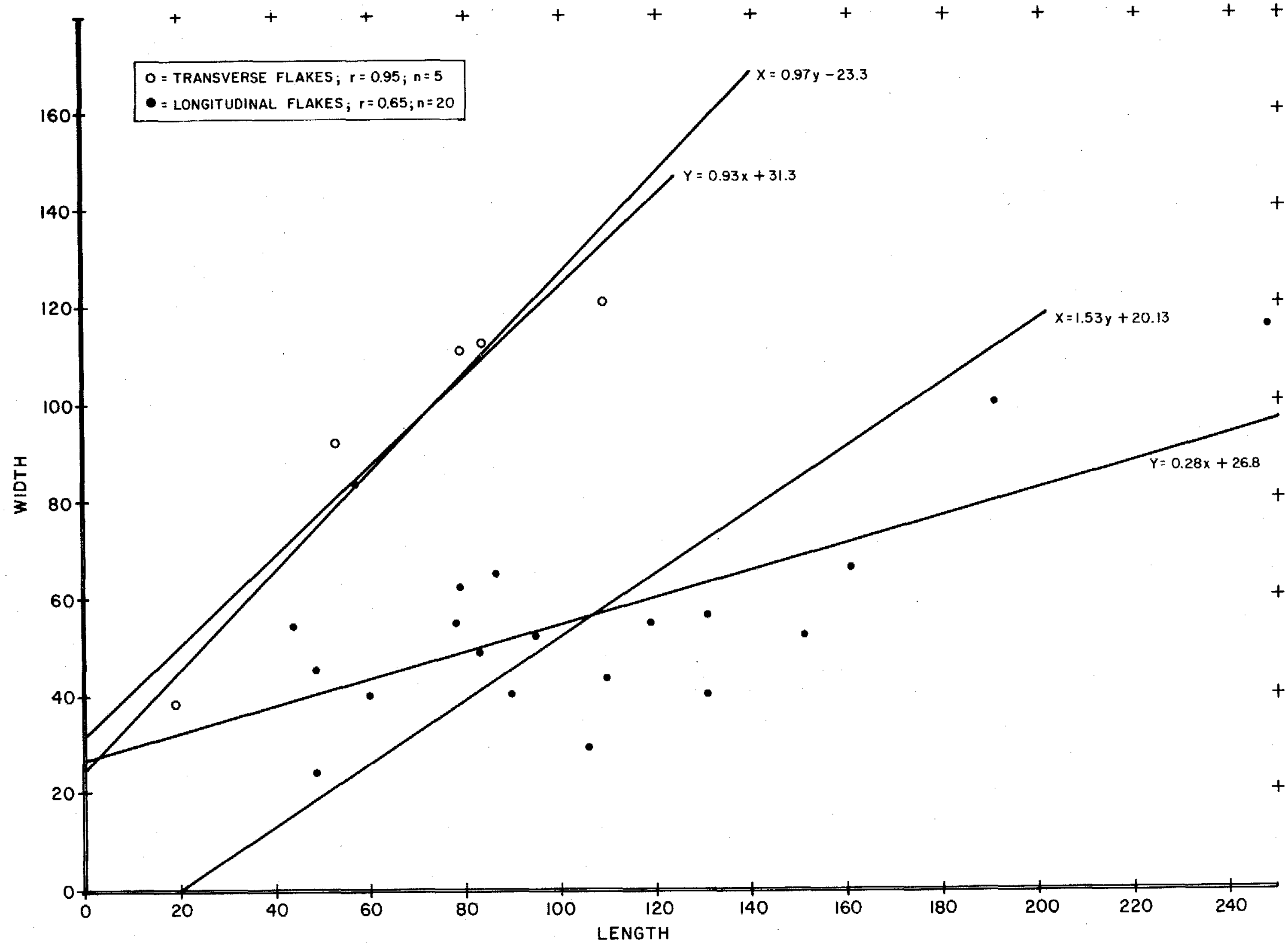


Fig. 4.2. Scattergram of length and width of bone flakes. Note high correlation for transverse flakes and lower correlation for longitudinal flakes.

Table 4.8. Summary of non-metric data for flake scars on cores and flakes from reworked deposits in the Old Crow region, northern Yukon Territory.

Category	Total Specimens	Total Platforms	Total Scars	Number of scars/platform								Distal terminations					
				1	2	3	4	5	6	Many	Scat.	1	2	3	4	5	6
Cores lacking platforms, Table B3	15	17	34+	5	8	1	1	1		1					21+	13	
Cores with unmodified platforms, Table B5	9	11	24	3	3	5								1	18	5	
Cores with retouched platforms, Table B7	12	15	36	4	6	2	2		1					2	20	14	
Transversely flaked cores, Table B9	11	16	29+	6	2		2	1	1	2	2			+	22+	7+	
Totals	47	59	123														
Previous scars on flakes, Table B11	28	28	32	3	3	6		1									
Flakes, Table B11	28											2	2	2	6	12	2
																2	

Legend
Distal terminations: 1, recent fracture; 2, jagged; 3, stepped; 4, hinged; 5, feathered; 6, bipolar

natural fracture by such processes as freeze and thaw cycling.

Measurements of flake scars and flakes made on mammoth bones are summarized in Table 4.7, and the length and chord data have been plotted in Figs. 4.1-4.2. Comparisons of length:width ratios between longitudinal and transverse (and diagonal) flakes reveal interesting differences which undoubtedly are related to the influence of bone structure on the propogation of fracture waves. Length and width are highly correlated for transverse flake scars on cores ($r = 0.78$) and for transverse and diagonal flakes ($r = 0.95$). The flakes and scars are much broader than long, apparently as a result of the resistance of the longitudinally oriented collagen fibers. The longitudinally struck flakes and scars have much more variable length:width ratios ($r = 0.64$ and 0.22, respectively), and there are many factors which influence flake length. Flakes may terminate prematurely due to hinge fractures already present on the core face or due to local changes in bone histology as occur in ridges which are developed under the influence of the musculature. Bonnichsen (1977:135-136) has noted that ridges can be used to control the size and shape of lithic flakes but the ridges which occur on large bones are not always reliable for this purpose as shown in recent experimental flaking (the Ginsberg experiment). Another factor which probably influences the apparent correlation of length and width in the longitudinal flakes is the frequent occurrence of lateral truncations where one flake scar intersects another. Such truncations may have significantly influenced the measurements of flake scars on the cores.

In comparing Figs. 4.1 and 4.2, the larger size of the flakes as opposed to the flake scars is quite noticeable. I suspect that this is a result of our collecting procedures in that cores are quite conspicuous on the sand bars and banks of the river even if their flake scars are small, but only the larger flakes are conspicuous while many smaller examples may go unnoticed. For whatever reason, it is apparent that the collection of flakes currently available from the reworked deposits is not closely related to the collection of cores.

The non-metric attributes of flakes and flake scars (Table 4.8) also reveal some interesting patterns. I have converted the flake scar fractions used in Tables B3, B5, B7, B9, and B11 to simple flake scar counts in Table 4.8, and it is noteworthy that the majority of the cores exhibit multiple flake scars. Multiple platforms occur on five longitudinal and four transverse cores, and an average of 2.2 flakes were struck from the platforms of longitudinal cores. A comparable figure is difficult to derive for the transverse cores since four of them exhibit large numbers of overlapping or scattered flake scars. It is interesting that the transverse cores more frequently exhibit large numbers of flake scars, for this may reflect the lack of constraint on the platform widths of such specimens.

Hinged distal terminations are much more common than feathered terminations on the cores, but the reverse is true of the flakes. This difference is probably related to the relatively larger size of the flakes which results from collecting bias, because a flake large enough to have been collected may be large because it did not hinge out prematurely.

Table 4.9. Distribution of platform types on mammoth bone cores and flakes from reworked deposits in the Old Crow region, northern Yukon Territory.

Platform types on cores	Table	Frequency
Platform lost by:		
Recent fracture	B3	2
Facial flaking	B3	2
Too deep a bite	B3	13
Other green flaking	B7	2
Platform on unmodified green fracture surface	B5	11
	B7	1
	B9	15
Platform is a retouched surface	B7	12
	B9	1
Totals		59

Platform types on flakes (Table B11)	Frequency
Platform lost by:	
Recent fracture	1
Snapping during detachment	3
Shattering during detachment	5
Sharp-edge remnant	5
Platform on unmodified green fracture surface	5
Platform is a retouched surface	6
Platform is a gabled surface	3
	28

It is possible to match general platform types on the cores with the types of platform remnants preserved on the flakes. Rough pairing and frequencies of types are shown in Table 4.9, and it is apparent that the flakes do not reflect the cores with respect to platform type any more than they do with respect to distal terminations. Given all the biases which have influenced this peculiar collection such observations are not surprising.

Fractured and Flaked Mammoth Tusk Ivory

One fragment, four cores, and three flakes of ivory exhibit smooth surfaces which cross-cut the lamellar structure of the tusk at various angles (Table B12). These specimens appear to be the products of flaking in that they frequently preserve hackle marks and ribs on their flake scars and fracture surfaces. They have been isolated as a group because of the very distinctive histology and macrostructure of tusks which make them quite different from bones. They have also been kept separate from the bones because I understand the structure of tusks only through the literature (Sikes 1971:Fig. 32) and through inferences based upon my observations of the fossil specimens; I have not had an opportunity to fracture and flake fresh ivory and therefore I am less familiar with its properties. Nonetheless I am confident that the specimens described here were artificially modified when the tusks were in a fresh condition. In many instances, the lamellae of the tusks have begun to separate as a result of weathering, and these separations intersect the fracture surfaces created when the tusk fragments were fresh.

This small sample is of little use in gaining an overall comprehension of ivory flaking properties, but it shows that mammoth and mastodon tusk ivory should not be ignored in evaluating artifacts made by flaking techniques.

Cores and Flakes made on Smaller Large Mammal Bones

Seventeen cores and two flakes were made on large mammal bones smaller than those of mammoths. The high frequency of platform removal by green fracture (Table B14) reflects the fact that thin bone walls often do not withstand the shock required for flake removal. With such thin-walled specimens as NbVl-6:1, any effort to prepare a platform by flaking across the bone wall toward the medullary cavity would so thin the bone that successful flaking would be impossible. This small long bone shaft fragment could be readily broken by carnivores and could be extensively "flaked" by their gnawing, but NbVl-6:1 exhibits such regular spacing of flake scars along a 40.3 mm section of one edge that carnivore activity would seem to be precluded as a likely explanation (Pl. 4.20).

In his comments on an earlier draft of this report, Bonnichsen (pers. com. in 1980) replied that he doubts that thin walled bones present as difficult a problem in platform preparation as I have implied, and he suggests that experimental work will be needed to verify this idea. He also notes that fresh bone walls can simply be mashed flat to secure a platform and that grinding techniques can be employed for this purpose. With the possible exception of one of the mammoth bone cores (MlVl-1:143, Tables B2-B3, Pl. 4.8), I have not observed grinding on any of the platform remnants from the Old Crow area, and "mashed" platforms might be difficult to recognize on slightly to moderately rounded specimens.

Bones and Antlers with Reduced and Incised Surfaces

Classification

Bonnichsen (1979:131-139) subsumed polished specimens under three categories: (a) polished facets (rubbing tools); (b) expedient tools; and (c) miscellaneous polished and ground bone artifacts. Rubbing tools are those with facets on one end of a specimen in such a position and form that the facet appears to comprise a working end. Expedient tools are characterized by any form of workmanship or apparent use wear which occurs on a spiral fracture surface, and the evidence of use may or may not include polishing. Miscellaneous polished specimens do not fall neatly into either of these categories and must be individually described. Although these distinctions may have some descriptive merit and may indeed reflect levels of incidental versus deliberate human behaviour, they beg the questions of precisely what sorts of functions are represented, what sorts of altering processes are responsible for the polish, and which specimens can be admitted as genuine artifacts. Bonnichsen (pers. com. in 1980) agrees that this classification needs revision.

I will propose a somewhat different classificatory approach to these specimens, but I wish to say at the outset that I doubt that it is the revision we will eventually need for these specimens. There is too much uncertainty as to the mode of origin for many of these pieces to afford much hope of erecting a classificatory framework which would prove to be adequate in dealing with a primary archaeological assemblage. The rationale for the classification used here is simply that its criteria are morphological and require little if any inference in the assignment of specimens. I hasten to add that the criteria require very careful microscopic observations because some of the critical features cannot be seen with the unaided eye on these specimens.

The classification begins with two kinds of surface reduction and three forms of surface incision. Surface reduction may consist of: (1) grinding, a form of general surface alteration which reduces high spots to a plane but which does not produce a highly reflective (glossy) surface; or (2) polishing, a surface alteration which not only planes the surface but also produces a relatively high gloss or reflectivity. Surface incisions may take the form of: (1) scratches, defined as very fine (microscopic) parallel straight incisions which occur in groups with well defined orientations; (2) scrapes, defined as coarse (macroscopic) sub-parallel straight or wavy incisions which occur in groups with poorly defined orientations; and (3) cuts, defined as single incisions or grooves with highly variable shapes and orientations. Some of these surface reduction and incision features may occur together as shown in Table 4.10. Scratches or scrapes may occur with or without grinding or polishing. They may occur independently on the same specimen or they may occur in superimposed arrangements which indicate either simultaneous production or truncation of one alteration by another. Scratches which appear in direct association with polishing are referred to as striae. Cuts appear to be entirely independent of surface reduction processes, but two antlers exhibit both cuts and polish which were probably acquired separately. The scratches and polish on the one tooth indicated in Table 4.10 also appear to have been acquired independently.

Ideally one would present the contents of each cell of Table 4.10 in some logical sequence, and for the most part that procedure has been followed in this chapter and in Appendix B. The sequence has been altered, however, in the presentation of the polished bones, because the presence or absence of visible striae seems to me to be a less important criterion than the association of the alterations with green fractures. Therefore the specimens are introduced in the following order: (1), scratched bones lacking surface reduction; (2) scratched tooth (surface reduction regarded as independent of incision); (3) scraped bones lacking surface reduction; (4) ground bones with surface incisions (scratches or striae); (5) all polished bones (with and without surface incisions); (6) all antlers; and (7) all incised bones lacking surface reduction.

The polished bones are further subdivided as follows: (1) polished facets on bones not fractured when green; (2) polished facets and green fractures in different locations on the same bone; (3) polished facets which intersect green fractures; and (4) polished facets which occur on green fracture surfaces.

On the basis of their individual descriptions in Appendix B these specimens have been classified into several "statuses": natural or artificial, probably artificial, and artificial. The discussion in Chapter 3 indicated that such assignments were made on the basis of the complexity of the alterations and their truncations of or by other features on the specimens. A number of specimens were carefully studied and omitted from this report because they appeared to hold no promise of being interpreted as artificially modified. The reasons for these omissions are as follows: (1) the alterations are so simple that they could easily have been produced by natural agencies such as abrasion during stream transport (MlVl-16:1, *NbVl-2:20, NbVl-6:2); (2) the alterations truncate the rind of permineralization (MlVl-1:2, NaVk-5:41, NbVn-2:1); (3) the alteration occurs on a recent fracture surface (NbVm-3:1); (4) the alteration occurs on an exfoliated surface (MkVl-9:31.1); (5) the alteration truncates rootlet etching (MlVl-9:7, NbVl-8:1); (6) the alteration is geometrically complex but conforms to the natural contours of the bone (NaVl-11:1, see Morlan 1978a:85, Fig. 4); (7) the alteration closely resembles carnivore gnawing (MlVl-5:34; cf. Bonnichsen 1979:139, Pl. VIII-25); and (8) the apparent alteration is in fact a complex anatomical feature (MlVl-1:57; cf. Bonnichsen 1979:139). It is noteworthy that when these pieces are omitted from consideration, all but a few of the surface-reduced and -incised specimens also exhibit green bone fractures (81% of the bones).

Table 4.10. Classification of surface reduction and surface incision forms, showing their associations as observed among the Old Crow specimens.

Surface Incision \ Surface Reduction:	None	Ground	Polished
None	X	X	12 bones*
Scratches	2 bones	2 bones	1 tooth, 1 antler, 13 bones*
Scrapes	8 bones	X	X
Cuts	2 antlers, 5 bones		2 antlers

* one bone exhibits striae (scratches) on one facet but none on another

X marks associations observed in other samples but not in the collection reported in this section.

Other entries indicate the frequencies of the alterations reported in this section.

Summary

Most of these 49 pieces are unique and have been individually described in Appendix B (see also Pls. 4.21-4.30, 5.6). Sixteen of these specimens are bones for which artificially induced green fractures have already been described. In two cases I do not know whether these additional alterations (scraping and grinding) are natural or artificial. Two examples of grinding and one of polishing are probably artificial, and the remainder of the additional alterations (one ground, four scraped, and six polished) have been classified as artificial.

Of 22 other bones and one tooth for which I had not previously described fracture patterns, a natural or artificial classification has been assigned to one scratched bone, the scratched tooth, and eight polished bones. Scraping on one bone and polishing on three other bones (Pls. 4.25, 4.26) are probably artificial, and one scratched bone (Pl. 4.21) and eight polished bones (Pls. 4.23. 4.24) have been classified as artificially modified.

The other ten specimens include one polished and four cut antler pieces and five cut bones all of which are classified as artifacts. In most cases I have very little idea of the possible functions which could have produced the surface reductions and incisions (although hide working seems to be a reasonable suggestion for many of them), but suggestions as to function can be made for the five antler specimens and five cut bones.

Antler "pestle"

The polished antler specimen (NbVl-2:6) has been described several times in the past, but this is the first time that a fifth (lateral) facet has been mentioned. Harington (1975a) suggested that this piece might have been used as a pestle, and Bonnichsen (1979 131, Pl. VIII-20) classified it as a rubbing tool which might be associated with hide working (see also Harington, *et al.* 1975:48). Experimental work on this kind of antler polishing might provide some information on the range of possible functions. This specimen was found in association with the *Anodonta* phase.

Antler billet

The pocking on the base of a cut and polished antler specimen (NbVl-2:15) is identical to that seen on antler billets or hammers used experimentally in flint-knapping (Pl.4.27; Morlan 1978a:Fig.6). It is possible that the nicking of the edges of the bez tine resulted from various platform strengthening procedures such as the removal of overhanging lips which accumulate following the detachment of a row of flakes. The bez tine could have served as a handle in operating this specimen as a billet, but an interesting question emerged from the replication and use of such a billet. Given the angle of the antler base, the most intensive facetting occurs in a position which is hidden from a flintknapper's view at the moment of impact. My use of a replica of this billet led to pocking on the opposite side of the base as I automatically attempted to keep the working area in view. The pocking on the fossil is located at the anterior edge of the base while on the replica it is concentrated on the lateral margin. I believe that the difference is related to the holding position adopted during flint knapping. Whereas I normally position the core on my left leg during flaking, I can best match the position of billet impact seen on the fossil by elevating the core nearly to eye level which makes visible a contact area on the anterior edge of the antler base. I have attempted to follow the lead of Bordes (1974) by searching with a microscope for small fragments of chert or obsidian which might have become imbedded in the base of this billet. Although several sand grains are firmly wedged in the antler structure as a result of the redeposition of the specimen by fluvial processes, I have not been able to find fragments which might represent the original use of the tool. This is one of the specimens recovered by excavating in deposits representing the *Anodonta* phase.

Antler Wedges

Three caribou antler wedges have been found on the banks of the Porcupine River just south of Old Crow Flats, and several similar specimens have recently been recovered in the Old Crow valley itself (J. Cinq-Mars, pers. com. in 1979). All three wedges were made in a similar fashion and constitute our only repeated artifact "type" other than the bone cores and flakes. Each of the wedges was provided with a transverse butt which was formed by chopping and snapping the antler beam to form a relatively flat area at right angles to the longitudinal axis of the beam. The opposite end was bevelled unilaterally to form a rounded or slightly pointed working end, and this end was driven in its work by means of blows delivered to the butt. There can be no doubt regarding the artificial status of these pieces, but the age of at least two of them is in doubt whereas the third specimen must be assigned to the historic period in view of tool marks preserved on its surface. The wedges have been described in Appendix B.

Because of their dark staining and the appearence of permineralization these antler wedges have been discussed repeatedly (Harington, *et al.* 1975:46; Morlan 1978a:87; Morlan and Matthews 1978; Bonnichsen 1979:129-131, Pl. VIII-19, -20) in a collective manner, but these are the first detailed individual specimen descriptions which have been published. That is unfortunate, for the impression has already been created that these pieces can be reliably regarded as elements of the Pleistocene record in the Old Crow region, and this impression must be abruptly altered by the recognition of metal file marks on one specimen and by the reminder that another was found on the Klo-kut beach. One author (Bryan 1978a:310-311) has based a discussion of "specialized bone working technology in Beringia during the Mid-Wisconsinan stage" partially on these antler wedges, one of which must now be assigned to the historic period. This is a good illustration of the hazards involved in summarizing discoveries of redeposited specimens before detailed descriptions have been completed, and I openly offer my apologies for misleading Bryan and other readers of some of my shorter papers which were written before the current work was completed. This is the kind of error which we have long known, theoretically, could occur in discussing these redeposited specimens, but it is the first demonstration that such an error has already been made. Antler wedges may well belong in the Pleistocene record of the Old Crow region, but that remains merely a possibility and not a demonstrated fact.

Cut bones

Of the five cut bones from reworked deposits in the Old Crow basin, only two (MkVl-12:16, MlVl-5:56) are thought definitely to have been cut during butchering (Pl. 4.28) while two others (MlVl-1:64, NbVl-2:12) are difficult to interpret (Pl. 4.29). The fifth (MlVl-1:1c) is the famous flesher which has been widely discussed and illustrated (Pl. 4.30; Irving and Harington 1973). Most of the shaft of the flesher was sacrificed for a radiocarbon date based upon the apatite fraction of the bone: 27,000 +3000 -2000 (GX-1640: Irving and Harington 1973:336). A 64 X 10 mm section of the outer wall had earlier been removed for uranium, nitrogen and fluorine tests which did not provide interpretable results (Irving, pers. com. in 1967).

Summary of all Redeposited Specimens

The 246 specimens which have been presented in this chapter are summarized in Table 4.11. In examining the distribution among the three status classifications, the reader must bear in mind that I have selected the specimens for presentation in this chapter and that there are thousands of bones, tusks, and teeth (and a few dozen antler fragments) which have been altered entirely by natural agencies. Therefore the 92% artificial frequency has little meaning except to reflect my lack of confidence in the interpretation of the other 8% of the specimens. Most of the uncertain interpretations are in the scratched, scraped and polished categories which will require more experimental study and field observation before a better understanding of these alterations can be achieved.

All the mammoth bones which were fractured or flaked when green have been referred to the artificial category with the exception of one fragment and two flakes which were fractured or detached when dry. It should be understood that this classification represents a position which I am adopting in this report and that I cannot actually prove that each of these specimens was artificially altered. My position is a hypothesis (see Chapter 3) which is susceptible to testing through further field and experimental work, viz, that green fractures on mammoth limb bones (and a few other skeletal elements) are indicative of human activity in the Old Crow valley. One fractured mammoth bone and two mammoth bone flakes exhibit attributes suggesting that the pieces had begun to dry before the fracturing or flaking was accomplished, and these are only "probably artificial" in view of the structural changes which can occur rather rapidly in bones which become dessicated.

Since this is the second major study which has presented many of these specimens, I feel obliged to indicate precisely how my results compare with those of Bonnichsen (1979). This comparison is made in Table 4.12 for each specimen reported by Bonnichsen (1979) which is

Table 4.11. Summary of alterations and statuses for bones, teeth, tusks, and antlers from the reworked deposits of the Old Crow region, northern Yukon Territory.

Alterations	Tables	Total	Nat. or Art.	Prob. Art.	Art.	Chronological Data 1	2	3	4
Mammoth bones fractured green		104							
Green fracture only	B1				95	86	8	1	
Green fractured and scraped	B1, B16				5	4	1		
Green fractured and ground	B1, B15				2	2			
Green fractured and polished	B1, B17				1	1			
Fractured when dry	B1			1		1			
Mammoth bone cores without platforms		15							
Flaked only	B2-B3				13	11	2		
Flaked and polished	B2-3, B17				2	1	1		
Mammoth bone cores with unmodified platforms		9							
Flaked only	B4-B5				8	8			
Flaked and scraped	B4-5, B16				1	1			
Mammoth bone cores with retouched platforms		12							
Flaked only	B6-B7				11	9	2		
Flaked and scraped	B6-7, B16				1	1			
Mammoth bone transverse cores		12							
Flaked only	B8-B9				9	8		1	
Flaked and polished	B8-9, B17				3	2	1		
Mammoth bone core fragments	B10	4			4	4			
Mammoth bone misc. "cores"	B10	2			2	1		1	
Mammoth bone flakes		28							
Detached when green	B11				26	26			
Detached when dry	B11			2		2			
Mammoth tusk ivory		8							
Cores	B12				4	4			
Flakes	B12				3	3			
Fragment	B12			1		1			

Table 4.11 (Continued).

Alterations	Tables	Total	Nat. or Art.	Prob. Art.	Art.	Chronological Data 1	2	3	4
Large mammal bone cores and flakes		19							
Longitudinal cores	B13-14				13	13			
Transverse cores, flaked only	B13-14				3	3			
Transverse core, polished	B13-14, B17				1	1			
Flakes					2	1	1		
Cut and scratched pieces (excl. mammoth)		33							
Scratched bones	B15		1		1	2			
Scratched tooth	B15		1			1			
Scraped bones	B15			1		1			
Polished bones	B17		8	3	8	19			
Cut and polished antler	B18				5	1	2		2
Cut bones	B19				5	2	1	1	1
Totals		246	10	8	228	220	19	4	3

Legend

Statuses: Alterations are classified by Nat. or Art. (natural or artificial), Prob. Art. (probably artificial), or Art. (artificial).

Chronological Data: 1, no information other than dark stain on specimens and/or identity as extinct mammal; 2, recovered by excavated in association with the *Anodonta* phase (10,000-12,000 B.P.); 3, radiocarbon dated on collagen (green fractured bone) or apatite (other three specimens); 4, light stain or evidence of metal tool marks suggest relatively young age.

housed in the National Museum of Man. The reader should bear in mind the significant differences in the circumstances of these two studies. Bonnichsen was required to complete all his observations in one year, and his access to the collections involved visits to the National Museum of Natural Sciences and to the University of Toronto as well as ongoing study in the National Museum of Man. In contrast, I have been able to study the specimens reported here during a period of four years with all the pieces assembled in one laboratory. I have been able to return to each piece as new ideas and information became available, and I have been able to change my interpretation of any specimen as required by new understanding of various bone altering agencies; these luxuries were not available to Bonnichsen. Furthermore there have been a number of significant learning opportunities since the year (1973-74) when Bonnichsen made his study of the Old Crow fossils. These include more field work in Old Crow Flats, participation in a multi-disciplinary project through which modes of sedimentation and fossil redeposition have been better understood, preliminary results from Parama's taphonomic experiment, and several laboratory experiments of which the Ginsberg elephant butchering experience (Stanford, *et al.*1980) is the most outstanding. I have benefited from each of these opportunities as well as from Bonnichsen's monograph and several others (e.g., Binford n.d.; Harington 1977; Tomenchuk 1976).

In view of these considerations, it is not surprising that my treatment of the Old Crow fossils differs to some extent from that published by Bonnichsen (1979), and the differences can be summarized in terms of a few themes. I have not altered the "artificial" status of any of the mammoth bones published by Bonnichsen, but I have interpreted a few of them somewhat differently. One "core" and one "flake" are interpreted by me as merely green fractured mammoth bones, and several of the cores are regrouped because I defined my categories on the basis of different criteria than were used by Bonnichsen. These are minor changes which have resulted from slight differences in the interpretation of flake scars and particularly from the recognition (as a result of the Ginsberg experiment) of scars which represent rebound flakes detached during primary fracture (see Appendix B).

The major differences between this study and Bonnichsen's arise with respect to large mammal bones smaller than those of mammoths. Green bone fractures on limb bones smaller than those of mammoths are difficult to interpret because of the possibility that carnivores induced them. Although I have omitted from this report all the green fractured bones other than those of mammoths which were summarized by Bonnichsen (1979: Table 8), I cannot demonstrate that the omitted bones were not artificially fractured. Secondly I have placed "in limbo" a number of other specimens which exhibit flake scars in view of the possibility that carnivore gnawing produced them; in particular any such specimen with visible evidence of carnivore gnawing (e.g. Bonnichsen 1979: Pl. VIII-3, 58-19076; Pl. VIII-9, 89-13662, 89-19426; Pl. VIII-10, 89-23265; Pl. VIII-12, 97-17110) was omitted from consideration as demonstrated artificially modified bone.

The other major changes arose from the restudy of a "cut" bone and a "sawn" bone, both of which were omitted from the "artificially" modified

Table 4.12. Comparison of classifications by Bonnichsen (1979) with the treatment of redeposited specimens in this report.

Bonnichsen's Categories Cat. No.	(Number in Bonnichsen 1979)	Treatment in this report (Table references)
Bone cores: flakes removed from dorsal face		
NbV1-2:8	29-4	In limbo: nature of edge adjacent to flake scars suggests that scars represent rebound flakes
NbV1-2:11	29-5	Green fracture only, not a core (Table B1)
NbV1-2:7	29-7	Core fragment with confusing features (Table B10)
NaV1-4:6	52-16326	Longitudinal core on large mammal bone (Tables B13-14)
NaVk-1:6	58-19076	In limbo: possible carnivore alterations
NaVk-5:28	60-15306	Mammoth bone core with retouched platform (Tables B6-7)
NaVk-5:31	60-24042	Mammoth bone core with retouched platform (Tables B6-7)
NaVk-6:8	64-14421	Longitudinal core on large mammal bone (Tables B13-14)
NaVk-6:10	64-20606	Mammoth bone core without preserved platform (Tables B2-3)
M1V1-5:21	74-21	Mammoth bone core with unmodified platform (Tables B4-5)
M1V1-5:33	74-17328	Longitudinal core on large mammal bone (Tables B13-14)
M1V1-1:2c	80-2	Mammoth bone core flaked transversely (Tables B8-9)
M1V1-1:3c	80-3	Mammoth bone miscellaneous "core" (Table B10)
M1V1-1:25	80-25	Mammoth bone core without preserved platform (returned from a loan too late to be included in Appendix B)
MkV1-12	(89-119, 206, 285, 321, 394, 850, 854, 860, 861)	(University of Toronto collections, not available for this study)
MkV1-12	89-13662	In limbo: possible carnivore alterations
MkV1-12:7	89-19426	In limbo: possible carnivore alterations
MkV1-12:9	89-23265	In limbo: possible carnivore alterations
MkV1-12:15	89-24901	Mammoth ivory core (Table B12)
MkV1-8:18	81-18	Mammoth bone core with unmodified platform (Tables B4-5)
MkV1-18:4	98-4	Longitudinal core on large mammal bone (Tables B13-14)
Bone cores: flakes removed from lateral edges		
NbV1-1:27	31-15664	Longitudinal core on large mammal bone (Tables B13-14)
M1V1-5:30	74-14982	Longitudinal core on large mammal bone (Tables B13-14)
M1V1-1:21	89-21	Mammoth bone core with retouched platform (returned from a loan too late to be included in Appendix B; incorrectly attributed to MkV1-12 in Bonnichsen 1979:114)

Table 4.12 (Continued).

Bonnichsen's Categories

Cat. No.	(Number in Bonnichsen 1979)	Treatment in this report (Table references)
Bone cores: flakes removed from lateral edges (cont.)		
MkVl-12:8	89-24910	In limbo: green fracture only on large mammal bone
MkVl-23:3	97-17110	In limbo: possible carnivore alterations
Bone and Ivory Flakes		
NbVm-5:8	17-16303	Bone flake (Table B11)
NbVm-4:13	26-13	Ivory flake (Table B12)
NbVl-1:6	31-6	Bone flake (Table B11)
NbVl-1:24	31-24	Bone flake (Table B11)
NaVk-5:26	60-14530	Green fractured mammoth bone (Table B1)
MlVl-5:48	74-15032	Ivory flake (Table B12)
MlVl-5:49	74-15033	Bone flake (Table B11)
MlVl-5:50	74-15034	Bone flake (Table B11)
MlVl-1:51	80-51	Ivory flake (Table B12)
MlVl-1:53	80-53	Bone flake (Table B11)
MlVl-1:87	80-87	Bone flake (Table B11)
MlVl-1:154	80-15363	Bone flake (Table B11)
MkVl-12	(89-20, 567, 684, 855, 1331)	(University of Toronto collections, not available for this study)
MkVl-12:12	89-23556	Bone flake (Table B11)
MkVl-12:11	89-24904	Bone flake (Table B11)
MkVl-8:11.1	91-111	Bone flake (Table B11)
MkVl-8:21	91-16904	Bone flake (Table B11)
MkVl-8:22	91-16906	Bone flake (Table B11)
Bones with thinning scars		
NaVk-1:7	58-23678	Mammoth bone core flaked transversely (Tables B8-9)
NaVk-5:4	60-4	Mammoth bone core flaked transversely (Tables B8-9)
MlVl-5:27	74-15085	Mammoth bone core flaked transversely (Tables B8-9)
MlVl-5:26	74-15143	In limbo: flaking heavily rounded, may be naturally induced
MlVl-1:4	80-4	Mammoth bone core flaked transversely (returned from a loan too late to be included in Appendix B)
MkVl-10:15	83-14197	Mammoth bone core flaked transversely (Tables B8-9)
MkVl-12	(89-155, 602)	(University of Toronto collections, not available for this study)

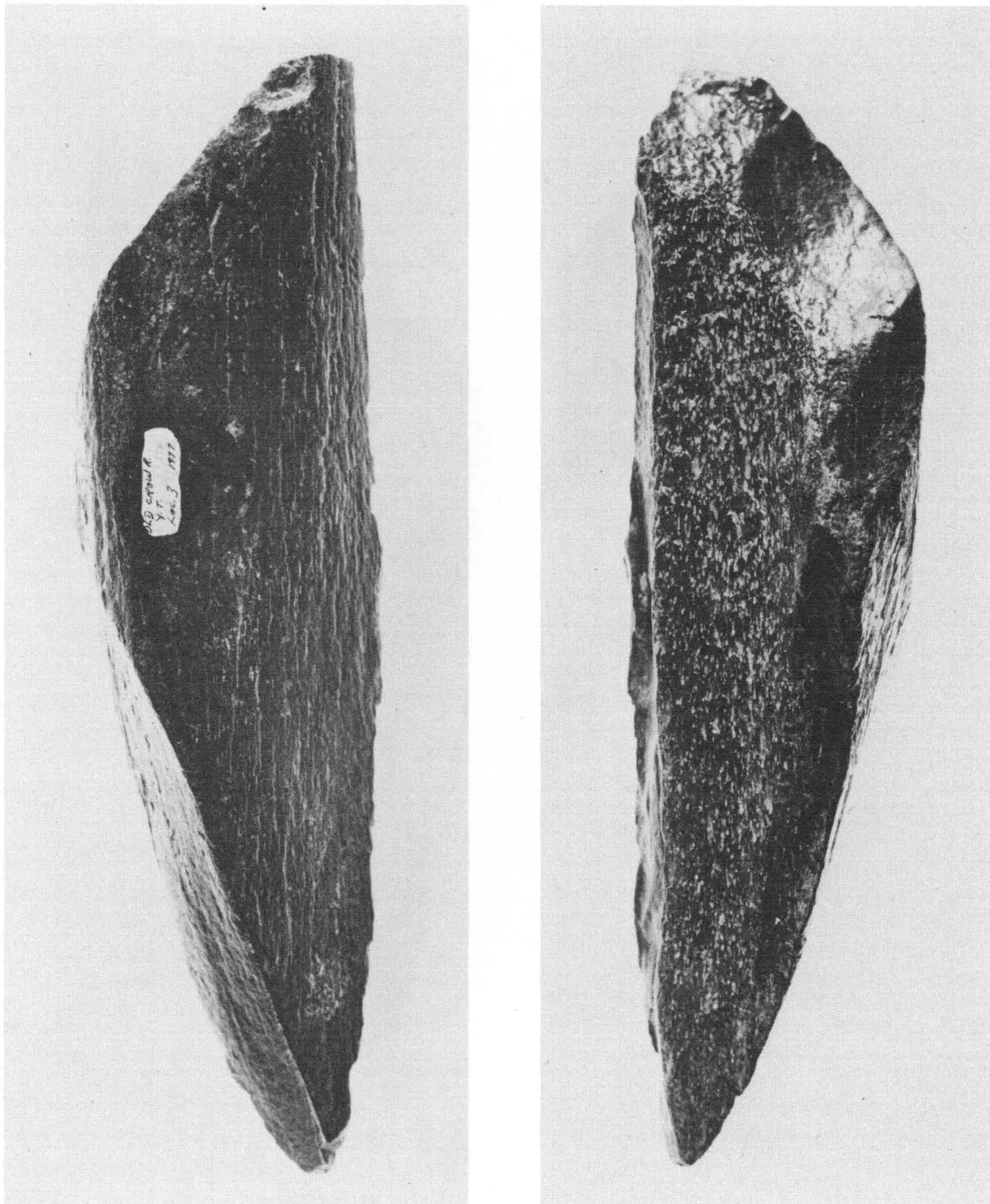
Table 4.12 (Continued).

Bonnichsen's Categories Cat. No.	(Number in Bonnichsen 1979)	Treatment in this report (Table references)
Bones with distal shaping flakes		
?	999-999	(Not seen)
MlVl-1:35	80-35	Polished bone; "flake scars" are normal irregularities (Table B17)
MkVl-4:11.8	103-8	Mammoth bone core with retouched platform (Tables B6-7)
Shaped bone and antler		
MlVl-1:1c	80-1	Cut bone; flesher (Table B19)
MiVl-1:1	109-1	Cut and polished antler; wedge (Table B18)
MjVj-6:1	114-1	Cut and polished antler; wedge (Table B18)
MjVl-1:26c	115-26	Cut and polished antler; wedge (Table B18)
Polished facets		
NbVl-2:6	29-6	Cut and polished antler; "pestle"
NaVk-5:1	60-8	Polished bone (Table B17)
NaVk-5:32	60-23753	Polished bone (Table B17)
MkVl-12	(89-795)	(University of Toronto collections, not available for this study)
Expedient tools		
NaVk-5:29	60-15288	In limbo: flake scars represent rebound flakes
NaVk-5:33	60-23761	Polished bone (Table B17)
NbVn-1:1	12-16431	Polished bone (Table B17)
NaVl-8:1	46-23741	Polished bone (Table B17)
Miscellaneous ground and polished artifacts		
MlVk-1:1.1	73-11	Green fractured and polished mammoth bone (Tables B1, B17)
MlVl-5:46	74-15028	Mammoth bone core flaked transversely and polished (Tables B8-9, B17)
MlVl-1:93	80-93	Transverse core on large mammal bone, polished and cut (Tables B13-14, B17)
MlVl-1:104	80-15359	Polished bone (Table B17)
MlVl-1:155	80-15450	Polished bone (Table B17)
Cut bone		
MlVl-5:34	74-15029	In limbo: possible carnivore alterations
Sawn bone		
MlVl-1:57	80-57	Rejected: "sawn" grooves are natural sutural grooves

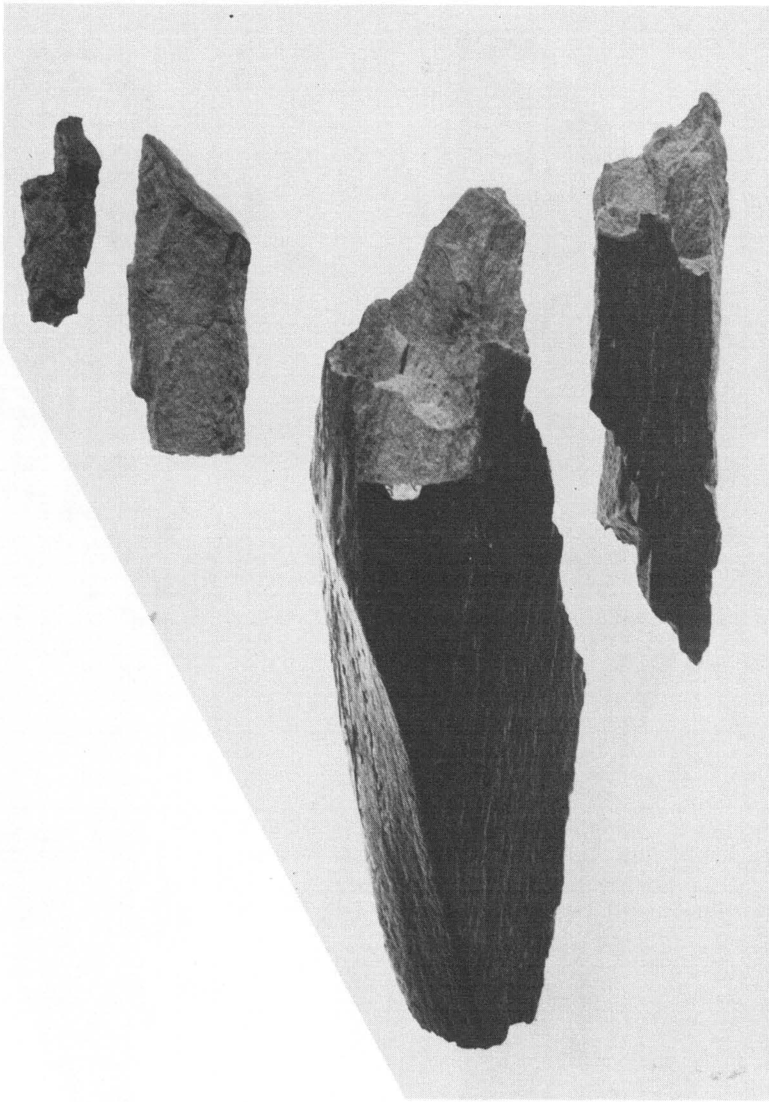
list. The "cut" bone is the splint bone of a horse on which diagonal grooves on opposing sides may represent attrition created by the carnassial teeth of a large carnivore. The "sawn" bone has for years been featured as a cranial fragment on which the "deep angular grooves... could only have been made by man" (Irving 1971:69; Bonnichsen 1979:139), but a careful examination of the fracture surface adjacent to the grooves shows that no bone has been removed from this piece while the grooves themselves terminate in tiny foramina which are typical of the "tongue-and groove" overlapping sutures between the temporal and parietal bones.

These kinds of errors are easily made if descriptions are based only upon macroscopic observations or if the descriptive work is done in poor light and in haste. Bonnichsen's observations were not so poorly made, but the fossils are very difficult to clean in the laboratory because they literally fall apart if they are rewetted after drying during shipment. In recent years we have adopted the practice of carefully cleaning the fossils in the field before they become too dry to withstand washing in water. Several of the pieces which have been reinterpreted in this report were subjected to additional cleaning under the microscope, and the sutural grooves of the "sawn" bone were recognized in that manner.

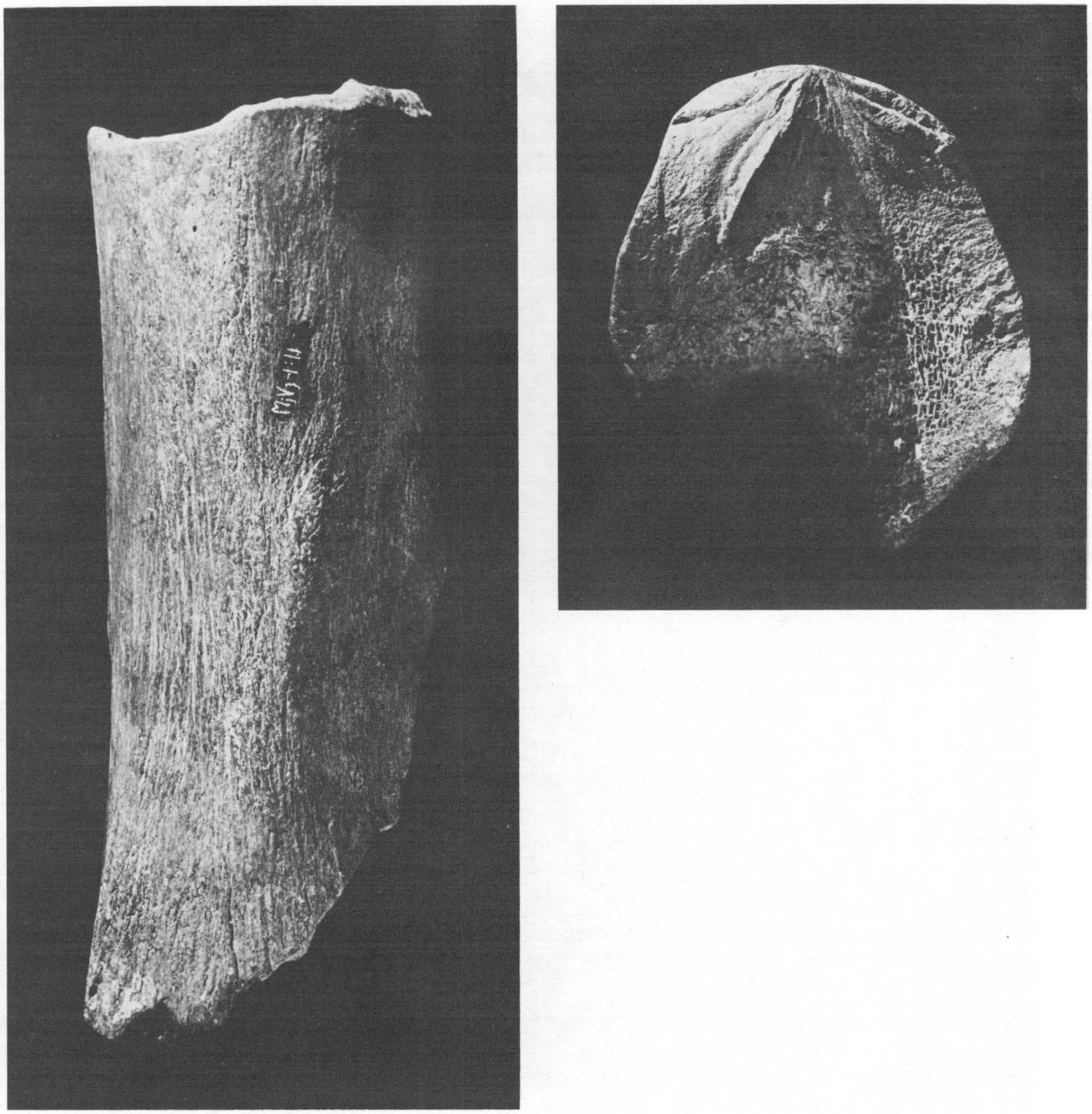
A more important observation in this summary is that Bonnichsen and I agree fundamentally not only on the existence of a substantial number of artificial modifications among the Old Crow fossils but also on the general nature of the modifications. Bones, tusks, and antlers were artificially altered in the green state by means of fracturing, flaking, polishing, and cutting, and these alterations occur on a small but numerically significant portion of the total fossil yield in the Old Crow valley. As the collections have grown through further field work, the artificially modified pieces have continued to accumulate as well. Bonnichsen (1979) reported 68 artificially modified specimens (in addition to green fractured bones) which had been collected as of 1973 and stored at the National Museum of Man (Table 4.11), and this report includes 151 such pieces as of 1979 (Table 4.10). Our general agreement about these collections far outweighs the interpretive differences concerning a relatively minor number of particular specimens.



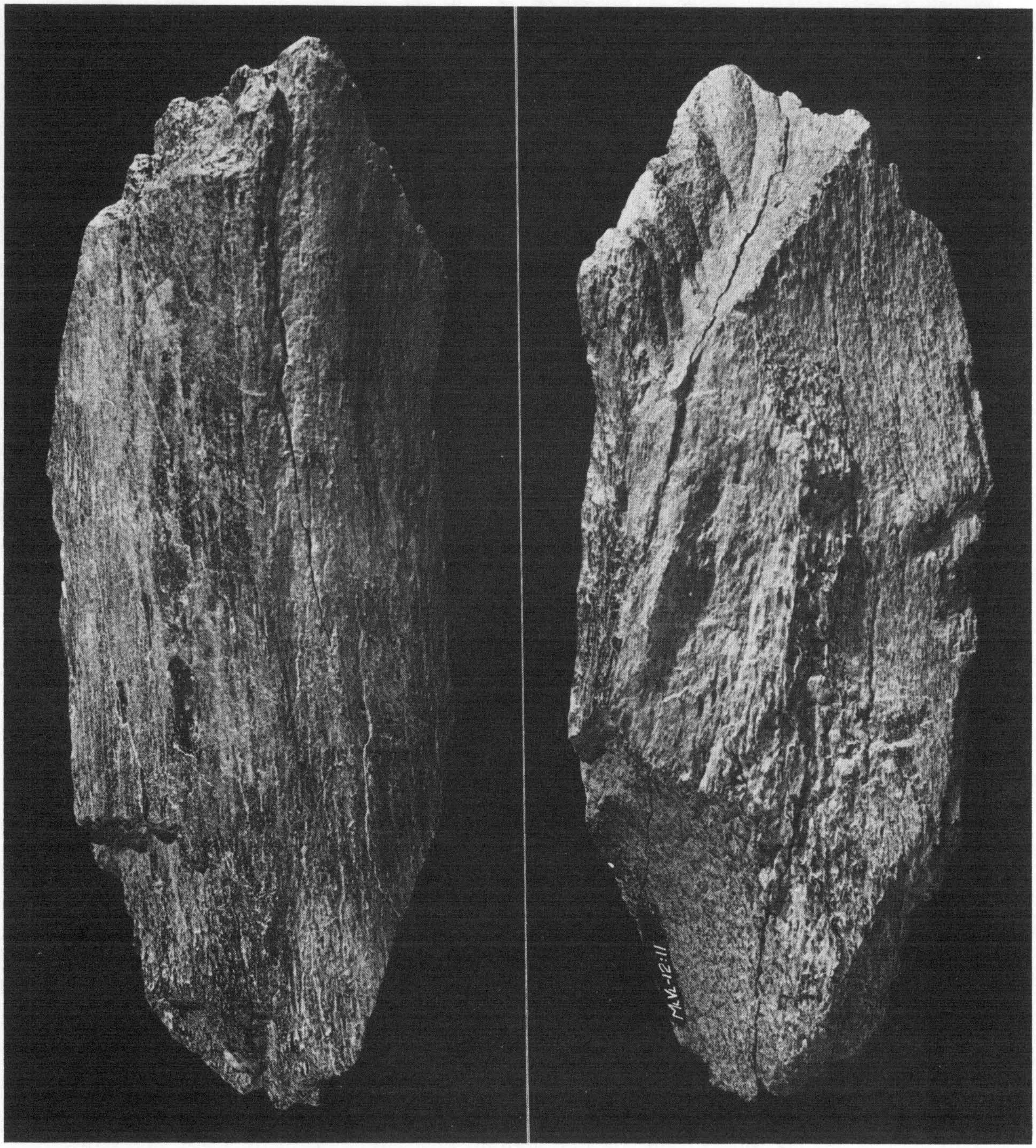
Pl. 4.1. Green fractured mammoth (cf. *Mammuthus* sp.) long bone fragment from MkVl-3, Old Crow River, northern Yukon Territory. Note the smoothly curving spirals and the acute angles between the fracture surfaces and the outer bone surface; smooth texture and even staining of the fracture surface also reflect green fracture. ½ Nat. size.



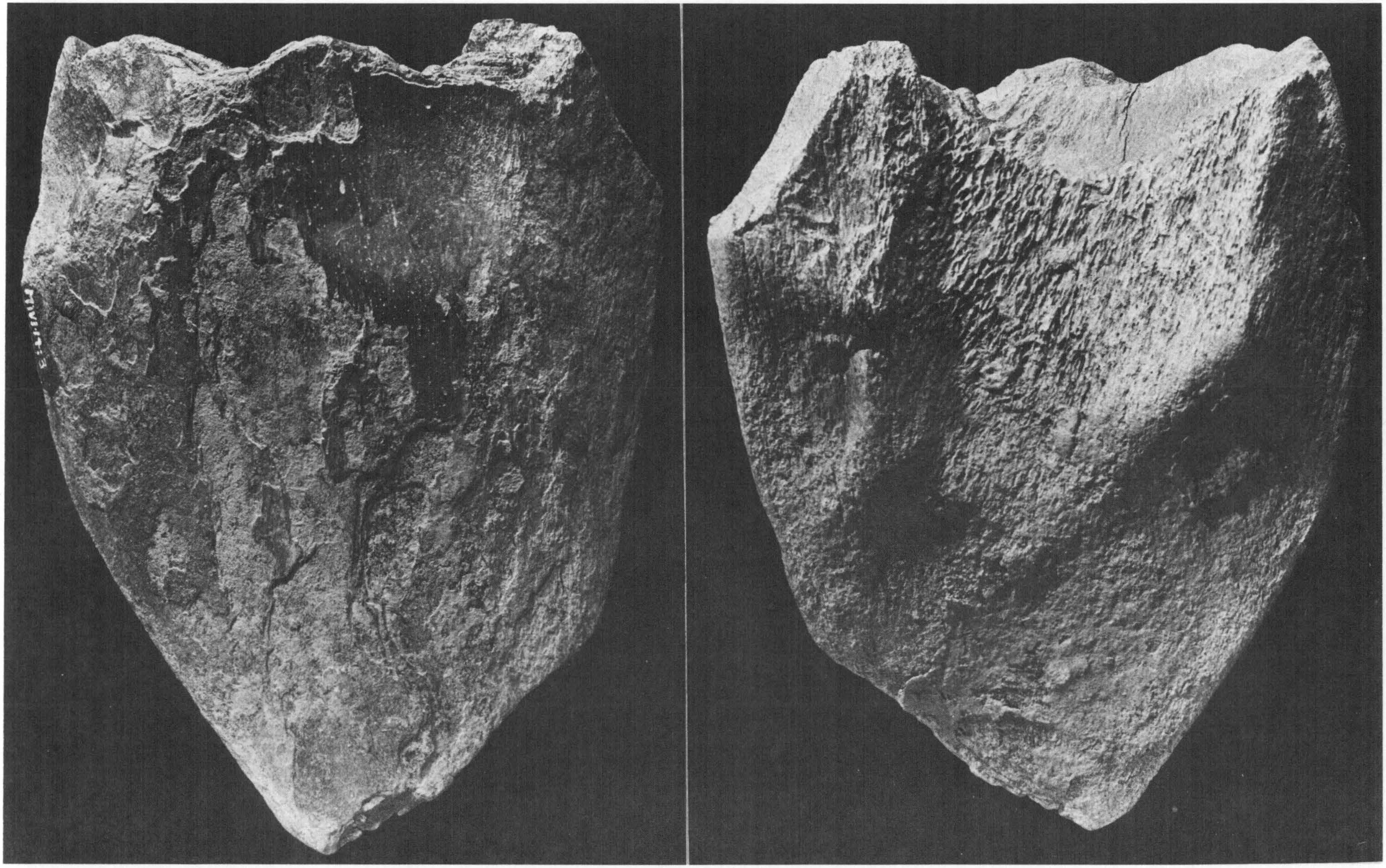
Pl. 4.2. Experimentally detached fragments from the same bone shown in Pl. 4.1 prior to its sacrifice for radiocarbon dating. Note the contrasting colour and rough texture of the fracture surfaces, the right angles formed with the outer surface and the rectilinear outlines of the fractures. ½ Nat. size.



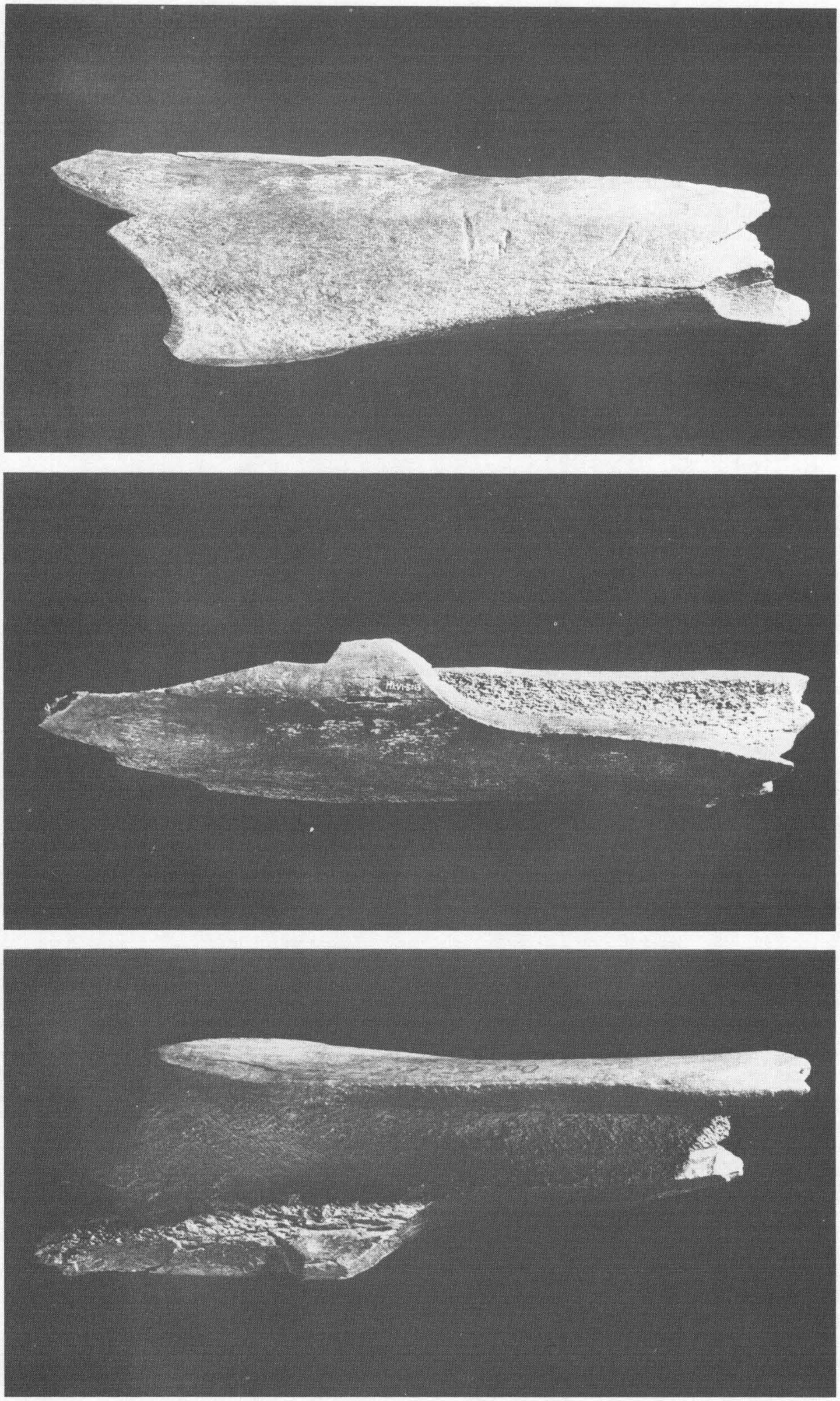
Pl. 4.3. Green fractured and scraped mammoth (cf. *Mammuthus* sp.) long bone fragment (MjVj-1:1.1) from the Porcupine River, northern Yukon Territory. In the view on the left the upper end is the green fractured margin, and the sub-parallel scraping marks are clearly visible on much of the bone surface. The view on the right is of the pronounced loading point cone preserved on the end of the specimen. ½ Nat. size.



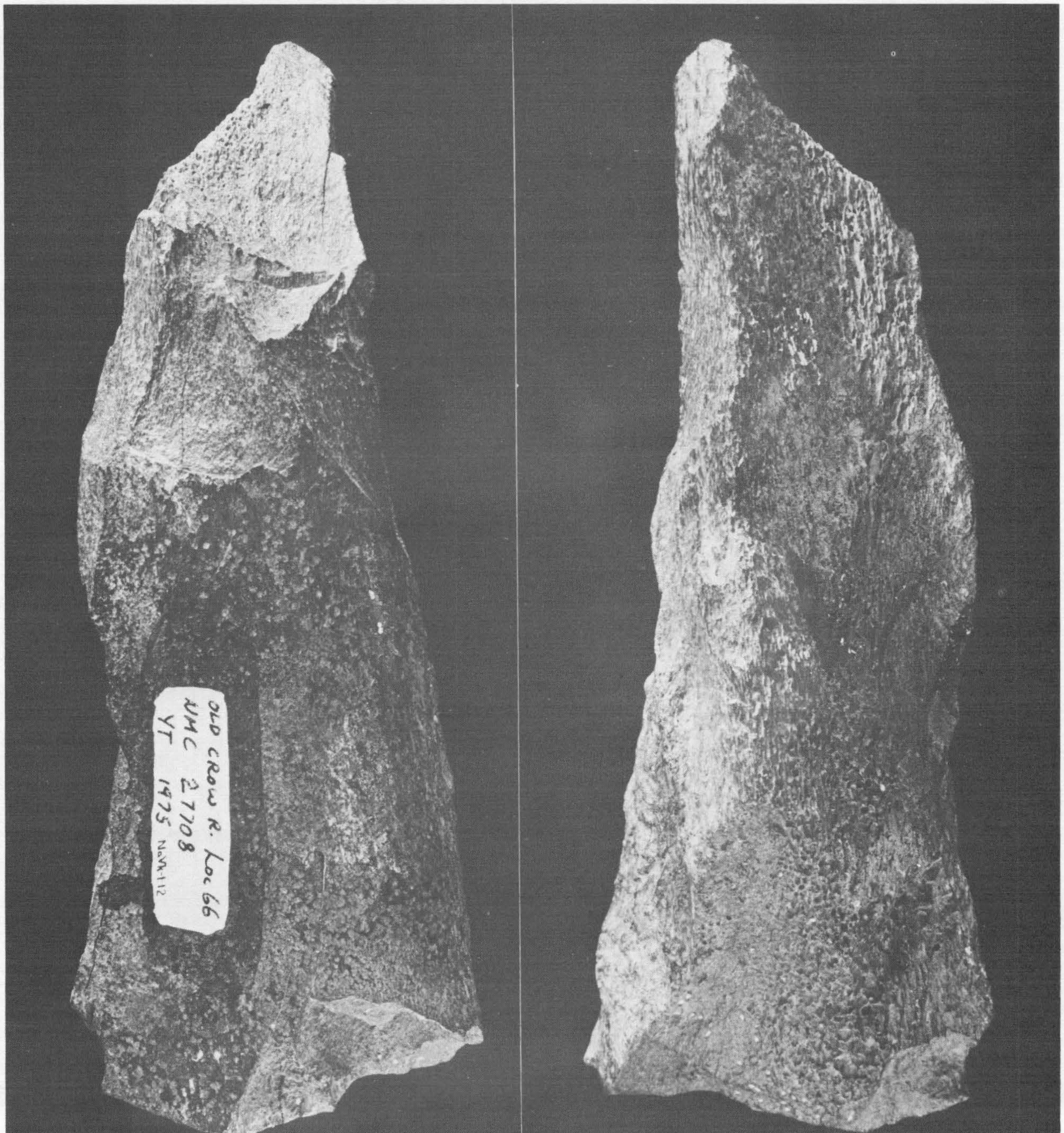
Pl. 4.4. Green fractured mammoth (cf. *Mammuthus* sp.) long bone (M1V1-12:11) from Old Crow River, northern Yukon Territory. Nat. size.



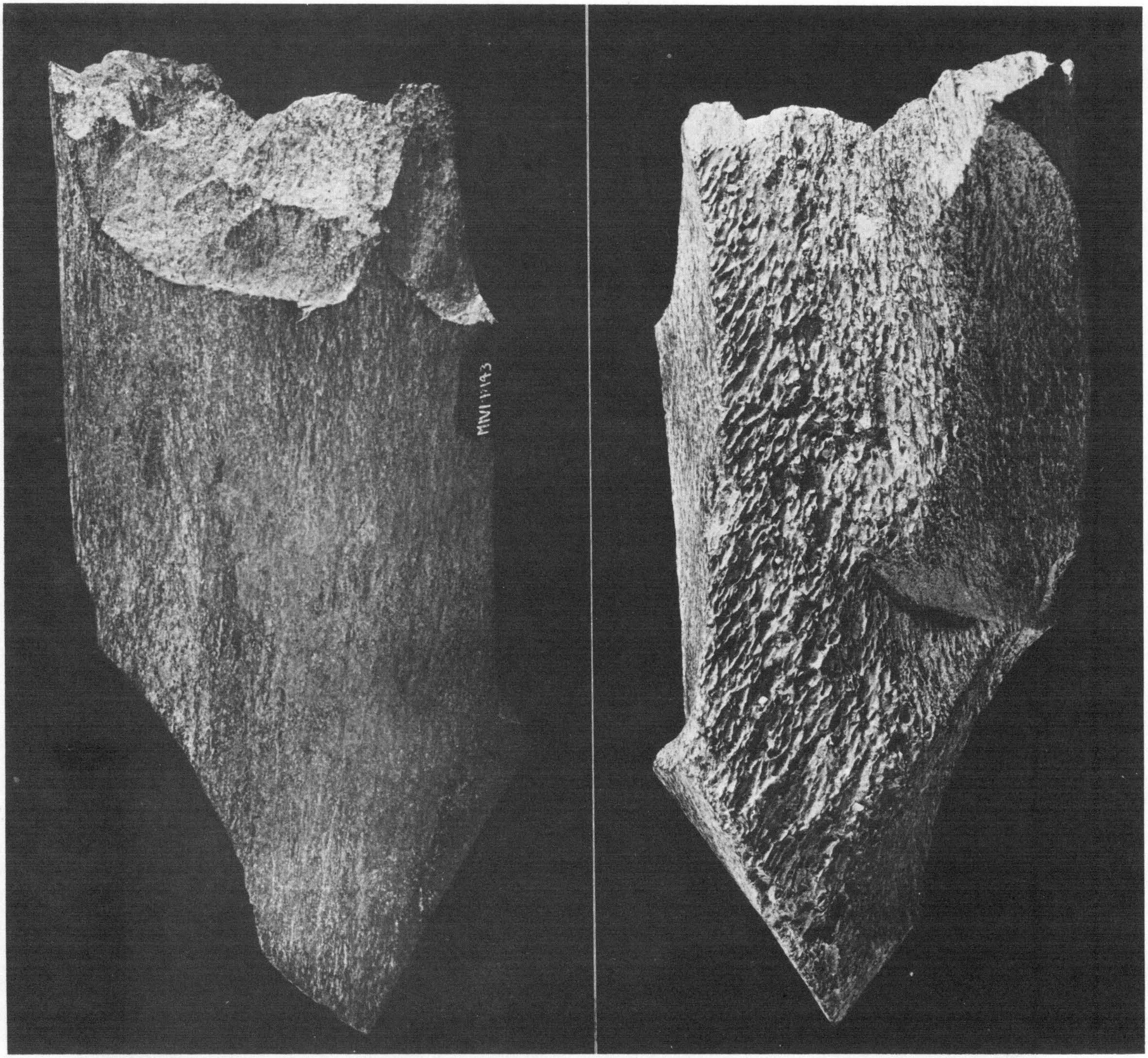
Pl. 4.5. Green fractured mammoth (cf. *Mammuthus* sp.) long bone (MlVl-14:3) from Old Crow River, northern Yukon Territory. Nat. size.



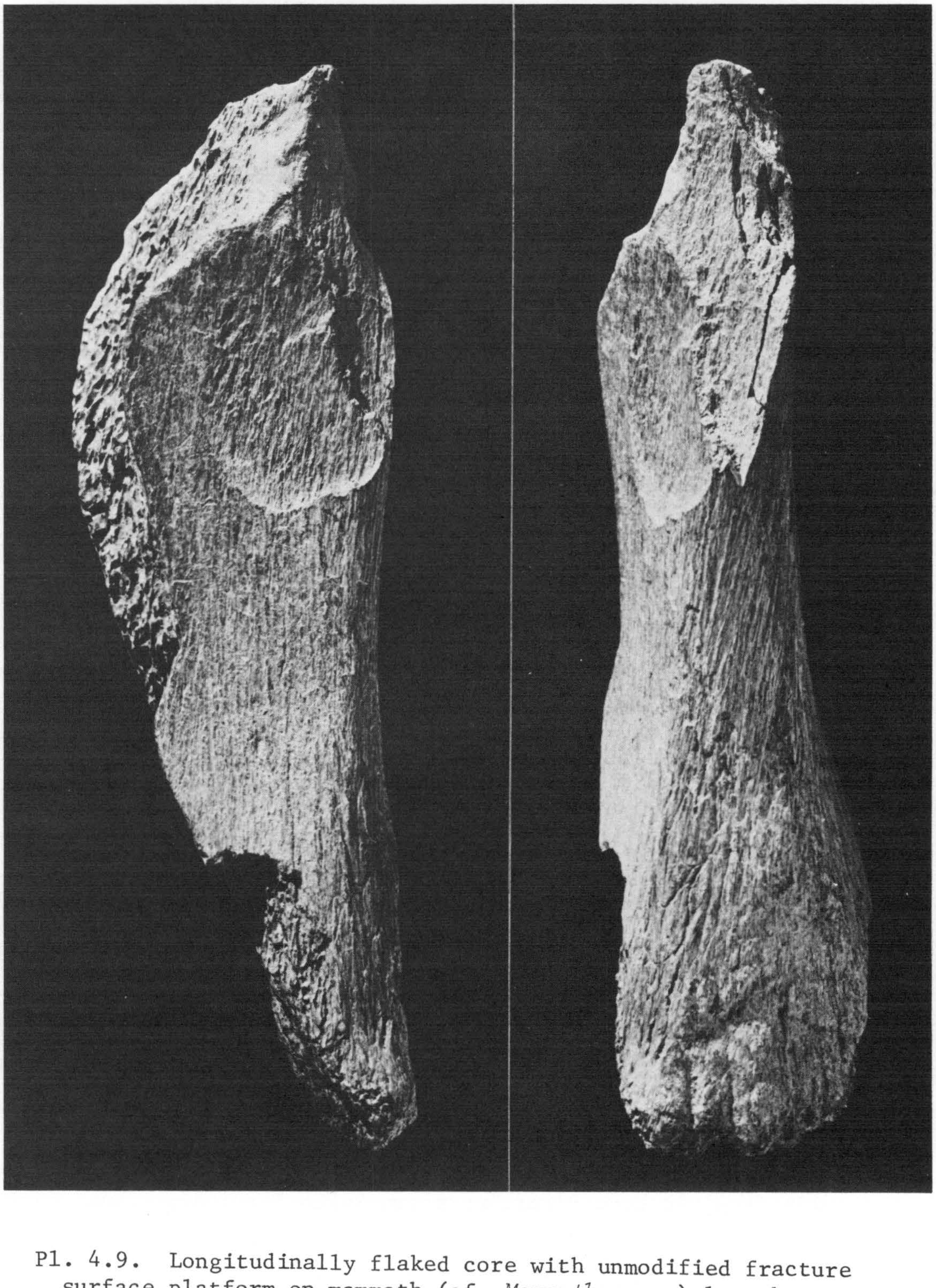
Pl. 4.6. Green fractured mammoth (cf. *Mammuthus* sp.) long bone (MkV1-5:13) from Old Crow River, northern Yukon Territory. $\frac{1}{4}$ Nat. size.



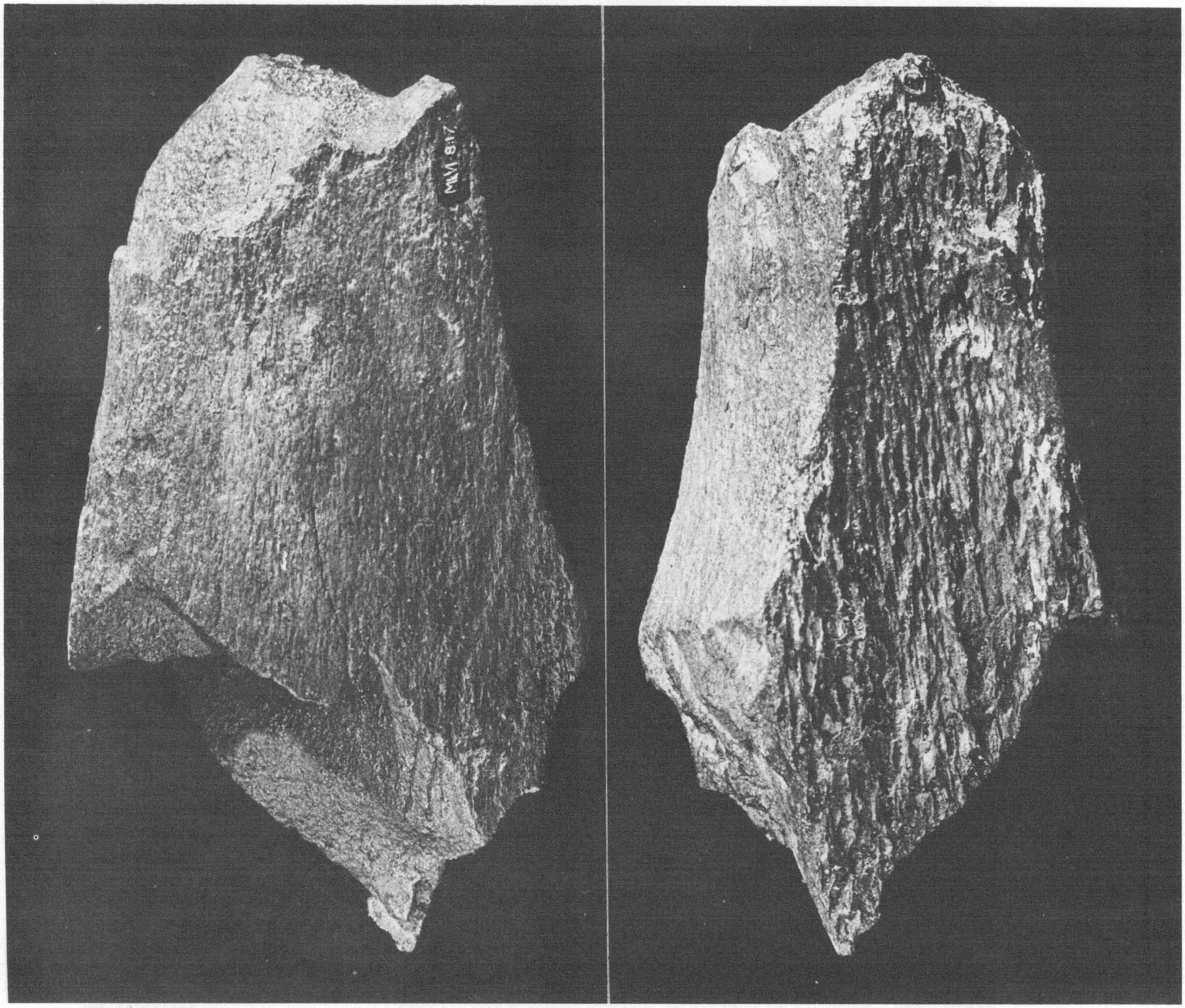
Pl. 4.7. Longitudinally flaked core without preserved platform on mammoth (cf. *Mammuthus* sp.) long bone (NaVk-1:12) from Old Crow River, northern Yukon Territory. Nat. size.



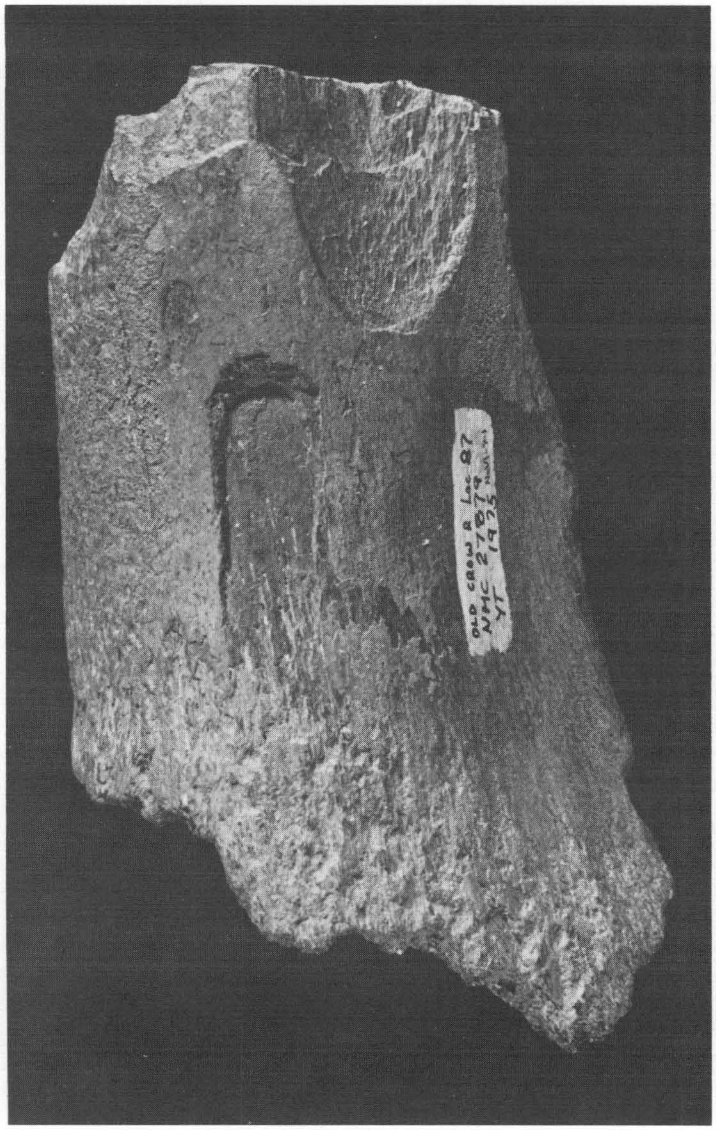
Pl. 4.8. Longitudinally flaked core without preserved platform on mammoth (cf. *Mammuthus* sp.) long bone (MlVl-1:143) from Old Crow River, northern Yukon Territory. Nat. size.



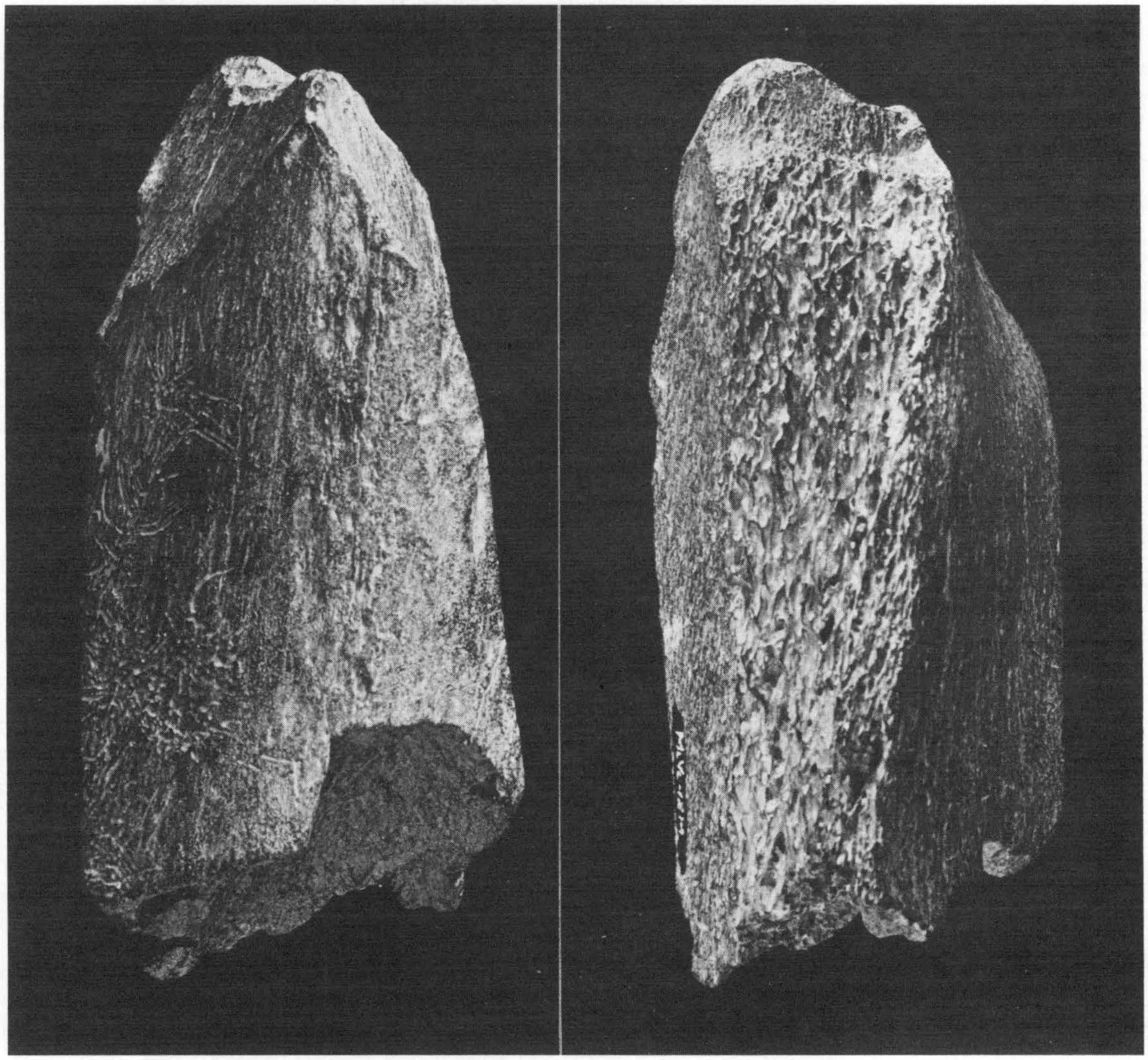
Pl. 4.9. Longitudinally flaked core with unmodified fracture surface platform on mammoth (cf. *Mammuthus* sp.) long bone (MiVl-1:12) from the Porcupine River, northern Yukon Territory. Transverse flaking and slightly diagonal scraping are visible in the lateral view on the right. 3/4 Nat. size.



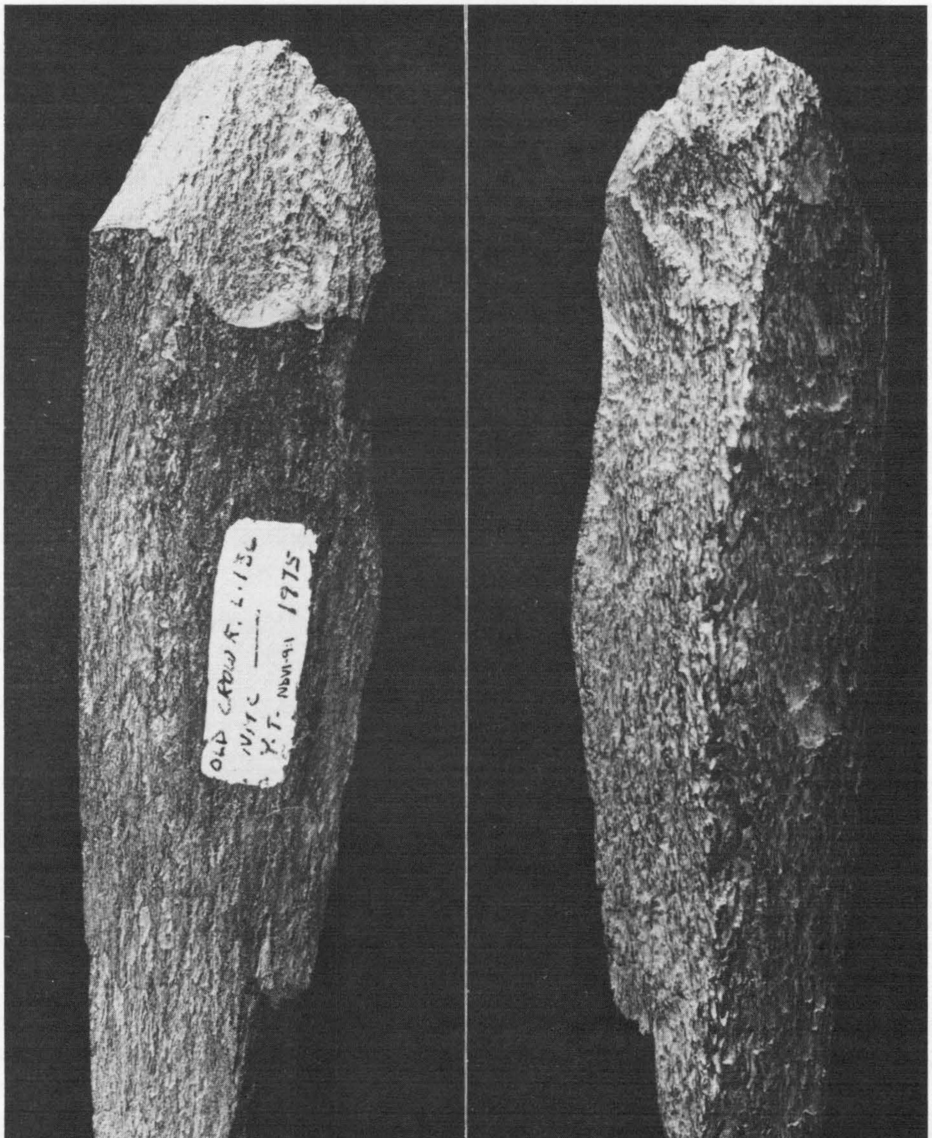
Pl. 4.10. Longitudinally flaked core with unmodified fracture surface platform on mammoth (cf. *Mammuthus* sp.) long bone (MkVl-8: 17) from Old Crow River, northern Yukon Territory. Nat. size.



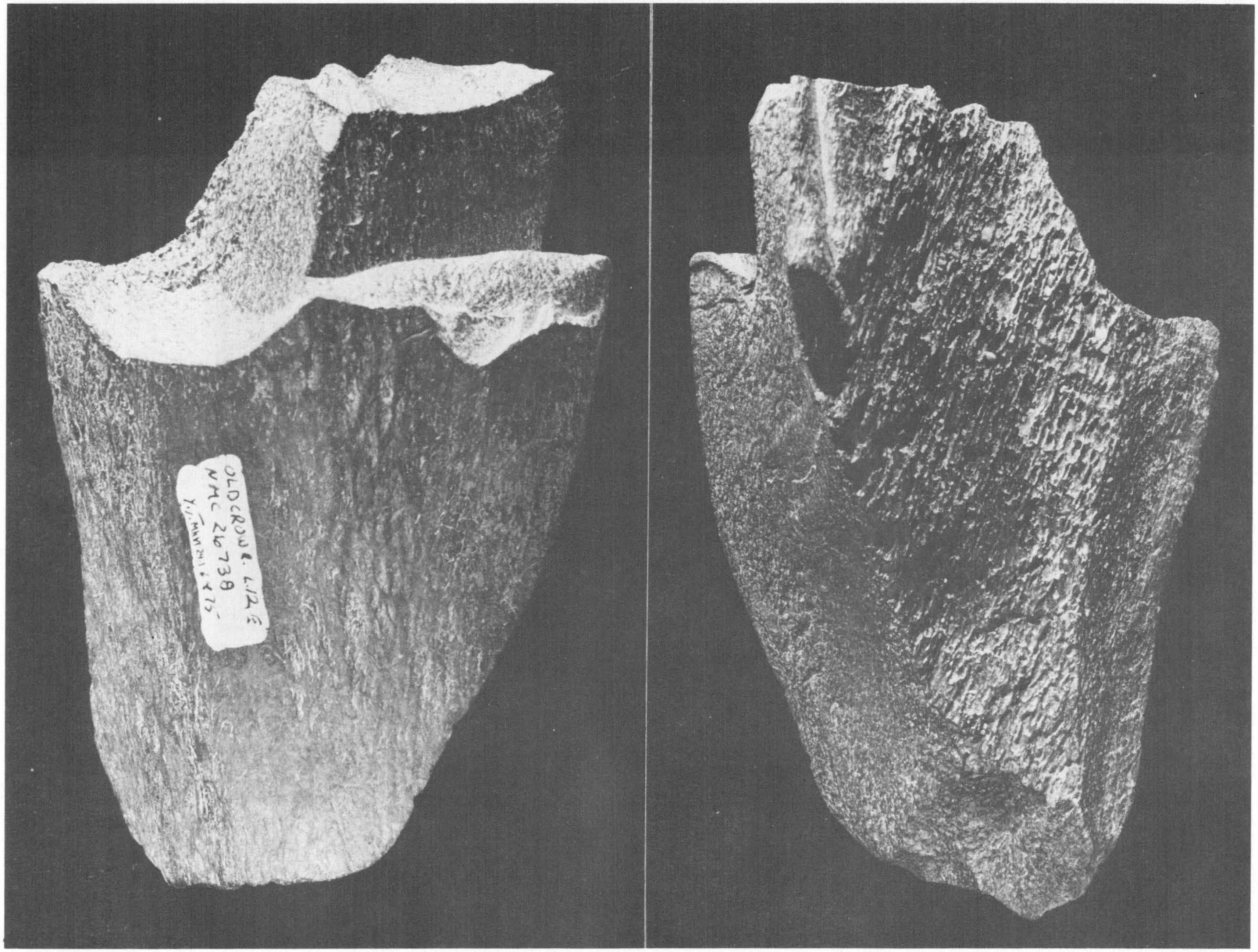
Pl. 4.11. Longitudinally flaked core with retouched platform on mammoth (cf. *Mammuthus* sp.) long bone (NaVl-7:1) from Old Crow River, northern Yukon Territory. Nat. size.



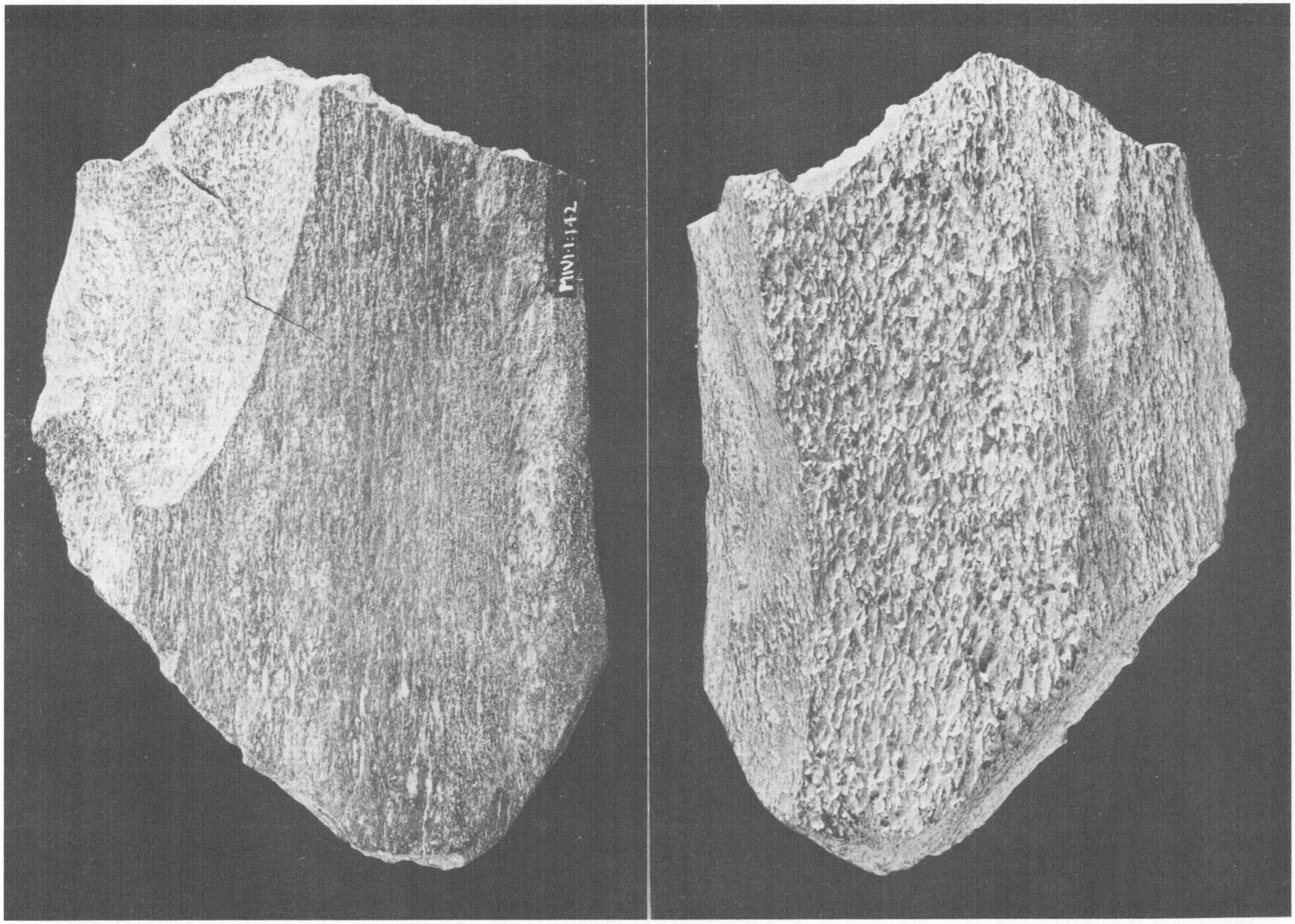
Pl. 4.12. Longitudinally flaked core with retouched platform on mammoth (cf. *Mammuthus* sp.) long bone (M1V1-12:4) from Old Crow River, northern Yukon Territory. Nat. size.



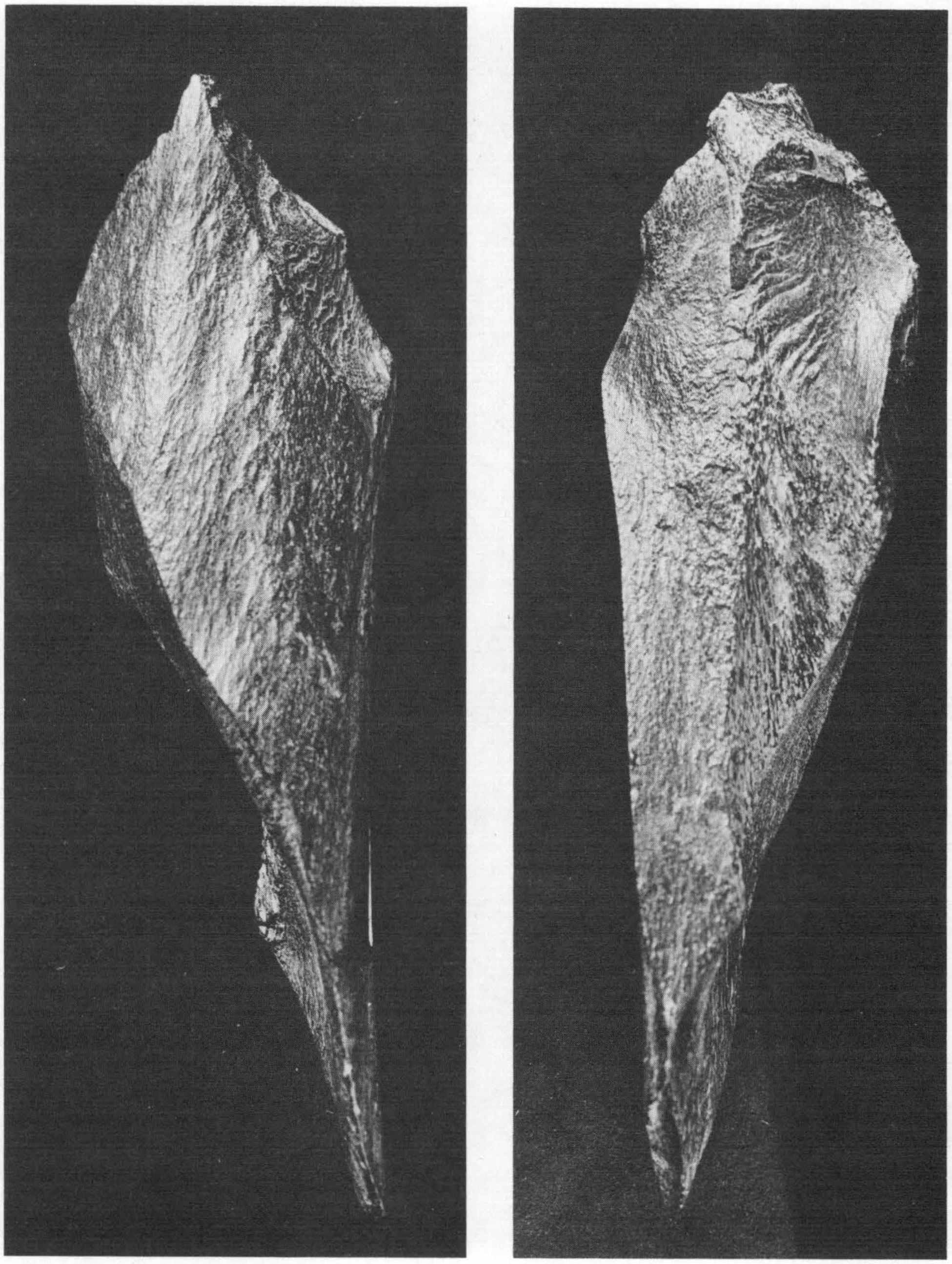
Pl. 4.13. Longitudinally flaked core with retouched platform on mammoth (cf. *Mammuthus* sp.) long bone (NbVl-9:1) from Old Crow River, northern Yukon Territory. Nat. size.



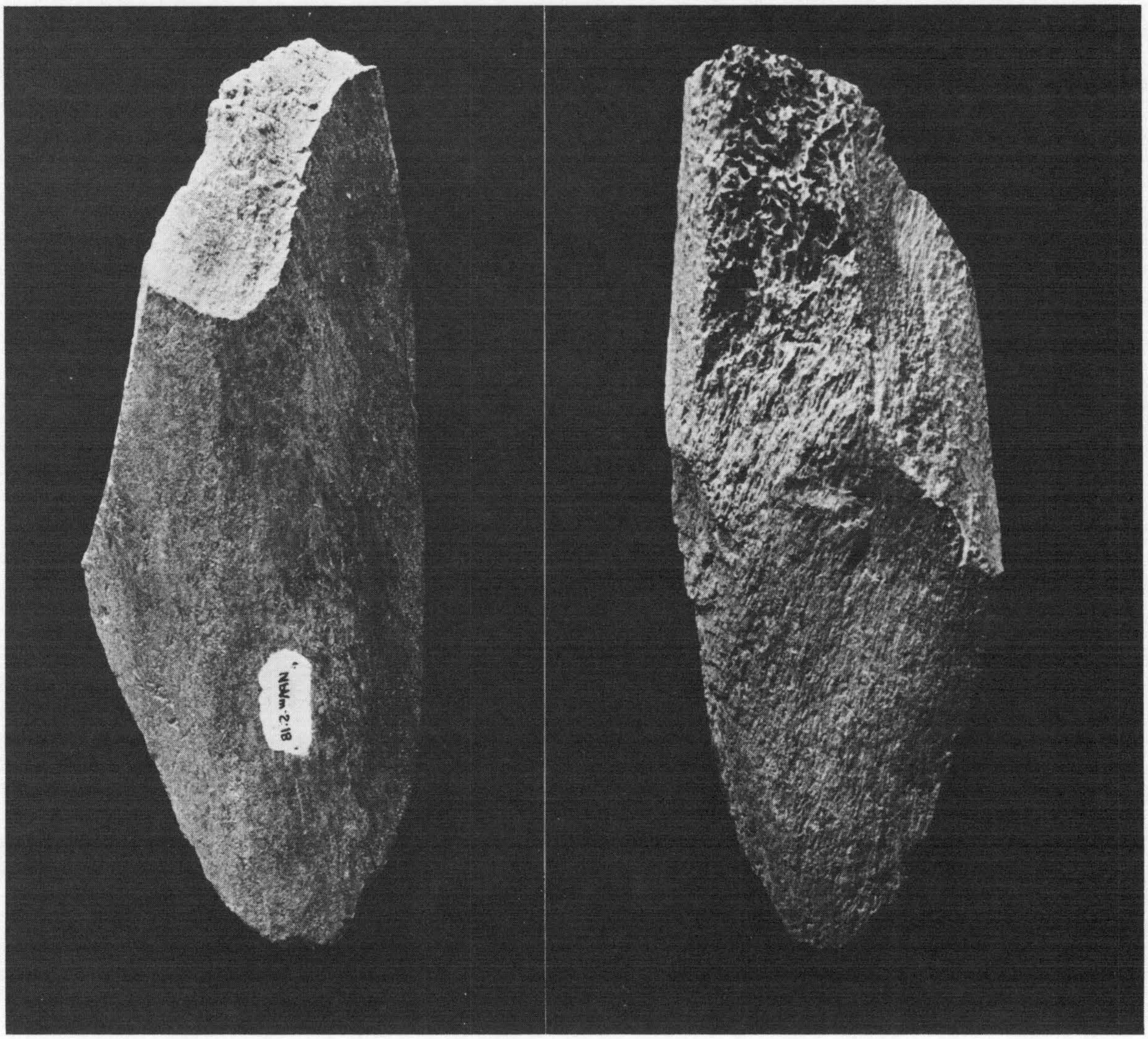
Pl. 4.14. Longitudinally flaked core with retouched platform on mammoth (cf. *Mammuthus* sp.) long bone (MkVl-24:1) from Old Crow River, northern Yukon Territory. Nat. size.



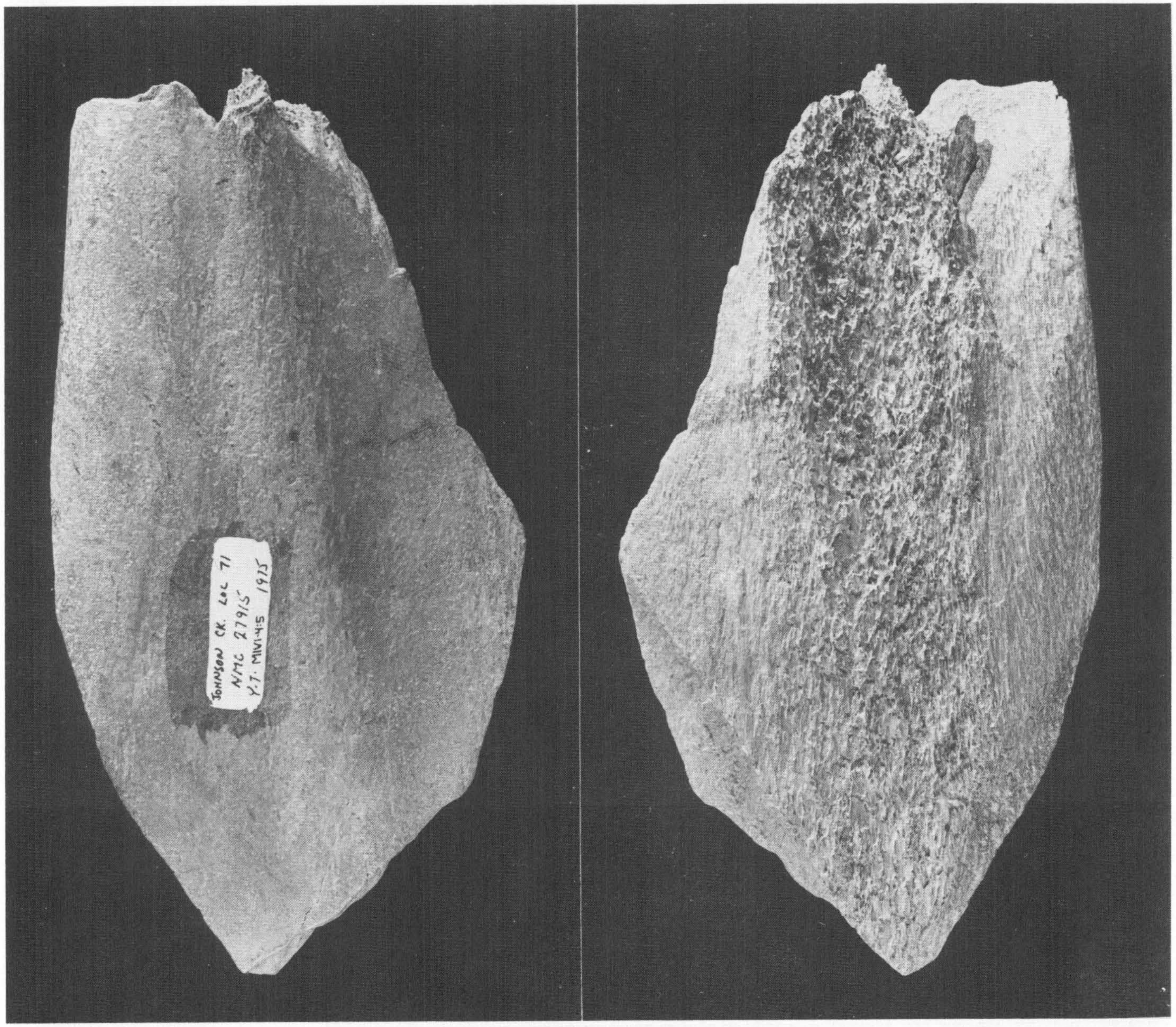
Pl. 4.15. Transversely flaked core on mammoth (cf. *Mammuthus* sp.) long bone (M1V1-1:142) from Old Crow River, northern Yukon Territory. Nat. size.



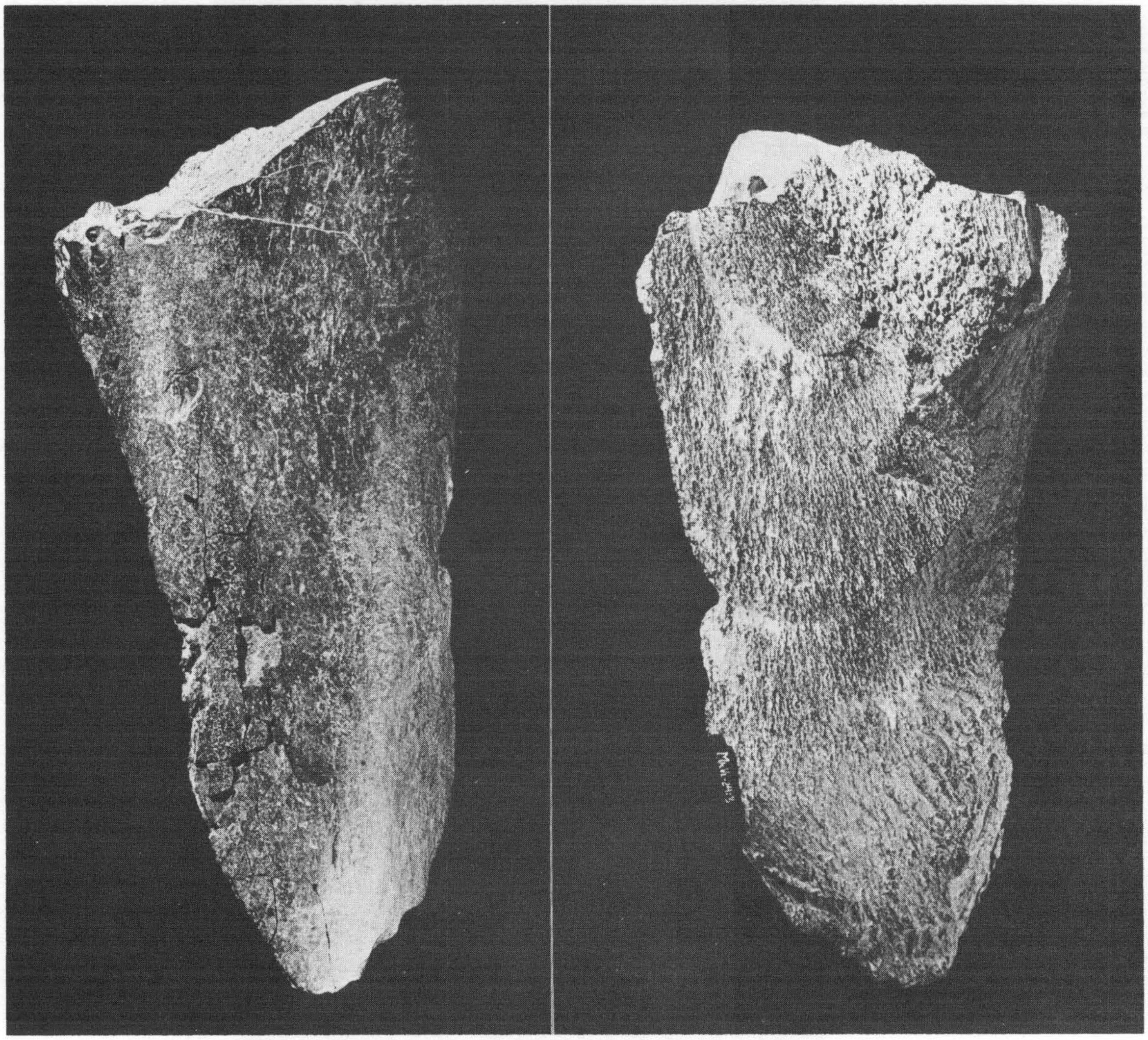
Pl. 4.16. Transversely flaked core on mammoth (cf. *Mammuthus* sp.) long bone (MkVl-26:1) from Old Crow River, northern Yukon Territory. Note the prominent hackle marks in the flake scar on the right. ½ Nat. size.



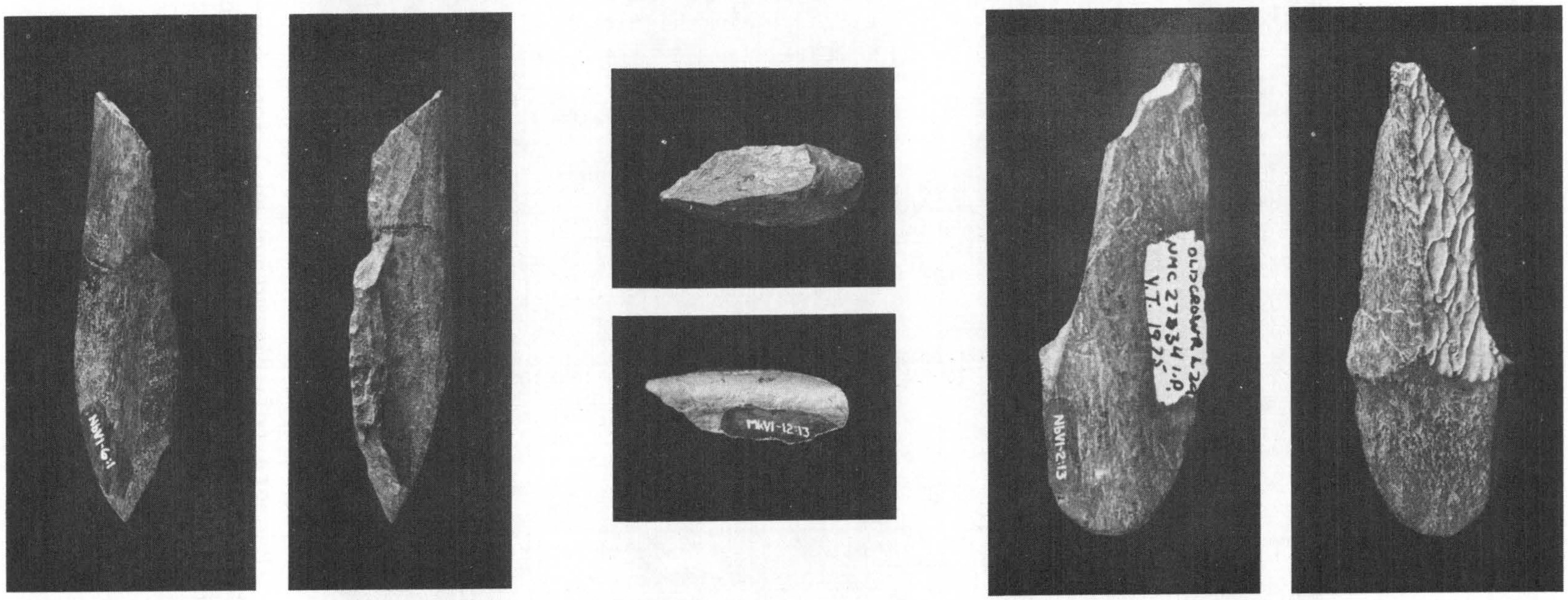
Pl. 4.17. Mammoth (cf. *Mammuthus* sp.) long bone flake (NbVm-2:18) from Old Crow River, northern Yukon Territory. Nat. size.



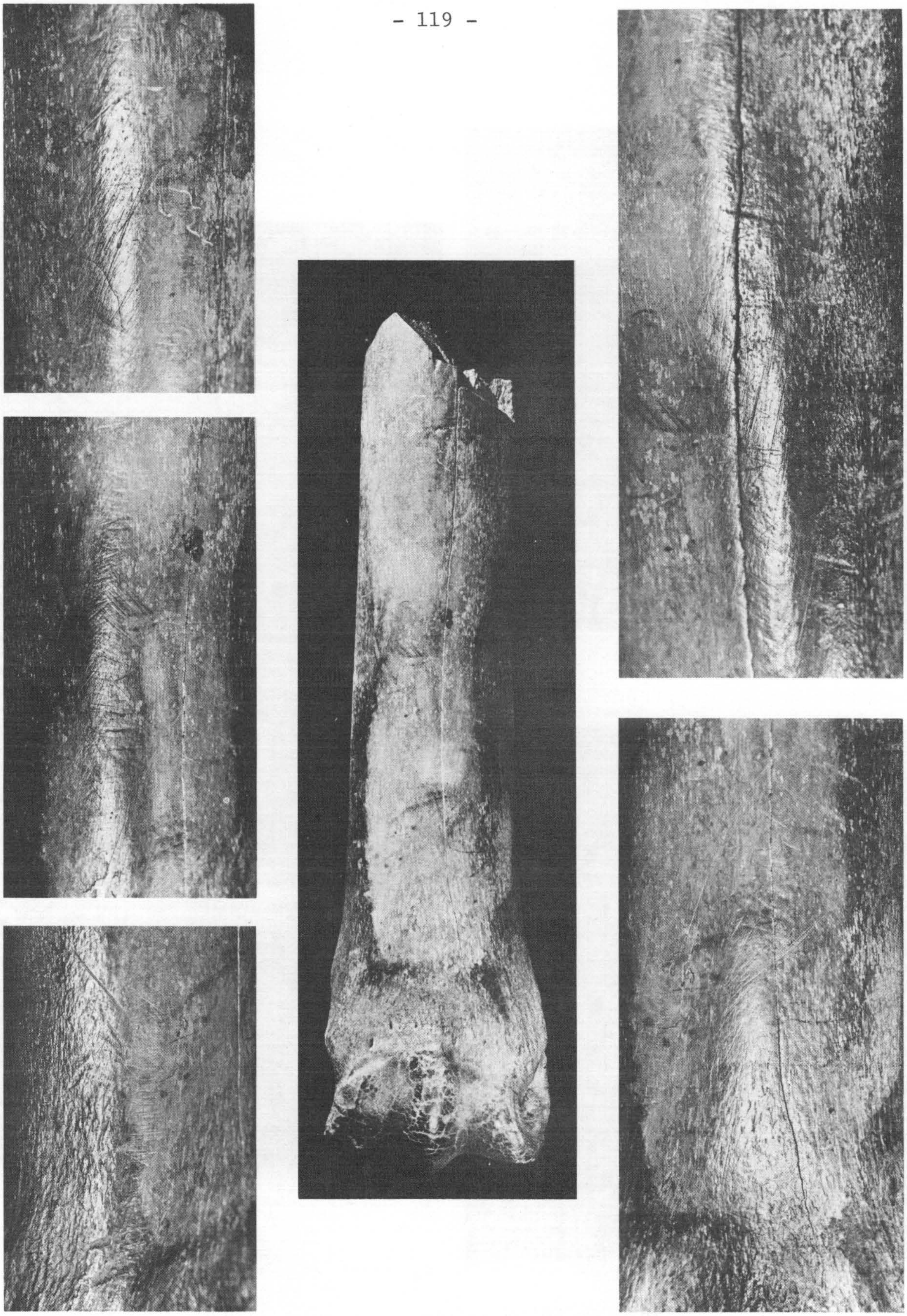
Pl. 4.18. Mammoth (cf. *Mammuthus* sp.) long bone flake (M1V1-7:507) from Johnson Creek, Old Crow basin, northern Yukon Territory. Catalogue number corrected after photograph was made. 3/4 Nat. size.



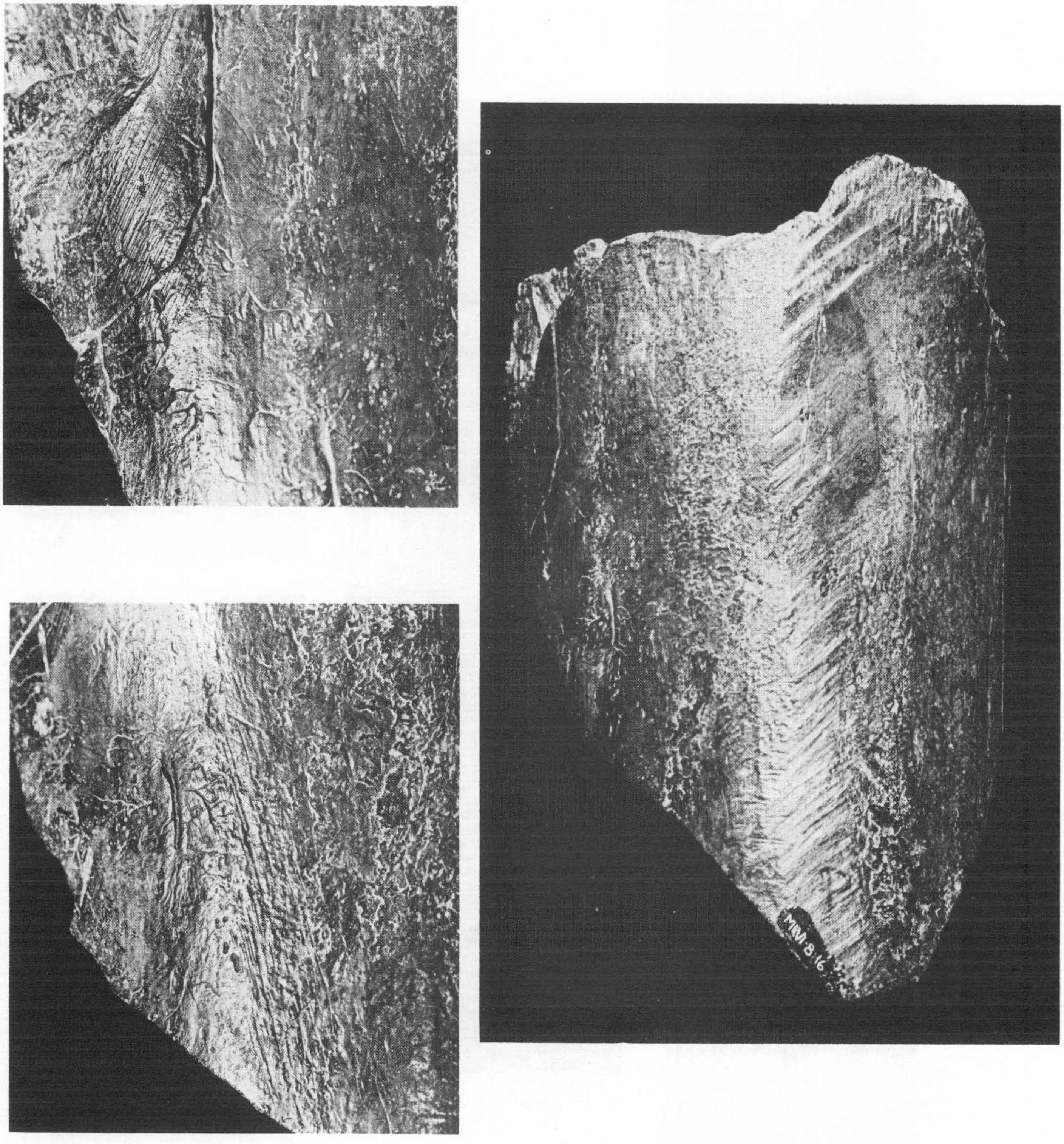
Pl. 4.19. Mammoth (cf. *Mammuthus* sp.) long bone flake (MkV1-24:3) from Old Crow River, northern Yukon Territory. ½ Nat. size.



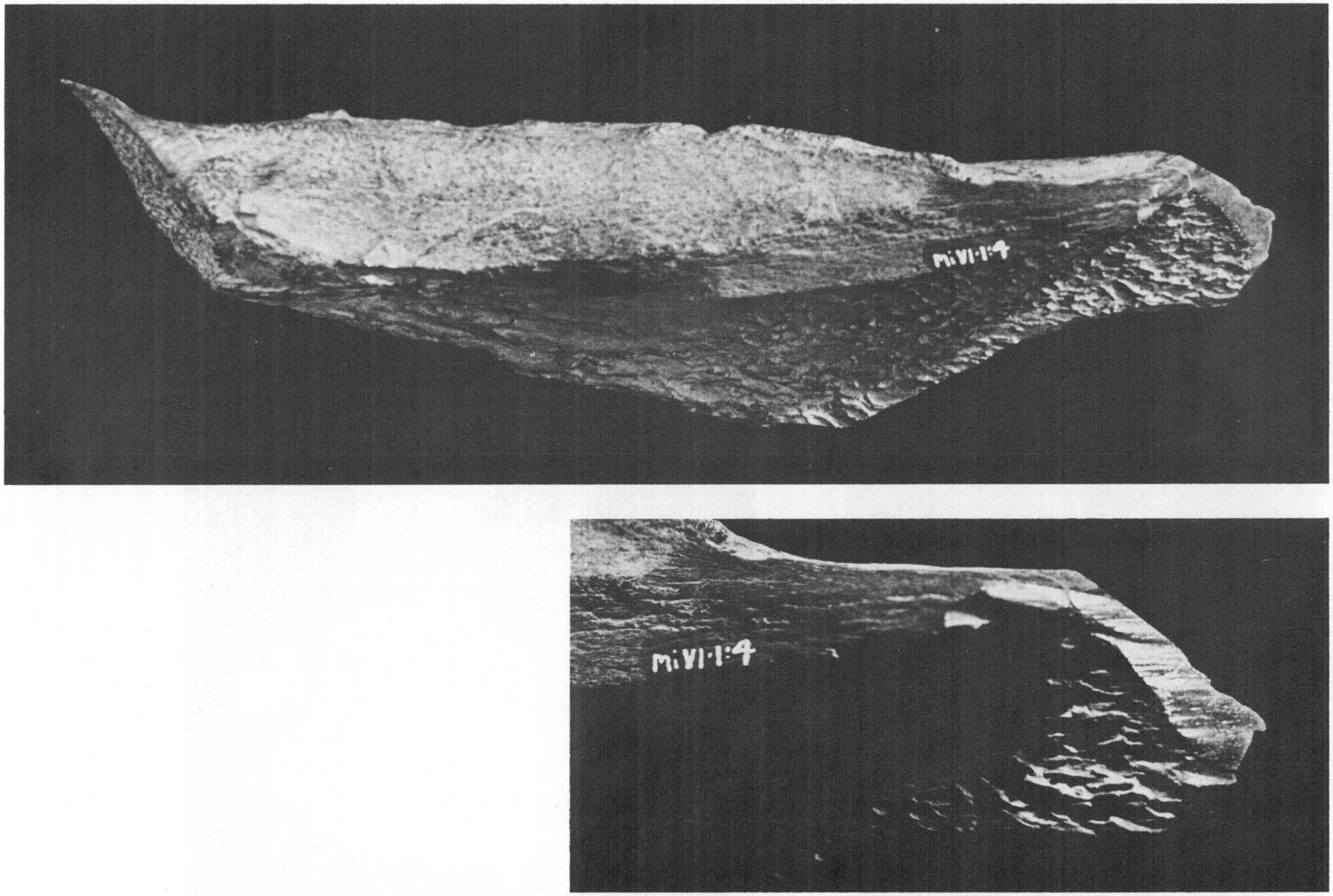
Pl. 4.20. Flakes and core on unidentified large mammal bones from Old Crow River, northern Yukon Territory. Left: transverse core (NbV1-6:1); center: loading point flake (MkV1-12:13); right: longitudinally struck flake (NbV1-2:13). Nat. size.



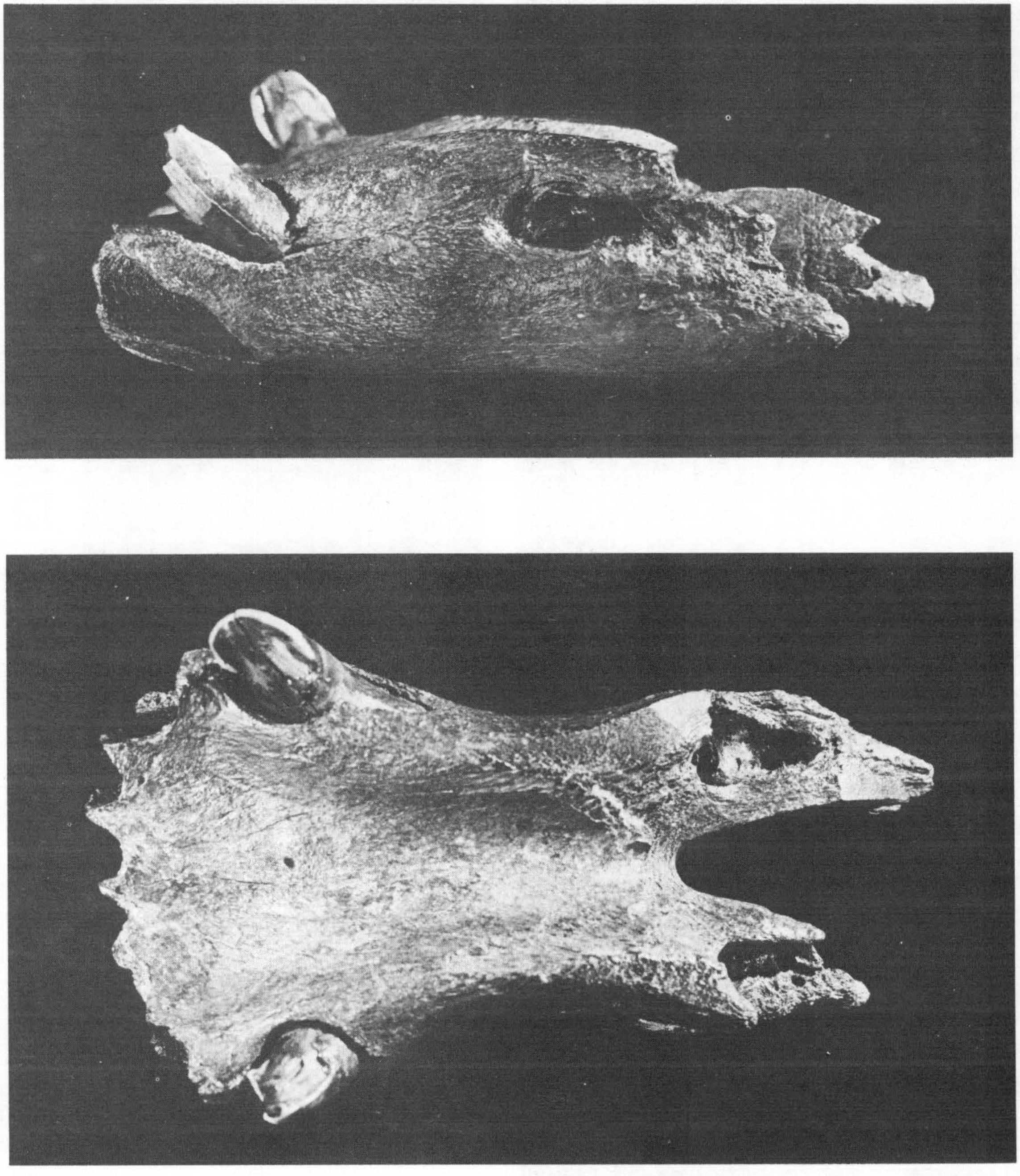
Pl. 4.21. Extensively scratched horse (*Equus* sp.) metapodial (NbVm-1:3) from Old Crow River, northern Yukon Territory. Plan view 3/4 Nat. size; other views ca. 2¼ Nat. size.



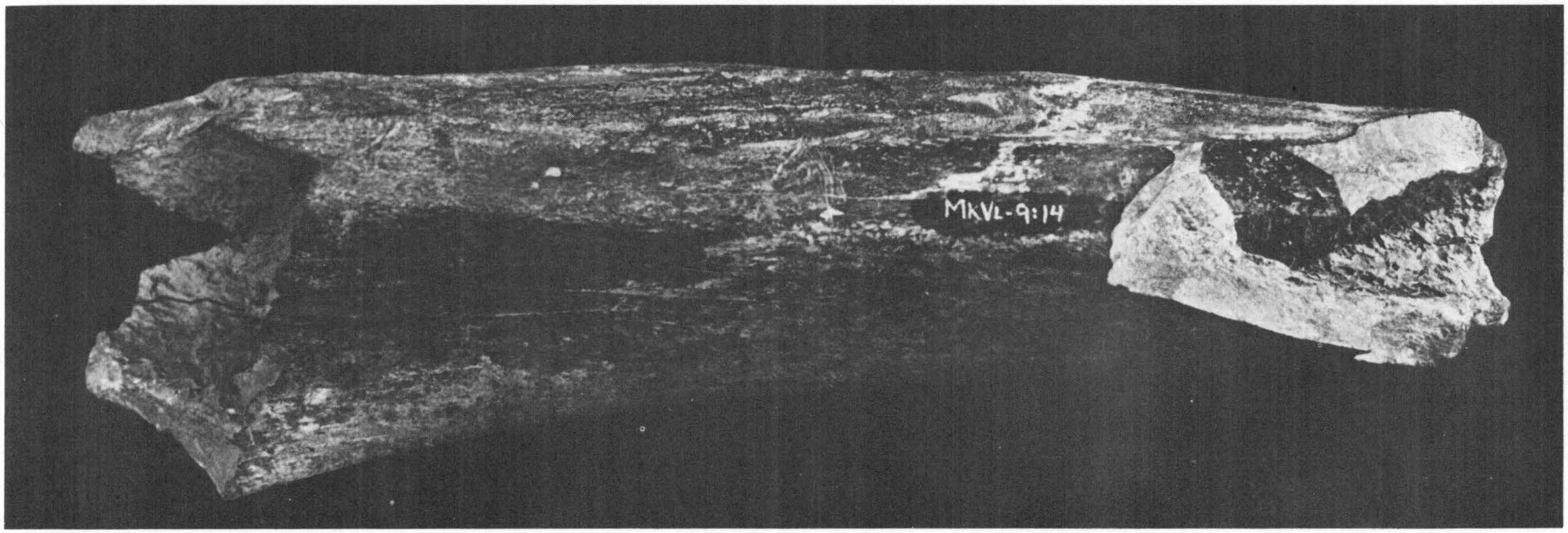
Pl. 4.22. Green fractured and ground mammoth (cf. *Mammuthus* sp.) long bone (MkVl-8:16) from Old Crow River, northern Yukon Territory. Note long ground facet with oblique and transverse striae in overview on right (Nat. size). Two views on left show close-ups (1.6 X Nat. size) of different groups of striae in various orientations.



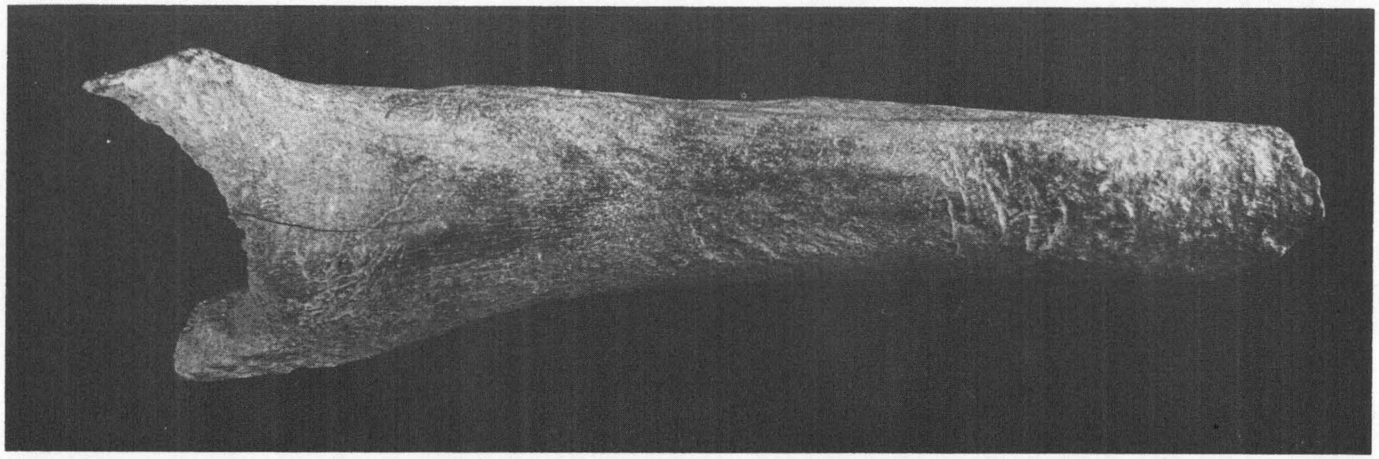
Pl. 4.23. *Bison* sp. right scapula blade with polished and grooved facet on fracture surface at the distal end, from Porcupine River, northern Yukon Territory (MiVl-1:4). Plan view nat. size.



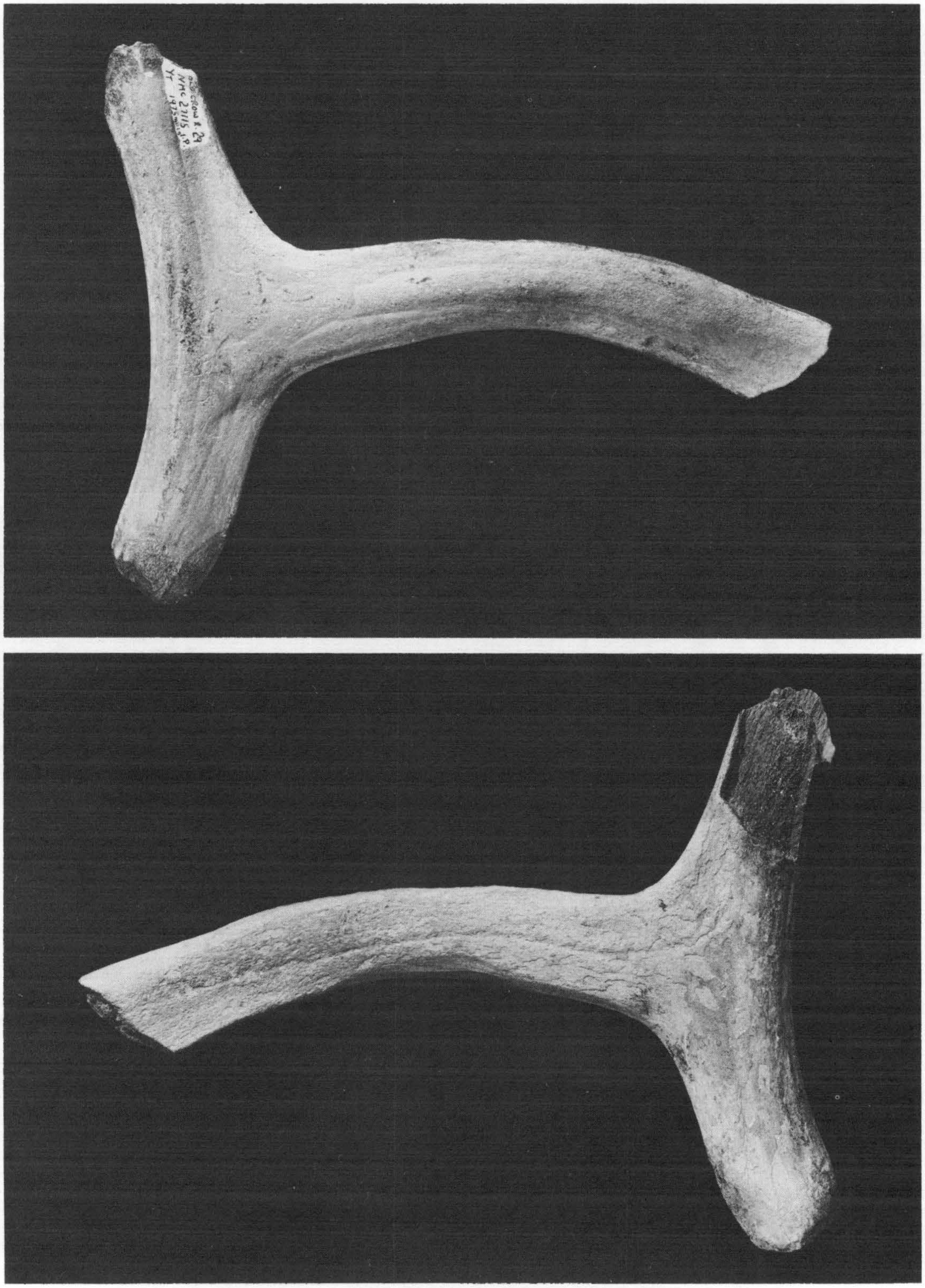
Pl. 4.24. Polished horse (*Equus* sp.) mandible (NaVk-5:1) from Old Crow River, northern Yukon Territory. Lateral view (above) shows orientation of facets on superior border of corpus, and superior view (below) reveals orientation of facet on alveolar ridges which separate the sockets of the incisor teeth. Nat. size.



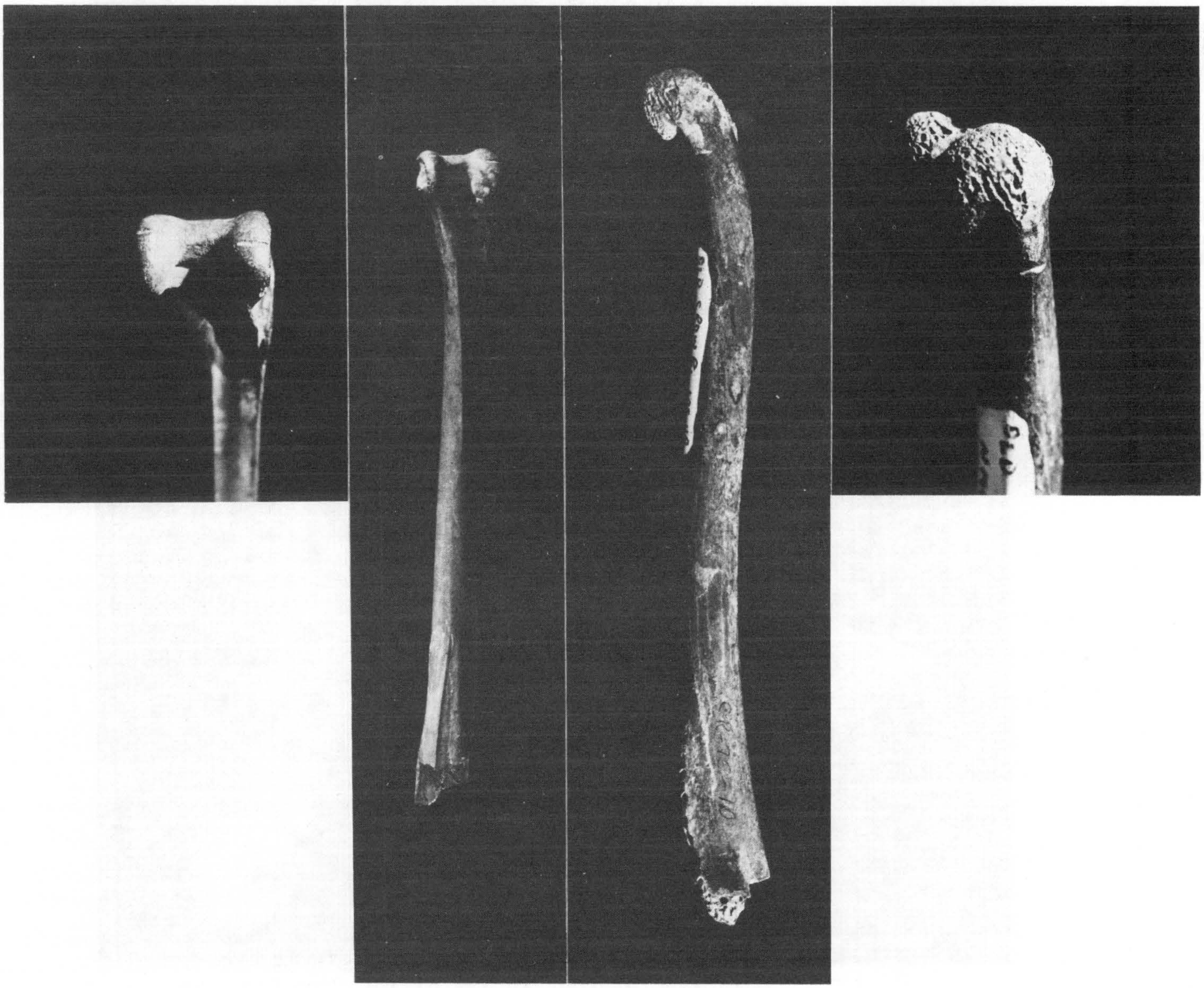
Pl. 4.25. *Equus* sp. left tibia shaft with polished facets on green fracture surfaces at the distal end (to the right), from Old Crow River, northern Yukon Territory (MkVl-9:14). Nat. size.



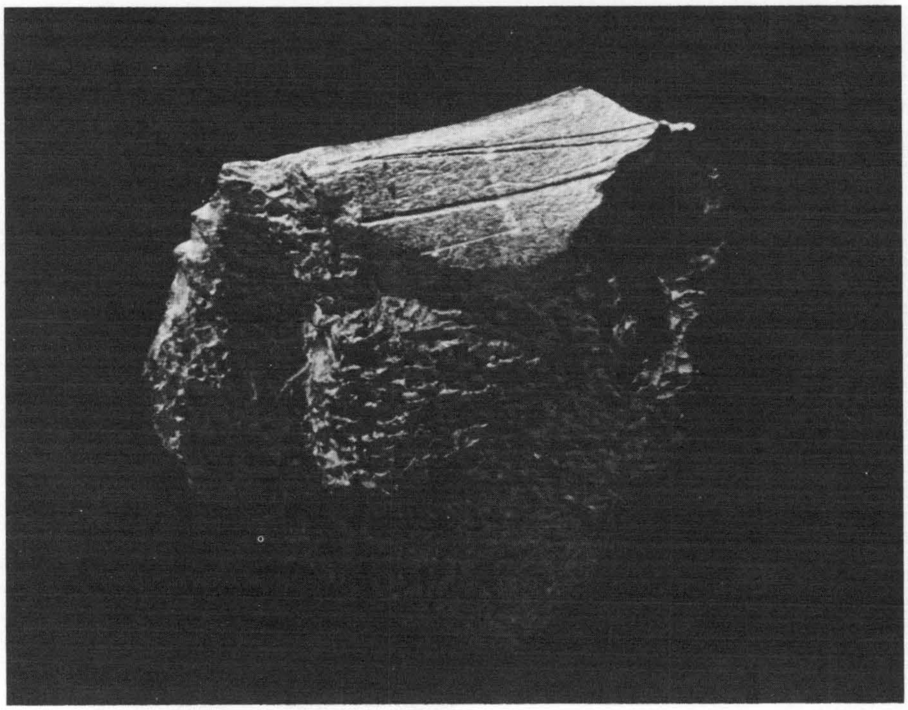
Pl. 4.26. *Equus* sp. right tibia shaft fragment with polished outer and fracture surfaces at the distal end (to the right), from Old Crow River, northern Yukon Territory (M1V1-1: 125). The visible carnivore gnawing marks truncate the polish on the outer surface (see discussion in text). 3/4 Nat. size.



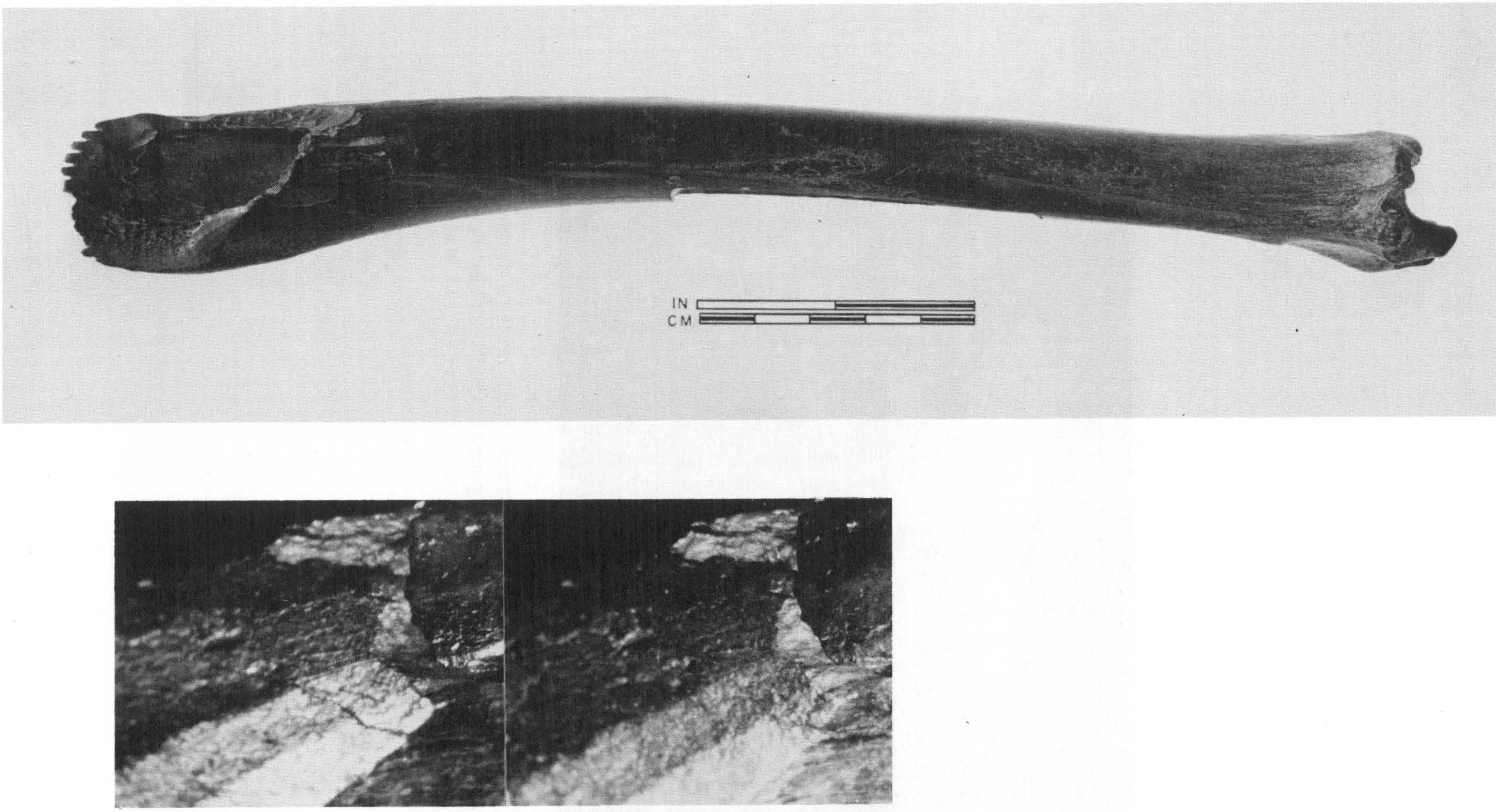
Pl. 4.27. *Rangifer tarandus* antler billet from Old Crow River, northern Yukon Territory (NbVl-2:15). This specimen was associated with the *Anodonta* phase (see text for discussion and description). ½ Nat. size.



Pl. 4.28. Cuts made by stone tools on bones of white-fronted geese (*Anser albifrons*) from Old Crow River, northern Yukon Territory. Left: tibiotarsus (MlVl-5:56) with cuts on distal condyles. Right: humerus (MkVl-12:16) with cut on shaft near distal end. Both Nat. size in plan views.



Pl. 4.29. Cuts made by a stone tool on the innominate of an unidentified large mammal (NbVl-2:12) from Old Crow valley, northern Yukon Territory. $1\frac{1}{2}$ Nat. size.



Pl. 4.30. Caribou (*Rangifer tarandus*) tibia fleshing tool (MlVl-1:1) from Old Crow River, northern Yukon Territory. Plan view (above) is from Nat. Museums of Canada Neg. No. J19221-7. Stereo pair (below) shows whittled facets resulting from the use of a stone tool to shape the working end. A longitudinal split has opened in the specimen since it was sawn through the shaft to obtain a radiocarbon sample.

CHAPTER 5. M1V1-7: A MODERN BAR ON JOHNSON CREEK

Description

Much of the collecting from modern banks and bars in the Old Crow region has been selective with an eye toward specimens of archaeological and paleontological significance. Beginning in 1977, we decided to collect every specimen which could be found on a particular bar in the Johnson Creek valley, a left bank tributary of the Old Crow River which enters 72 km above the river mouth. The bar (Harington's Loc. 71) had been extensively collected by C.R. Harington in 1975 (Harington 1977:61) but had remained untouched by collectors during 1976 and the spring break-up of 1977. We collected every bone, tooth, tusk, and antler in sight on 26 July 1977 and on 24 July 1978, and these two samples form the basis for the discussion which follows. An additional sample, collected by Mr. David Parama, University of Alberta, in August 1979, has been carefully examined, but it arrived the day after the previous materials had been tabulated and it appears not to offer outstanding reasons for altering the presentation.

The bar designated M1V1-7 is interesting in part because of its recent formation. In 1967, when I first travelled up Johnson Creek with W.N. Irving and J. Cinq-Mars, this bar was quite small and was situated on the inside of the seventh bend above the mouth of Johnson Creek, downstream from a long meander loop. In 1968, the narrow neck of land at the base of the long meander loop was breached by Johnson Creek so that the M1V1-7 bar began to enlarge at the inside of a much more energetic bend situated just below the newly formed channel. The bar is now approximately 100 m long and 20 m wide at lowest water, and it receives fossil bones from eroding deposits (M1V1-10) just above the new channel as well as from farther upstream. Most of these fossils accumulate at the upper end of the bar, and there is a noticeable thinning of the fossil density as one walks away from the central axis of the stream. Many fossils have been collected from under the water at the edges of the bar, and fossils probably could be found anywhere in the stream channel in this area. It is possible that some of the fossils were deposited early in the downcutting history of the Old Crow basin and that these are now being newly exposed as Johnson Creek continues to adjust its new course. Other fossils are probably introduced to the surface of the bar during spring break-up when the bones can be ice-rafted and washed downstream. Although many of the fossils probably have been exposed and reworked by Johnson Creek itself, it is also possible that the Old Crow River is responsible for some of the accumulation since the bar is situated just within the lateral-most valley wall of the river. In fact it is possible to envision an ancient meander loop which would have made M1V1-7 a point bar only a short distance downstream from M1V1-2 (to be described in Chapter 6).

Since all the visible fossils were collected during each visit to M1V1-7, this sample is suitable for a more comprehensive analysis of all varieties of bone alteration. Ideally the analysis would account for all alterations which have occurred to the specimens from the time of each

Table 5.1. Distribution of bones, teeth, tusks, and antlers from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory.

Taxon	Bones	Teeth	Tusks	Antlers	Totals
Pisces (fish)	1				1
Lepus americanus (snowshoe hare)	1				1
L. arcticus (Arctic hare)	1				1
Castoroides ohioensis (giant beaver)	1	2			3
Alopex lagopus (Arctic fox)	1				1
Ursidae, Genus? (bear)		1			1
cf. *Mammuthus* sp. (mammoth)	127	37	49		213
Equus sp. (horse)	49	7			56
Rangifer tarandus (caribou)	3	1		2	6
Alces alces (moose)				1	1
Ovibos moschatus (muskox)		1			1
?Symbos sp. (extinct muskox)		1			1
Bison sp. (bison)	19	3			22
Unidentified large mammals	277	11			288
Cervidae, Genus?				5	5
Totals	480	64	49	8	601

animal's death until the time of collection and analysis. Such an analysis would specify the "taphonomic pathway" followed by each specimen in its passage from the biosphere to the lithosphere to the laboaratory. The analysis given below provides a partial fulfillment of this ideal by summarizing the frequencies of observable alterations in relation to inferences regarding the likely "causes" or agencies of alteration as described in Chapter 3. On that basis the "taphonomic history" of the sample is approximated, and the archaeological component is identified as one of many contributors to the modification of individual specimens and assemblages.

The vertebrate fossils from M1V1-7 have been analyzed from several standpoints: size of sample, size of specimens, permineralization, degree of rounding, exfoliation, split lines, etching, pitting, fracture patterns, flaking, and polishing. One of our goals in summarizing the occurrence of these alterations is to identify the presence or absence of an archaeological component in this collection, and I believe that the proper approach to this problem is through the analysis of all features on the specimens which can shed light on the array of altering agencies which have operated on the total assemblage.

Sample Size

Of the 601 fragmentary and intact specimens analyzed from M1V1-7, 480 are bones, 64 are teeth, 49 are tusks, and eight are antlers (Table 5.1). Only the bones are included in subsequent tables since the teeth, tusks, and antlers were found to exhibit little systematic variation which would be useful in this analysis. Individual specimens of tooth and tusk will be mentioned under appropriate headings, but their overall distributions will not be tabulated.

Specimen size

Table 5.2 summarizes length, width, and weight for the 480 bones from M1V1-7. The standard deviations are very large for most categories, even for those which include large numbers of specimens. The large amount of variance reflects the highly skewed distribution of most categories since the majority of the specimens are relatively small but may be accompanied by a few much larger pieces. The skewdness of these distributions would render meaningless any statistical test which assumes a normal distribution, so such tests have not been used in comparing the M1V1-7 sample with others in the Old Crow basin.

It should be borne in mind that the bones collected from M1V1-7 were generally the largest objects on the bar. The associated sediments consisted primarily of coarse sand and silt and very little fine gravel. The only other large objects were several pieces of wood including a few nearly intact trees which had been stranded on the bar as the water receded. Very few small fossils of any kind have been recovered from M1V1-7 despite our deliberate efforts to avoid overlooking them. Probably the smaller mammal, bird, and fish remains have been carried farther downstream by Johnson Creek.

Table 5.2. Distribution of metric data for bones from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory. Width measurements not recorded for unidentified bones; lbf, long bone fragments

Taxon	No.	Length (mm)			Width Chord (mm)			Weight (g)		
		Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range
Identified bones										
Pisces	1	10.0			9.0			0.3		
Lepus americanus	1	41.0			38.0			2.0		
L. arcticus	1	68.0			7.0			2.1		
Castoroides ohioensis	1	85.0			39.0			27.1		
Alopex lagopus	1	41.0			11.0			1.5		
cf. *Mammuthus* sp. ribs	30	88.3	36.2	37-185	37.2	12.5	16-92	50.5	63.7	6.6-342.8
cf. *Mammuthus* sp. lbf	75	111.5	57.5	40-289	55.9	25.1	19-163	155.3	211.1	7.5-1391.0
cf. *Mammuthus* sp. misc.	22	131.4	57.2	67-274	88.4	29.5	30-145	385.2	458.5	44.3-1996.0
Equus sp.	49	85.1	46.9	38-256	51.3	13.4	29-85	92.7	98.1	16.3-536.8
Rangifer tarandus	3	64.7	18.2	45-81	42.3	12.5	28-51	44.8	31.9	13.7-77.5
Bison sp.	19	74.7	30.5	36-153	46.0	20.6	23-103	78.9	76.2	15.5-320.6
Unidentified large mammals										
Rib fragments	50	50.6	29.1	17-192				8.1	9.0	0.7-45.5
Long bone fragments	180	53.5	23.1	12-155				13.2	11.7	0.3-52.9
Misc. fragments	28	64.8	35.0	25-210				32.4	26.9	2.7-116.7
Unclassifiable fragments	19	38.4	15.4	12-68				13.0	12.7	0.3-47.6
Total	480									

Permineralization and Staining

In general the MlVl-7 specimens appear to be permineralized and stained in the same ways and to the same degrees as most of the other redeposited fossils in the Old Crow basin. Exceptions include several of the antler fragments which could represent Holocene caribou antler shedding in the valley. One mammoth rib fragment has a very light stain (5YR4/4), but its density suggests that it has been permineralized and subsequently bleached by sub-aerial weathering.

Vivianite and Hematite

The occurrence of secondary minerals on the fossils from MlVl-7 is probably influenced by their recent removal from sedimentary matrix. Vivianite was observed on only 3.3% of the MlVl-7 bones, but hematite was seen on 75.4% of these specimens (Table 5.3). Some of the bones from MlVl-7 may have been reworked through sedimentary environments in which ferric iron is abundant. Such iron-rich sediments have been observed on the right bank of Johnson Creek only 0.1 km above MlVl-7, and the sediments appear to have accumulated secondarily in channels cut into the lower glacio-lacustrine unit and capped by Holocene terrace alluvium. Abundant bone fragments have been observed in these small channels, and some of them are completely coated with iron oxides.

Rounding

Each bone was examined at a magnification of 12X under a Wild M5 microscope equipped with two lamps controlled with variable transformers. The specimens were illuminated at a low angle (ca. 30°) so as to obtain a clear view of surface discontinuities and edge conditions. Each specimen was assigned to one of four rounding classes (Table 5.4) which were defined as follows: 0, not rounded, means that all edges and ridges are sharply defined so that no rounding is apparent, even under magnification; S, slightly rounded, means that rounded features are apparent under magnification but are not noticeable to the unaided eye and that no appreciable change of shape has been caused by rounding; M, moderately rounded, means that some rounding is evident to the unaided eye but that little or no change of shape is attributable to rounding; and H, heavily rounded, means that conspicuous shape-altering rounding has occurred (see Pl. 2.5).

The distribution of these rounding classes is shown in Table 5.4 for the bones from MlVl-7. All of the specimens are rounded to some degree, and moderate rounding characterizes the majority of the pieces. Many of these fossils may have been reworked repeatedly with progressive rounding taking place on each such occasion. A major unknown variable with respect to rounding is the influence of ice in the annual breakup of the stream. Both ice and repeated reworking may have contributed to the remarkable and conspicuous rounding seen on the MlVl-7 bones, and these specimens have been damaged to an extent never seen in samples found in primary contexts in the banks of the Old Crow River.

Table 5.3. Distribution of hematite and vivianite stains on bones from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory.

Taxon	No.	Hematite	None	Vivianite	None
Identified bones					
Pisces	1		1		1
Lepus americanus	1		1		1
L. arcticus	1		1		1
Castoroides ohioensis	1	1			1
Alopex lagopus	1		1		1
cf. *Mammuthus* sp. ribs	30	29	1		30
cf. *Mammuthus* sp. lbf	75	65	10	2	73
cf. *Mammuthus* sp. misc.	22	17	5	2	20
Equus sp.	49	39	10	2	47
Rangifer tarandus	3	1	2		3
Bison sp.	19	14	5		19
Unidentified Large Mammals					
Rib fragments	50	45	5		50
Long bone fragments	180	108	72	7	173
Miscellaneous fragments	28	26	2	2	26
Unclassifiable fragments	19	16	3	1	18
Totals	480	361	119	16	464

Table 5.4. Distribution of rounding classes, exfoliation, and split lines for bones from MlV1-7, Johnson Creek, Old Crow basin, northern Yukon Territory.

Taxon	No.	Rounding S	M	H	Exfoliated	None	Split Lines	None
Identified bones								
Pisces	1	1				1		1
Lepus americanus	1	1				1		1
L. arcticus	1	1				1		1
Castoroides ohioensis	1		1		1		1	
Alopex lagopus	1		1			1	1	
cf. *Mammuthus* sp. ribs	30	4	19	7	8	22	16	14
cf. *Mammuthus* sp. lbf	75	4	46	25	28	47	34	41
cf. *Mammuthus* sp. misc.	22	2	14	6	3	19	12	10
Equus sp.	49	15	27	7	15	34	40	9
Rangifer tarandus	3		2	1	3		2	1
Bison sp.	19	3	13	3	9	10	14	5
Unidentified Large Mammals								
Rib fragments	50	8	35	7	23	27	26	24
Long bone fragments	180	15	119	46	80	100	83	97
Miscellaneous fragments	28	8	11	9	10	18	13	15
Unclassifiable fragments	19	1	8	10	1	18	8	11
Totals	480	63	296	121	181	299	250	230

Legend
S, slightly rounded; M, moderately rounded; H, heavily rounded
(see text for definitions)

Table 5.5. Distribution of pitting and etching on bones from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory. See text for explanation of pitting types. Etching occurs on outer (O), inner (I), fracture (F), and multiple (OIF) surfaces.

		Pitting				Etching					
Taxon	No.	A	BF	BC	None	O	I	OF	IF	OIF	None
Identified bones											
Pisces	1				1						1
Lepus americanus	1				1						1
L. arcticus	1				1						1
Castoroides ohioensis	1		1								1
Alopex lagopus	1				1	1					
cf. *Mammuthus* sp. ribs	30		2	3	25	2		1			27
cf. *Mammuthus* sp. lbf	75	4	6	5	60	12		3			60
cf. *Mammuthus* sp. misc.	22		2	1	19	3					19
Equus sp.	49	2	5	8	34	3					46
Rangifer tarandus	3			2	1	1					2
Bison sp.	19		2		17	4		1			14
Unidentified Large Mammals											
Rib fragments	50	1		4	45	3					47
Long bone fragments	180	8	13	11	148	12	2	10	1	6	149
Miscellaneous fragments	28	3	2	3	20	7					21
Unclassifiable fragments	19		2	2	15	1					18
Totals	480	18	35	39	388	49	2	15	1	6	407

Exfoliation and Split Lines

These features are attributed primarily to sub-aerial weathering of bones and appear to be functions primarily of time, temperature, moisture, and soil chemistry (see Chapter 3; Behrensmeyer 1978). The frequency of exfoliation and split lines in the M1V1-7 sample is shown in Table 5.4. Split lines occur on slightly more than half of the specimens, and exfoliation is seen among a smaller portion of the sample. Some of the exfoliation may have resulted from repeated wet and dry conditions during redeposition of the M1V1-7 fossils, and the high frequency of split line observation is related in part to the relatively large size of the individual specimens. Smaller specimen sizes can be achieved simply by split line separation which reduces the number of observable split lines remaining on the specimens. It is possible that some of these features developed after the permineralization of the bones, so the frequencies shown in Table 5.4 do not represent a direct measure of the extent of sub-aerial weathering in the history of this sample.

Pitting

A variety of pitting features were observed on the bones from M1V1-7, and several distinguishable types are probably attributable to different agencies of bone alteration. Their distributions are shown in Table 5.5.

Type A pitting. A few of the bones are pitted so as to reduce the general cortical surface of the specimens, leaving behind "high spots" where the original outer surface can still be observed. I suggest that this kind of pitting is due primarily to acid attack by humates in soil and other acids in ground water, but some specimens may have been so intensely attacked by plant rootlets (see below) that coalescent etching features are responsible for some of these alterations. Bonnichsen (1979: 29-30) attributed a sort of ridge-and-valley morphology to the work of acids on bone surfaces, and I observed such features on several bones from M1V1-7 but did not record this pattern systematically.

Type B pitting. A larger number of bones exhibit discrete pits on one or more surfaces, and some of these pits are very fine and precisely round (Type BF) while others are coarser and more irregular in shape (Type BC). Often the Type BC pits are associated with scrapes, scratches, and perforations which are commonly seen on bones chewed by carnivores, and I suggest that this entire category can be attributed to carnivore gnawing. The Type BF pits are much too small and too precisely defined to be explained as gnawing features, and they commonly occur with etching patterns thought to be attributable to plant rootlets (see below). Type BF pits are interpreted as the contact points of rootlet tips from which most root exudates are produced (Strang 1979). Type BF and BC pitting each occurred on less than 10% of the M1V1-7 bones (Table 5.5).

Table 5.6. Distribution of fracture types on bones from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory. 0/0, intact bone; 0/y, bone fractured after permineralization; x/y, bone fractured when fresh.

Taxon	No.	0/0	0/y	x/y	Wall thickness (x/y) Mean	S.D.	Range
Identified bones							
Pisces	1		1				
Lepus americanus	1		1				
L. arcticus	1		1				
Castoroides ohioensis	1		1				
Alopex lagopus	1		1				
cf. *Mammuthus* sp. ribs	30		27	3	11.8		8.9-16.0
cf. *Mammuthus* sp. lbf	75		50	25	17.4	6.2	8.5-28.5
cf. *Mammuthus* sp. misc.	22		21	1	64.6		
Equus sp.	49	12	30	7	8.1	1.9	6.3-11.9
Rangifer tarandus	3		2	1	6.8		
Bison sp.	19	7	11	1	10.1		
Unidentified Large Mammals							
Rib fragments	50		40	10	4.2	1.8	1.4-6.7
Long bone fragments	180		104	76	8.4	3.2	2.4-18.1
Miscellaneous fragments	28		27	1	4.3		
Unclassifiable fragments	19		19				
Totals	480	19	336	125			

Etching

Distinctive dendritic etching patterns seen on many bones are thought to represent the attack of plant rootlets. The frequency of etching is shown for M1V1-7 in Table 5.5 where the data are cast so as to show the location of etching on the fossils. Most of the etched bones are etched only on their outer surfaces, but etching in the medullary cavity can occur if roots are able to grow through an unbroken shaft the ends of which have been removed or if a shaft is broken open to expose the medullary cavity. Obviously the occurrence of etching on a fracture surface indicates that the fracture occurred prior to plant rootlet attack.

Fracture Patterns

Attributes used to distinguish green bone fractures from dry and permineralized bone fractures were discussed at length in Chapter 3 (see Tables 3.2-3.3). These attributes were used in classifying the M1V1-7 bones with the same fractional coding procedure which has been described in Appendix B (Table 5.6). Green bone fractures were observed on 25.8% of the M1V1-7 specimens, and these fracture patterns occurred only on large mammal bones and were particularly abundant among the mammoth long bone fragments (31.5%) and the unidentified large mammal long bone fragments (42.3%). Detailed observations on the green fractured mammoth bones were already presented in Tables B1, B4, and B6.

An important aspect of the fracture pattern analysis is the relationship between green bone fractures and evidence for carnivore alterations. Wall thicknesses were measured on all green fractured specimens and are displayed in Table 5.6. Marked variation can be seen in these measurements with a maximum of 64.6 mm of compact bone occurring in a mammoth scapula which was fractured through the blade and the base of the spine. Most of the bone elements smaller than those of mammoths could have been broken by carnivores, although carnivore gnawing cannot be demonstrated for the majority of the green fractured bones. The distribution of carnivore alterations in relation to fracture patterns has been arrayed in Table 5.7, and there is a significant departure from randomness in their association ($P = 0.939$ that χ^2 will not be exceeded). Two of the 23 green fractured mammoth long bone fragments exhibit evidence of carnivore gnawing. On one (M1V1-7:285; Table B1) of these the gnawing is not directly associated with the green fractured margins, and it is unlikely that the carnivore was responsible for the fractures. The second case is an immature mammoth tibia shaft which has extensive Type BC pitting in association with very ragged green fractures at both the proximal and the distal ends. The remainder of the shaft is preserved as a cylinder (M1V1-7: 110; Pl. 5.1), and the fractured ends consist of chipped back edges rather than through-shaft fractures. Such cylinders are typical of carnivore activity, and the fracture form is quite distinctive and unlike any of the fractures on adult mammoth bones which I have attributed to human activity.

Table 5.7. Distribution of carnivore alteration features on bones from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory. Only those taxa which contain green bone fractures (x/y) are listed here. The three types of alteration shown for green bone fractures (pitting, scoring, chipping) cannot be summed since one bone can occur in all three columns.

			0/y			x/y					
Taxon	No.	0/0	Type BC Pitting	None	0/y Total	Type BC Pitting	Scoring	Chips	Altered Total	None	x/y Total
Identified bones											
cf. *Mammuthus* sp. ribs	30		3	24	27					3	3
cf. *Mammuthus* sp. lbf	75		3	47	50	2	1		2	23	25
cf. *Mammuthus* sp. misc.	22		1	20	21					1	1
Equus sp.	49	12	4	26	30	3	2	2	5	2	7
Rangifer tarandus	3		1	1	2	1			1		1
Bison sp.	19	7		11	11					1	1
Unidentified Large Mammals											
Rib fragments	50		1	39	40	3	1		3	7	10
Long bone fragments	180		6	98	104	5	2	1	5	71	76
Misc. fragments	28		3	24	27					1	1
Totals	456	19	22	290	312	14	6	3	16	109	125

	Carnivore alterations Present		Absent		Totals
Fracture 0/y	22	*27*	290	*285*	312
Fracture x/y	16	*11*	109	*114*	125
Totals	38		399		437

$\chi^2 = 3.51$; df $= 1$; P $= 0.939$ that χ^2 will not be exceeded

Expected frequencies in italics

Bone Flaking

Cores and flakes from MlVl-7 were already presented along with similar specimens from other reworked deposits (Chapter 4, Appendix B). The following examples were found at MlVl-7: (1) one mammoth bone longitudinal core with an unmodified platform (Tables B4-5, Pl. 5.2); (2) one complex longitudinal core with a retouched platform made on a mammoth scapula fragment (Tables B6-7, Pl. 5.3); (3) one mammoth bone core fragment (Table B10, Pl. 5.4); (4) three mammoth bone flakes (Table B11, Pls. 4.19 and 5.5); and (5) three longitudinally flaked cores made on large mammal bones smaller than those of mammoths (Tables B13-14). One of the mammoth bone flakes (MlVl-7:507) is not included in the totals reported in this chapter, because the specimen was selected from the 1975 collection made by Harington rather than being recovered during our comprehensive collections of 1977 and 1978.

Bones with Reduced and Incised Surfaces

Four bones in this category were described with other specimens from reworked deposits in the Old Crow valley. These included a scratched bone (Table B15, Pl. 5.6a) and two polished bones (Table B17) which might have been altered either naturally or artificially as well as one polished specimen (Table B17, Pl. 5.6b) which was classified as artificially modified. Four bones which appeared on first examination to have been cut were finally classified as naturally altered or unaltered because the supposed "cuts" are either natural split line features (MlVl-7:152) or vascular grooves produced in response to blood vessels (MlVl-7:72, 219-6, 256).

Summary

In Table 5.8, the bone, tooth, tusk, and antler alterations observed in the collection from MlVl-7 have been summarized so as to identify the archaeological potential of the locality. All alterations observed on teeth, tusks, antlers, and intact bones are attributed to natural causes. Less than 1% (3 specimens) of the bones fractured after permineralization are thought possibly to have been altered by artificial means, and two of these pieces could readily be explained in terms of natural agencies. Fifteen bones which were fractured when green and which exhibit signs of carnivore chewing are attributed to probable natural agencies, and one of these bones is the tibia of an immature mammoth. One other chewed specimen is an adult mammoth limb bone on which the evidence of chewing is not directly associated with the green fractured margins, and this is believed to have been broken by man. Of 99 green fractured bones which show no other significant alteration, only the 19 mammoth limb bone fragments listed in Table B1 have been attributed to the action of man. Any or all of the remaining 81 specimens may well have been broken by man, but they might have been fractured by carnivores and are therefore placed in the "natural or artificial" column. The artificial status of the

Table 5.8. Distribution of bone, tusk, tooth, and antler alterations with respect to the archaeological potential of MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory.

Fracture category and other alterations	Tables	Total	Natural Agencies	Probably Natural	Natural or Artificial	Artificial
Teeth	5.1	64	64			
Tusks	5.1	49	49			
Antlers	5.1	8	8			
Intact bones (0/0)	5.6	19	19			
Post-permineralization fractures (0/y)		336	333			
Scratched bone	B15				1 (326)	
Polished bones	B17				1 (321)	1 (289)
Green bone fractures (x/y)		125				
Chewed	5.7, B1			15		1*(285)
No other alterations	5.6, B1				81	19*
Core with unmodified platform	B4-5					1*(157)
Core with retouched platform	B6-7					1*(192)
Core fragment	B10					1*(282)
Flakes	B11					2*(79, 156)
Large mammal bone cores	B13-14					3 (32, 224-4, 87)
Polished bone	B17				1 (288)	
Totals		601	473	15	84	29

Legend
* marks mammoth bones
(numbers in parentheses are catalogue numbers)

remaining eight specimens in the "artificial" column has already been explained. This conservative view of the MlVl-7 collection features 6% of the bones as artificially modified, and a less conservative view would add an additional 84 specimens to this list to bring the percentage to 23.5%

This examination of the MlVl-7 collection provides an indication of the approximate amount of the fossil record in the Old Crow valley which is of interest to archaeologists. In his study of 1794 bones from MkVl-12, Bonnichsen (1979:79, Table 8, "Loc. 89") found that 13.2% had been "spirally fractured," but, unlike this study, the total count of such features was attributed to artificial causes. If we restrict the artifact count to mammoth and mastodon bones which were broken when green, the corresponding percentage is approximately 4.8% based on 86 specimens at MkVl-12 as of 1973. This compares very favourably with the proportion of artificially modified bones reported here from MlVl-7.

Taphonomic Pathways to MlVl-7

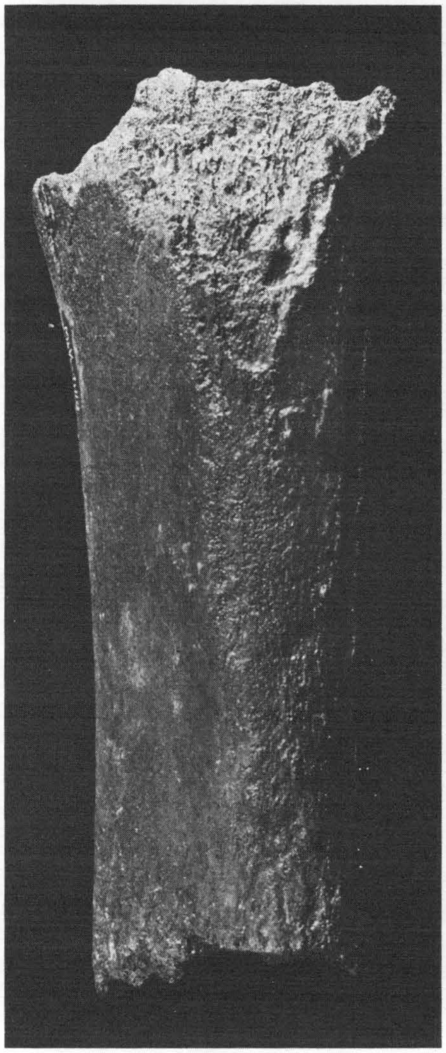
Taphonomic factors which have influenced the vertebrate remains from MlVl-7 are summarized in Table 5.9. In this tabular presentation I have attempted to account for the various taphonomic factors identified by Clark and Kietzke (1967) and presented above as Fig. 3.1. One important variable which is not included in this model is the extent to which the bones of a given taxon are reduced in size with corresponding losses of diagnostic features. This factor is reflected in identifiability (41.9% at MlVl-7), but the significance of specimen reduction is quite different for lemming and mammoth bones. It is very important to remember that few small mammals, no birds, and only one fish bone were found at MlVl-7.

Some of the alteration patterns which I have used in this analysis are rather difficult to assign to the taphonomic factors listed in Table 5.9. For example, post-permineralization fractures can occur as diagenetic processes after primary burial and in the absence of erosion and redeposition, but such fractures can also occur (probably even more frequently) during reworking of the fossil deposits and reburial in secondary contexts. To account for these possibilities I have listed such fractures as alterations pertaining to both taphic and anataxic factors. A second example is Type A pitting which I have attributed to acid attack and which I consider to be a taphic factor. Data to be presented in Chapter 6 shows that this pitting type is independent of the burial environment, at least with respect to secondary contexts, and this result throws some doubt on the question of its placement in the model. Perhaps it also calls into question the association between Type A pitting and acid attack. Other such problems can be identified as well but would not likely affect the archaeological part of this analysis.

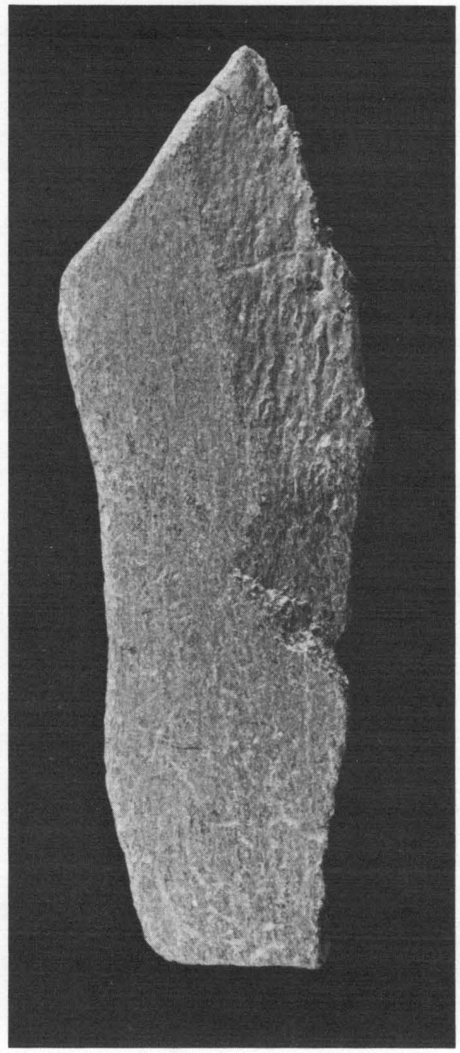
At this stage in the presentation it is rather difficult to make historical sense of the data in Table 5.9 since I have offered no comparable data set with which to make comparisons. Therefore we will return to this table during a discussion of similar data based upon excavated samples from MlVl-2, directly across the Old Crow valley from MlVl-7.

Table 5.9. Taphonomic factors pertaining to bones from MlVl-7, Johnson Creek, Old Crow basin, northern Yukon Territory.

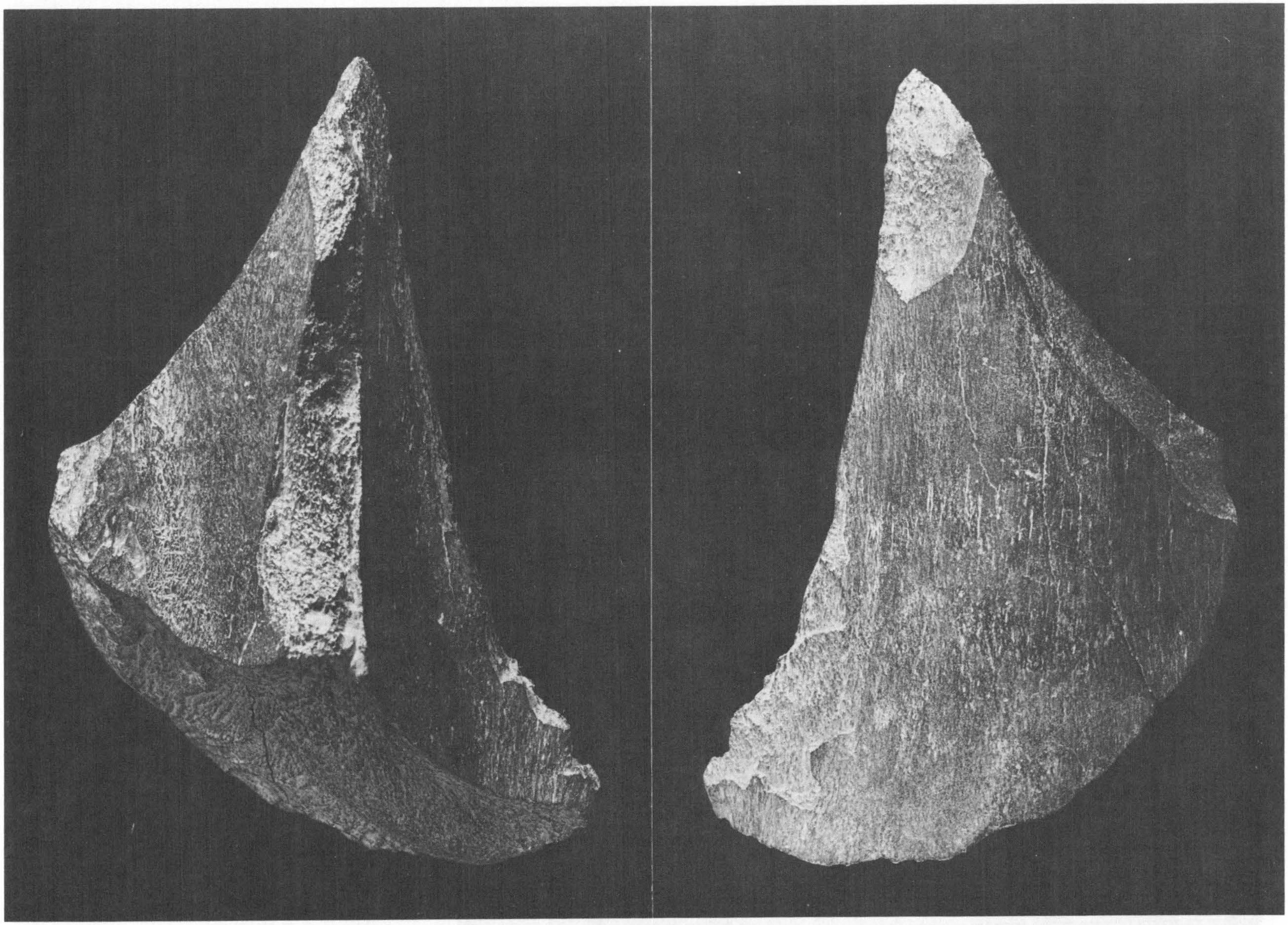
Factors/ Assemblages	Bone Alterations	Occurrence
Biotic factors		
Life Assemblage (to be reconstructed)		
Thanatic factors (cause of death)		
Death Assemblage (to be reconstructed)		
Perthotaxic factors (post-death, pre-burial)		
	Exfoliation	37.7%
	Split lines	52.1%
	Type BC pitting (chewing)	8.1%
	Green bone fractures (x/y)	26.0%
	Natural or artificial alterations	17.5%
	Artificial alterations	6.0%
Taphic factors (time and nature of burial)		
	Sedimentation rate	Seasonally variable
	Thickness of increments	Annually variable
	Velocity of current	Seasonally variable
	Nature of sediment	Sand, silt, clay, fine gravel, flat bedded
	Type A pitting (acids)	3.8%
	Etching (rootlets)	15.2%
	Type BF pitting (rootlets)	7.3%
	Post-permineralization fractures	70.0%
Fossil Assemblage		
Anataxic factors (weathering, redeposition)		
	Vivianite	3.3%
	Hematite	75.2%
	Rounding (O/S/M/H)	0.0/13.1/61.7/25.2%
	Post-permineralization fractures	70.0%
	Ancient redeposition	Unknown but probable
	Modern slumping	None
	Modern flooding	Annual
Sullegic factors (collecting)		
	Time investment in collection	Adequate
	Collection technique	Visual inspection
Trephic factors (laboratory)		
	Identifiability	41.9%



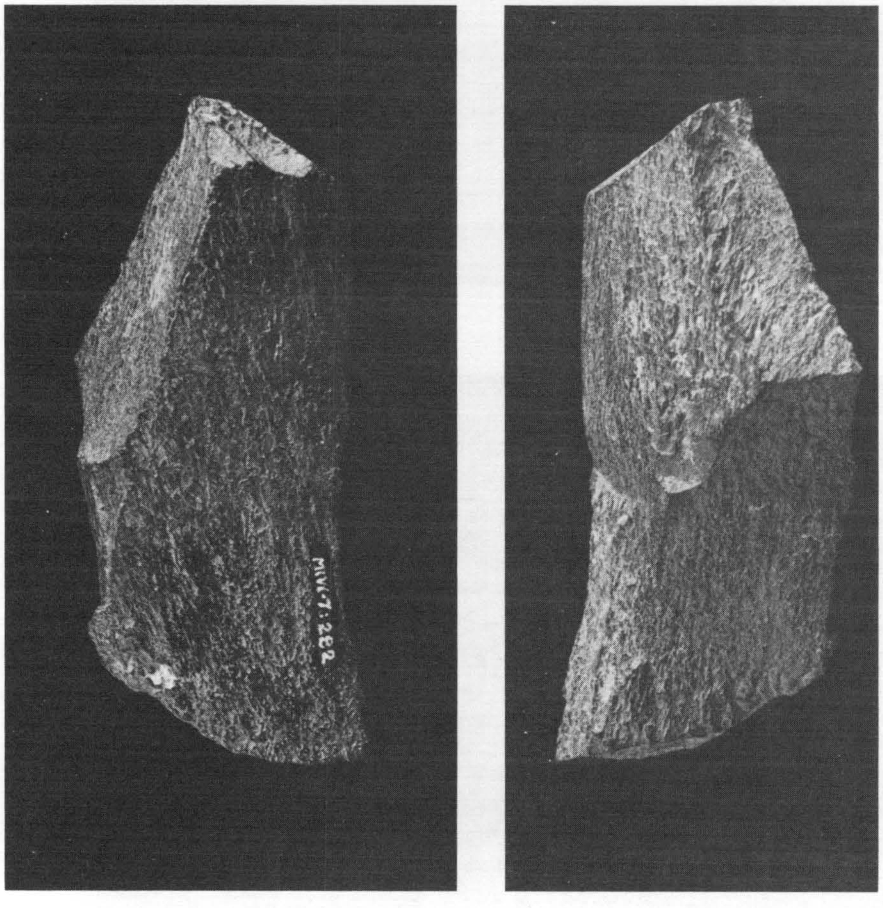
Pl. 5.1. Immature mammoth (cf. *Mammuthus* sp.) tibia (M1V1-7: 110) from Johnson Creek, Old Crow basin, northern Yukon Territory. Note chewing by carnivores at both ends. ½ Nat. size.



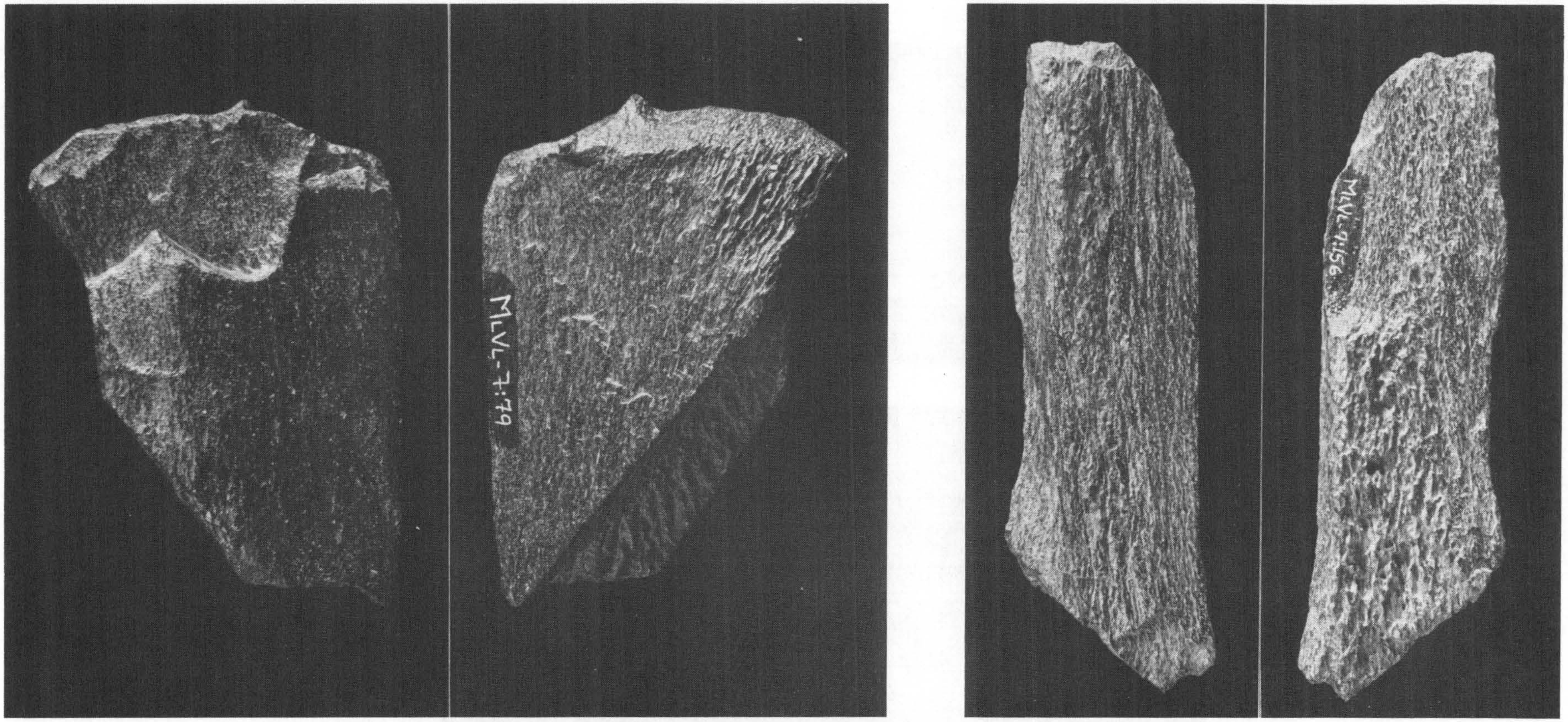
Pl. 5.2. Longitudinally flaked core with unmodified fracture surface platform on mammoth (cf. *Mammuthus* sp.) long bone fragment (M1V1-7:157) from Johnson Creek, Old Crow basin, northern Yukon Territory. Nat. size.



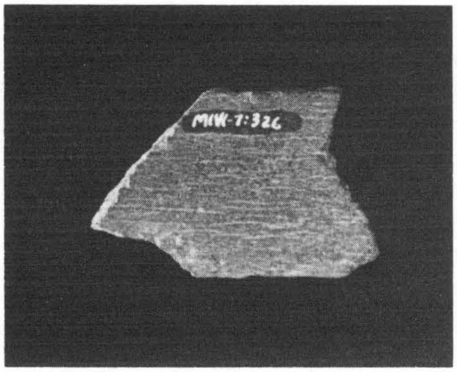
Pl. 5.3. Longitudinally flaked core with retouched platform on mammoth (cf. *Mammuthus* sp.) scapula (MlVl-7:192) from Johnson Creek, Old Crow basin, northern Yukon Territory. 3/4 Nat. size.

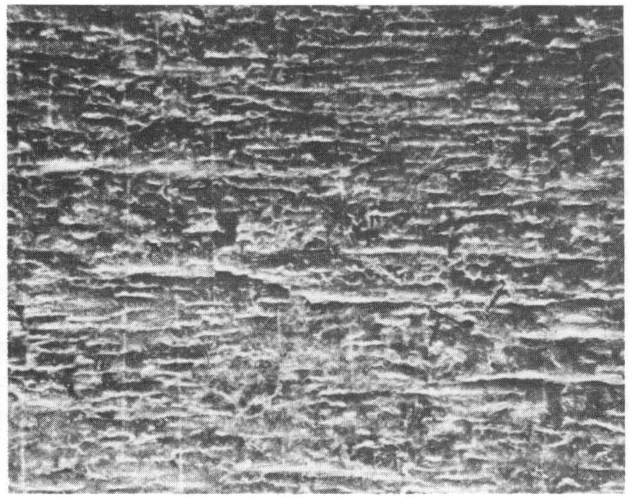


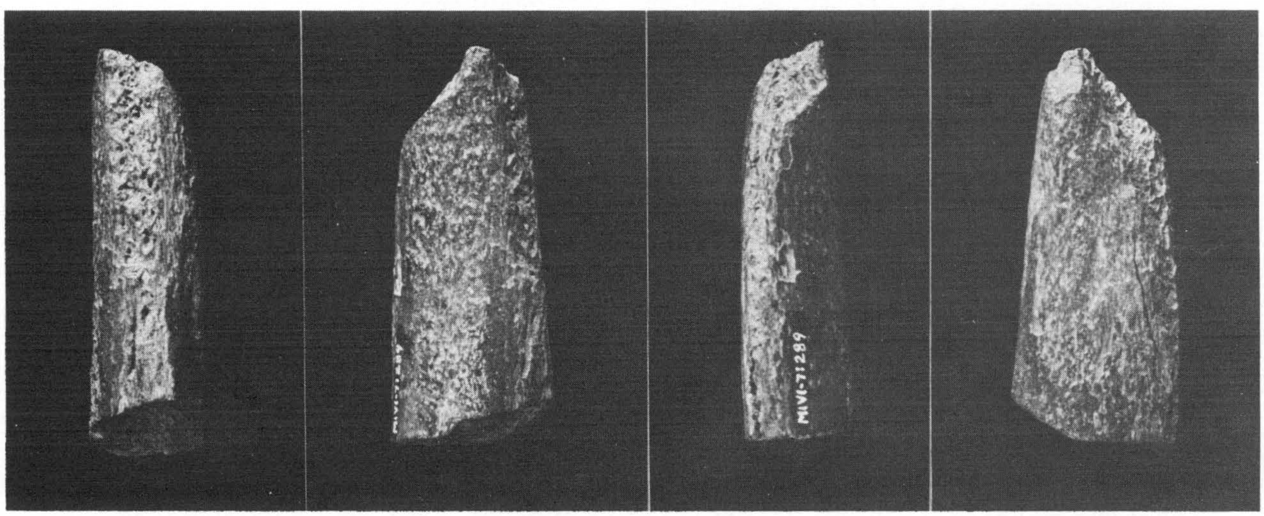
Pl. 5.4. Mammoth (cf. *Mammuthus* sp.) core fragment (MlVl-7:282) from Johnson Creek, Old Crow basin, northern Yukon Territory. Nat. size.



Pl. 5.5. Two flakes struck from mammoth (cf. *Mammuthus* sp.) limb bone cores (MlVl-7:79, 156) from Johnson Creek, Old Crow basin, northern Yukon Territory. Both Nat. size.







Pl. 5.6. Above: scratched large mammal rib fragment (M1V1-7:326). Left: Nat. size; right: 7.5X.

Below: shaped and polished large mammal rib fragment (M1V1-7:289). Nat. size.

Both from Johnson Creek, Old Crow basin, northern Yukon Territory.

CHAPTER 6. MlVl-2: A HIGH BLUFF ON OLD CROW RIVER

Stratigraphy and Stations

MlVl-2 is one of the best and largest exposures along the Old Crow valley and is located approximately one kilometer above the mouth of Johnson Creek on the right bank of the Old Crow River. The bluff stands about 35 m high during lowest stages of water and forms a southeastward-facing exposure about one kilometer long. Approximately half of the upstream end of the bluff has not been actively eroded in recent decades so that the stratigraphy is obscured by vegetation, but 400 m of the downstream end is largely free of vegetation and is in excellent condition for stratigraphic observations and fossil prospecting. Even in this well exposed area, however, our investigations have been hampered locally by slumped sediments which conceal primary stratigraphy and which force us to conduct our studies in spatially separated portions of the bluff which we have called stations. A given station may offer good exposures at the base of the bluff or higher in the section, but few stations have afforded opportunities to study the entire sequence of sediments in a single vertical column. Therefore we have taken great care to correlate prominent stratigraphic units from one station to another so that fossil samples from the various stations can be combined to provide adequate sample sizes representative of major units in the overall stratigraphy.

Intensive excavations in 1977 and 1978 form the basis for the presentation of three stratigraphically separate vertebrate fossil samples from MlVl-2. We will not need all the stratigraphic details for an understanding of these samples, and such detailed presentation and discussion will be made elsewhere (Hughes, *et al.* 1980). For present purposes it will be adequate to identify the stations along the MlVl-2 exposure and to indicate in general terms the manner in which they have been sampled and related to one another. Three major stratigraphic positions have yielded the vertebrate sample to be described in this chapter, and they can be identified as follows in terms of the major units presented in Chapter 2 (Fig. 2.2).

1. Disconformity A: the contact between Units 3 and 4 has been identified at most of our stations at MlVl-2, and correlations between stations are aided by the occurrence of a volcanic ash 30-50 cm below the disconformity. At all stations the disconformity consists of cross-bedded silts and sands overlying blue-gray silty clay, and at two stations we have documented large ice-wedge pseudomorphs which formed during a period of sub-aerial weathering and were subsequently melted and filled with sediment. These wedges were then truncated by a minor degree of erosion which was followed by the deposition of the cross-bedded silts and sands. One small area, two meters across, reveals a gleysol profile on the disconformity, and this area seems to preserve the original soil which formed on the surface and which has elsewhere been removed by erosion. The surface of the soil yielded a remarkably well preserved suite of plant and invertebrate fossils which indicate a former forest floor consisting of spruce twigs with their needles still attached, criss-crossed sticks which had fallen from the trees, cones and mosses

and gastropods and insects which lived or accumulated beneath the tree cover. Some of the mosses are so well preserved that they spring back into their growth positions when removed from the surrounding sediment. Very few vertebrate fossils occur in the area where the soil is preserved. While it is unfortunate that we have not found larger areas of soil preservation, our vertebrate sample would be much smaller were it not for the concentration of fossils which was produced during erosion and the deposition of the overlying silts and sands (Table 6.1).

2. At depths of 10 to 12 m below Disconformity A, vertebrates have been excavated from sands and silts interbedded with clays and detrital organic concentrations (Table 6.2). This sample of fossils will be called the mid-section sample since it was recovered from sedimentary units about half way up the bluff. The sample was obtained from three stations at the downstream end of MlVl-2 where we suspect that a major channel deposit represents an episode of cutting and filling in the alluvial sequence. We cannot see a cross-section of such a channel in this area, but we suspect that a channel is exposed near its longitudinal section so that major dipping of the beds is not noticeable. Measurements of the vertical distance between Disconformity A and the mid-section deposit in successive field seasons indicate that the vertical separation of the two samples is growing less as the bluff continues to erode. This would be expected if the beds exposed in the bluff are dipping toward the river. On the basis of channel cross-sections seen at other localities (e.g., MkVl-9 and MkVl-10) nearby in the valley, we believe that it is likely that Disconformity A represents a floodplain associated with the channel deposits which produced our mid-section sample. Therefore there may be very little difference in the age of the two deposits despite their vertical separation in the exposure. The channel deposits would have formed as point bars grew in a meandering stream such as the present Old Crow River. An analogy can be drawn between these ancient geomorphological relationships and those which we see today in the same area. The mid-section deposit is analogous to the modern sand bars, and Disconformity A is analogous to the modern terrace surface, approximately 15 m above the water level, on which we placed our camp.

3. A small sample of vertebrates was obtained by excavation in detrital organic sands which overlie the reworked glaciolacustrine clays at the base of the bluff (Table 6.3). These sands form the oldest deposits of Unit 3 (see Chapter 2), and they seem not to have been disturbed by subsequent alluvial activity. The fossils may be very much older than the other two samples and could date to Sangamon Interglacial times. Marked differences in the nature of the bone alterations will be noted in the analysis, and there is no sign of an archaeological component in this small sample.

Fifteen stations have been designated at MlVl-2, and they were numbered in the order in which we happened to study them. Therefore the numbers do not systematically increase in any given direction, and a map is needed to understand their locations (Fig. 6.1). The stations will be summarized to indicate their significance for stratigraphic observations and fossil samples. The downstream end of the bluff was paced off to

Table 6.1. Distribution of vertebrate taxa by station at MlVl-2, Disconformity A, Old Crow River, northern Yukon Territory. Roman style (1), bones; italics style (*1*), teeth; small numbers ($_{1}$), tusk fragments.

Taxon	Stations: 1	2	3	5	6	7	9	12	13	14	15	Totals
Pisces, Family?		1	5		1			4				11
Coregoninae, Genus?								1				1
cf. *Coregonus* sp.					1							1
Coregonus sp.			1									1
Lota lota			3		1			1				5
L. cf. lota						1		2				3
Aves, Family?	1		1									2
Anatidae, Genus?		4	4					1	1			10
Lagopus sp.			1	1								2
Passeriformes, Family?			1									1
Lepus americanus		1 *4*	*4*	1								2 *8*
L. arcticus	*2*	*3*	8 *4*	*1*			1	2	1			12 *10*
Marmota monax			1							1		2
Spermophilus parryi	1		3					1	1			6
Castor canadensis			2 *1*				1					3 *1*
Castoroides ohioensis			1 *2*									1 *2*
Lemmus sibiricus		1	1					*1*				2 *1*
Dicrostonyx torquatus		1	6 *3*	2	1			1 *1*				11 *4*
Ondatra zibethicus		8	8 *1*			2	2	2	2			24 *1*
Microtus xanthognathus		1										1
Cricetidae, Genus?	1 *1*	8 *2*	12 *8*	1	1 *1*	1	1	2 *8*	1	*2*		28 *22*
Alopex lagopus		2	*1*									2 *1*
cf. *Ursus* sp.			1									1
Mustela erminea			1									1
cf. *Felis canadensis*		1										1
Panthera leo atrox					1							1
cf. *Mammuthus* sp.	2 *3* $_{4}$	15 *3* $_{26}$	1 *1* $_{47}$		3 $_{2}$	$_{2}$		4 $_{21}$	$_{1}$	*1* $_{2}$		25 *8* $_{105}$
Equus sp.		1										1
cf. *Equus* sp.		*1*				1						1 *1*
Alces sp.			*1*									*1*

Table 6.1 (Continued).

Taxon	Stations: 1	2	3	5	6	7	9	12	13	14	15	Totals
Rangifer tarandus	1	2	*1*							1		4 *1*
cf. *Rangifer tarandus*		*2*	*1*						*1*			*4*
Bison sp.	1 *1*	3 *3*	1 *4*				*1*	3		*3*	1	9 *12*
cf. *Bison* sp.	*1*		2 *2*					1				3 *3*
Mammalia, Family?												
(Large mammals)	*5*	*27*	*26*	*1*	*3*	*3*		*8*	*11*	*9*		*93*
Cranial fragments	2	3	5	2	1			1	1	3		18
Mandible fragments								1	1			2
Scapula fragments	2	2	1	1								6
Vertebra fragments	2	3	1		2				1			9
Innominate fragments		1	1									2
Rib fragments	6	47	56	1	6	10	1	17	11	6		161
Distal metapodial			1									1
Long bone shaft fragments	64	294	332	18	34	40	9	60	69	50		970
Unclassifiable fragments	11	46	74	6	9	4	1	15	3	13		182
(Small mammals)		*1*	*1*									*2*
Cranial fragments		1										1
Mandible fragments			2					1				3
Vertebra fragments		1						1				2
Rib fragments			4						2			6
Long bone shaft fragments	11	40	40		3	1		23	1	3		122
Unclassifiable fragments		1	5			1		5	2			14
Total bones	105	488	586	33	64	61	16	149	97	77	1	1677
Total teeth	*13*	*46*	*61*	*2*	*4*	*3*	*1*	*18*	*12*	*15*		*175*
Total tusks	4	26	47		2	2		21	1	2		105
Grand totals	122	560	694	35	70	66	17	188	110	94	1	1957

N.B.: These numbers refer to fragments (not whole specimens or elements).

obtain the approximate lateral measurements shown in Fig. 6.1 but such distances for the upstream end have been estimated by examining aerial photographs.

Station 1. This is the north side of a gully about 365 m from the downstream end of M1V1-2. It was on this exposure that I found the first vertebrate fossils on Disconformity A in July 1977. In addition to 122 vertebrate fossils (Table 6.1), 23 lithic specimens and a sample of wood fragments were trowelled from the face at this station. A 20-bucket sample of the cross-bedded sands which cap the disconformity was collected here and at the adjoining portion of Station 2, and this sample was coarse-screened in the field in order to recover insect and microtine rodent fossils. The results will be reported elsewhere (Hughes, *et al.* 1980).

Station 2. This station is on the face of the bluff overlooking the river, and it has been intensively studied from several standpoints. An ice-wedge pseudomorph above Disconformity A and a large depression filled with contrasting sediment and detrital peat balls on Disconformity A will be described elsewhere. Detailed stratigraphic observations were made in a continuous section from the disconformity to the river by N.W. Rutter in 1977. The volcanic ash just below Disconformity A is concentrated in a major "pod" at this station, and it is above this pod at the upstream end of the station that the preserved gleysol profile has been observed. Most of the vertebrate fossils (Table 6.1) and 235 lithic fragments were recovered from Disconformity A where erosion had removed the original soil and produced the widespread contact of cross-bedded silts and sands on blue-grey silty clay. In addition one large mammal rib was found 3.55 m above Disconformity A at this station.

Station 3. This station is two "facets" downstream from Station 2 and has produced two vertebrate samples from widely separated contexts. The larger sample was trowelled from Disconformity A (Table 6.1) along with 144 lithic specimens and a lump of detrital lignite, and a much smaller sample with 17 lithic fragments was obtained from detrital organic sands immediately overlying the basal clay at the "foot" of the bluff (Table 6.3). Three buckets of the cross-bedded sands overlying Disconformity A were coarse-screened in the field and yielded a small sample of insect and microtine rodent remains which will be reported elsewhere (Hughes, *et al.* 1980). The volcanic ash, which is often difficult to find without on-the-spot microscopic aids, is preserved at Station 3 as a thin and discontinuous lens. The lower seven meters of this station were used to complete a stratigraphic column begun at the top of the bluff at neighbouring Station 7. It was necessary to move to Station 3 for the lower part of the profile due to accumulating overburden.

Station 4. This station is located at the head of a gully approximately 750 m above the downstream end and seen near the upstream limit in Fig. 6.1. No vertebrates have been collected at Station 4, but a complexly disturbed peat ca. 50-60 cm below the base of the upper lake clays has yielded a radio-carbon date of 41,100 ± 1650 B.P. (GSC-2574). On the basis of levelling to Station 5 as well as observations on the bedding of the sediments, I believe that this dated peat is several meters

Table 6.2. Distribution of vertebrate taxa by station at MlVl-2, mid-section deposit, Old Crow River, northern Yukon Territory. Roman style (1), bones; italics style (*1*), teeth; small numbers ($_{1}$), tusk fragments. All numbers refer to fragments.

Taxon Stations:	6	9	10	Totals
Pisces, Family?	4		9	13
Catostomus catostomus			1	1
cf. *Catostomus* sp.	1			1
Lota lota	1		2	3
cf. *L. lota*			1	1
Aves, Family?	1		1	2
Anatidae, Genus?	1	1	2	4
Bonasa umbellus			2	2
Ochotona sp.			1	1
Lepus arcticus	3	6 *5*	15 *5*	24 *10*
Marmota monax			3	3
Sermophilus parryi			3	3
Castor canadensis			*1*	*1*
Lemmus sibiricus		1	3	4
Dicrostonyx torquatus	1		*1*	1 *1*
Ondatra zibethicus	1		3 *1*	4 *1*
Microtus xanthognathus			1	1
Cricetidae, Genus?	2		5 *7*	7 *7*
Carnivora, Genus?			1	1
Canis cf. *lupus*			1 *1*	1 *1*
cf. *Mammuthus* sp.	1 $_{22}$	4 *5* $_{13}$	30 *6* $_{119}$	35 *11* $_{154}$
Equus cf. *(Plesippus) verae*			1	1
Equus sp.			4 *4*	4 *4*
cf. *Equus* sp.			*1*	*1*
Rangifer tarandus		*1*	1	1 *1*
Mammalia, Family?				
(Large mammals)			*17*	*17*
Cranial fragments		4	21	25
Mandible fragments			2	2
Scapula fragments			2	2
Vertebra fragments		1	4	5
Rib fragments	2	2	36	40
Long bone shaft fragments	13	26	144	183
Unclassifiable fragments	9	4	25	38
(Small mammals)				
Cranial fragments			2	2
Mandible fragment	1			1
Vertebra fragments			4	4
Phalange			1	1
Rib fragments			13	13
Long bone shaft fragments	7	5	29	41
Unclassifiable fragments	3	3	16	22
Total bones	51	57	389	497
Total teeth		*11*	*44*	*55*
Total tusks	$_{22}$	$_{13}$	$_{119}$	$_{154}$
Grand totals	73	81	552	706

higher in the profile than Disconformity A which was completely buried by slumped materials at Station 4.

Station 5. Located at the mouth of the Station 4 gully, this station provides our only secure basis for relating the radiocarbon-dated peat to Disconformity A. A small sample of vertebrate fossils and 10 lithic fragments were obtained from the disconformity at Station 5 (Table 6.1).

Station 6. At the downstream end of MlVl-2 is a long facet narrowly incised by two gullies and bounded on the upstream end by dense vegetation. A large ice-wedge pseudomorph on Disconformity A is of interest because it is clearly truncated by erosion and because its fill contained one fossil bone and small wisps of volcanic ash which were reworked into the wedge fill from the surrounding area. In addition to the small vertebrate sample (Table 6.1), Disconformity A yielded 49 lithic fragments. Nine meters deeper in the exposure and approximately 30 m downstream from the ice wedge pseudomorph a small sample of vertebrates (Table 6.2) and 13 lithic fragments were collected and assigned to the mid-section sample.

Station 7. Station 7 is the facet between stations 2 and 3 on the face of the bluff, and most of our attention here has been focussed upon stratigraphic description. A small vertebrate sample and 82 lithic fragments have been trowelled from Disconformity A (Table 6.1).

Station 8. This is on the south face of the gully in which Station 1 is located, and it has not produced a vertebrate sample partly because little effort has been devoted to the exposure except for stratigraphic description.

Station 9. This station, which is next upstream from Station 6, has produced a small vertebrate sample and 9 lithic fragments from Disconformity A (Table 6.1), a small component of the mid-section sample with 19 lithic fragments (Table 6.2), and a radiocarbon date of 38,800 ± 2000 (GSC-2756) on a detrital peat which sagged into an ice-wedge pseudomorph when the ice was melted by formation of the upper lake. A large tusk (cf. *Mammuthus* sp.) was found protruding from the bank about mid-way up the bluff upon our arrival in 1978 (see Canby 1979:344-345).

Station 10. This station is just upstream from Station 9 but has been separately designated because the flow from a gully high in the bluff prohibits a direct link between our excavations on either side. It is not at all difficult to correlate across the gully, however, and the bulk of our mid-section sample was obtained at this station (Table 6.2) along with 225 lithic fragments. The upper part of the exposure is covered by slumped materials.

Station 11. This is the facet just downstream from Station 3, and the upper portion is covered by vegetation. At the foot of the bluff we recovered most of the basal sample, including seven lithic specimens, at this station (Table 6.3). In addition a large sediment sample has produced a rich assemblage of insect fossils which will be reported elsewhere (Hughes, *et al.* 1980).

Table 6.3. Distribution of vertebrate taxa by station at MlVl-2, basal, Old Crow River, northern Yukon Territory. Roman style (1), bones; italics style (*1*), teeth. All numbers refer to fragments.

Taxon	Stations: 3	11	Totals
Equus sp.	4 *4*	2	6 *4*
Mammuthus primigenius		*1*	*1*
Mammuthus sp.		*1*	*1*
cf. *Mammuthus* sp.		11	11
Mammalia, Family?			
(Large mammals)			
Cranial fragment		1	1
Rib fragments		2	2
Long bone shaft fragments	6	16	22
Unclassifiable fragments		4	4
Total bones	10	36	46
Total teeth	*4*	*2*	*6*
Grand totals	14	38	52

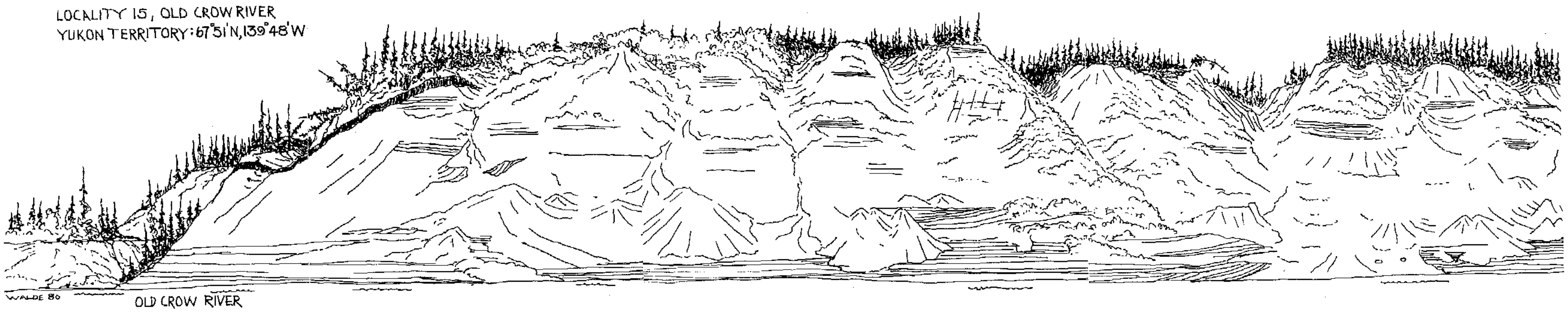
Table 6.4. Distribution of bone, tooth, and tusk fragments from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory.

Level	Bones	Teeth	Tusks	Totals
Disconformity A	1677 *1598*	175 *169*	105 *190*	1957
Mid-section	497 *576*	55 *61*	154 *69*	706
Basal	46	6		52
Totals	2220	236	259	2715

$\chi^2 = 158.3$; df = 2; P = 1.0 that χ^2 will not be exceeded

Expected frequencies in italics (basal sample omitted from test).

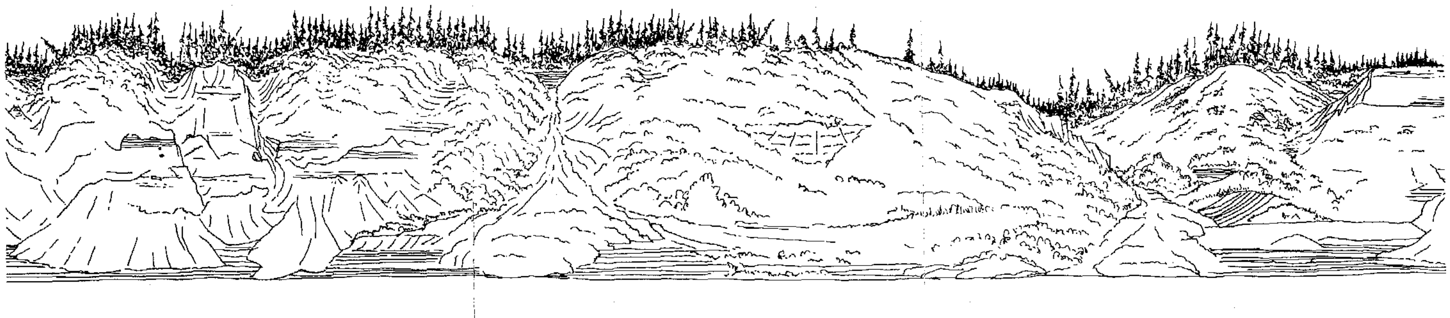
Stations: 6 9 10



← Downstream

0 50 100 m

Stations: 11 3



← Disconformity A

← Mid-section

← Basal

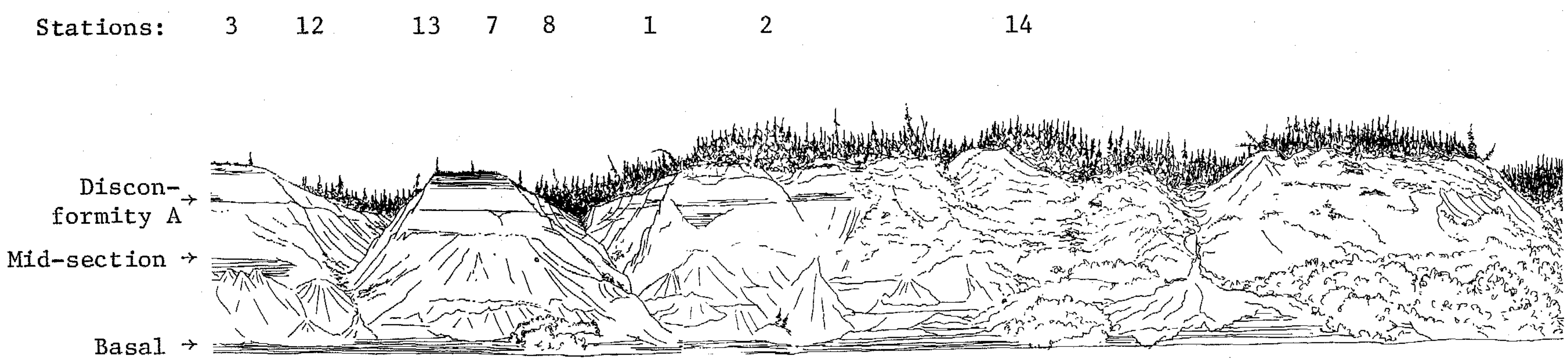


Fig. 6.1. Sketch of M1V1-2 (Location 15), Old Crow River, northern Yukon Territory, showing locations of stations and levels of excavation. Drawn by Keary Walde and reduced photographically.

Station 12. The south side of the gully between Stations 3 and 7 was extensively trowelled to recover a vertebrate sample from Disconformity A (Table 6.1) along with 85 lithic fragments. In addition, a single green-fractured bone was found on a textural contact 2.9 m above Disconformity A (one meter below the base of the upper lake), but additional specimens could not be found at that level.

Station 13. This is the north face of the same gully where 110 vertebrate fossils (Table 6.1) and 32 lithic fragments were recovered from Disconformity A. Of special interest is an ice-wedge pseudomorph on the "corner" between Stations 7 and 13 in which the sediments in the wedge contrast markedly in colour, texture, and structure with the surrounding and overlying sediments. I believe it is likely that this fill was derived from the gleysol which may have been widespread before Disconformity A was eroded. The wedge fill yielded 72 of the 110 vertebrate fossils and 24 of the lithic specimens. Pollen, plant macrofossils, and insect fossils have also been recovered from the wedge.

Station 14. Approximately 50 m upstream from Station 2 on the face of the bluff, the vegetation which consists mostly of "rhubarb" can be pulled away to permit excavation of Disconformity A. A modest vertebrate sample (Table 6.1) and 40 lithic fragments were collected by this means.

Station 15. This is at the extreme upstream end of the bluff where the face of the exposure is clearly reduced in height by recent erosion leading gradually downward to a terrace about 15 m high. Keary Walde reported on the last day of the 1978 field season that a large bone was in place on the face of this exposure, and I returned to the spot specifically for the purpose of confirming its stratigraphic position and collecting the specimen which proved to be a nearly intact *Bison* sp. humerus (Table 6.1). Since this is the largest bone yet found on Disconformity A it would be of some interest to explore the station more carefully in the future.

Having indicated in general terms what we have found at each of the stations at MlVl-2, we will not need to present each station separately in the description of the vertebrate remains. To do so would be to reduce the respective sample sizes below acceptable levels, and I have found no meaningful or systematic differences among the various station samples from a given stratigraphic unit. Therefore the total contents of Tables 6.1, 6.2, and 6.3, respectively, will become our units of analysis for descriptive purposes.

In describing the stations, I have mentioned various small sums of lithic specimens which accompanied the vertebrate remains, and these have been examined with respect to their lithology and fracture attributes. Despite such care I have been unable to recognize struck flakes among these specimens so there appears to be no direct evidence of a lithic industry in association with the MlVl-2 vertebrates. The lithology of the pieces does not appear to include unexpected rock types; all are native to the basin. The lump of detrital lignite from Station 3 may have been derived from an Eocene outcrop in the Johnson Creek valley.

Description of the Vertebrate Fossils

The vertebrate remains from M1V1-2 will be described with respect to the same categories used in Chapter 5: sample size, specimen size, permineralization and staining, vivianite and hematite, rounding, exfoliation and split lines, pitting, etching, fracture patterns, bone flaking, cutting, and polishing. An additional section on differential staining will be added, and a summary statement of the relative importance of each variable in the three samples will then point the way toward a synthesis of their taphonomic histories. Where appropriate, simple statistical tests will be used to identify the significance of differences among the samples. The chi-square test will be used in most comparisons, but the small basal sample has often been excluded because its expected frequencies are too low (see Siegal 1956:110). Whenever there are enough cells in the test to provide two or more degrees of freedom, the standard equation for chi-square has been used:

$$\chi^2 = \Sigma\frac{(o - e)^2}{e} = (\frac{o^2}{e}) - N \qquad (1)$$

Many of the tests which exclude the basal sample involve 2 X 2 contingency tables with only one degree of freedom, and these tests have been conducted with an equation which incorporates a correction for continuity (Siegal 1956:107):

$$\chi^2 = \frac{N(|AD - BC| - \frac{N}{2})^2}{(A + B)(C + D)(A + C)(B + D)} \qquad (2)$$

The appropriate equation is identified by number in the accompanying tables.

Since we believe that the three samples from M1V1-2 were obtained from quite different sedimentary environments which in turn reflect differences in geomorphology and previous burial history, it is of some interest to determine whether the taphonomic factors listed above are related to the burial environments from which the bones were recovered. Most of the chi-square tests in this chapter will be designed to examine this question and will test the following null hypothesis: *Variable x (e.g., vivianite, rounding, exfoliation, etc.) is independent of the differences in burial environment observed at M1V1-2.*

The results of all the tests are summarized in Table 6.21 which was devised to support the taphonomic reconstruction.

Sample Sizes

The three samples from M1V1-2 are summarized in Table 6.4 where the frequencies of bones, teeth, and tusk fragments have been arrayed. All subsequent tables will include only the bones from these three samples since the tooth and tusk fragments were found to exhibit little systematic

Table 6.5. Distribution of length measurements (mm) for bones from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory.

Taxon	Disconformity A				Mid-section				Basal			
	No.	Mean	S.D.	Range	No.	Mean	S.D.	Range	No.	Mean	S.D.	Range
Identified bones												
Pisces	22	22.5	10.5	12-45	19	24.9	14.0	10-69				
Aves	15	27.2	13.9	13-61	8	24.8	9.1	10-41				
Lagomorpha	14	25.7	27.5	7-117	25	32.1	21.4	10-94				
Sciuridae	8	22.3	15.1	6-46	6	20.8	6.3	13-32				
Castoridae	4	44.0	36.5	20-98								
Ondatra zibethicus	24	14.8	5.3	7-29	4	13.8	5.9	9-22				
Cricetidae	32	11.9	4.1	7-23	13	13.8	3.7	10-22				
Carnivora	6	25.0	14.1	12-50	2	56.0		19-93				
cf. *Mammuthus* sp.	25	65.8	30.1	23-118	35	112.6	106.7	45-650	11	119.4	71.6	48-247
Equus sp.	2	65.6		51.80	5	60.8	11.7	46-78	6	82.0	61.7	34-201
Rangifer tarandus	4	31.3	18.3	18-54	1	39						
Bison sp.	12	70.6	48.6	20-199								
Unidentified Large Mammals												
Rib fragments	161	22.7	16.2	5-120	40	37.6	26.0	5-109	2	74.5		57-92
Long bone fragments	971	17.8	10.4	5-109	183	28.3	17.2	5-171	22	37.2	15.6	10-74
Misc. fragments	37	33.6	14.2	13-68	34	29.4	17.4	10-79	1	63		
Unclassifiable	182	15.3	7.6	2-44	38	25.3	18.4	5-94	4	34.8	2.6	30-39
Unidentified Small Mammals												
Rib fragments	6	14.5	5.2	5-24	13	12.8	5.7	5-29				
Long bone fragments	122	10.1	5.1	1-34	41	12.7	5.5	5-29				
Misc. fragments	6	11.0	4.0	7-17	8	14.5	4.0	10-24				
Unclassifiable	14	9.9	6.1	1-24	22	8.8	3.3	5-19				
Totals	1667				497				46			

Table 6.6. Distribution of weight measurements (g) for bones from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory.

Taxon	Disconformity A				Mid-section				Basal			
	No.	Mean	S.D.	Range	No.	Mean	S.D.	Range	No.	Mean	S.D.	Range
Identified bones												
Pisces	22	0.3	0.5	0.01-1.8	19	0.5	0.8	0.02-3.5				
Aves	15	0.5	0.4	0.1-1.4	8	0.4	0.3	0.1-0.9				
Lagomorpha	14	1.1	2.6	0.1-10.1	25	1.1	1.0	0.1-4.3				
Sciuridae	8	0.4	0.3	0.1-0.9	6	0.5	0.3	0.2-0.8				
Castoridae	4	7.9	12.3	0.2-26.3								
Ondatra zibethicus	24	0.3	0.2	0.02-0.6	4	0.2	0.1	0.1-0.3				
Cricetidae	32	0.1	0.04	0.01-0.2	13	0.1	0.1	0.02-0.4				
Carnivora	6	7.1	14.9	0.1-37.4	2	3.4		0.4-6.5				
cf. *Mammuthus* sp.	25	33.5	38.2	2.9-130.5	35	321.0	1100.1	10.7-6265.0	11	423.4	751.2	28.6-905.2
Equus sp.	2	34.7		29.7-41.7	5	29.1	17.2	13.9-58.0	6	73.0	100.4	6.6-256.5
Rangifer tarandus	4	9.6	11.1	1.4-24.9	1	5.9						
Bison sp.	12	81.3	183.2	2.3-656.9								
Unidentified Large Mammals												
Rib fragments	161	1.2	2.3	0.05-17.8	40	4.6	7.2	0.1-35.3	2	32.9		18.2-47.7
Long bone frags.	971	1.0	2.2	0.02-35.7	183	3.3	10.7	0.1-140.4	22	9.1	11.4	0.3-33.8
Misc. fragments	37	5.7	7.7	0.3-29.0	34	3.6	5.1	0.2-20.2	1	5.7		
Unclassifiable	182	0.9	1.4	0.02-9.5	38	4.4	9.1	0.1-44.5	4	13.1	2.5	9.4-14.7
Unidentified Small Mammals												
Rib fragments	6	0.1	0.2	0.02-0.3	13	0.1	0.1	0.04-0.3				
Long bone frags.	122	0.1	0.1	0.01-0.4	41	0.1	0.1	0.03-0.4				
Misc. fragments	6	0.1	0.1	0.01-0.3	8	0.3	0.3	0.1-0.8				
Unclassifiable	14	0.1	0.1	0.01-0.4	22	0.1	0.1	0.02-0.4				
Totals	1667				497				46			

variation which would be useful in this analysis. Individual specimens of tooth and tusk will be mentioned under appropriate headings, but their overall distributions will not be tabulated.

The data in Table 6.4 reveal some interesting patterns. The basal sample is too small to include in a chi-square test, but the bone, tooth, and tusk frequencies from the other two levels were arranged in a contingency table and found to depart significantly from random. The frequencies of teeth are near expected values, but bone fragments are under-represented and tusk fragments over-represented in the mid-section deposit. I believe that this results from the recovery of more small bone fragments on Disconformity A where the sediments imply slow-moving water which would not remove so many of the small fragments. The somewhat higher energy fluvial environment of the mid-section deposit may have removed many of the smaller bone fragments and left behind the larger ones as a lag deposit. The higher frequency of tusk fragments could have resulted from greater weathering and fragmentation of large tusk pieces in the mid-section deposit with sediment loading possibly playing a role in the *in situ* fracture of tusk portions.

When the data in Tables 5.1 and 6.4 are compared, statistically significant differences can be noted between M1V1-7 and the Disconformity A and mid-section samples from M1V1-2. More teeth and tusks than expected have been found at M1V1-7, and their abundance is probably due to their greater density in relation to their volume which causes them to remain in lag deposits.

Specimen Sizes

The mean, standard deviation, and range for length and weight are provided in Tables 6.5 and 6.6, respectively. Some grouping of taxa (e.g., all fish, all birds, most rodents to family level) has been done to enlarge the sizes of the sub-samples and to simplify the presentation in these and later tables. It is apparent from inspection of Tables 6.5 and 6.6 that there is a tendency for both the length and weight of specimens to increase as one goes downward through the profile. This is especially noticable for the unidentified large mammal rib and long bone fragments where the numbers of specimens increase to significant levels. The smallest bones occur on Disconformity A, with larger specimens being found in the mid-section deposit and even larger ones in the basal sample. These observations are consistent with our interpretation of the sedimentary history of these units.

A somewhat more precise view of the specimen size distributions as measured by length is shown in Figs. 6.2 and 6.3. These histograms reveal not only the highly skewed character of the distributions but also the level of confidence which can be placed on the recovery of smaller items. The abrupt fall-off in the left tails of the histograms for Disconformity A (Station 3) and the mid-section sample (Station 10) suggest that many very small specimens were missed during trowelling of the sediments. We know that this is the case for Disconformity A where the matrix was sieved in the field to provide a large number of microtine rodent remains and fish scales (Morlan 1978c; Cumbaa, *et al.* 1980). The loss of small specimens is not likely to influence significantly the archaeological purpose of this presentation, but it must be borne in mind with respect to taphonomic and paleoecological reconstructions. The only bones included in the tables accompanying this report are those obtained by trowelling.

The left tail of the basal sample histogram does not fall off as abruptly as the others representing MlVl-2, but the sample size is too small to make a confident interpretation. A histogram has also been included in Fig. 6.3 for the MlVl-7 materials which were presented in Chapter 5. It shows a nearly symmetrical peak centered on 40-50 mm with a gradual decline in frequencies to both the left and the right and a very long tail for the larger size categories. This kind of distribution suggests that our recovery from MlVl-7 was reasonably good and that smaller specimens were probably carried farther downstream by Johnson Creek.

While on the subject of specimen size it is appropriate to mention the relative size of bones and lithic particles in these deposits. In general, large rocks are very rare in Old Crow Flats, and the fossil bones include some of the largest particles transported by the Old Crow River. This seems also to have been true of fluvial systems of the past in Old Crow Flats. The largest rock seen on Disconformity A at MlVl-2 is a quartzite pebble 56 mm long and weighing 64 g. The largest bone is a nearly intact bison humerus (at Station 15) 199 mm long and weighing 656 g. The lithic size range grades downward from pebbles through gravel to sand, silt, and clay, while the bones range downward in size to microtine incisors and fish scales. In the mid-section deposit, 10-12 m below Disconformity A, the largest rock observed was 55 mm long and 70 g in weight, while the largest bone is a nearly intact mammoth or mastodon femur which is 650 mm long and weighs 6265 g. We will return to a fuller discussion of the implications of these comparisons (see Chapter 9).

Taxon by taxon comparisons of length and weight among the MlVl-2 (Tables 6.5-6.6) and MlVl-7 (Table 5.2) specimens reveal that the latter are generally much larger than the former (see also Figs. 6.2-6.3). With few exceptions, both the means and the ranges are higher on the MlVl-7 bar than in the primary deposits at MlVl-2. This is particularly noticeable in the data for unidentified large mammals, and only the basal sample at MlVl-2 compares closely with the sample from MlVl-7. Statistical tests of these differences have not been attempted in view of the highly skewed nature of most of the distributions.

Permineralization and Staining

Processes of permineralization and staining at MlVl-2 appear to have been similar to those affecting bones elsewhere in the basin. That "typical" staining characteristics can be roughly defined for a given deposit is shown by the exceptions. In Table 6.7 are listed Munsell colour readings for bones from four samples from Disconformity A. Each sample is drawn from a single day's recovery of vertebrate fossils at

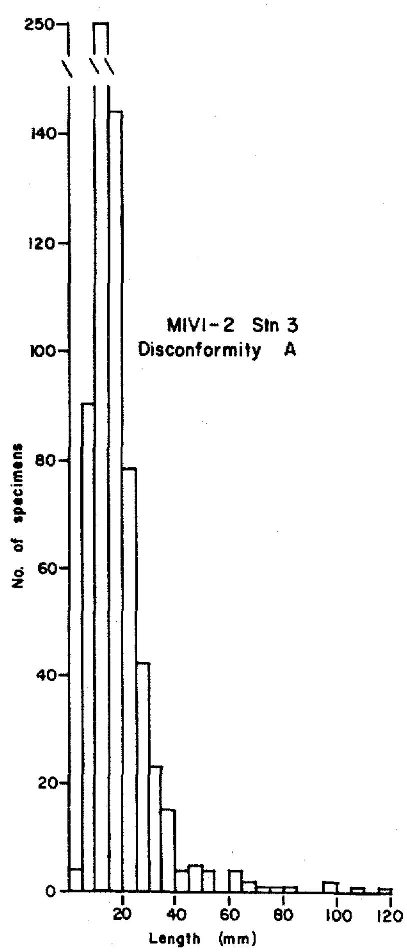


Fig. 6.2. Histogram of specimen length for Disconformity A at M1V1-2, Station 3, in 5 mm intervals.

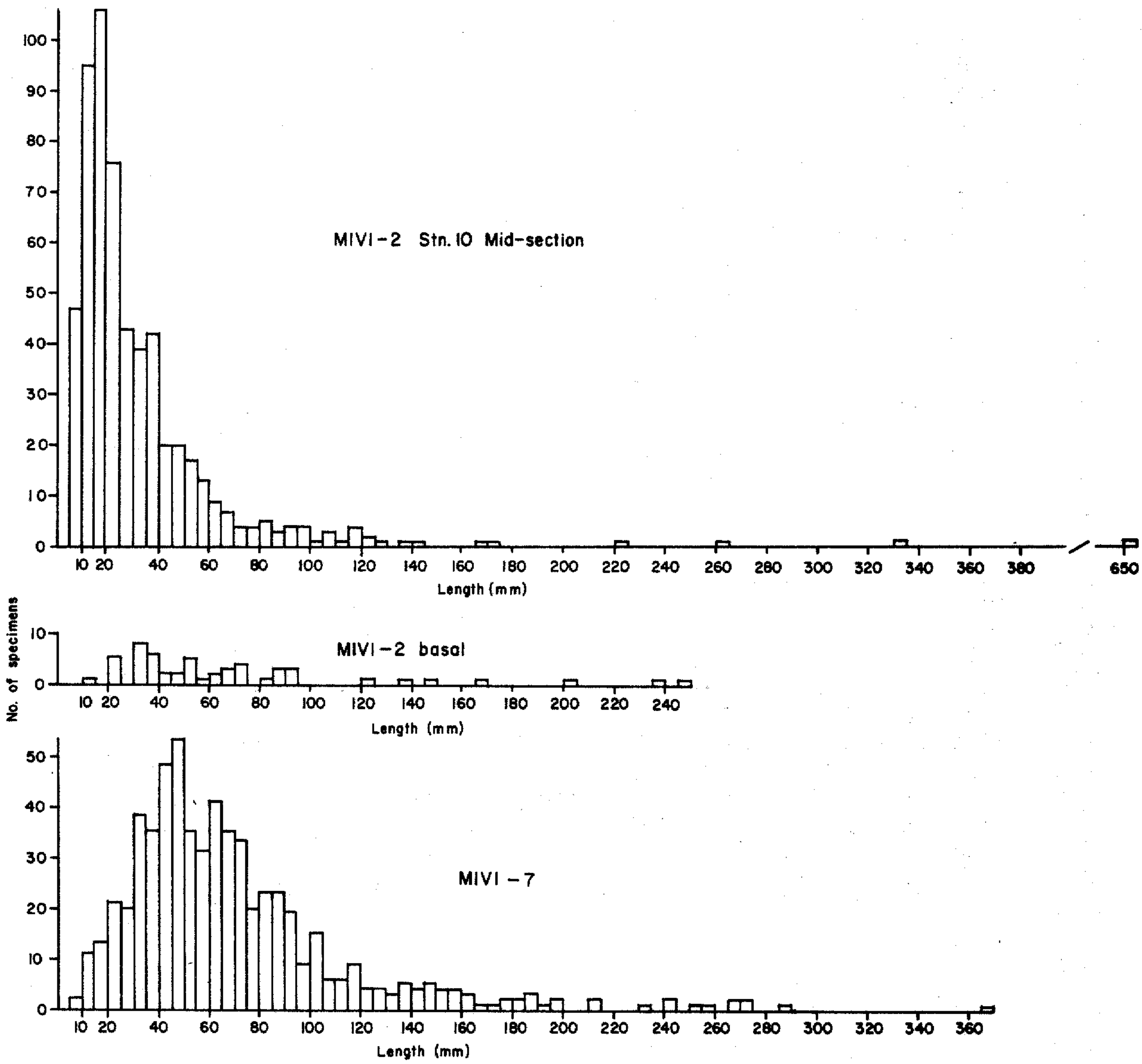


Fig. 6.3. Histograms of specimen lengths, in 5 mm intervals, for the Mid-section sample at M1V1-2, Station 10 (upper), the basal sample at M1V1-2 (middle), and the M1V1-7 bar (lower).

Table 6.7. Staining characteristics of bones from four samples recovered on Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory

Station	Sample No.	Light stain: Taxon and Element	Light stain: Colour	"Typical" stain: Taxon and Element	"Typical" stain: Colour
7	MlVl-2:11	Cricetid mandible	7.5YR5/6	Large mammal long bone	2.5YR3/2
2	MlVl-2:33	Cricetid ilium	7.5YR4/4	*Ondatra zibethicus* femur	2.5YR2/1
		Large mammal long bone	7.5YR4/4		
		Bison sp. phalange	5YR3/3		
3	MlVl-2:71	*Spermophilus parryi* mandible	5YR5/4	*Lepus arcticus*	7.5YR3/2
12	MlVl-2:107	*Spermophilus parryi* ulna	2.5YR4/4	*Ondatra zibethicus* mandible	2.5YR2/2

one station on the M1V1-2 exposure. All examples of noticeably light stain are included in Table 6.7 along with colour values for the "typical" stain seen on bones immediately adjacent to the light-coloured ones. It is noteworthy that four of the light-stained bones represent small rodents which could have introduced themselves to the sediment at a later time through burrowing (*Spermophilus*: ground squirrels) or through entering pre-existing burrows (the Cricetids). The bison phalange in sample 33 is intermediate in its colour, and the associated large mammal long bone fragment is the only light-stained megafaunal element in the M1V1-2 collection. Since it is believed that all these fossils have been moved to some extent by fluvial processes, some variation in permineralization and staining may have resulted from primary burial in variable sedimentary and edaphic environments.

Vivianite and Hematite

The distribution of vivianite varies markedly in the M1V1-2 deposits. Table 6.8 exhibits much higher frequencies of vivianite in the mid-section sample than in the other deposits, and the departure from randomness is highly significant. This indicates that our null hypothesis should be rejected and that the occurrence of vivianite should be regarded as a taphic or anataxic factor related to either primary or secondary burial environments.

Hematite was not systematically recorded during the M1V1-2 analysis because it was so seldom seen that its importance was not apparent until the M1V1-7 collection was examined. High frequencies of hematite were noticed in the basal sample at M1V1-2, but it was quite rare in the other two deposits.

Vivianite was much more common at M1V1-2 (Table 6.8) than at M1V1-7 (Table 5.3), and I have discussed possible reasons for this difference in the presentation of the M1V1-7 data.

Rounding

The same rounding classes were used for M1V1-2 as for M1V1-7: O, not rounded; S, slightly rounded; M, moderate rounding; and H, heavy rounding. Very few specimens from M1V1-2 (5% or less) are not rounded at all, and slightly rounded pieces account for 45-92% of the samples from each layer (Table 6.9). There is a clear trend toward heavier rounding in the deeper levels as would be expected in relatively high energy fluvial environments. A chi-square test of the distribution of the four classes on Disconformity A and in the mid-section deposit provided highly significant results which indicate a rejection of our null hypothesis and the adoption of the logically reasonable conclusion that rounding is related to the burial environment. The basal sample could not be tested in this way due to low expected frequencies.

In evaluating these data we should note that many very fragile specimens are extremely well preserved. For example, some of the microtine

Table 6.8. Distribution of vivianite on bones from three stratigraphic levels at M1V1-2, Old Crow River, northern Yukon Territory.

	Disconformity A			Mid-section			Basal		
Taxon	No.	Vivianite	None	No.	Vivianite	None	No.	Vivianite	None
Pisces	22	4	18	19	7	12			
Aves	15		15	8	6	2			
Lagomorpha	14	2	12	25	20	5			
Sciuridae	8		8	6	5	1			
Castoridae	4	1	3						
Ondatra zibethicus	24	3	21	4	4				
Cricetidae	32	2	30	13	8	5			
Carnivore	6	2	4	2	2				
cf. *Mammuthus* sp.	25	9	16	35	15	20	11	1	10
Equus sp.	2	1	1	5		5	6	4	2
Rangifer tarandus	4		4	1		1			
Bison sp.	12	1	11						
Unidentified Large Mammals									
Rib fragments	161	16	145	40	28	12	2		2
Long bone fragments	971	137	834	183	119	64	22	3	19
Misc. fragments	37	5	32	34	28	6	1		1
Unclassifiable	182	17	165	38	21	17	4		4
Unidentified Small Mammals									
Rib fragments	6		6	13	2	11			
Long bone fragments	122	4	118	41	30	11			
Misc. fragments	6	1	5	8	6	2			
Unclassifiable	14	1	13	22	16	6			
Totals	1667	206 *401*	1461 *1266*	497	317 *119*	180 *378*	46	8 *11*	38 *35*

Equation 1: $\chi^2 = 559$; df $= 2$; P $= 1.0$ that χ^2 will not be exceeded

Expected frequencies in italics

bones are in excellent condition despite our presumptive evidence of fluvial transport and despite the brittle character conferred by permineralization. Some of the fish bones are intact even though they are so thin as to be translucent (Cumbaa, *et al.* 1980). Perhaps the smaller specimens have travelled shorter distances than the larger ones. This could result from the reworking of primary deposits situated variable distances from MlVl-2. Some of the larger specimens could have originated at considerable distances from MlVl-2 and been introduced to associations with smaller pieces which had travelled relatively short distances. This view is supported by the fact that the larger mammal remains appear to account for the increased rounding observed with greater depth in these deposits. Perhaps the rounding is produced on the larger pieces because they can only be moved when the stream is in full flood as during spring breakup.

In general, I have the impression on the basis of the predominance of slightly rounded bones that most of our specimens have not been moved very far and that most of them may belong together as a death assemblage barring other (e.g. perthotaxic) factors which could alter the composition of the collections. It must be emphasized however, that the occurrence of moderately and heavily rounded pieces is a signal that a possibly significant number of elements has been introduced to these samples. This would appear to be a greater hazard in the mid-section deposit than on Disconformity A as would be expected from the differences in the sedimentary environments represented by the two levels.

The MlVl-7 bones are much more heavily rounded than those from MlVl-2. Comparisons between Tables 5.4 and 6.9 show that the MlVl-7 specimens are even more heavily rounded than the basal sample at MlVl-2 which is the most heavily rounded sample at the latter locality. Either the MlVl-7 specimens have been reworked more often or their reworking in the spring breakup of modern Johnson Creek (and formerly Old Crow River?) has subjected them to greater damage than that created by the ancient streams responsible for the deposition of the MlVl-2 samples. Both of these factors may have contributed to the remarkable and conspicuous rounding which is immediately noticeable on the MlVl-7 bones.

Exfoliation and Split Lines

The present and absence of exfoliation and split line features has been tabulated for all bones from MlVl-2 (Table 6.10). A close relationship would be expected between the occurrence of these weathering features and the time which elapsed before primary burial, but there are no independent data with which to test for such a relationship.

Chi-square tests of the exfoliation frequencies were predicated on our null hypothesis that exfoliation is independent of the burial environment. Test 1 in Table 6.10 suggests that the null hypothesis is quite weak with much of the departure from randomness being attributable to the small basal sample. When the basal sample is removed from the contingency table and the same test run on Disconformity A and the mid-section sample the result (Test 2, Table 6.10) indicates a failure to reject the null hypothesis. This outcome suggests that the burial environments of

Table 6.9. Distribution of rounding classes for bones from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory. O, not rounded; S, slightly rounded; M, moderately rounded; H, heavily rounded (see Chapter 5 for definitions).

	Disconformity A					Mid-section					Basal				
Taxon	No.	O	S	M	H	No.	O	S	M	H	No.	O	S	M	H
Identified bones															
Pisces	22	8	14			19	6	13							
Aves	15	2	13			8		7	1						
Lagomorpha	14		14			25	1	22	2						
Sciuridae	8	1	7			6		6							
Castoridae	4		4												
Ondatra zibethicus	24		24			4		4							
Cricetidae	32	3	29			13	2	11							
Carnivora	6		6			2		2							
cf. *Mammuthus* sp.	25		24		1	35	1	25	9		11		3	7	1
Equus sp.	2		2			5		5			6		5	1	
Rangifer tarandus	4	1	3			1			1						
Bison sp.	12	1	11												
Unidentified Large Mammals															
Rib fragments	161	2	156	2	1	40		33	6	1	2		1	1	
Long bone fragments	971	4	915	33	19	183		151	24	8	22	2	11	6	3
Misc. fragments	37	1	33	3		34	1	33			1		1		
Unclassifiable	182	16	157	6	3	38	6	24	7	1	4				4
Unidentified Small Mammals															
Rib fragments	6	1	5			13		5	8						
Long bone fragments	122	21	97	3	1	41	1	35	5						
Misc. fragments	6		6			8	4	4							
Unclassifiable	14	3	11			22	4	15	3	1					
Totals	1667	64	1531	47	25	497	26	395	65	11	46	2	21	15	8
Expected frequencies		*69*	*1484*	*86*	*28*		*21*	*442*	*26*	*8*					

Equation 1: $\chi^2 = 85.7$; df = 3; P = 1.0 that χ^2 will not be exceeded.

Table 6.10. Distribution of exfoliation and split line features on bones from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory. Exfol., exfoliation; S.L., split lines.

	Disconformity A					Mid-section					Basal				
Taxon	No.	Exfol.	None	S.L.	None	No.	Exfol.	None	S.L.	None	No.	Exfol.	None	S.L.	None
Identified bones															
Pisces	22	2	20	4	18	19	1	18	2	17					
Aves	15		15		15	8		8	3	5					
Lagomorpha	14		14	1	13	25	1	24	2	23					
Sciuridae	8		8		8	6		6		6					
Castoridae	4		4	1	3										
Ondatra zibethicus	24	2	22		24	4	1	3		4					
Cricetidae	32		32		32	13		13		13					
Carnivora	6		6	1	5	2		2		2					
cf. *Mammuthus* sp.	25	6	19	2	23	35	16	19	4	31	11	3	8	3	8
Equus sp.	2	2		1	1	5		5	2	3	6	3	3		6
Rangifer tarandus	4	2	2		4	1		1		1					
Bison sp.	12	3	9	1	11										
Unidentified Large Mammals															
Rib fragments	161	22	139		161	40	4	36	1	39	2	2			2
Long bone fragments	971	178	793	1	970	183	44	139	1	182	22	4	18	1	21
Misc. fragments	37	6	31	1	36	34	1	33		34	1		1		1
Unclassifiable	182	7	175		182	38	2	36		38	4		4		4
Unidentified Small Mammals															
Rib fragments	6		6	1	5	13		13		13					
Long bone fragments	122	4	118	3	119	41	2	39		41					
Misc. fragments	6		6		6	8		8		8					
Unclassifiable	14		14		14	22	1	21		22					
Totals	1667	234	1433	17	1650	497	73	424	15	482	46	12	34	4	42
Expected frequencies															
Test 1 Eq. 1		*240*	*1427*				*72*	*425*				*7*	*39*		
Test 2 Eq. 2		*236*	*1433*				*71*	*426*							
Test 3 Eq. 2				*25*	*1642*				*7*	*490*					

Test 1: $\chi^2 = 4.4$, df = 2, P = 0.889; Test 2: $\chi^2 = 0.085$, df = 1, P = 0.230; Test 3: $\chi^2 = 9.17$, df = 1, P = 0.998

P = the probability that χ^2 will not be exceeded.

Table 6.11. Distribution of pitting types (A, BF, BC) on bones from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory. See text for definitions of pitting types.

Taxon	Disconformity A No.	A	BF	BC	BF&BC	None	Mid-section No.	A	BF	BC	BF&BC	None	Basal No.	BF	BC	None
Identified bones																
Pisces	22					22	19			1		18				
Aves	15	1		3		11	8		1			7				
Lagomorpha	14		2	1		11	25	1		7		17				
Sciuridae	8		1	3		4	6			1		5				
Castoridae	4				1	3										
Ondatra zibethicus	24		1	2		21	4					4				
Cricetidae	32		2	1		29	13			1		12				
Carnivora	6		2	1		3	2					2				
cf. *Mammuthus* sp.	25	1		1		23	35	1	1			33	11			11
Equus sp.	2					2	5					5	6	1		5
Rangifer tarandus	4	1				3	1					1				
Bison sp.	12			3		9										
Unidentified Large Mammals																
Rib fragments	161	3	10	10	2	136	40	1	1	4		34	2			2
Long bone fragments	971	14	27	29	1	900	183	1	1	7	2	172	22	1		21
Misc. fragments	37		5	3	1	28	34	1	1	2		30	1		1	
Unclassifiable	182	3	6	7		166	38			1	1	36	4			4
Unidentified Small Mammals																
Rib fragments	6					6	13			1		12				
Long bone fragments	122	1	8	3		110	41		1			40				
Misc. fragments	6					6	8		1			7				
Unclassifiable	14		1			13	22					22				
Totals	1667	23	65	67	5	1506	497	5	7	25	3	457	46	2	1	43
Expected frequencies																
Type A Eq. 2		*22*				*1645*		*6*				*491*				
Type BF Eq. 2				*62*		*1605*				*18*		*479*				
Type BC Eq. 2				*77*		*1590*				*23*		*474*				

Type A: $\chi^2 = 0.18$, df = 1, P = 0.326; Type BF: $\chi^2 = 4.55$, df = 1, P = 0.967; Type BC: $\chi^2 = 1.22$, df = 1, P = 0.730

P = the probability that χ^2 will not be exceeded.

Disconformity A and the mid-section deposit are not closely related to the frequency of exfoliation but that the basal deposit may have undergone one or more cycles of sub-aerial weathering in addition to the period prior to primary burial. This suggestion is consistent with the high frequency of hematite staining which was mentioned above.

A somewhat different result is obtained from the split line data in Table 6.10. Chi-square test 3 indicates a significant difference between the frequencies of split lines on Disconformity A and in the mid-section sample and would seem to call for rejection of our null hypothesis. I suspect that our hypothesis is inappropriate because it does not take specimen size into account. As noted in Chapter 5 the occurrence of split lines is more reliably recorded on larger specimens and is less often visible on smaller ones. As will be seen below, most of the fractures observed on the M1V1-2 specimens were formed after the bones had been permineralized. It is quite likely (and sometimes demonstrable) that these fractures formed along split lines which originally began to develop as a result of sub-aerial weathering. Smaller specimen sizes must have resulted from more complete fracture along such split line networks so that fewer remaining split lines can be observed on the Disconformity A pieces than on those from the mid-section deposit.

In general it appears that the bones from M1V1-2 were not intensely weathered prior to burial, but it must be remembered that many of them are too small to reveal clear exfoliation patterns and that their small sizes may be in part a result of split line formation. The great majority of exfoliation features occurred on the outer cortical surfaces of the bones, but exfoliation on inner surfaces (in the medullary cavities of long bones), demonstrating that the bone was broken open during or prior to weathering, occurred on 27 bones on Disconformity A, seven specimens from the mid-section deposit, and two bones in the basal sample. In addition, two bones from Disconformity A revealed exfoliation features on their fracture surfaces.

Much higher frequencies of these sub-aerial weathering features are seen on the M1V1-7 specimens than on those from M1V1-2 (compare Tables 5.4 and 6.10). Some of the exfoliation at M1V1-7 may have resulted from repeated wet and dry conditions during reworking of the fossils, and the higher frequency of split line observation at M1V1-7 is undoubtedly related to the larger sizes of those specimens. Therefore it should not be assumed that the M1V1-7 specimens underwent more intensive sub-aerial weathering prior to primary burial than those from M1V1-2.

Pitting

The same types of pitting features described above for M1V1-7 were used in the analysis of the M1V1-2 specimens (Table 6.11). Disconformity A and the mid-section deposit do not differ significantly according to a chi-square test of their Type A pitting frequencies. Whether acids or some other agency are responsible for Type A pitting, it appears to be independent of the burial environments in which these specimens were found.

Type BC pits are regarded as important features since they are

Table 6.12. Distribution of etching on bones from three stratigraphic levels at M1V1-2, Old Crow River, northern Yukon Territory. O, outer surface; I, inner surface; F, fracture surface; OIF, all three surfaces, etc.

Taxon	Disconformity A									Mid-section								Basal		
	No.	O	I	F	OF	OI	OIF	Etched	None	No.	O	I	OF	OI	OIF	Etched	None	No.	O	None
Identified bones																				
Pisces	22	3						3	19	19	3					3	16			
Aves	15	3						3	12	8	2					2	6			
Lagomorpha	14	3						3	11	25	3					3	22			
Sciuridae	8	2						2	6	6	1					1	5			
Castoridae	4								4											
Ondatra zibethicus	24	3						3	21	4							4			
Cricetidae	32	8						8	24	13							13			
Carnivora	6	1						1	5	2							2			
cf. *Mammuthus* sp.	25	7			1	1		9	16	35	4			1		5	30	11	2	9
Equus sp.	2								2	5	1					1	4	6	1	5
Rangifer tarandus	4	2						2	2	1	1					1				
Bison sp.	12	4						4	8											
Unidentified Large Mammals																				
Rib fragments	161	27			4	1		32	129	40	3					3	37	2		2
Long bone fragments	971	77	3	2	5	13	13	113	858	183	6		1		2	9	174	22	1	21
Misc. fragments	37	15	2					17	20	34	3	3		1		7	27	1		1
Unclassifiable	182	13				2	1	16	166	38	3			3		6	32	4		4
Unidentified Small Mammals																				
Rib fragments	6								6	13							13			
Long bone fragments	122	6	1			1	1	9	113	41	3					3	38			
Misc. fragments	6								6	8							8			
Unclassifiable	14	3						3	11	22				1		1	21			
Totals	1667	177	6	2	10	18	15	228	1439	497	33	3	1	6	2	45	452	46	4	42
Expected frequencies								*209*	*1458*							*62*	*435*		*6*	*40*

Equation 1: $\chi^2 = 8.07$, df $= 2$, P $= 0.982$

thought to have been produced by carnivores, and their association with certain types of fractures influences our interpretation of the archaeological record. The distributions in Table 6.11 were tested by means of chi-square after adding together the bones on which Type BC pits and both Type BF and BC pits occurred. The results were not highly significant in the comparison of Disconformity A and the mid-section sample. Type BC pitting therefore seems to be independent of the burial environment as would be expected if it results from carnivore gnawing rather than some aspect of stream transportation.

As noted above, Bonnichsen (1979:29-30) recognized a ridge-and-valley surface morphology which he attributed to acid attack in his analysis of fossils from reworked deposits in the Old Crow basin, but I have not observed such features in the MlVl-2 samples possibly because of the smaller specimen sizes among the excavated collections. Type BF pitting will be discussed along with etching.

The frequency of all three types of pitting at MlVl-7 is approximately double that of MlVl-2, Disconformity A (compare Tables 5.5 and 6.11). This might seem to imply more acid attack, more rootlet etching, and more carnivore gnawing at the former than at the latter, but the larger specimen sizes at MlVl-7 may have afforded an opportunity to record the occurrence of these processes with greater accuracy. It is probably more important that the same kinds (if not the same percentages) of pitting were observed on the MlVl-2 specimens as had been defined for the sample from MlVl-7.

Etching

The distribution of etching patterns is shown in Table 6.12, and a chi-square test of the overall frequencies on Disconformity A and in the mid-section sample gave a significant result. This was an unexpected result and required rejection of the null hypothesis that etching is independent of the burial environment. Assuming that Type BF pitting has been correctly attributed to rootlet attack, a similar result would be expected from its distribution (Table 6.11), and this was confirmed by the chi-square test ($P = 0.967$ that χ^2 will not be exceeded). The significant differences between these two samples result from more etching and Type BF pitting than would be expected by chance in the Disconformity A sample and less than expected in the mid-section deposit. The bones on Disconformity A may have spent more time in stable soils where plant growth could lead to the development of these features than those in the mid-section deposit which may represent a sample reworked from positions like those on Disconformity A.

Another aspect of etching which deserves comment is its location on the outer, inner, and fracture surfaces of the bones. Most of the bones are etched only on their outer surfaces, but etching in the medullary cavity can occur if roots are able to grow through the unbroken cylindrical shaft or if the shaft is broken open to expose the medullary cavity. Obviously the occurrence of etching on a fracture surface indicates that the fracture occurred prior to plant rootlet attack. These distributions are also shown in Table 6.12 where it is evident that many more bones on

Table 6.13. Distribution of fracture patterns for bones from three stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory. 0/0, intact bone; o/y, post-dessication or post-permineralization fracture; x/y, green bone fracture.

Taxon	Disconformity A No.	Disconformity A 0/0	Disconformity A 0/y	Disconformity A x/y	Mid-section No.	Mid-section 0/0	Mid-section 0/y	Mid-section x/y	Basal No.	Basal 0/0	Basal 0/y
Identified bones											
Pisces	22		22		19	2	17				
Aves	15	1	10	4	8		8				
Lagomorpha	14	1	12	1	25	4	14	7			
Sciuridae	8	1	7		6	1	4	1			
Castoridae	4		4								
Ondatra zibethicus	24	3	21		4	1	3				
Cricetidae	32	2	30		13		13				
Carnivora	6	1	5		2	1	1				
cf. *Mammuthus* sp.	25		13	12	35	1	32	2	11	2	9
Equus sp.	2		1	1	5		4	1	6	1	5
Rangifer tarandus	4		4		1		1				
Bison sp.	12	1	6	5							
Unidentified Large Mammals											
Rib fragments	161		122	39	40		35	5	2		2
Long bone fragments	971		817	154	183		159	24	22		22
Misc. fragments	37		37		34	1	33		1		1
Unclassifiable	182		181	1	38		38		4		4
Unidentified Small Mammals											
Rib fragments	6		6		13		11	2			
Long bone fragments	122		101	21	41		31	10			
Misc. fragments	6		6		8		8				
Unclassifiable	14		14		22		22				
Totals	1667	10	1419	238	497	11	434	52	46	3	43
Expected frequencies											
Test 1 Eq. 2	*1657*		*1433*	*224*	*486*		*420*	*66*			
Test 2 Eq. 2	*1393*		*1196*	*197*	*334*		*287*	*47*			

Test 1 (all fractured bones): $\chi^2 = 4.0$, df = 1, P = 0.955

Test 2 (fractured large mammal bones): $\chi^2 = 6.6$, df = 1, P = 0.990

Disconformity A (but not a significantly higher percentage) were broken prior to plant rootlet attack than in the mid-section deposit. Of more importance is the specific occurrence of etching on fracture surfaces which is seen on 6.7% of the bones in the mid-section deposit and on 11% of the bones on Disconformity A. This difference is parallel to the difference in fracture patterns (see below), and the complete absence of inner or fracture surface etching in the basal sample is consistent with the absence of fresh bone fractures at that level.

Etching was observed on 15% of the M1V1-7 bones (Table 5.5) as compared with 13.7% from M1V1-2, Disconformity A and about 9% in the other two samples from M1V1-2 (Table 6.12). The location of etching reveals a significant difference between the M1V1-7 and M1V1-2 samples with 30.1% of the specimens from M1V1-7 exhibiting etching on fracture surfaces (compared with only 11.8% from Disconformity A). This higher figure might be attributed in part to the larger specimen sizes which permit the more realistic appraisal of individual pieces, but it would also appear that more green fractured bones from M1V1-7 were originally buried in stable plant-supporting deposits than may have been the case for the M1V1-2 specimens.

Fracture Patterns

The distribution of fracture patterns in the bones from M1V1-2 is shown in Table 6.13. Chi-square tests of the Disconformity A and mid-section frequencies indicate significant differences in these distributions regardless of whether all bones or only large mammal bones are considered. This result might be taken to mean that the fracture patterns are related specifically to the burial environment, but such an interpretation seems unlikely. One would expect fewer intact bones in the higher energy sedimentary environment of the mid-section deposit than on Disconformity A, and the opposite pattern is actually observed in both absolute numbers and percentages. Furthermore, since these samples are believed to have been reworked from their primary sites of deposition, the influence of the sedimentary environment should be to induce higher frequencies of post-permineralization fractures as the energy of that environment increases. One might suppose that such an effect is visible in these data in that the mid-section deposit contains more non-green fractures than expected while Disconformity A contains more green fractures than expected.

It is difficult to determine precisely when the post-permineralization fractures occurred. They could have occurred in the primary burial environment or in the secondary environment from which we excavated them. There is little indication of differential weathering of various fracture surfaces despite the fact that truly recent breaks, such as those produced during excavation and handling, are conspicuous for their lighter colour, contrasting surface textures, and lack of weathering. That some fractures occurred at the time of deposition at M1V1-2 is apparent from the frequent reconstructions which could be made during analysis. One nearly intact mammoth femur in the mid-section deposit was probably broken by the weight of the overlying sediment and has been reconstructed from 22 pieces. Several mammoth bone pieces were reconstructed from as

Table 6.14. Distribution of carnivore alteration features on bones from two stratigraphic levels at MlVl-2, Old Crow River, northern Yukon Territory. Only those taxa which contain green bone fractures (x/y) are listed here. The three types of alteration shown for green bone fractures (pitting, scoring, chipping) cannot be summed since one bone can occur in all three columns. Lg., large; Sm., small; Mam., mammal; Lbf, long bone fragment; Uncl. unclassifiable

				0/y			Green bone fracture (x/y)					
	Taxon	Total Bones	0/0	Type BC Pitting	None	0/y Total	Type BC Pitting	Scoring	Chipping	Altered Total	None	x/y Total
Disconformity A	Anatidae G. sp.	10	1		5	5	3			3	1	4
	Lepus arcticus	12	1	1	9	10		1		1		1
	cf. *Mammuthus* sp.	25		1	12	13					12	12
	Equus sp.	2			1	1					1	1
	Bison sp.	12	1	1	5	6	2			2	3	5
	Lg. Mam. Ribs	161		7	115	122	7	6	8	10	29	39
	Lg. Mam. Lbf	971		14	803	817	16	19	14	19	135	154
	Lg. Mam. Uncl.	182		7	174	181					1	1
	Sm. Mam. Lbf	122		1	100	101	5	8	10	18	3	21
	Totals	1497	3	32	1224	1256	33	34	32	53	185	238
	Expected freq.	*1494*		*71*	*1185*	*1256*				*14*	*224*	*238*
	Equation 2	$\chi^2 = 141.4$, df $= 1$, P $= 1.00$										
Mid-section	*Lepus arcticus*	24	4		13	13	6	6	5	7		7
	Marmota monax	3			2	2	1	1	1	1		1
	cf. *Mammuthus* sp.	35	1		32	32					2	2
	Equus sp.	5			4	4					1	1
	Lg. Mam. Ribs	40		2	33	35	2	2	2	2	3	5
	Lg. Mam. Lbf	183		4	155	159	5	4	4	5	19	24
	Sm. Mam. Ribs	13			11	11	1	1	2	2		2
	Sm. Mam. Lbf	41			31	31		3	7	9	1	10
	Totals	344	5	6	281	287	15	17	21	26	26	52
	Expected freq.	*339*		*27*	*260*	*287*				*5*	*47*	*52*
	Equation 2	$\chi^2 = 112.7$, df $= 1$, P $= 1.00$										

P = the probability that χ^2 will not be exceeded.

many as seven fragments found near one another on Disconformity A. These opportunities also demonstrate that the remains have not been further disturbed since their burial at MlVl-2. None of the reconstructions involved the reuniting of fractures made when green, although several remnants of green fracture surfaces were realigned by the reassembly of pieces separated after permineralization (Pl. 6.1). It seems, then, that the major contribution to the difference in fracture patterns is made by the green bone fractures which are overrepresented on Disconformity A.

An important aspect of the fracture pattern analysis is the relationship between fracture pattern and evidence for carnivore alterations. By constructing contingency tables with the distribution of Type BC pitting (Table 6.11) and the occurrence of green bone fractures (Table 6.13), chi-square tests of their associations can be examined. The results are highly significant ($P = 1.0$ that χ^2 will not be exceeded) for both Disconformity A and the mid-section sample. The association of carnivore chewing and green bone fracture is even more apparent when other gnawing features are considered. For example, some of the bones which lack Type BC pitting exhibit ragged scoring marks, perforations, scooped epiphyses, or small flake scars (chipping) associated with the fracture margins, and these features elevate the observable occurrence of carnivore alterations well above the totals for Type BC pitting. All the bones which were interpreted as having been fractured when green were reexamined and coded for these additional signs of carnivore activity, and the results are shown in Table 6.14. Nearly all the small mammal and bird bones which were fractured when green exhibit signs of carnivore alteration, but none of the mammoth and horse bones and only two of the bison bones (a phalange and an ilium fragment) exhibit such features. For the unidentified large mammal remains it is to be expected that higher percentages of carnivore alterations would appear among the ribs than among the long bone fragmens. Many of these pieces may represent caribou and other relatively small ungulates which are known to have their skeletal elements extensively damaged by carnivores.

The wall thickness of each bone which was fractured when green was measured adjacent to the fracture surface, and the results for all large mammal bones are shown in Table 6.15. In view of the generally small sample sizes and rather large standard deviations, these statistics have not been subjected to testing for significant differences. Inspections of the means and ranges reveal a tendency for not-chewed bones to be thicker than chewed ones, but there are exceptions as in the case of the large mammal ribs from Disconformity A. None of the carnivore-altered bones is thicker than 10 mm, and all but one of the mammoth bones is thicker than 10 mm. For all other taxa, the wall thickness ranges overlap between bones believed to have been chewed by carnivores and those which are not demonstrably chewed. It is not possible to demonstrate that the chewing of a given bone was responsible for its fracture, and the figures in Table 6.15 can only be regarded as approximate limits for the frequencies of carnivore-induced fractures. Mammoth bones showed no signs of chewing in association with green fractures, and their thicknesses seem generally to lie outside the range of fracture capabilities of carnivores.

Table 6.15. Metric data for bone wall thickness in bones fractured when green from two stratigraphic levels at M1V1-2, Old Crow River, northern Yukon Territory.

		Bones chewed by carnivores				Bones not demonstrably chewed by carnivores			
	Taxon	No.	Mean	S.D.	Range	No.	Mean	S.D.	Range
Disconformity A	cf. *Mammuthus* sp.					12[1]	15.0	5.1	7.9-23.0
	Equus sp.					1	7.3		
	Bison sp.	2	5.3		3.3-7.2	3	10.9		4.0-17.2
	Lg. Mam. Ribs	10	3.7	2.0	1.5-8.0	29	3.1	1.3	1.3-7.9
	Lg. Mam. Lbf	19	5.5	1.8	2.4-9.4	124[2]	5.7	2.2	1.8-13.4
	Lg. Mam. Uncl.					1	5.3		
	Totals	31				170			
Mid-section	cf. *Mammuthus* sp.					1[3]	12.4		
	Equus sp.					1	9.5		
	Lg. Mam. Ribs	2	4.5		3.0-5.9	3	5.9		4.8-6.6
	Lg. Mam. Lbf	5	6.1	2.4	3.1-9.3	19	6.7	3.0	2.6-14.3
	Totals	7				24			

[1] All 12 specimens are long bone fragments
[2] Eleven flakes not included due to thinning of the walls
[3] This specimen is a rib fragment; one flake is omitted due to thinning of the wall

On the basis of these observations, twelve mammoth long bone fragments from Disconformity A are advanced as evidence of a fracturing agency other than carnivore gnawing. Most of these specimens preserve orientation features on the fracture surfaces which indicate that fracture fronts have intersected from more than one direction to induce the form of the pieces preserved in the collection (Pl. 6.2). These features imply that the fragments have resulted from multiple impacts delivered to the shafts of mammoth long bones. The only fracturing agency which I have been able to identify which is likely to produce such a combination of attributes is man, and the twelve specimens in question are therefore identified as results of artificial fracturing (Table 6.16). Many of the smaller long bones may also have been broken by man, but they cannot be confidently separated from those believed to have been broken by carnivore gnawing.

A much higher frequency of green bone fractures was observed among the MlVl-7 specimens (Table 5.6, 25.4%) than among those from MlVl-2, Disconformity A (Table 6.13, 14.3%) or the mid-section deposit (Table 6.13, 10.5%). The green bone fractures occurred exclusively on large mammal bones and were particularly abundant among the mammoth long bone fragments and the unidentified large mammal long bone fragments at MlVl-7.

Bone Flaking: "Cores"

Nine flaked bone fragments have been recovered from Disconformity A at MlVl-2 (Pl. 6.3-6.5). Six were flaked longitudinally, three were flaked transversely, and three exhibit interesting alterations in addition to their flake scars. Only one of these specimens is a possible mammoth bone, and the others are long bone and rib fragments from unidentified large mammals, smaller than mammoths. In fact most of these specimens are so small that it is difficult to imagine how they could be manipulated by human hands, and it is relatively easy to imagine that they could be "flaked" by carnivore gnawing. None of these pieces exhibits unequivocal carnivore-induced scrapes or pits. In order to demonstrate forcefully just how confusing the activities of carnivores can be in interpreting samples of fossil vertebrate material, I have described each of these specimens as a "core" (Table C1-C2), and in Appendix C I have indicated the likelihood that each piece was naturally or artificially modified.

In a preliminary treatment of these specimens I classified all of them as artifacts (Morlan 1979b); here I have been less optimistic. Six of them have been classified as probably natural results of carnivore activity, two could have been altered either naturally or artificially, and only one exhibits alterations which are probably artificial.

Bone Flaking: Flakes

The attributes of 10 flakes from Disconformity A and one example from the mid-section deposit are displayed in Table 6.17. None of these specimens exhibits carnivore alterations, but all of the flakes from Disconformity A are probably within the range of potential carnivore "flake production" (chipping). All but two of these are classified as probably natural, and the two exceptions have been placed in the natural or artificial column because of the large size and proboscidean origin

Table 6.16. Attributes of green-fractured mammoth long bone fragments from M1V1-2, Disconformity A, Old Crow River, northern Yukon Territory.

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Other
1/4	M1V1-2:5-1	(36)	(11)	(11)	2.9	>10.5	
1/4	39-1	(113)	(80)	(82)	114.3	13.5-21.5	Reconstructed from 7 frags.; Pl. 6.1
1/4	42-1	(111)	(59)	(62)	88.2	10.2-21.1	Reconstructed from 7 frags.; Pl. 6.1
1/4	43-20	(23)	(14)	(15)	2.5	>13.2	Etched on fracture
1/4	61-1	(25)	(16)	(15)	5.0	>20.1	
1/4	83-1	(41)	(11)	(11)	4.4	>10.8	
2/3	85-1	40	(20)	(20)	5.7	10.0-14.5	Etched on fracture
2/3	105-9	(59)	23	24	8.4	15.1-19.2	Polished edge
3/4	29-2	(29)	14	14	3.2	>12.7	
3/3	79-2	40	15	15	4.5	>10.9	
3/3	102-1	118	52	52	74.1	12.4-15.8	Pl. 6.2
4/4	105-11	101	60	77	130.5	14.4-21.4	Polished edge; Pl. 6.2
	N	4	5	5	12	12 12	
	Mean	74.8	32.8	36.4	37.0	12.8 16.0	
	S.D.	40.7	21.6	27.4	49.7	2.9 4.4	

(measurements in parentheses not included in calculations)

Table 6.17. Attributes of ten flakes from Disconformity A and one flake from the mid-section deposit at M1V1-2, Old Crow River, northern Yukon Territory.

P.E.	D.E.	Length	Chord	Perim.	Thick.	Weight	P.A.	P.S.	V.C.	Cat. No.	Other
Disconformity A											
1	5	(54)	25	25	4.1	3.5	NM			M1V1-2:12-1	Prob. mammoth bone; Pl. 6.6
1	5	(13)	11	11	3.1	0.4	NM			99-3	
1	5	(7)	12	12	1.8	0.1	NM			112-1	Pl. 6.6
1	4	(18)	36	37	6.9	2.9	NM			114-13	Transverse flake
1	5	(10)	4	4	2.3	0.1	NM			117-1	
2a	5	13	14	16	6.0	0.5	NM			66-6	Pl. 6.6
4	4	26	12	12	5.6	1.2	30°	2/2		79-4	Pl. 6.6
4	1	(16)	14	14	5.7	1.2	55°			79-5	
4	5	18	16	16	3.4	0.6	40°			91-4	
4	5	9	14	14	3.6	0.2	50°			119-2	
N		4	10	10	10	10					
Mean		16.5	15.8	16.1	4.3	1.1					
S.D.		7.3	8.8	9.0	1.7	1.2					
Mid-section											
1	4	(96)	19	27	14.9	24.5	NM		10%	144-38	Mammoth long bone; Pl. 6.7

Legend

P.E. (proximal end): 1, recent fracture; 2a, platform lost because flake snapped at time of detachment; 4, platform remnant is an unmodified green fracture surface.

D.E. (distal end): 1, recent fracture; 4, hinged; 5, feathered.

P.A., platform angle; NM, not measurable; P.S., previous scars; V.C., ventral cancellous tissue

(See discussion of flakes in Appendix B for explanations of these attributes)

Table 6.18. Attributes of fractured ivory fragments from MlVl-2, Old Crow River, northern Yukon Territory.

Cat. No.	Length	Width	Thick.	Weight	No. of faces Fractured	Orientation of transverse axis
Disconformity A						
MlVl-2:25-4	6	10	2.3	0.1	1	Circumference
107-10	38	14	3.9	1.3	2	Radius
Mid-section						
129-8	29	11	4.7	1.2	1	Radius
142-39	13	10	4.3	0.3	2	Circumference
162-7	109	15	9.2	11.0	2	Diagonal to radius

(12-1; Pl. 6.6d) or because of the repeated flaking from one platform (79-4; Pl. 6.6c).

The flake from the mid-section deposit exhibits a well developed rib on its ventral face (Pl. 6.7). This evidence of massive dynamic loading, the considerable length of the piece, and its derivation from a proboscidean long bone prompt me to classify it as an artifact. In fact this flake, when complete, may have been an excellent cutting implement for a variety of butchering functions.

Fractured and Flaked Ivory

Two of the 105 tusk fragments from Disconformity A and three of the 154 specimens from the mid-section deposit differ from the others in exhibiting flat or conchoidal fracture surfaces on one or more faces. Their attributes are listed in Table 6.18 where the orientation of the transverse axis of each fragment is given in relation to the original structure of the tusk. Most of the ivory fragments from MlVl-2 would be classified as having transverse axes in the tusk circumference since they are pieces which have been removed from the tusk by delamination during weathering and fluvial transport. The two specimens in Table 6.18 with this orientation are struck flakes which exhibit the usual ventral face characteristics of conchoidal fracture. The other three pieces in Table 6.18 have their transverse axes parallel or diagonal to the tusk radius. I have no idea what created these pieces, and I suppose that they could be either natural or artificial.

MlVl-2:131-1 is a more complex piece of modified tusk ivory from the mid-section deposit (Pl. 6.8). The inner side is a normal delamination surface, but the outer surface is complexly cratered by at least five concavities which resemble flake scars. These scars lie in the middle of the ivory surface rather than originating from a flakable edge. Orientation features in the scars suggest that the flakes were detached by transverse and diagonal forces. The specimen measures 126 X 49 X 14.4 mm, weighs 78.5 g, and the largest flake scar is 18 mm long and 35 mm wide. A possible explanation for this kind of modification involves a chisel and hammerstone approach to flake detachment as reconstructed experimentally by Semenov (1964:Fig. 74-7) and Jelínek (1975:Fig. 277) on the basis of central European Paleolithic materials. Since such specimens are apparently known in archaeological sites elsewhere in the world, I have classified this piece as probable artifact.

Bones with Reduced and Incised Surfaces

The same surface incision and reduction concepts described in Chapter 4 and Appendix B were used in evaluating the bones from MlVl-2. Three scratched, three scraped, and 15 polished bones were recovered from MlVl-2, but no ground specimens have been observed. They are described individually in Appendix C (see Table C3). In ten cases I cannot find a criterion which points toward either a natural or an artificial origin for the alterations seen on these specimens, but five of the pieces exhibit features which suggest natural causes while six specimens were probably altered by man.

Of three scratched bones from Disconformity A, one has been classified as either natural or artificial, and the other two exhibit probably artificial alterations which are quite complex (Table C3, Pl. 6.9).

Three scraped bones from Disconformity A include two with either natural or artificial alterations and a third on which the attributes suggest the use of a rib as a cutting and rubbing implement which is therefore classified as probably artificial (Table C3, Pl. 6.10-6.11).

Of the fifteen polished bones, twelve from Disconformity A include three with probably natural alterations and seven with either natural or artificial alterations (Table C3, Pl. 6.11-6.12). The other two are green fractured mammoth long bone fragments with polished edges (Pl. 6.2) which might have been used in a cutting or scraping function and are therefore classified as artificial (as were the fractures).

The polish on two of the bones from the mid-section deposit at MlVl-2 is probably natural, but a third specimen exhibits such a complex polished tip that I suspect an artificial origin for the alteration.

Three cut bones from Disconformity A and one example from the mid-section deposit are described in Appendix C, and all four specimens were artificially cut with stone tools (Pl. 6.13-6.15). Three of the four are easily understood as butchering scars, but the fourth, from Disconformity A, exhibits a complex cut pattern suggestive of artistic expression. Although I would not hazard a firm interpretation of this piece, I would be remiss if I did not report that I recently made a crude sketch of the cut pattern from memory at a public lecture, and a member of the audience (Ms. Ruth Kirwan of Ottawa) pointed out that the design bears a striking resemblance to a stylized lateral view of a mammoth. Ever since, I have been unable to examine the specimen without seeing the "mammoth" every time, and Plate 6.13 has been oriented to encourage a similar perception of the part of the reader of this report.

Grooved Tooth

A fragment of interior enamel, measuring 18 X 11 X 1.4 mm (0.3 g), from an unidentified large mammal cheek tooth exhibits a pattern of grooves which at first glance appear to be cuts (Pl. 6.16). The "cuts" must have been produced either during or after the separation of the tooth into fragments. Noone who has seen this specimen can think of a natural agency which could produce the fine, perfectly formed lines which make a roughly radial pattern on this piece of enamel. On the other hand, Dr. George Swinton assures me that no human being lacking metal tools and vice-like stabilizing supports could possibly produce such perfect lines even in materials of less hardness than enamel. I have attempted to replicate the specimen by shattering weathered caribou teeth with an antler billet, and the results are equivocal; a somewhat similar pattern of radiating lines can be made, but the lines have entirely different cross-sections and intersections than seen on the fossil specimen. In the absence of an explanation I must classify the alteration as either natural or artificial.

Polished Tusk

Two pieces of tusk from the mid-section deposit are probably part of the same original specimen (Pl. 6.17). The larger piece (MlVl-2:142-37: 210 X 43 X 12.9 mm, 100.9 g) is differentially polished on a fracture surface which formed one end of the specimen. The piece is from the circumference of the tusk, and the outer surface is a typical delamination surface; the polished fracture surface was originally in the interior of the tusk. The polish covers an area 112 mm long and extends around the transverse end of the specimen where a small platform remnant represents the locus of flaking. One corner of this end has been removed by a relatively recent longitudinal fracture, and MlVl-2:162-8 (47 X 13 X 5.5 mm, 2.7 g) is probably part of this missing corner. The size, curvature, and high degree of polish on 162-8 permit its placement in the missing corner area, but the two pieces cannot be jointed due to missing material. The excellent condition of these ivory specimens is unique in the mid-section deposit where most tusk fragments were very brittle and readily delaminated upon handling. The polishing of these pieces must have been completed when the ivory was fresh since delamination of the polished area has been very slight but has significantly interrupted the continuity of the darkly stained polish. I believe that this specimen can only be interpreted as a rubbing tool on which the polished area is the working end. Such a tool might have served as a flesher or hide scraper. I doubt that a natural agency could produce such high polish without other kinds of damage, especially given the differential distribution of the polish and the rounding of the edge at the presumed working end. The two fragments have been classified together as a single artifact.

Differential Staining

A category of bone alteration which might indicate human activity at MlVl-2 is inferred very tentatively on the basis of differential staining. Seven small bone fragments from Disconformity A (MlVl-2: 35, 49-1, 61-37, 66-11, 75-5, 77-2, 112-3) exhibit areas of darker stain which contrast with other surfaces on the same pieces. Every archaeologist who has examined these specimens agrees that they resemble charred bones found commonly in more recent archaeological sites. It seems possible, however, that differential permineralization could produce similar effects as I observed recently on a *Bison* sp. humerus from the Fort Saskatchewan gravels in Alberta. The solution to this problem must await the use of appropriate trace-element tests, and the alterations have been classified as either natural or artificial.

Summary

In Tables 6.19 and 6.20 I have summarized the fracturing, flaking, cutting, polishing, and differential staining alterations so as to identify the archaeological potential of the samples from MlVl-2. Only the Disconformity A and mid-section materials are considered here since the basal sample did not exhibit alterations believed to be indicative of human activity. The great majority of bones, teeth and tusks from the disconformity (87%) and the mid-section (92%) are modified only by natural agencies which have been presented in tabular form without individual specimen descriptions. The remainder fall into four categories: (1) probably natural, indicating that some attribute of the specimen is suggestive of a natural altering agency; (2) natural or artificial, for specimens which lack suggestive, much less diagnostic, features to identify the altering agency; (3) probably artificial, for specimens seeming to require the hand of man to explain their alterations; and (4) artificial, for a few pieces which I am willing to assert were modified by man.

In view of the considerable antiquity of these deposits, the identification of artifacts among these bones is of profound importance to our understanding of the peopling of the New World, and it is not an exercise which should be taken lightly. Therefore the contents of the "artificial" columns in Tables 6.19 and 6.20 will be explicitly rationalized. Three considerations form the basis for these artifact identifications:

1. The hypothesis that only man can fracture and flake fresh proboscidean limb bones so as to produce indicators of intersecting fracture fronts and large cores and flakes. This hypothesis accounts for 12 artificially modified bones from Disconformity A and one flake from the mid-section deposit. The identification of natural agencies capable of producing such fractures on the fresh limb bones of mammoths and mastodons would necessitate a reevaluation of all but five specimens in the "artificial" columns of Tables 6.19 and 6.20.

2. Recognition criteria for cuts made on bones by means of stone tools have been discussed in this study (Chapter 3), and these criteria form the basis for identifying three artificially modified bones from Disconformity A and one specimen from the mid-section deposit. Should future work find these criteria less than perfectly diagnostic, these four specimens would require reevaluation.

3. The complexity and apparent patterning of the polished tusk

Table 6.19. Distribution of tooth, tusk, and bone alterations with respect to the archaeological potential of Disconformity A at MlVl-2, Old Crow River, northern Yukon Territory.

Fracture category and other alterations	Total	Natural Agencies	Probably Natural	Natural or Artificial	Probably Artificial	Artificial
Teeth	175	174				
Grooved molar				1 (81-4)		
Tusks	105	103				
Fractured ivory				2 (25-4, 107-10)		
Bones (1677)						
Intact bones (0/0)	10	10				
Post-permineralization fractures (0/y)	1419	1406				
Scratched bones					2 (4-9, 75-9)	
Scraped bones					1 (17-7)	
Cut bones						2 (27-1, 61-13)
Polished bones			2 (16-3, 83-2)	3[1]		
Differential stain				3[2]		
Green fractures (x/y)	238					
Chewed			53 (Table 6.14)			
Fractured only				143		10 (Table 6.16)
Flaked bones			5[3]	1 (88-1)	1 (15)	
Flaked and polished				1 (66-5)		
Flaked and diff. stained				1 (49-1)		
Bone flakes			8 (Table 6.17)	2 (12-1, 79-4)		
Scratched bones				1 (115-17)		
Scraped bones				2 (71-14, 107-9)		
Cut bones						1 (25-3)
Polished bones			1 (9-3)	3[4]		2[5]
Differential stain				3[6]		
Totals	1947	1693	69	166	4	15

Legend: Numbers in parentheses are catalogue numbers, and others are referenced as follows: [1]MlVl-2:27-6. 61-45, 91-1; [2]35, 61-37, 66-11; [3]4-1, 47-2, 61-2, 75-6, 97-4; [4]35-10, 39-21, 105-12; [5]105-9, 105-11; [6]75-7, 77-2, 112-3.

Table 6.20. Distribution of tooth, tusk, and bone alterations with respect to the archaeological potential of the mid-section sample from MlVl-2, Old Crow River, northern Yukon Territory.

Fracture category and other alterations	Total	Natural Agencies	Probably Natural	Natural or Artificial	Probably Artificial	Artificial
Teeth	55	55				
Tusks	154	148				
Fractured ivory				3[1]		
Flaked ivory					1 (131-1)	
Polished ivory						2 (142-37, 162-8)
Bones (497)						
Intact bones (0/0)	11	11				
Post-permineralization fractures (0/y)	434	433				
Cut bone						1 (132-8)
Green fractures (x/y)	52					
Chewed			26 (Table 6.14)			
Fractured only				22		
Bone flake						1 (144-38)
Polished bones			2 (144-22, 167-8)		1 (144-21)	
Totals	706	647	28	25	2	4

Legend: Numbers in parentheses are catalogue numbers, and others are referenced as follows: [1]MlVl-2:129-8, 142-39, 162-7.

specimen from the mid-section deposit (142-37 and 162-8) encourages me to propose a functional interpretation for this object (fleshing or hide scraping) and to include it in the "artificially" modified list. If a natural means of altering mammoth or mastodon ivory in this way can be identified experimentally or through field observations, the artificial status of this specimen would need reevaluation.

A more conservative view of these bone and ivory fossils would reject them all from the archaeological record on the grounds that they have not been found in an "archaeological site." If I were more certain that we could find undisturbed human habitation sites which could account for the bulk of the artifacts in the reworked deposits of the Old Crow valley, I might delay the publication of our existing collections until such a site had been discovered and excavated. However, I believe that it is possible that no such site is presently exposed in the eroding banks of the Old Crow River. If that is so, there may be no way to improve the quality of our data within the foreseeable future, and we would be well advised to make the best of what we have.

A less conservative view of these collections would add to the "artifact" count the contents of the "probably artificial" columns in Tables 6.19 and 6.20. Although I believe that each of those six specimens exhibits attributes which are most parsimoniously explained as artificial alterations, I cannot defend the six specimens with the simple sorts of hypotheses and criteria outlined above for the 18 "artifacts." None of these six specimens would be out of place in a late Pleistocene mammoth kill site in the New World and if found in such a site I suspect that all six would be described as artifacts.

All bone fragments from animals smaller than mammoths which were fractured when green but show signs of carnivore gnawing have been placed in the "probably natural" columns. This is a conservative stance with respect to archaeology but is not at all conservative with respect to the bone-altering capabilities of carnivores. It is not possible to separate bones which were fractured while being chewed from those which were chewed after being naturally or artificially fractured. It is commonplace in northern archaeological sites to find bones which were fractured by man for the purpose of marrow extraction or other needs and which were subsequently chewed by carnivores (either wild wolves or domestic dogs). In the northern Yukon today we can see hundreds of bones which have been thrown to the dogs in Old Crow while in scattered cabin and campsites in the region most bones left on the surface have been gnawed either by the dogs or by the wolves. Therefore even the "probably natural" columns may contain artificially modified bones.

This seems even more likely for the "natural or artificial" columns in which I have placed all green fractured bones smaller than those of mammoths which lack evidence of gnawing by carnivores. I doubt that the largest of these specimens could be broken by carnivores which live today in the northern Yukon, but the short-faced bear may have lived there when these bones were fresh (Harington 1977: 380-394) and may have been capable of destroying much larger bones than those which can be fractured by wolves and wolverines. Of the 165 bone fragments in this category many (or even all) may have been broken by man.

A lot of laboratory and field work is needed to aid our interpretation of scratches, scrapes, and polish on bones. The great majority of such alterations in the MlVl-2 samples cannot be interpreted with confidence at the present time, and an interesting component of the potential archaeological record may be hidden among these specimens.

When the figures in Tables 6.19 and 6.20 are compared with those from MlVl-7 (Table 5.8), it is apparent that a statistically significant higher frequency of artificial modifications has been recovered from MlVl-7 than from either of the relevant MlVl-2 samples. This suggests that richer archaeological accumulations than found at MlVl-2 have contributed to the collection of redeposited materials on the MlVl-7 bar. Some of the higher artifact frequency results from the higher percentage of mammoth remains as might be expected from a modern lag deposit, and other major differences in the fauna, such as a relatively high frequency of horse bones and teeth, are comparable to Harington's (1977) findings on the overall distribution of redeposited fossils in the Old Crow basin. These differences in the fauna, the higher percentage of artifacts, and a few of the artifact categories such as well developed cores and flakes, suggest that Disconformity A is not an especially important contributor to the redeposited fossil record on the modern valley floor of the basin. Instead there must be other stratigraphic units in the undisturbed profiles which supply the bulk of the fossils to the reworked deposits, and we will return to this point with a hypothesis as to where such units might exist.

Taphonomic Pathways to MlVl-2

On the basis of all the foregoing data and discussion, we may now devise an approximate model of the taphonomic history of the three fossil assemblages from MlVl-2. Since it is useful to bear in mind whether differences observed among the samples are statistically significant, all the results of chi-square tests discussed above have been summarized in Table 6.21, and these results provide guidance in the interpretation of trends shown in Table 6.22. Table 6.22 represents an attempt to fit all our information into the general model proposed by Clark and Kietzke (1967; see Fig. 3.1). In reexamining the chi-square results it must be remembered that the basal sample was too small to enter into many of the tests and that the chi-square test itself is probably too weak to discriminate between moderately and highly significant differences. Hence most of the results suggest highly significant differences between the samples even when as little as 2% difference (e.g., split lines) is found among the samples.

With these cautionary notes in mind, we can turn to a discussion of the taphonomic factors listed in Table 6.22. The reconstruction of death and life assemblages from our fossil collections will not be treated here since it is primarily a paleontological problem which will be reported elsewhere. It is necessary, however, for both paleontological and archaeological analysis, to reconstruct as much as possible of the taphonomic history of the fossil collection so as to identify the biases which have been introduced to the sample prior to its analysis. We can directly observe that the fossils are being redeposited today through slumping

Table 6.21. Chi-square tests of differences among the samples from M1V1-2, Old Crow River, northern Yukon Territory. Sample numbers: 1, Disconformity A; 2, Mid-section; 3, Basal.

Attributes (basis for scoring)	Samples	Eq.	χ^2	df	P	Table
Bones, teeth, tusks (fragment counts)	1-3	1	158.3	2	1.000	6.4
Vivianite (present or absent)	1-3	1	559.0	2	1.000	6.8
Rounding (none, slight, moderate, heavy)	1-2	1	85.7	3	1.000	6.9
Exfoliation (present or absent), Test 1	1-3	1	4.4	2	0.889	6.10
Exfoliation (present or absent), Test 2	1-2	2	0.09	1	0.230	6.10
Split lines (present or absent)	1-2	2	9.17	1	0.998	6.10
Type A pitting (present or absent)	1-2	2	0.18	1	0.326	6.11
Type BF pitting (present or absent)	1-2	2	4.55	1	0.967	6.11
Type BC pitting (present or absent)	1-2	2	1.22	1	0.730	6.11
Etching (present or absent)	1-3	1	8.07	2	0.982	6.12
Fracture pattern, all bones (0/y, x/y)	1-2	2	4.0	1	0.955	6.13
Fracture pattern, large mammal bones (0/y, x/y)	1-2	2	6.6	1	0.990	6.13
Carnivore alterations, Disconformity A	0/y, x/y	2	141.4	1	1.000	6.14
Carnivore alterations, Mid-section	0/y, x/y	2	112.7	1	1.00	6.14

Legend
Eq., Equation
χ^2, chi square
df, degrees of freedom
P, probably that χ^2 will not be exceeded

Table 6.22. Trends in the distributions of taphonomic factors among the three stratigraphic levels sampled at M1V1-2, Old Crow River, northern Yukon Territory (see also Fig. 3.1).

Factors/ *Assemblages*	Bone Alterations	Disconformity A	Mid-section	Basal
Biotic				
Life Assemblage (to be reconstructed)				
Thanatic				
Death Assemblage (to be reconstructed)				
Perthotaxic	Exfoliation	14.0%	14.7%	26.1%
	Split lines	1.0%	3.0%	8.7%
	Type BC pitting (chewing)	4.3%	5.6%	2.2%
	Green bone fractures (x/y)	14.3%	10.5%	none
→→→redeposition→→	Artifacts, probable artifacts	1.1%	1.2%	none
Taphic	Sedimentation rate	Relatively slow	Relatively rapid	Relatively rapid
	Thickness of sediment increments	Few cm	Many cm	Many? cm
	Velocity of current	Slow	Rapid	Rapid?
	Nature of sediment	Silt, sand, ripple bedded	Silt, sand, clay fore-set beds	Detrital organic sands, flat beds
	Type A pitting (acids)	1.4%	1.0%	none
	Etching (rootlets)	13.7%	9.1%	8.7%
	Type BF pitting (rootlets)	4.2%	2.0%	4.3%
	Post-permineralization fractures	85.1%	87.3%	93.5%
Fossil Assemblage				
Anataxic	Vivianite	12.4%	63.9%	17.4%
	Hematite	rare	rare	common
	Rounding (0:S:M:H)	3.8:91.8:2.8:1.6%	5.2:79.4:13.1:2.3%	4.3:45.7:32.6:17.4%
	Post-permineralization fractures	85.1%	87.3%	93.5%
	Ancient redeposition	Low energy	High energy	High? energy
	Modern slumping	Frequent	Frequent	Rare
	Modern flooding	None	None	Annual?
←←←←erosion←←←←				
Sullegic	Time investment in excavation	Most	Moderate	Least
	Excavation technique	Trowel	Trowel	Trowel
Fossil Collection				
Trephic	Identifiability	10.0%	23.4%	37.0%

transportation

and erosion of the river bank, and we must presume that these kinds of (anataxic) factors came into play more than 10,000 years ago when the Old Crow basin was originally downcut to its present level. Several lines of evidence point to the view that the fossils were redeposited at least once prior to the downcutting of the basin. No instance of articulation of skeletal elements was observed during excavation, although a metatarsal and proximal phalanx of *Lepus arcticus* found near one another on Disconformity A probably represent articulated elements only slightly separated from one another. In many cases it was possible to fit together as many as seven fragments of bones which were fractured at the time of deposition. This was particularly true on Disconformity A and shows that the fossils were not further disturbed after the erosion of an ancient surface and its subsequent burial more than 50,000 years ago. Likewise the shattered ends of a mammoth femur could be reconstructed from the mid-section deposit, revealing that disturbance has not occurred to disperse the fragments since the bone was emplaced. That the great majority of fractures on the fossils occurred following permineralization of the bone is indicative of redeposition and possibly of fracture during primary burial.

If it is true that all the fossils have been deposited at least once, it is of interest to consider whether redeposition has been more frequent or more damaging to one fossil assemblage or another. The degree of rounding appears to indicate strongly that the Disconformity A sample has been redeposited only once or else has never been subjected to high energy alluvial environments during multiple episodes of redeposition. Less than 5% of the fossils are visibly rounded when viewed with the unaided eye, and many delicate bone and tooth structures are perfectly preserved. More than 15% of the mid-section fossils and approximately half of the basal specimens are visibly rounded and have either been redeposited more often or been more heavily eroded by alluvial processes than the fossils on Disconformity A. These observations are consistent with sedimentological and geomorphological considerations. The coarse bedded sands of the basal deposit and the fore-set beds of the mid-section probably represent alluviation very near an active channel while the finer sediment textures and delicate ripple bedding seen on Disconformity A suggest deposition on a broad, flat braided floodplain or overbank sedimentation on an elevated floodplain or terrace.

The contents of the fossil collections suggest similar conclusions. The relatively large, heavy bones of the basal and mid-section deposits probably represent lag in alluvial systems. On the other hand, the abundant microtine and other small mammal, bird, and fish remains on Disconformity A could be readily transported by moving water and would not be expected to occur among the lag in a fast-flowing stream deposit. It is probable that the Disconformity A fossils were brought together on an elevated floodplain or terrace at some distance from the main channel and that formerly associated large specimens remained in the more active part of the alluvial system or in lag deposits elsewhere on the floodplain.

Although the occurrence and identification of secondary minerals on the fossils has not been fully explored in this study, the approximate figures for vivianite and hematite in Table 6.22 have some interesting implications. Since hematite is rare on Disconformity A and in the mid-section deposit, we must suspect that the fossils have not long been exposed to oxygen. In contrast the basal deposit must have undergone more intensive subaerial weathering after the permineralization of the bones. The high frequency of vivianite in the mid-section deposit is associated primarily with the large number of tusk fragments on which this secondary mineral forms quite readily.

All of the factors we have discussed thus far could have occurred after primary burial and during or after secondary redeposition of the fossils. Pitting and etching by acids and rootlets must likewise have occurred after primary burial but are more likely to have taken place prior to secondary redeposition of the specimens. This inference is based upon the observation that the pitting and etching features are evenly stained in relation to the unaffected bone surfaces, suggesting that acid and rootlet attack occurred when the bones were fresh and not yet permineralized and stained. In only a few cases have I seen rootlet etch marks with contrasting (usually lighter) colour; these few cases show that not every fossil loses its nutrient value for plant rootlets, but in general it appears that rootlets attack the bones when the latter are fresh. This relationship between rootlet attack and fresh bone could also result from burial history itself in that fresh bones are more likely (than fossils) to be deposited on stable surfaces where plants are actively growing, while bones which have been buried sufficiently to lead to permineralization are more likely to be redeposited in active alluvial environments where plant growth would be discouraged. There are no live rootlets in the MlVl-2 deposits today, and all such rootlets must have been eliminated at least as early as the inundation by Glacial Lake Old Crow in classical Wisconsinan time.

The location of rootlet attack may be of special interest if it is indicative of which surfaces were exposed at the time a bone became buried. An intact bone can only be etched on its outer surface whereas a broken fragment can also be etched on the inner and fracture surfaces. As seen in Table 6.12, 22% and 27% of the etched bones on Disconformity A and the mid-section deposit, respectively, were etched on inner and/or fracture surfaces whereas no such etching was observed in the small sample from the basal deposit. Furthermore all the etched fracture surfaces observed in these samples revealed additional attributes of green bone fracture.

The distribution of rootlet etching thus brings us to a significant perthotaxic factor which took place following the death of an animal but prior to its primary burial. This factor is the fracture of green bone which has been observed with significant frequency on Disconformity A and in the mid-section sample but not at all in the basal deposit. Demonstrable evidence of carnivore chewing must account for some of the green bone fractures, and the identification of probable artifacts has introduced the likelihood of artificial practices to account for other examples, particularly for the mammoth or mastodon bones. There remains a large uninterpretable sample of green-fractured bones which could have been broken either by carnivores or by humans (or, more rarely, such events as accidents during life).

The occurrence of exfoliation and split lines demonstrates that the bones underwent some degree of subaerial weathering, and the even staining of these features suggests that at least some of the weathering took place prior to permineralization of the fossils. The frequencies of these features in the basal deposits are nearly double those of the other two samples, and this difference is consistent with the oxidized state of iron staining in the basal deposit.

In summarizing this discussion of taphonomic history it is important to emphasize the reasons for undertaking the exercise in the first place. Our interest in the archaeological potential of the MlVl-2 deposits arose from the study of thousands of redeposited vertebrate fossils which had been gathered from the modern banks and bars of the Old Crow River. Among these fossils were many specimens which could be interpreted as artifacts (Harington 1977; Bonnichsen 1979), but no empirical evidence could be mustered to define their ages or associations with one another. The recovery of green fractured bones from Disconformity A in 1977 led us to believe that the disconformity might "be one source of the archaeological collections which have gradually appeared in reworked deposits elsewhere in the valley" (Morlan 1978a:91). When our sample from Disconformity A is evaluated in relation to the larger collections from the modern valley floor, it seems unlikely that the portion of the disconformity which we have been able to sample represents a significant source of the redeposited artifacts. The following brief scenario will attempt to place the three MlVl-2 samples in a larger perspective.

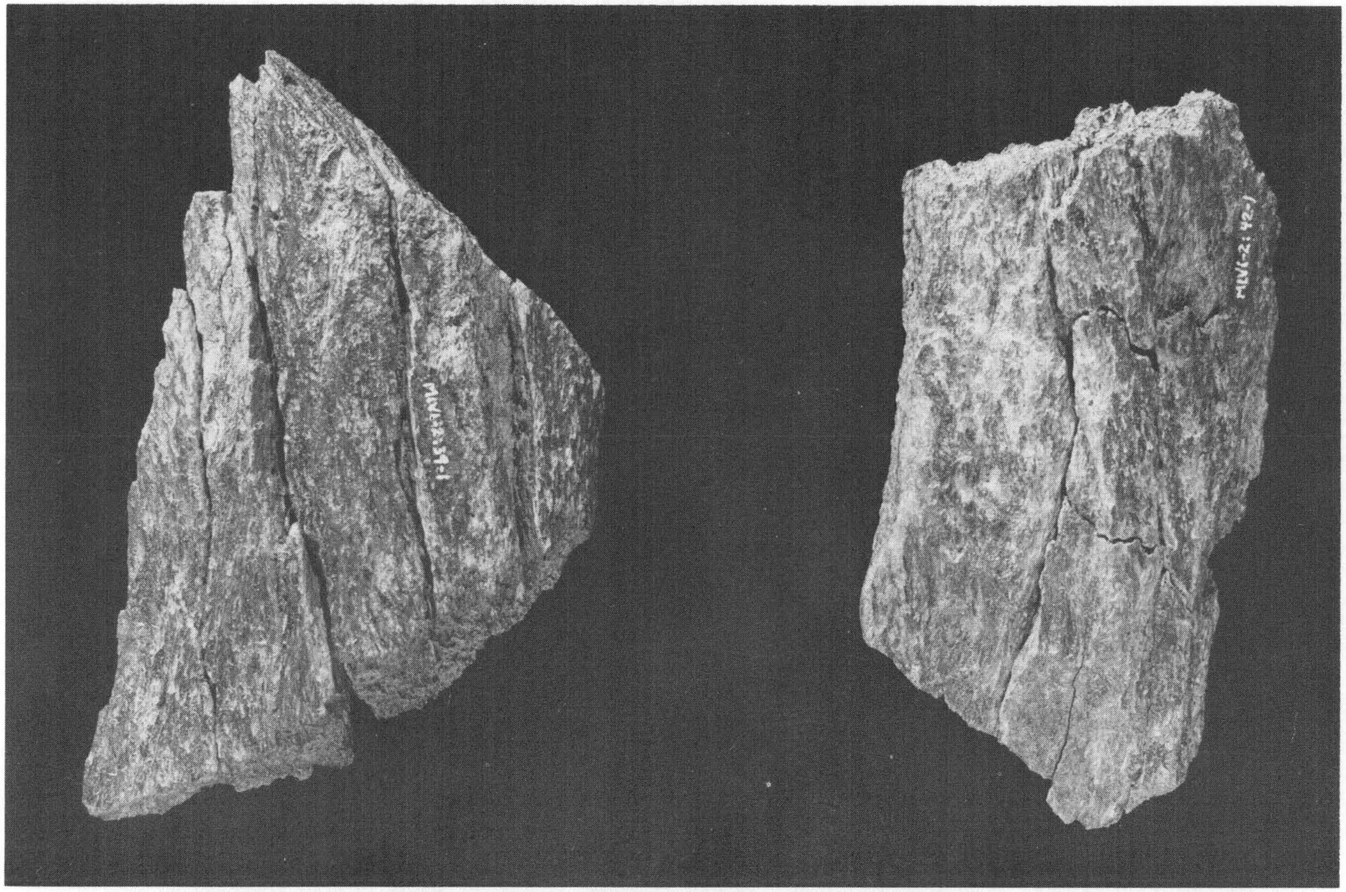
We still know too little about the basal deposits to characterize their history with any confidence. The sample from MlVl-2 probably represents a lag deposit of fossils which were reworked by alluvial processes in early Sangamon Interglacial times. Some of the bones reveal evidence of sub-aerial weathering and rootlet etching, a minor amount of gnawing by carnivores, and a significant amount of permineralization which is frequently associated with staining by oxidized iron. Only two taxa -- mammoth and horse -- are represented, and there is no evidence that human occupation was contemporaneous with these remains or with the stratigraphic levels from which they were obtained.

By late Sangamon or early Wisconsinan times, a drainage system of substantial size had developed in the Old Crow basin. Some exposures, such as MkVl-10 (ca. 8 km downstream from MlVl-2), reveal point bar growth along a river valley in which vertical relief from channel bottom to floodplain may have exceeded 12 m. At MlVl-2 it is likely that the mid-section sample has been derived from the fore-set beds of such a point bar system, and the vertebrate fossils probably represent a lag concentrate of bones derived from floodplain and channel deposits further upstream. A moderate amount of sub-aerial weathering and rootlet attack is exhibited by these bones, and a somewhat greater occurrence of carnivore gnawing is indicated by pitting. The major difference from the basal deposit is the occurrence of green-bone fractures on 10% of the specimens. Half of the bones fractured when green are demonstrably chewed by carnivores, but the other half includes one mammoth bone flake which is believed to be indicative of human activity. This piece, in addition to one cut bone, and one polished tusk, suggest that an artificial component had been added to the complex set of "perthotaxic" factors operating upon bones in the basin. Among the deposits being eroded upstream from MlVl-2 there must have been at least one archaeological site from which this small sample of artifacts could be derived.

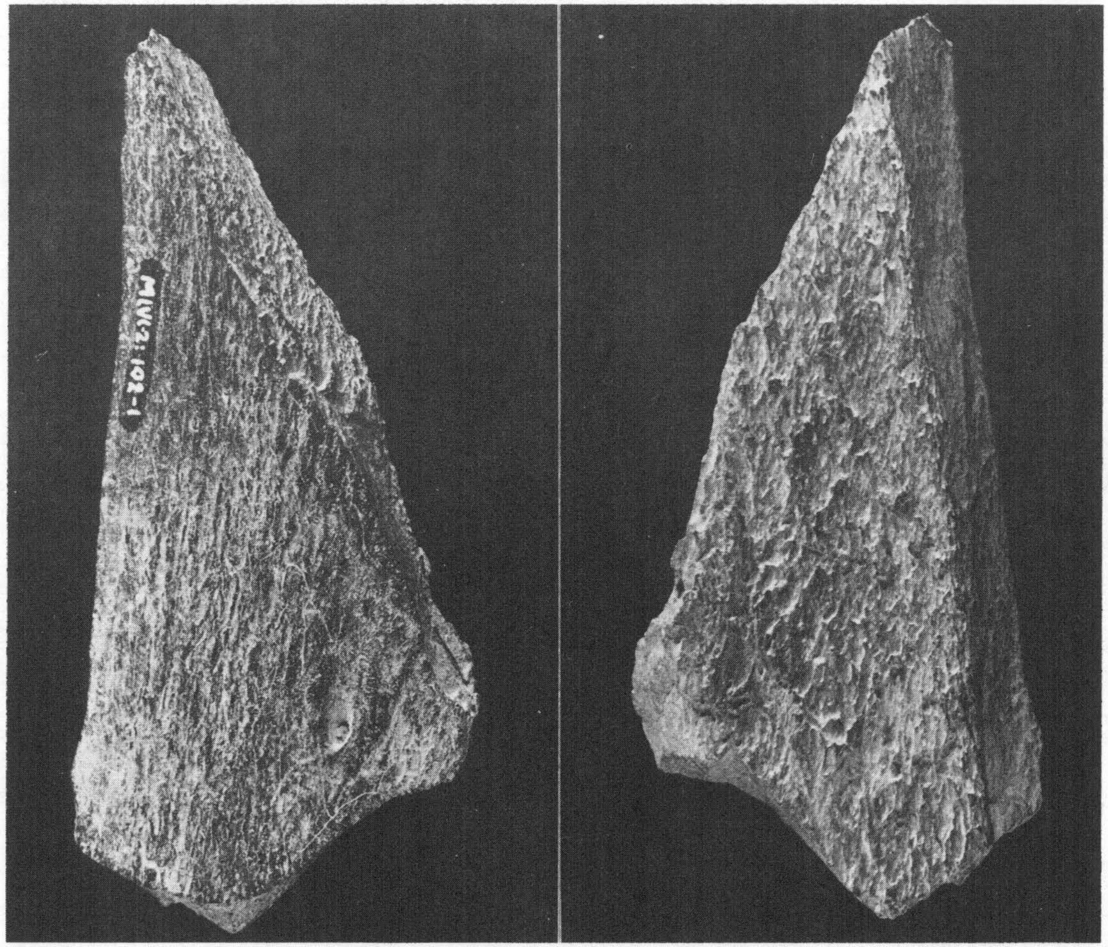
It is possible that the fore-set beds of the mid-section deposit are related to top-set beds at the approximate level of Disconformity A and that the latter could be a floodplain contemporaneous with the former. This relationship will be difficult to define precisely because we appear to be viewing the point bar deposit in longitudinal section at MlVl-2. Major differences between the faunas represented by the two samples (Morlan 1978c) could imply a temporal difference between them, but such differences might be explained by means of the taphonomic history of the deposits. The sample on Disconformity A reveals a more diverse fossil assemblage in which small mammals, birds, and fish play an important role. The bone fragments are generally smaller than those of the deeper deposits, and it is likely that they represent the transported component of a fossil assemblage for which the lag is elsewhere. Similar frequencies are seen for most taphonomic factors on Disconformity A and in the mid-section deposit, but the green bone fractures on Disconformity A are nearly 50% more abundant while artificial alterations are five times more abundant. Only 20% of the bones fractured when green on Disconformity A are demonstrably chewed, and a dozen of the green fractured specimens are mammoth bones thought to have been broken by man. The very slight degree of rounding and the fact that the sediments themselves indicate slow-moving overbank flooding suggest that the Disconformity A specimens have not been transported very far from their original burial sites even though they are thought to represent the transported component of the original assemblage. Thus it seems likely that an archaeological site is or was located at no great distance from MlVl-2 on the surface which was eroded to form Disconformity A, and such a site could have been contemporaneous with the erosion which introduced artifacts into the mid-section deposit.

Perthotaxic factors such as sub-aerial weathering and green bone fracture have played a more prominent role in the history of the MlVl-7 materials (Table 5.9) than in any of the MlVl-2 samples. The bones are much more heavily rounded than at MlVl-2, and recent oxidation of iron is probably responsible for the high ratio of hematite to vivianite among the MlVl-7 specimens. Largely due to the larger sizes of the specimens, identifiability is enhanced at MlVl-7, and a number of weathering features such as split lines are more readily observed. On the other hand, the general absence of small fossils has provided an impoverished fauna in which fish, birds, and microtines are obviously underrepresented. It is possible that the specimen size factor has contributed to the higher frequency of artifacts identified at MlVl-7 in that artificial alterations are easier to interpret on larger pieces. Were it not for the heavily rounded condition of the MlVl-7 fossils, we might consider this assemblage as a general indicator of the sort of lag concentrate which would have been left behind during the erosion and deposition which brought the Disconformity A sample to MlVl-2. The numerous differences between the two samples would then be seen as the expression of opposite ends of a single hydrological process. The mid-section sample at MlVl-2 may be mixed in this regard because it could contain fossils deposited at different stages of alluvial activity in which marked seasonal variation is an annual phenomenon.

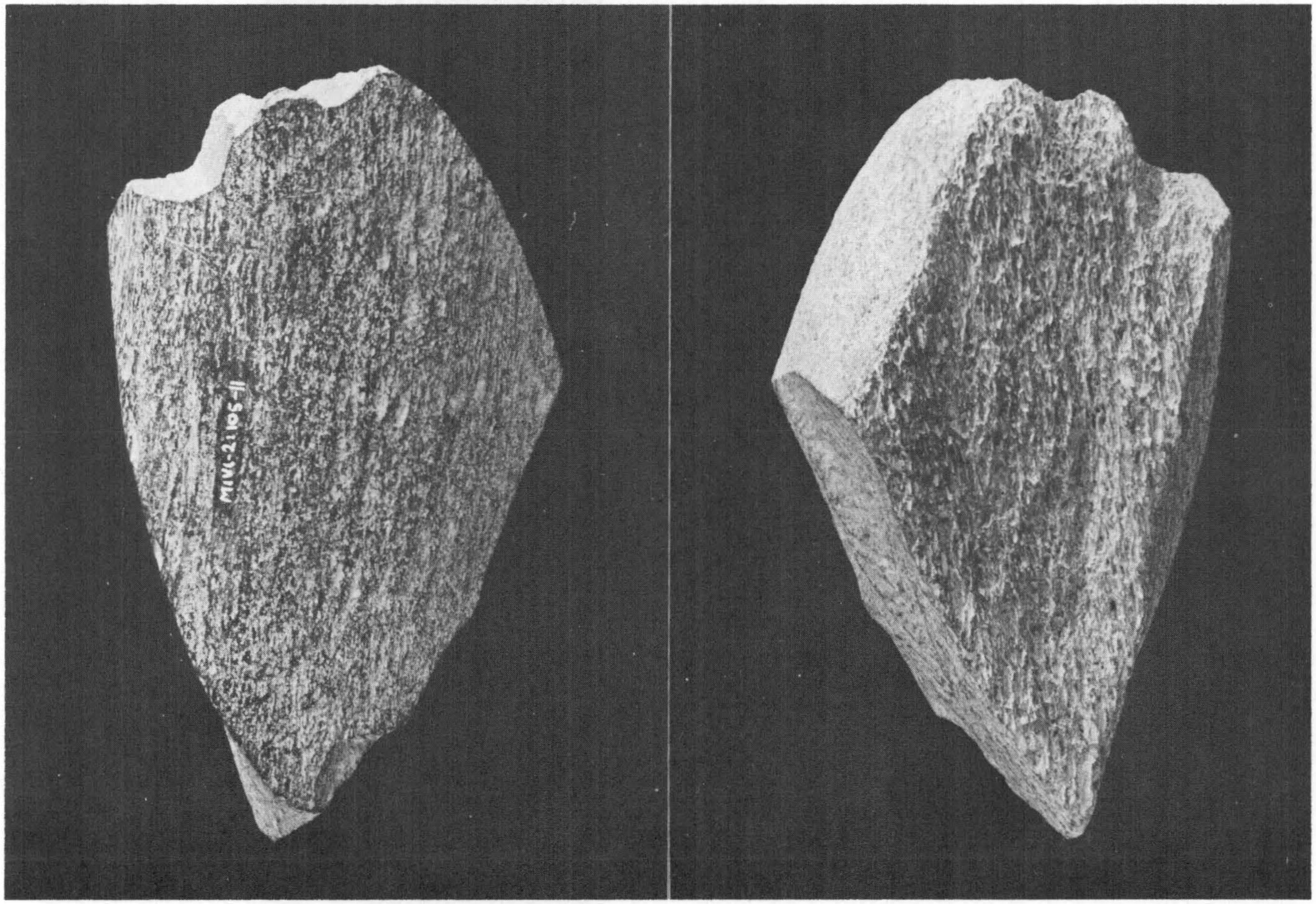
Some of the implications of these ideas will be mentioned in larger perspective after we have reviewed other scattered vertebrate fossil occurrences in primary stratigraphic contexts.



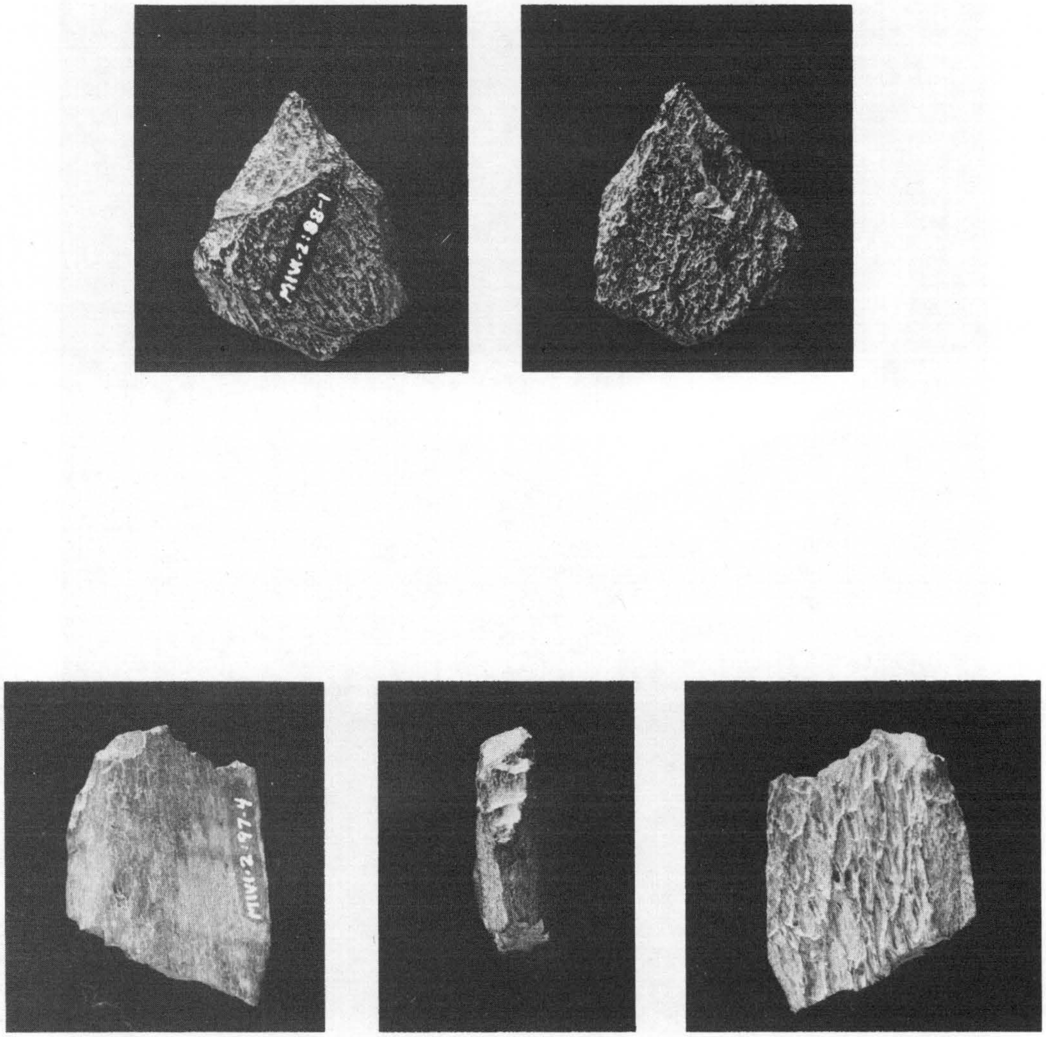
Pl. 6.1. Two green fractured mammoth (cf. *Mammuthus* sp.) long bone fragments (M1V1-2: 39-1, 42-1), each reconstructed from seven pieces found on Disconformity A at M1V1-2 on Old Crow River, northern Yukon Territory. The green fractures are on the upper margin in each case, and the one on 42-1 (right) is a poorly preserved hinge fracture. Nat. size.



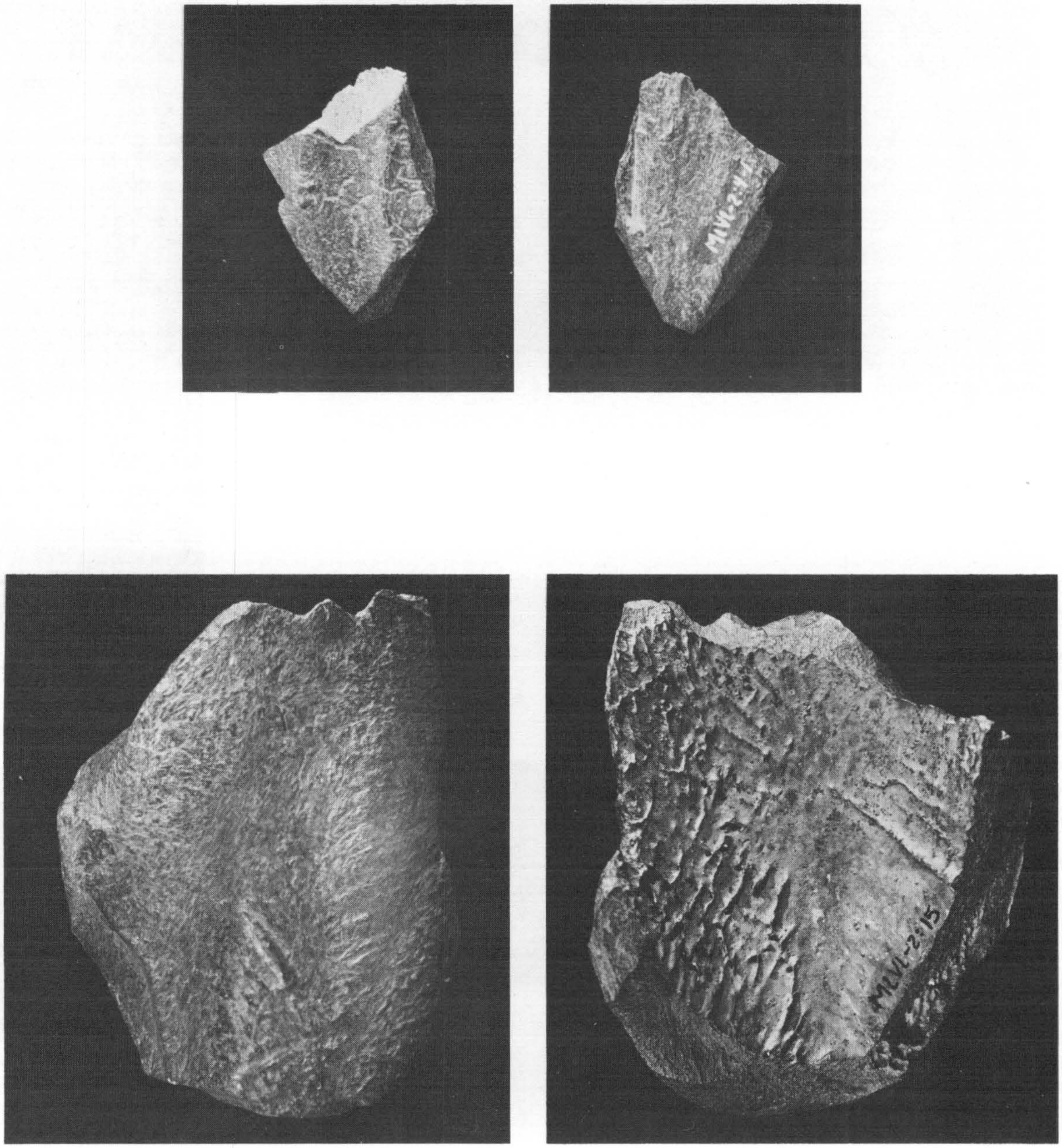
Pl. 6.2a. Green fractured mammoth (cf. *Mammuthus* sp.) long bone fragment (M1V1-2:102-1) from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Nat. size.



Pl. 6.2b. Green fractured mammoth (cf. *Mammuthus* sp.) long bone fragment (M1V1-2:105-11) from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Nat. size.



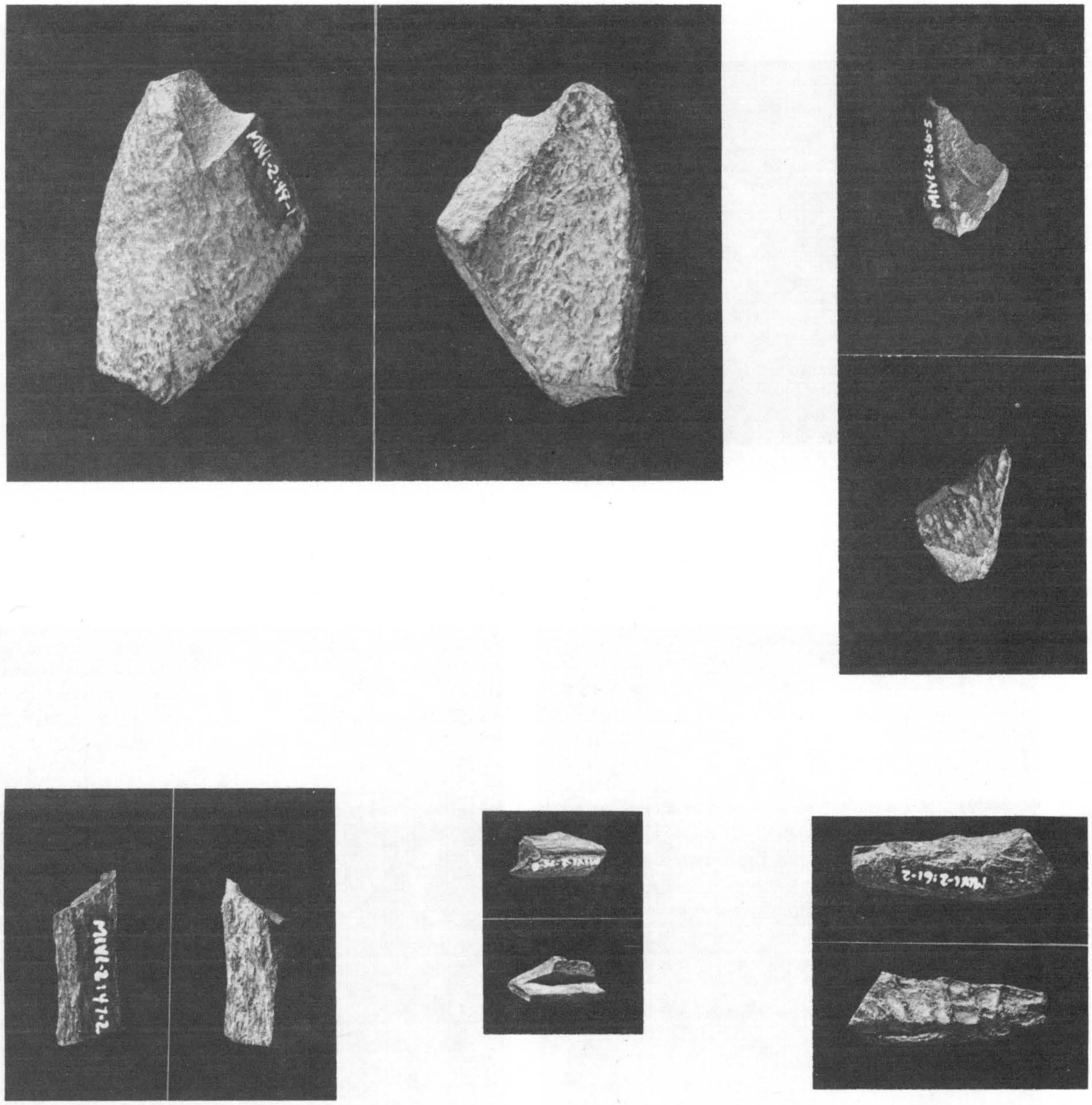
Pl. 6.3. Two "cores" made on unidentified large mammal long bone fragments (M1V1-2:88-1, 97-4) from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Nat. size.



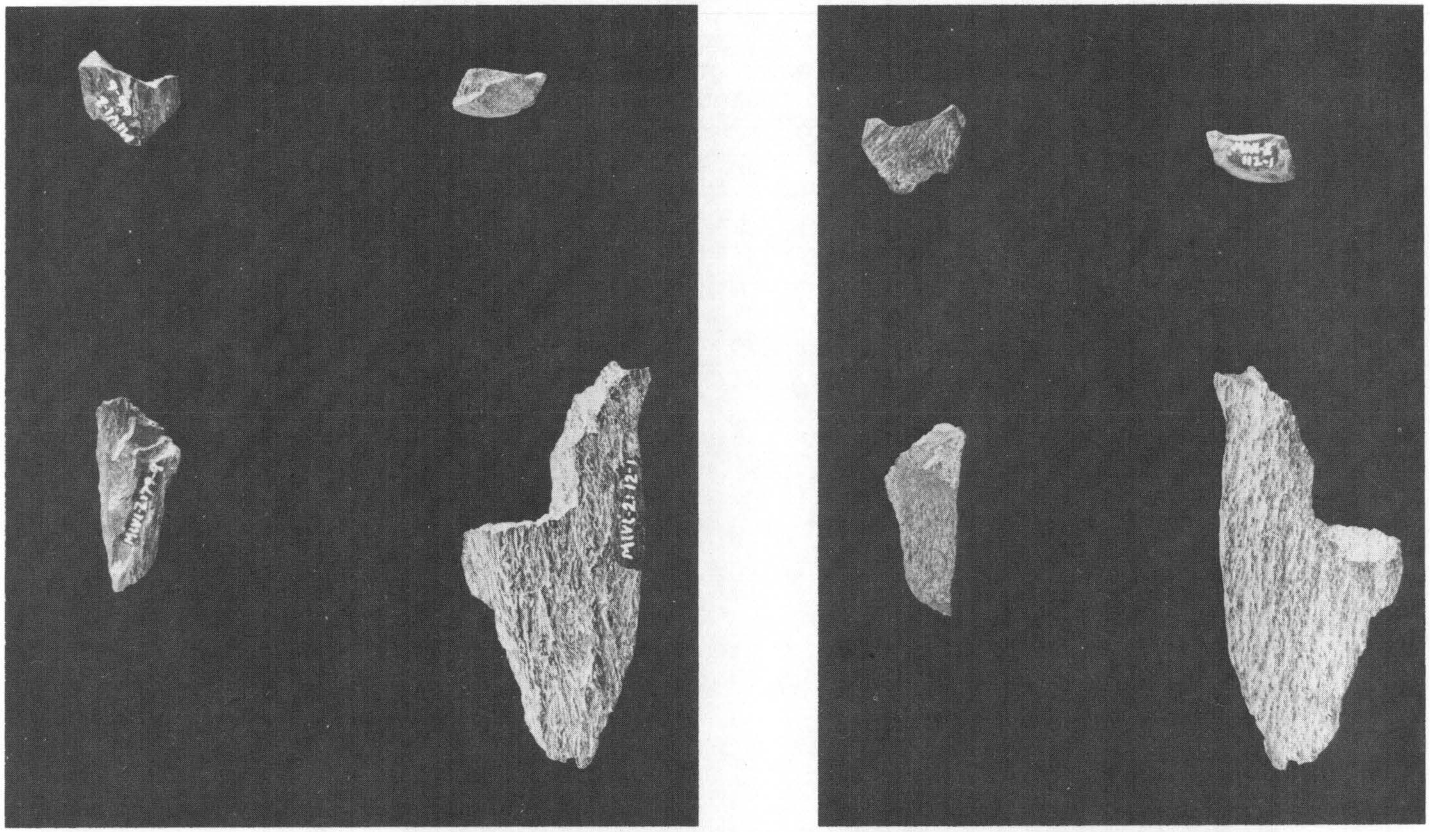
Pl. 6.4. Above: "Core" made on unidentified large mammal long bone fragment (MlVl-2:4-1).

Below: Green fractured and flaked bison (*Bison* sp.) humerus fragment (MlVl-2:15).

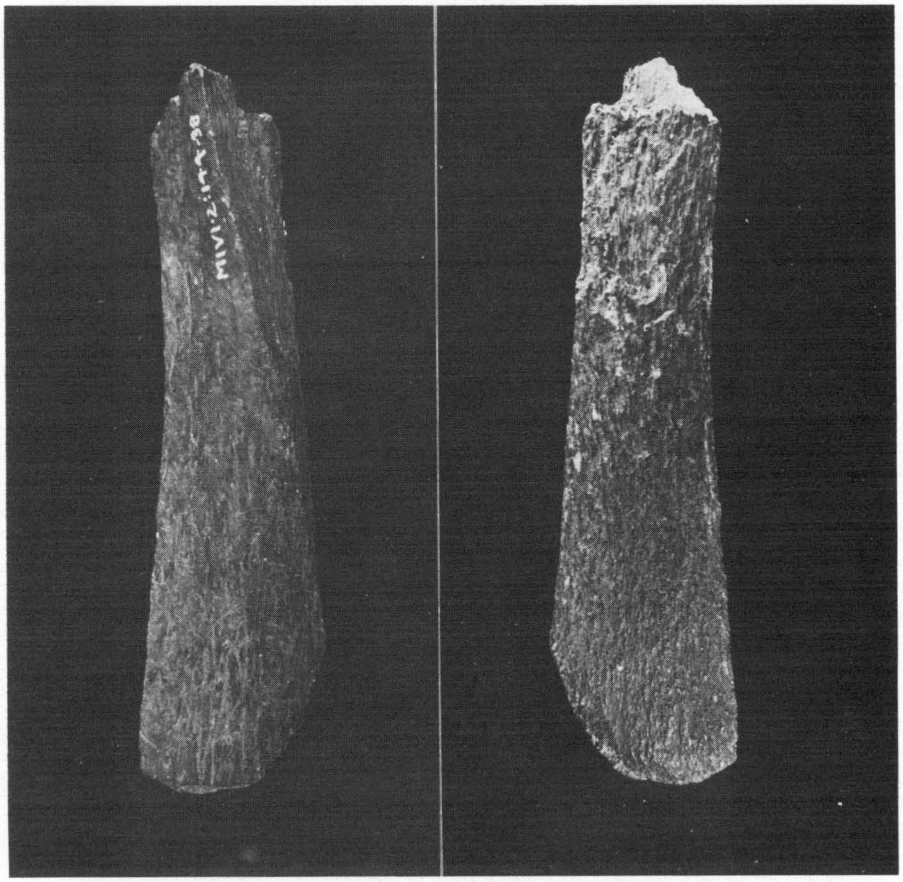
Both from Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory. Nat. size.



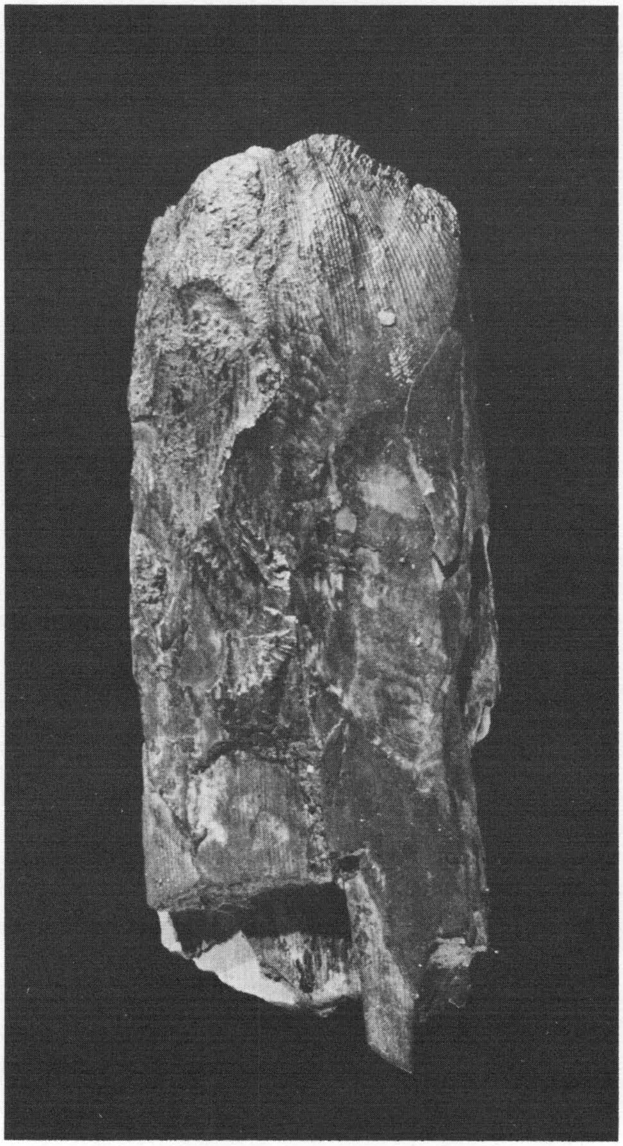
Pl. 6.5. Five "cores" made on unidentified large mammal long bone fragments and rib fragments from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Nat. size. Clockwise from upper left: M1V1-2:49-1, 66-5, 61-2, 75-6, and 47-2.



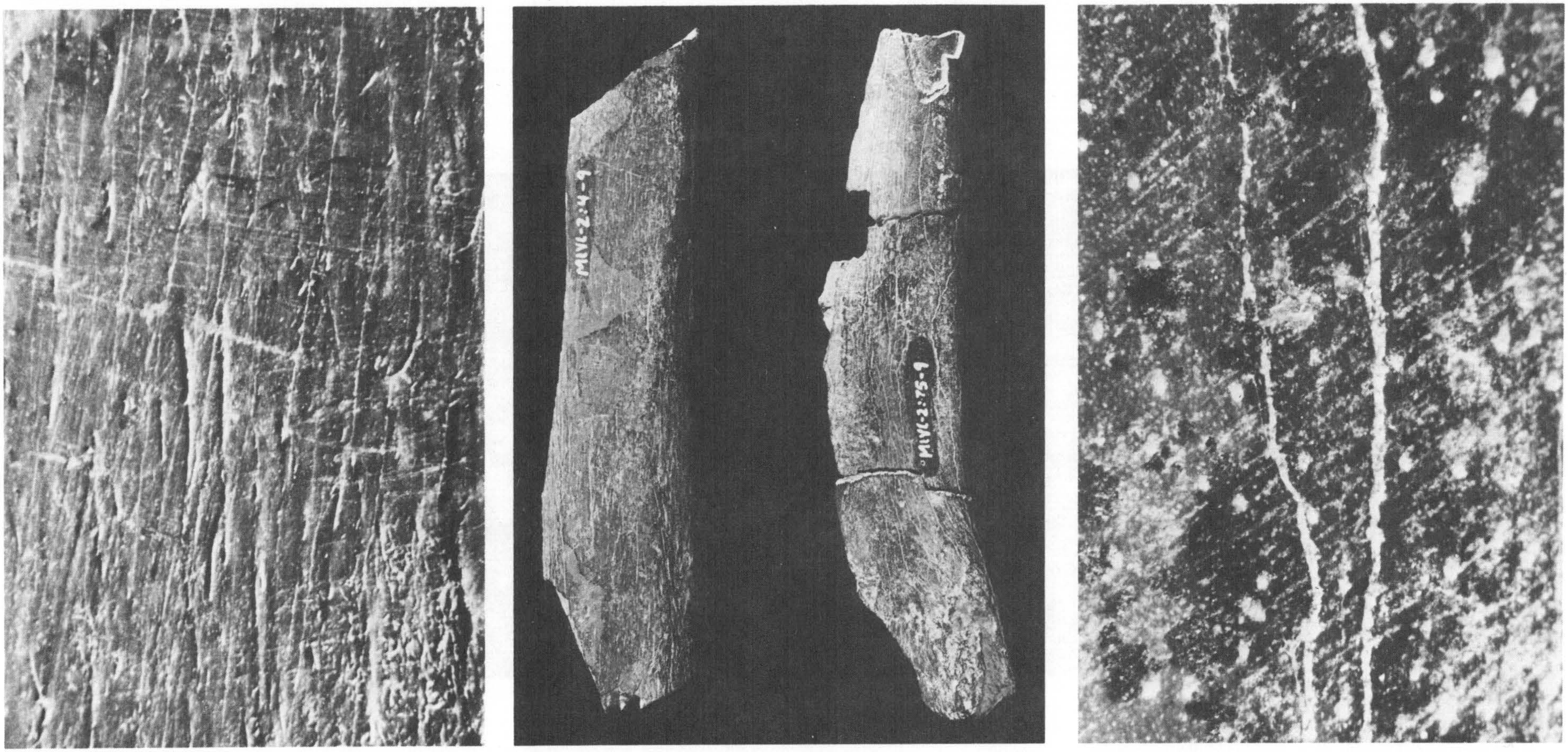
Pl. 6.6. Four flakes from large mammal long bones from Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory. Left, dorsal; right, ventral. Clockwise from upper left in each view: MlVl-2:66-6, 112-1, 12-1, 79-4. Nat. size.



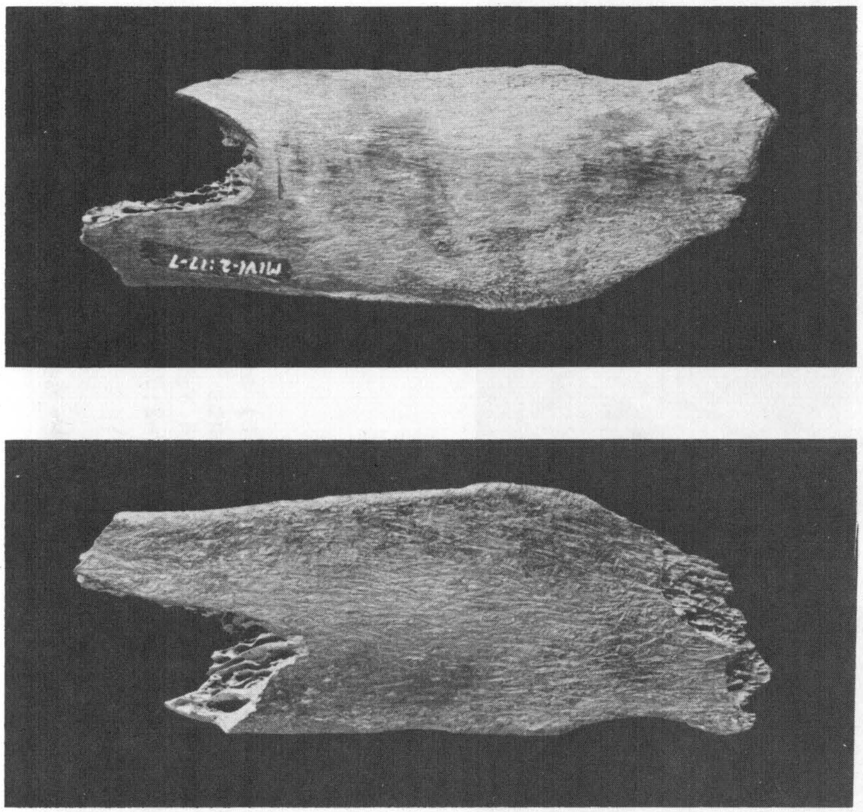
Pl. 6.7. Mammoth (cf. *Mammuthus* sp.) long bone flake (MlVl-2:144-38) from Mid-section deposit, MlVl-2, Old Crow River, northern Yukon Territory. Nat. size.

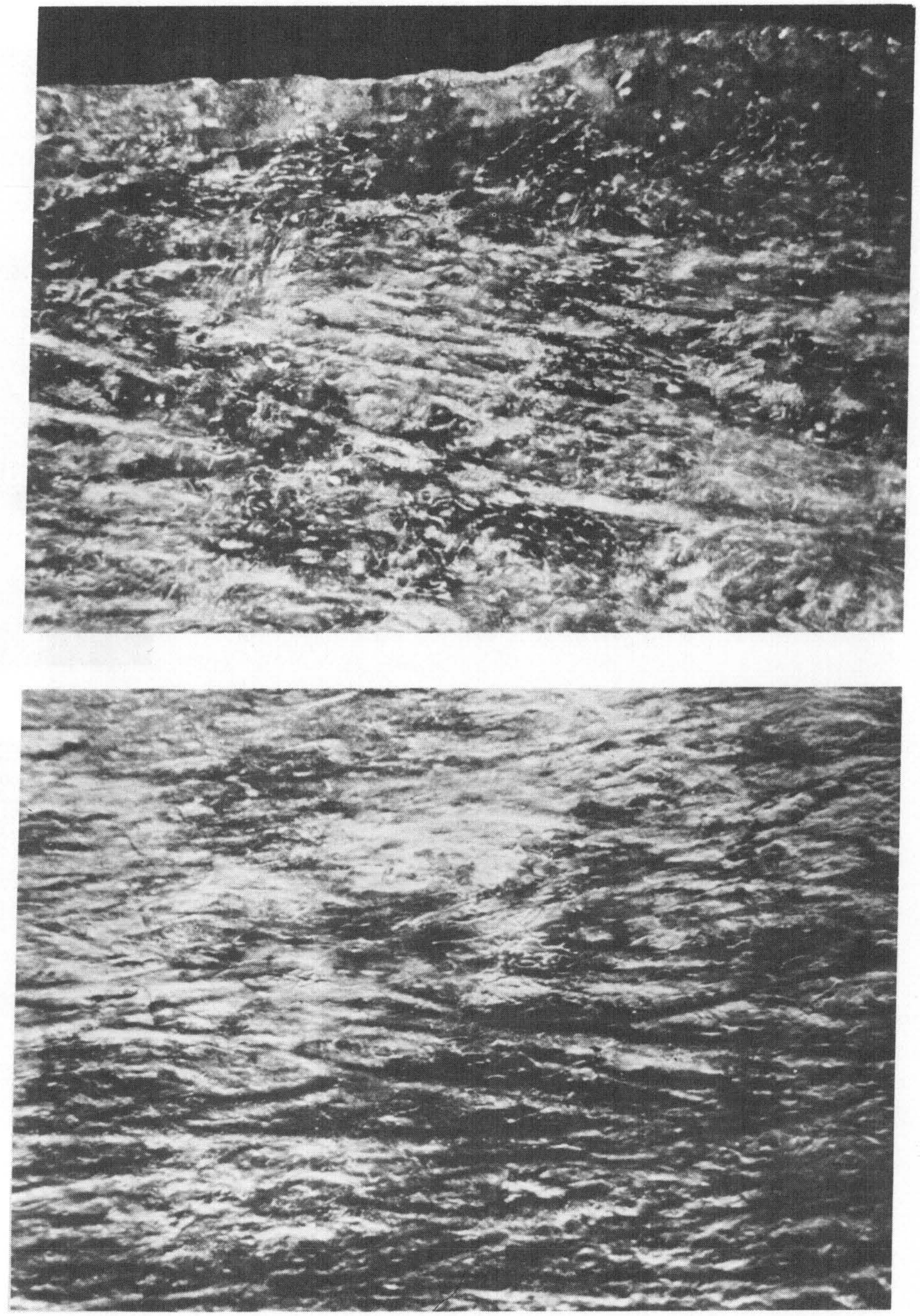


Pl. 6.8. Mammoth (cf. *Mammuthus* sp.) tusk core (MlVl-2:131-1) with flakes driven from center of outer surface, from Mid-section deposits, MlVl-2, Old Crow River, northern Yukon Territory. Nat. size.

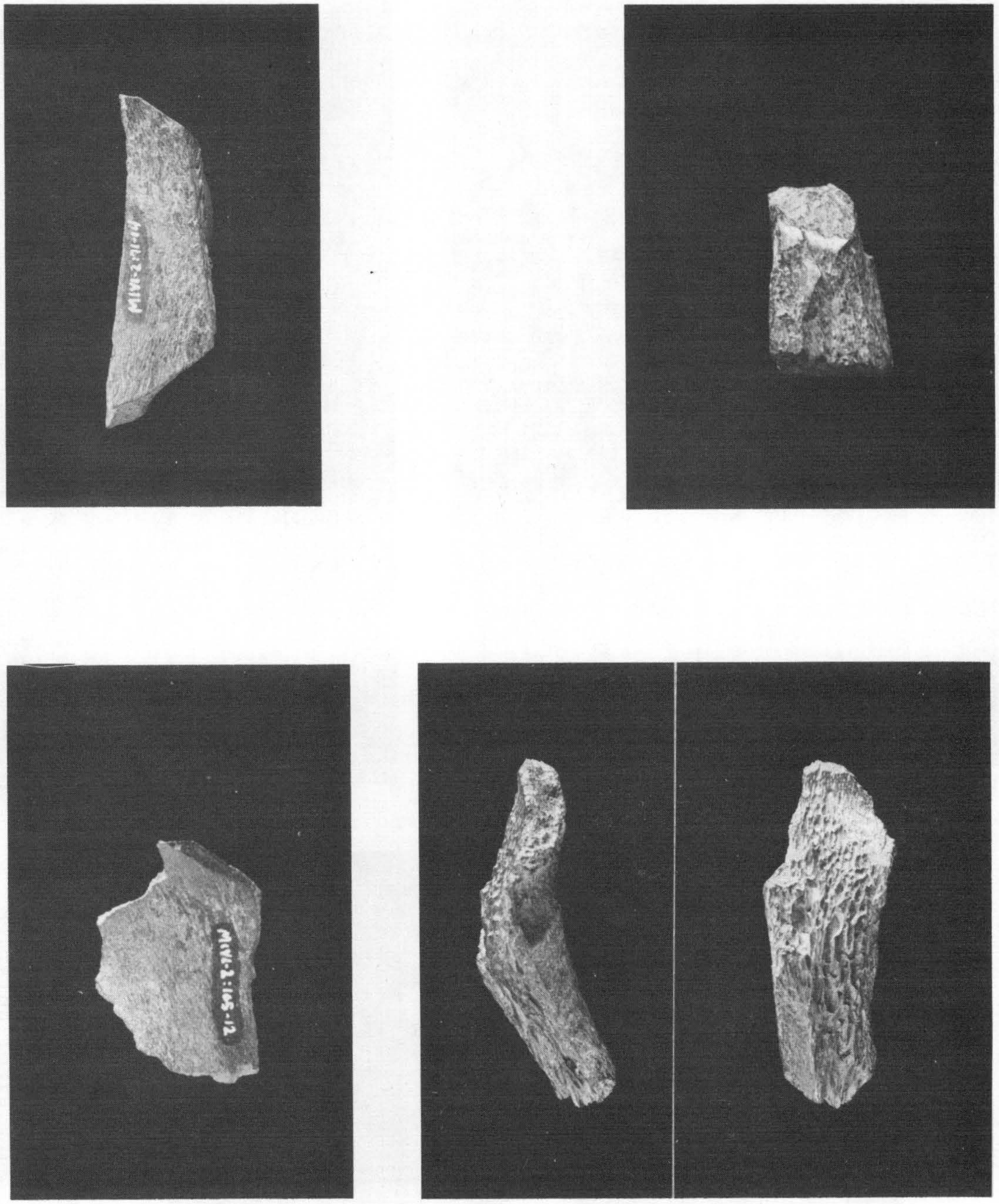


Pl. 6.9. Scratches on two unidentified large mammal long bones (MlVl-2:4-9, 75-9) from Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory. Overview, Nat. size; enlarged views, ca. 14X.

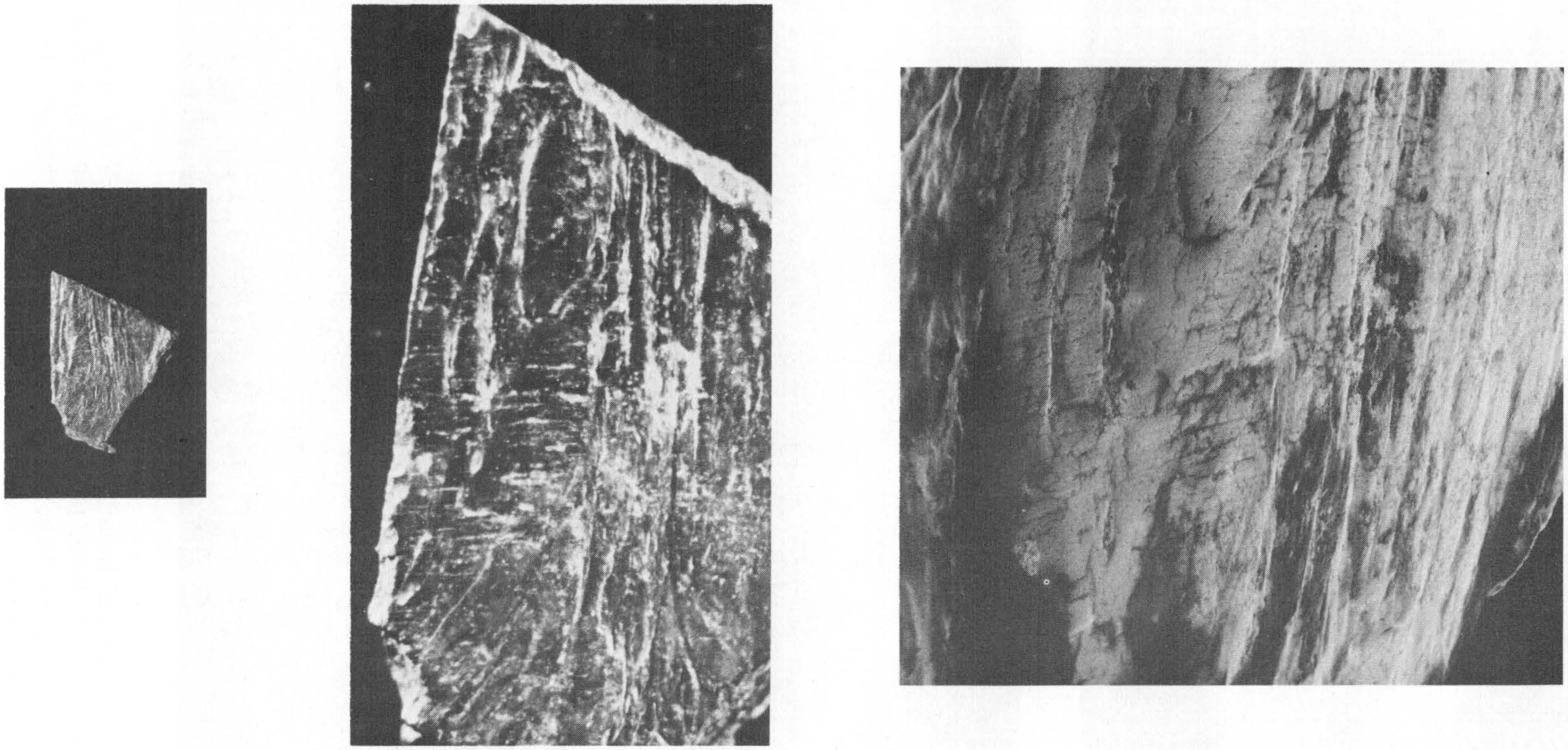




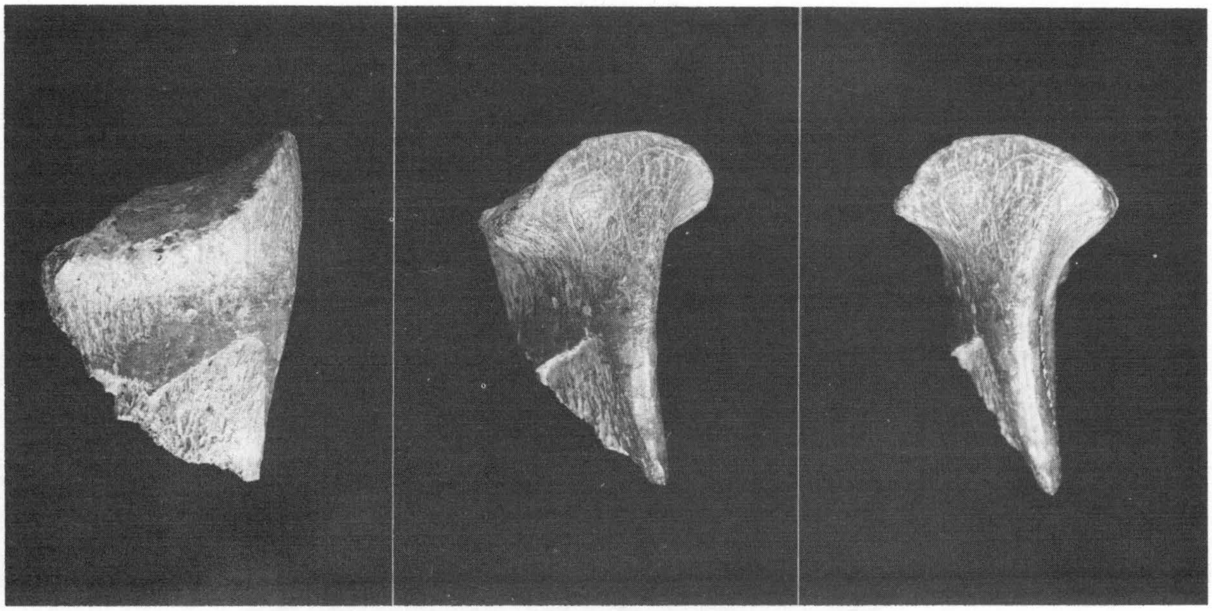
Pl. 6.10. Scraped rib of unidentified large mammal (M1V1-2:17-7) from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Overviews, Nat. size; enlarged views, ca. 14X.

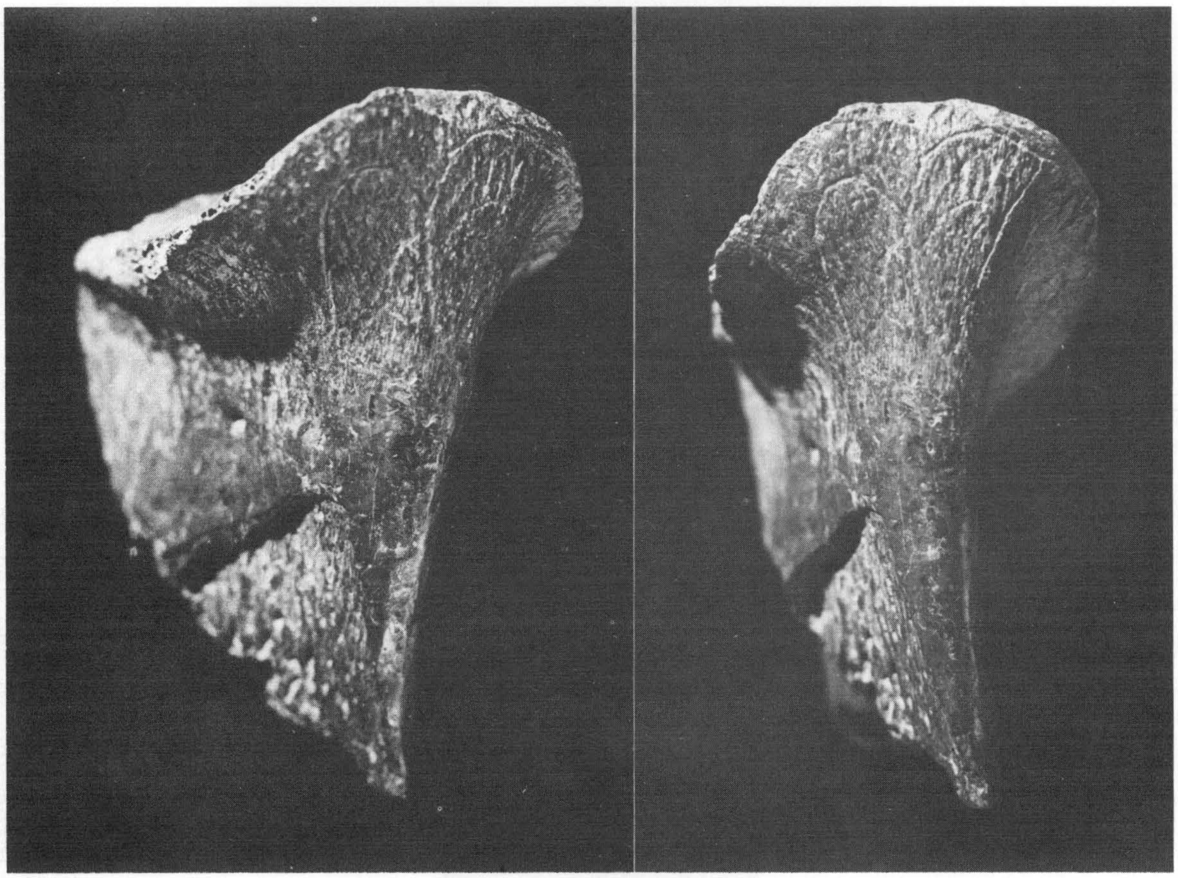


Pl. 6.11. One scraped (upper left) and three polished large mammal long bone and rib fragments from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Nat. size. Clockwise from upper left: M1V1-2:71-14, 27-6, 91-1 (two views), and 105-12.

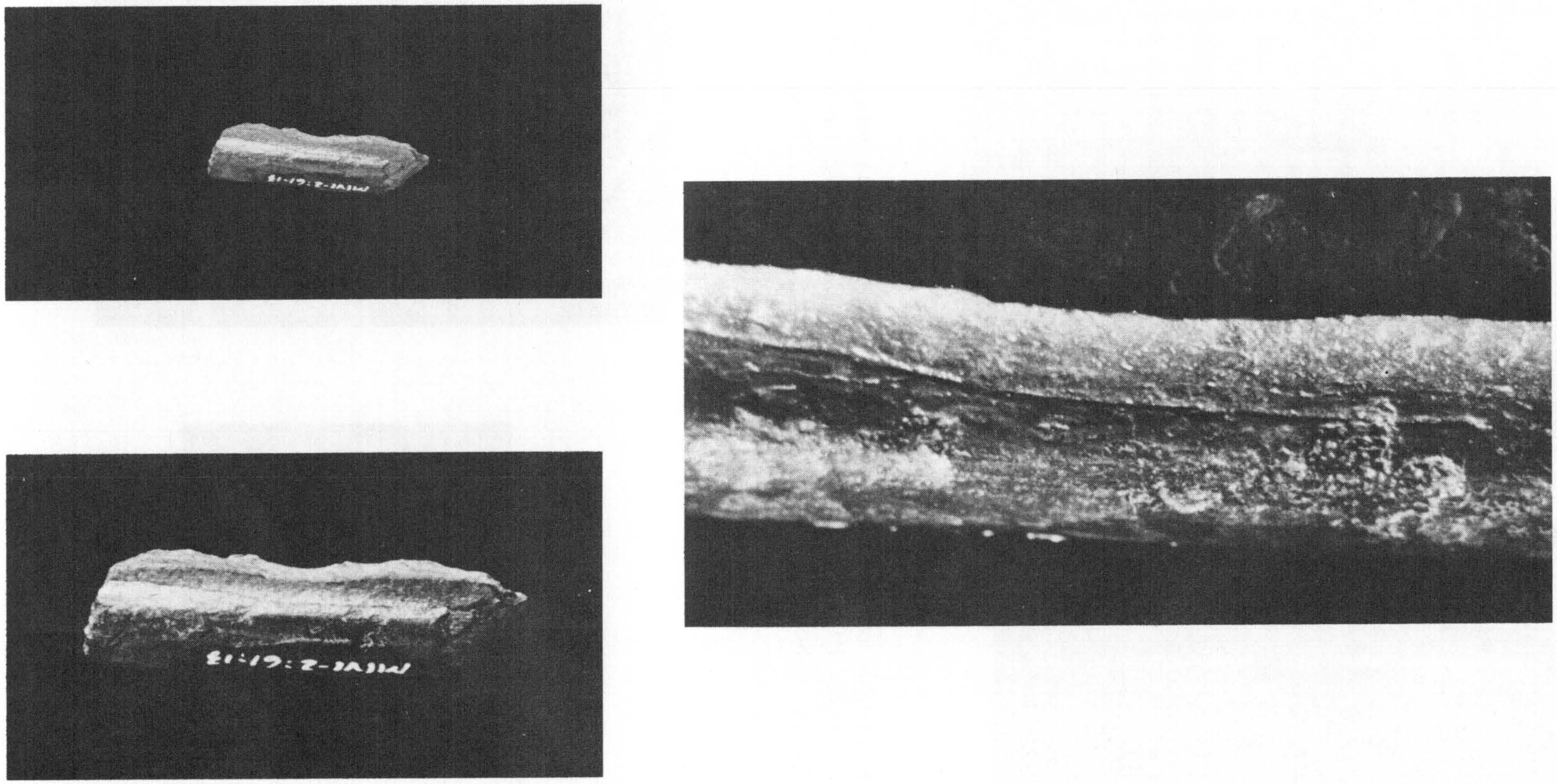


Pl. 6.12. Scraped and polished unidentified large mammal long bone fragment (M1V1-2:61-45) from Disconformity A, M1V1-2, Old Crow River, northern Yukon Territory. Scale on the left is 2X; the photomicrograph in the center is at 9X; scanning electron micrograph on the right, 21X.

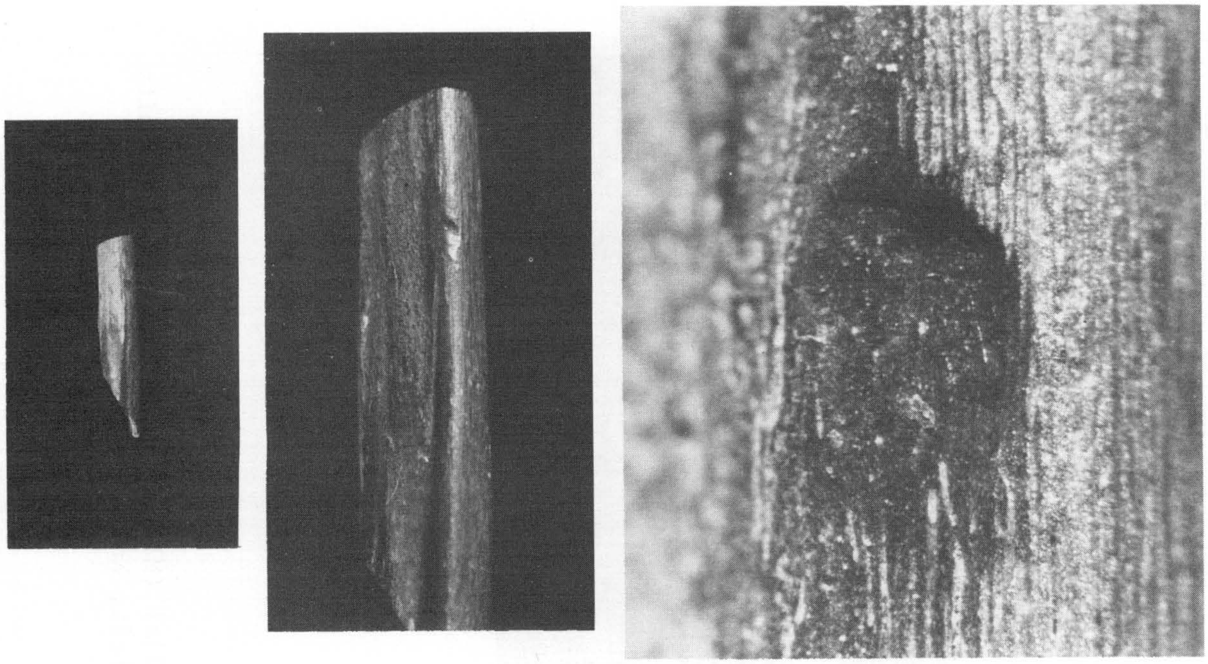




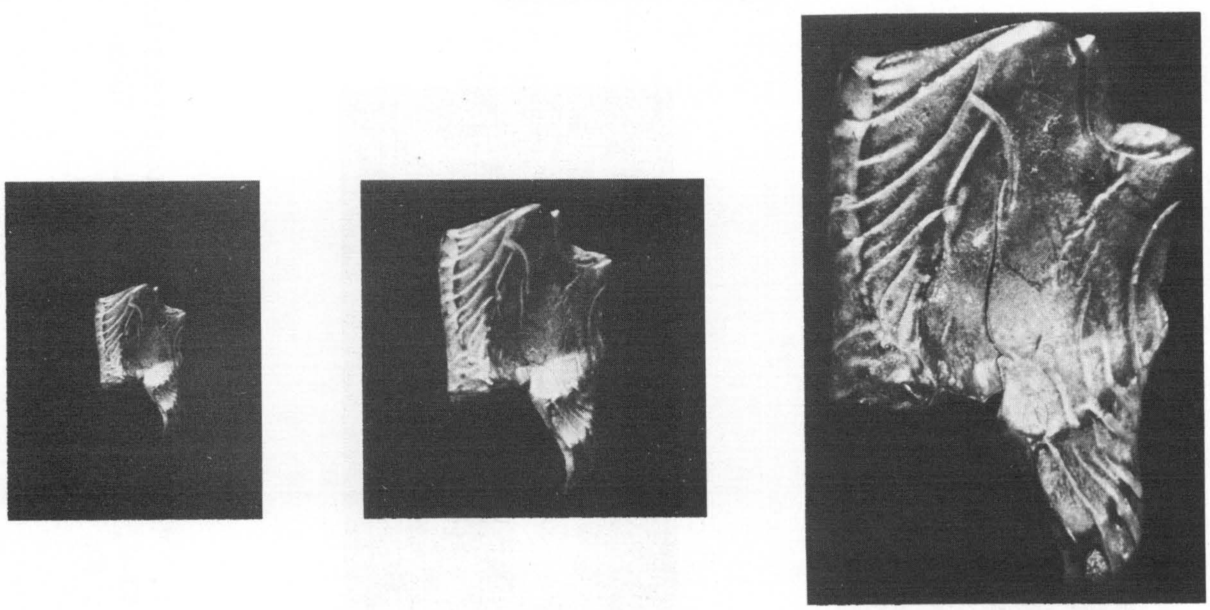
Pl. 6.13. Curvilinear design on a bison (*Bison* sp.) ulna (MlVl-2:27-1) from Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory. Above, three views, Nat. size; below, two views, 2X.



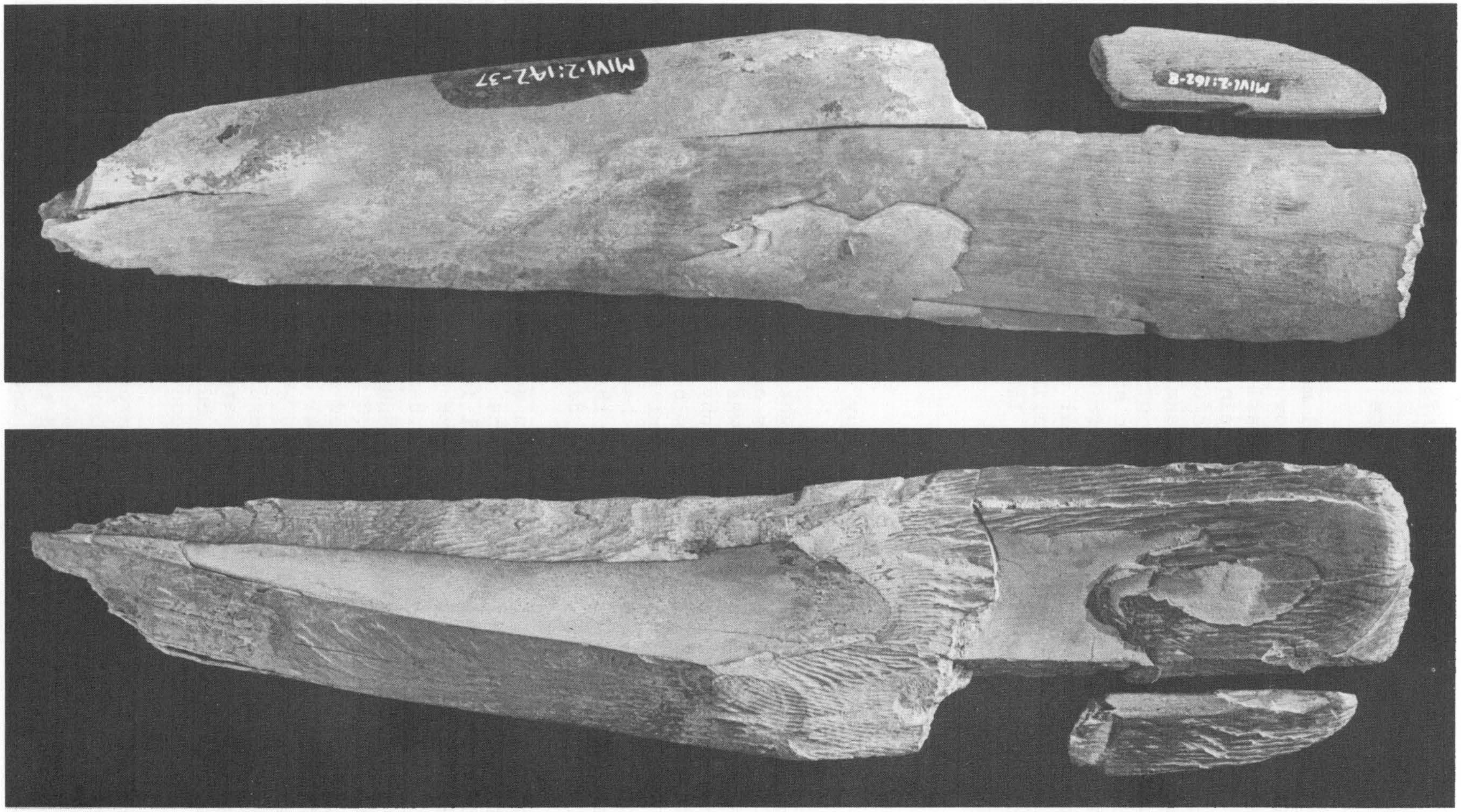
Pl. 6.14. Butchering mark on unidentified large mammal metapodial (MlVl-2:61-13) from Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory. Upper left, Nat. size; lower left, 2X; right, 8X.



Pl. 6.15. Arctic hare (*Lepus arcticus*) radius (MlVl-2:132-8) with cut near middle of shaft, from Mid-section deposit, MlVl-2, Old Crow River, northern Yukon Territory. Scales: left, Nat. size; center, $3\frac{1}{4}$X; right, 35X.



Pl. 6.16. Unexplained curvilinear grooves on an interior enamel fragment from an unidentified large mammal cheek tooth (MlVl-2:81-4) from Disconformity A, MlVl-2, Old Crow River, northern Yukon Territory. Scales: left to right, Nat. size, 2X, 4X.



Pl. 6.17. Polished mammoth (cf. *Mammuthus* sp.) tusk fragment (MlVl-2:142-37, 162-8) from the mid-section deposit, MlVl-2, Old Crow River, northern Yukon Territory. Nat. size.

CHAPTER 7. OTHER EXCAVATED SPECIMENS

Introduction

Specimens with possible artificial modifications have been excavated from six other localities in the Old Crow region. These finds will be very briefly described, and they can be summarized as follows. Only one piece (MkVl-9:7) has been found in ancient point bar deposits in Unit 3 where an age similar to or greater than Disconformity A is implied by its stratigraphic position, and it is a small flake which could have been produced either artificially or naturally. Most of the other excavated specimens are from Disconformity A or from similar stratigraphic positions in various profiles (MkVl-10, MlVl-13). Two localities (MlVl-3, MlVl-13) have yielded interesting bones from possible erosional contacts or weathered surfaces well above Disconformity A, and two localities (MfVe-1, MlVj-1) have produced specimens from above the upper lake clays at the base of the Holocene sediments.

MlVl-13

Stratigraphy

MlVl-13 is a high bluff on the right bank of the Old Crow River, 88.3 km above the river mouth. Portions of only four days were devoted to the examination of this bluff which was studied originally by O. L. Hughes in 1969 (HH69-21). The gross stratigraphy is very similar to that of MlVl-2, but a zone between 4.8 amd 6.8 m below the upper lake clays is thought to represent a complex equivalent of Disconformity A in which one or more units lost elsewhere to erosion have been preserved at MlVl-13. Since it is in these units that most of the archaeologically important materials have been found, they will be described in some detail.

A sequence of four layers has been seen at three widely separated places on the face of the bluff (Stations 1, 3, and 4). These layers were described in the field at Station 1 in relation to their depths below the upper lake clays (Fig. 7.1): (1) dark brown cross-bedded silts grading laterally to fine yellow brown sands, 4.8-5.0 m below the upper lake clays; (2) dark gray-brown clayey silts with angular blocky structure, many faults, and scattered bones near the top, 5.0-6.0 m; (3) red-brown clayey silts and fine sands, poorly sorted, with scattered organic matter and a few bones and abundant charcoal, 6.0-6.8 m; and (4) dark blue-gray to gray-brown clayey silts interbedded with light gray silts, 6.8-12.2 m. The contact between Layers 1 and 2 is sharp but irregular with many small faults and flame structures, and pebbles and bones are concentrated locally. The other contacts are less sharply defined but lack the irregularities and structural alterations and are clearly conformable.

Layer 1 is quite similar in most areas to the cross-bedded silts which overlie Disconformity A at MlVl-2, and Layer 4 is very similar to the silty clays which underlie the disconformity at MlVl-2. Layers 2 and 3 are unlike any sediments seen at MlVl-2, and these may together represent a lateral equivalent of Disconformity A. Such a correlation is suggested by a large and complex feature which was partially exposed at Station 2 in a gully between Stations 1 and 3 (Fig. 7.1). This feature consists of a remarkable deformation of the bedding planes accompanied by a significant truncation of the deformed beds. Outside this feature the contact between the oxidized bedded sands and the dark gray silty clays closely resembles the contact called Disconformity A at MlVl-2. The deformed beds in the feature appear to represent the layers numbered 2 and/or 3 on the face of the bluff, and the feature may have resulted from sub-aerial weathering on a surface which was planed off when the overlying sands were brought into the site. It is unfortunate that I was unable to dig out the base of the feature, because our available data do not indicate a clear interpretation of its origin. Cryoturbation, thermokarst collapse, or ice wedge formation might be responsible for the deformation of the bedding.

Layer 3 may represent a soil profile in view of its red-brown colour and organic contents including abundant charcoal, and Layer 2 may be a colluvial covering made up of similar materials. The loss of bedding in Layer 3 could result from pedogenesis, and colluviation of Layer 2 would destroy its original bedding while melting of segregated ice in the bedding planes could produce the angular blocky structure.

This is hardly a definitive explanation of the stratigraphy seen at MlVl-13, but it is enough to indicate that Layers 2 and 3 probably represent sedimentary increments which have been lost to erosion on Disconformity A elsewhere in the valley. The possibility that a paleosol is preserved at MlVl-13 can only be established by means of further field work, but the tentative interpretation offered above shows that bones occurring in Layers 2 and 3 may be penecontemporaneous with one another and with Disconformity A.

Paleontology

Only 53 vertebrate specimens were obtained from primary stratigraphic contexts at MlVl-13, but they are quite interesting from both archaeological and paleontological standpoints. At least ten taxa are represented in this small collection: a duck (Anatidae), a microtine rodent (Cricetidae), muskrat (*Ondatra zibethicus*). Arctic ground squirrel (*Spermophilus parryi*), Arctic fox (*Alopex lagopus*), a possible wolf (cf. *Canis* sp.), mammoth (cf. *Mammuthus* sp.), a possible horse (cf. *Equus* sp.), caribou (*Rangifer tarandus*), and bison (*Bison* sp.).

Three specimens were recovered from three separate positions above Disconformity A but below the upper lake clays, and the remainder were found in the complex stratigraphic sequence described above between 4.8 and 6.8 m below the upper lake clays. The uppermost specimen in the profile is a possible horse mandible fragment (MlVl-13:18) which occurred only 0.10 m below the upper lake clays in flat-bedded clayey silts; polish on this specimen is probably a result of natural processes. The next piece (MlVl-13:19) is a large mammal rib fragment on which a green fracture is associated with clear evidence of carnivore gnawing; it was found in massive silts 0.95 m below the upper lake clays. The third specimen (MlVl-13:10) may be a fragment of mammoth long bone, and it was found on a sharp contact

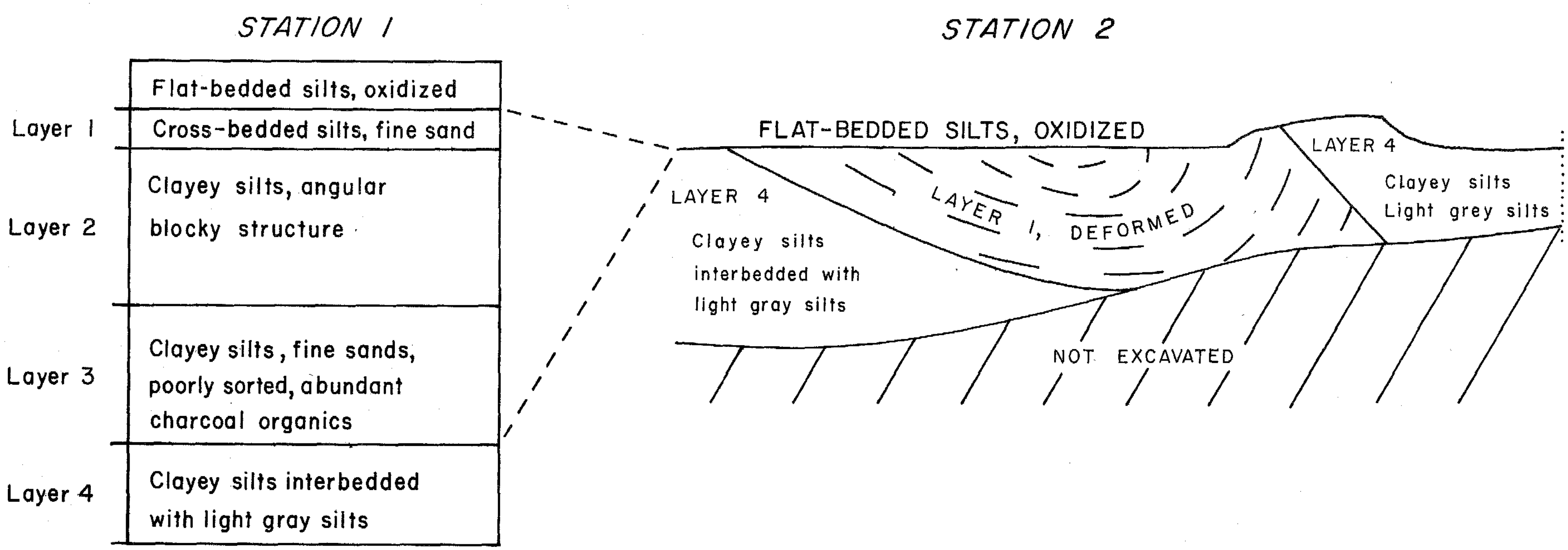


Fig. 7.1. Basis for correlation of stratigraphic units equivalent to Disconformity A at M1V1-13, Old Crow River, northern Yukon Territory.

at which cross-bedded silts and sands overlay flat-bedded silty clay and silts 1.30 m below the upper lake clays. The bedding of the flat-bedded sediments was locally deformed at the top of the unit, and the contorted bedding planes had been truncated by erosion which accompanied the deposition of the overlying cross-bedded materials (J.V. Matthews, field notes 24.vii.78). This erosional contact can be called a local disconformity which has been labelled "B" to distinguish it from Disconformity A. The bone found on this contact will be described below, because some of its alterations are probably artificial.

Of the remaining 50 specimens excavated from M1V1-13, 29 occurred at the contact between Layers 1 and 2 (Fig. 7.1), eight were found in the upper 20 cm of Layer 2, eight were found in the lower 20 cm of Layer 2, one was found in Layer 3, and four were recovered from the deformed beds in the Station 2 feature. Five of these specimens exhibit alterations which may be artificial, and at least six of the bones from Station 1 may represent a single bison carcass which was partially butchered by man.

The six bison bones include an intact left metatarsal and an intact left tarsal cuneiform from the contact between Layers 1 and 2, a cut rib from the same contact, a left innominate (with cuts on the ischium) and a sacrum found in articulated position in Layer 2, and a patella recovered from Layer 3. Three additional bones found on the bank below the exposure could represent the same bison (right metacarpal, right ilium fractured when green, and right calcaneus). Since the main purpose of this report is to summarize the archaeology, other details of the paleontology will be reported elsewhere (Hughes, *et al.* 1980).

Archaeology

Vertebrate fossils with suspected artificial alterations have been listed in Table 7.1, but several of them require more description. The possible mammoth long bone fragment from "Disconformity B" (M1V1-13:10) is polished on both faces and appears to have been shaped, possibly by cutting, to a blunt point (Pl. 7.1). The piece has a nearly symmetrical parallel-ovate shape and a plano-convex cross-section. The tip has been formed in part by the detachment of two flakes from the outer surface and the left edge and by one flake detached from the inner surface of the specimen. The polish extends onto the edges of the flake scars and forms a broad slightly concave facet with oblique striae on the inner surface of the bone. There is no sign of cancellous tissue on the inner surface, and this specimen may have been shaped from a struck flake. In view of the complexity of these alterations, I have classified them as probably artificial.

All three artificially modified bones from Disconformity A at Station 1 exhibit small incisions which were made by stone tools (Table 7.1). M1V1-13:20.1 is a green fractured large mammal long bone with numerous scratches on its outer surface (Pl. 7.2). These scratches are broad and shallow, often with fine grooves visible on their floors. The individual scratches range up to 0.16 mm in width, and they occur in bundles 1.4-1.6 mm across and as much as 14.0 mm long. Several of the bundles are made up

Table 7.1. Artificially modified vertebrate fossils from MlVl-13, Old Crow River, northern Yukon Territory.

Stn.	Cat.	Taxon and element	Length	Width	Thickness	Weight	Alterations	Status
"Disconformity B"								
1	10	cf. *Mammuthus* sp. long bone	63	22	9.4	9.2	Polished, cut(?), flaked tip	Prob. artif.
Disconformity A, Layer 1/2 contact								
1	20.1	Large mammal long bone	57	26	W3.3-3.8	5.6	Green fracture (4/4), scratched	Artif.
1	21	cf. *Bison* sp. rib	321	33	W2.3-6.2	152.4	Green fracture (cyl), cuts	Artif.
Disconformity A, Layer 2								
1	11	*Bison* sp. L. innominate	370	182		659.2	Cuts on ischium	Artif.
4	24.3	cf. *Mammuthus* sp. long bone	50	18	W>11.6	6.5	Green fracture (2/3)	Artif.
4	26	Large mammal rib	370	40	12.2	167.7	Split longitudinally	Artif.

Legend
Stn., station
Cat., catalogue number (all from MlVl-13)
W, wall thickness
Status: Prob. artif., probably artificial; Artif., artificial

of three major and many minor scratches with two of the major ones 0.8 mm apart and another such spacing measuring 0.9 mm, implying that the same tool was repeatedly moved against the surface of this bone. I have not been able to count the bundles of scratches because of the complex ways in which they overlap and truncate one another, but they nearly cover the outer surface and range from longitudinal to oblique in their orientations. The scratches are truncated by rootlet etching and by the green fractured margins of the specimen. I suggest that the scratches are the result of the use of a stone scraper to remove the periosteum from this bone prior to inducing the fractures, so they have been classified as artificial.

M1V1-13:21 is a large fragment of a large mammal rib probably attributable to bison. The proximal end of the rib was fractured when green, and the distal end exhibits evidence of carnivore gnawing but is too poorly preserved to reveal the nature of its fracture. Three cuts appear on the anterior border of the rib approximately 124, 147, and 152 mm from the proximal end, respectively (Pl. 7.3). These cuts, taken in their order from proximal to distal, measure 1.9, 1.9, and 4.1 mm in length, respectively. Each is oblique from proximal/medial to distal/lateral. One cut appears on the lateral face approximately 176 mm from the proximal end. It is 7.0 mm long and is oriented obliquely from proximal/anterior to distal/posterior. This cut could have resulted from follow-through in the same stroke which produced one of the cuts on the anterior border. All these cuts are 0.04 mm wide with U-shaped cross-sections, and their depths vary slightly as they are deeper in the areas of greatest surface convexity. A few minor scratches elsewhere on the rib are probably a result of natural processes, and they provide useful comparisons with the cuts which I have interpreted as artificially induced through the use of a stone tool in butchering.

The left innominate of a bison (M1V1-13:11) exhibits cuts in three locations on the medial face of the ischium (Pl. 7.4). Two cuts, 4.1 and 5.3 mm long, respectively, are located near the superior border just posterior from the position of the acetabulum, and these are oriented obliquely from superior/proximal to inferior/distal. Three major cuts, 3.3, 6.1, and 7.3 mm long, respectively, are seen near the angle of the ischium and share a transverse orientation from superior to inferior. A small scratch is also visible between two of these cuts and suggests that the whole bundle was produced by the edge of a stone scraping tool. A bundle of five major and two minor cuts occurs in the center of the ischium with the individual cuts ranging from 1.4 mm to 14.5 mm long. This bundle has a longitudinal orientation from posterior to anterior, and the configuration of the bundle also suggests the use of a stone scraping tool. The widest and deepest of the cuts on this ischium measures approximately 0.08 mm in both dimensions, and the cuts have U-shaped cross-section. I have interpreted them as butchering scars which might have resulted from defleshing of this bison innominate. The orientation directions mentioned above do not definitely indicate the direction in which the tool was moved, although the suggested directions are feasible in each case. Certainly these cuts were artificially induced.

Station 4 is located on the second facet downstream from Station 1 at a distance of approximately 50 m. Of two artificially modified bones excavated from Disconformity A at this station (Table 7.1), one is merely a green fractured mammoth long bone fragment without further modifications (MlVl-13:24.3). The other (MlVl-13:26) is a large mammal (bison?) rib which has been split longitudinally to preserve the inner face of the rib (Pl.7.5). Unfortunately the specimen is poorly preserved, but two areas of one edge exhibit remnants of the original cutting and polishing which elsewhere has been removed by relatively recent fractures. An area of this edge 40 mm long near the distal end of the rib preserves a cut and polished facet on which oblique striae point back toward the center of the specimen. Near the proximal end a smaller area of the same edge, only 10 mm long, preserves similar cutting and polishing features, but the oblique striae also point toward the center of the rib and therefore are oriented at 90° to the striae near the distal end. Several poorly preserved indentations along both edges of this rib suggest that the splitting was partially accomplished by fracturing. I have never seen such a large rib segment so perfectly split in the longitudinal axis by natural agencies, and the only similar Pleistocene specimen which has come to my attention is a split mammoth rib from the Dutton site in Colorado (Stanford 1979b: Fig. 3d). I have classified these alterations as <u>artificial</u>.

Summary

MlVl-13 has produced a rather remarkable series of vertebrate specimens given the small amount of time devoted to its study. I spent only a few hours there on 6 July 1978, four of us devoted a few more hours to the exposure on 12 July, John Matthews worked there on the afternoon of 24 July, I and my crew continued work for a half day on 26 July, and a day and a half were spent there by Keary Walde, Robert Vance, and Heather Morlan on 27 and 29 July. Of the many localities we studied in 1978, this bluff was the most distant from our base camp, and we spent most of the field season on exposures closer to "home." It is also significant that our multi-disciplinary teamwork was less well integrated at MlVl-13 than at the other localities we studied with the result that I did not appreciate the possible significance of the bluff until the analysis was well underway. The very small butchering scars described above cannot be seen under most field conditions, and they were not recognized until the bones had been carefully cleaned and examined under a microscope.

Our small sample from MlVl-13 shows that a relatively diverse local fauna can be obtained from primary stratigraphic contexts equivalent to Disconformity A, and the fauna may include butchered bison and other artificially modified forms (e.g., the green fractured mammoth bone). This would seem to imply that we are much closer to an archaeological site at MlVl-13 than at MlVl-2, and the articulation between the innominate and the sacrum of the bison demonstrates that the bones have not been moved since they were fresh. Certainly MlVl-13 has a high priority for further study in future field seasons.

MkVl-10

We devoted only two days in 1977 to this high bluff on the right bank of the Old Crow River, 66.8 km above the river mouth, but the exposure is of some importance since it is the second locality at which we indentified Disconformity A. The disconformity is very similar to the corresponding contact seen at MlVl-2 in most parts of the exposure, but the upstream end of MkVl-10 preserves a 10 cm increment of rich brown organic silt between the cross-bedded sands and the blue-gray silty clay, and this silt unit might represent a truncated remnant of a paleosol. The samples of vertebrates trowelled from Disconformity A at MkVl-10 are generally similar to those from MlVl-2, but large pieces have not been found at MkVl-10. The only green fractured bones recovered thus far represent unidentifiable large mammals, and the fractures could have been induced by either natural or artificial causes. Therefore I have chosen only two polished specimens for presentation in this report (Table 7.2). A sieved sample from Disconformity A produced microtine rodent, insect, and plant fossils which will be reported elsewhere (Hughes, *et al.* 1980).

MkVl-10:16 has been described elsewhere as a possible artifact (Morlan 1979a:137), but the possibility that it was altered naturally cannot be ruled out. Two green fractured margins converge to form an acute angle (75°) on which two adjacent polished facets are located (Pl.7.6). The larger facet measures 6.4 X 3.4 mm and the smaller only 2.5 X 1.7 mm. These two facets are barely differentiated from one another, having an angle of 160° between them, and they share identical oblique striae. While we might suppose that a polished corner such as this could result from its artificial use as a scraping edge, the facetting is such a simple affair that natural agencies might be responsible for it.

MkVl-10:28.1 is a mammoth or mastodon tusk fragment which appears to have been detached from the tusk by flaking, but the piece is difficult to evaluate in this regard because most of the inner surface has been lost to exfoliation. One end of the specimen is highly polished, and the polish covers a convex facet extending from the outer surface around the fractured end to high spots outside the exfoliated area of the inner surface. Visible striae on this polished end are transverse, indicating that the edge of the tusk was moved back and forth laterally against an abrasive surface (Pl. 7.7). On the inner surface at the opposite end, the tusk exhibits an obliquely scraped area approximately 6.9 mm long in association with slight polish which is truncated by the exfoliation scar. The complexity of the polished facet, the occurrence of scraping prior to exfoliation, and the suggestion that the specimen originated as a struck flake prompt me to classify the alterations as probably artificial.

MkVl-9

This high bluff on the left bank of the Old Crow River, 64.9 km above the river mouth, is the next major exposure downstream from MkVl-10, but it reveals some major differences in stratigraphic facies, probably because of the influence of Schaeffer Mountain which is nearby to the southeast. We believe that the lateral equivalent of Disconformity A at this exposure is a peat/sand contact at 41.85 m (in relation to a 50 m datum at the top of the bluff), and the peat at this contact is autochtonous and has produced a radiocarbon date of >51,000 B.P. (GSC-2559-2). Between 12 and 15 m lower in the profile are two layers of fine gravel and coarse sand in point bar deposits which are relatively rich in

Table 7.2. Attributes of selected vertebrate specimens excavated from MkV1-10, MkV1-9, MlV1-3, MlVj-1, and MfVe-1, Old Crow region, northern Yukon Territory (see Table 2.1, Fig. 2.3 for locations; Fig. 2.2 for stratigraphic units).

Cat. No.	Taxon and element	Length	Width	Thickness	Weight	Frac.	Other	Status
Disconformity A								
MkV1-10:16	Large mammal long bone	93	30	W5.5-7.9	15.6	2/4	Polished	Nat. or Artif.
MkV1-10:28-1	cf. *Mammuthus* sp. tusk	36	39	5.1	5.2	Flake?	Polished, scraped	Prob. Artif.
Unit 3 channels								
MkV1-9:7	Large mammal bone	15	18	7.2	1.1	Flake		Nat. or Artif.
"Disconformity B"								
MlV1-3:3,5,11	*Bison* sp. R. radius, proximal	223	68.3	D35.5 W8.6-16.2	539.0	Cyl.		Prob. Artif.
Unit 7								
MlVj-1:1	*Alces alces* L. metacarpal shaft	135	42	W5.9-9.3	93.3	5/5	Loading scar, >7.9	Prob. Artif.
MfVe-1:1	*Rangifer tarandus* L. femur	126	22.5	D28.0 W3.1-4.0	37.7	Cyl.	Burned	Nat. or Artif.
MfVe-1:2	*Anas* cf. *carolinensis* L. humerus	56	3.5	D3.2	0.5	0/0	Burned	Nat. or Artif.

Legend
Thickness: W, wall thickness; D, shaft depth; others, total thickness
Status: Nat. or Artif., natural or artificial; Prob. artif., probably artificial
Frac. (fracture): Cyl., cylinder

vertebrate fossils. Most of the vertebrates from screened samples of these layers are microtine rodents which will provide a good paleoenvironmental record when they are finally analyzed, but several larger animals are also represented including bison and beaver (*Castor canadensis*). The upper of the two gravel layers also produced a struck flake from a large mammal bone (MkV1-9:7; Pl. 7.8). Because of its small size, I might have rejected this flake as probably carnivore induced, but it exhibits a gabled platform remnant (Type 6 in Table B11) which implies considerable force in the primary fracture of the bone. The distal end terminates in a hinge, and other alterations include a coating of vivianite and moderate rounding. I do not know whether its production was natural or artificial.

MlVl-3

This is the first high bluff encountered when one travels up Johnson Creek. The bluff is located on the left creek bank, but aerial photograph analysis shows that much of the cutting of this exposure was accomplished by the Old Crow River which has since "migrated" westward across its valley floor with the mouth of Johnson Creek doing likewise. Thus MlV1-3 is the next major left bank exposure of the Old Crow River above MkV1-9, and the former is directly across the Old Crow valley from MlV1-2. MlV1-3 provides a critical link in our efforts to correlate these other exposures, because it offers a peat/sand contact which grades laterally to a cross-bedded silt/clayey sand contact below which the volcanic ash is well preserved to demonstrate that these are manifestations of Disconformity A as seen at MkV1-9 and MlV1-2, respectively.

Only a few minor vertebrate specimens have been recovered from Disconformity A at MlV1-3, but a second contact of highly organic silts resting on inorganic clayey silts approximately 3.2 m higher in the exposure and only 80 cm below the upper lake clays has produced several interesting bone fragments. MlV1-3:3 and 5 were seen *in situ* on this contact, and MlV1-3:11 was found by Keary Walde on the following day in the gully below the exposure. When these three pieces are rejointed, it is clear that a right bison radius was fractured when green by means of a massive impact on the medial side of the shaft. I doubt seriously that any carnivore could have created a mid-shaft fracture on a bone of this thickness and diameter, so I have classified this fracture as probably artificial (Table 7.2). Other interesting features of this specimen have been discussed at length and illustrated elsewhere (Morlan 1979a:138, Figs.6-7), and these need not be repeated except to say that reexamination of the locality in 1978 in an intensive search for an undisturbed archaeological site was frustrated by the fact that most of this north-facing exposure is frozen solid only a few centimeters behind the face.

Fine organic detritus was extracted from a sample of the organic silts which surrounded the bones at MlV1-3, and the resulting sample of spruce needles, seeds and several aquatic plant macrofossils was submitted for a radiocarbon date of >37,000 B.P. (GSC-2792). This is the first direct association between a bone thought to have been modified artificially and a radiocarbon date on surrounding matrix. Both pollen and macrofossil analysis suggest that an open spruce forest was growing in the area when these deposits were formed, and the character of the peat and abundance of aquatic plant seeds suggest that the organics may have accumulated in a thaw lake into which the spruce fossils and the bison bone were introduced. It is likely that the upper portion of the profile has been disturbed by flowing clay as the ice-rich glacio-lacustrine sediments have melted, but the organic silts are in undisturbed stratigraphic position and have not been directly affected by such changes.

MlVj-1

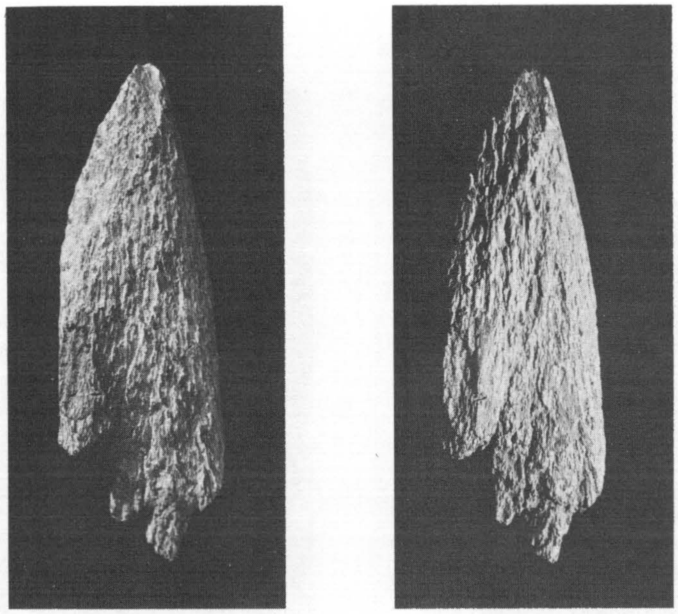
This high bluff on the right bank of Johnson Creek was visited for only one hour on 30 June 1975 when we stopped there with a helicopter. As I descended the bank from the top of the exposure, I encountered a badly weathered caribou antler fragment and a large long bone fragment which had eroded out of the silts which overlie the upper lake clays. The long bone fragment proved to be from a moose metacarpal, and a large loading point scar is preserved on one corner of the specimen suggesting that the bone was broken by a hammerstone so that its fracture is probably artificial (Table 7.2, Pl. 7.9).

MfVe-1

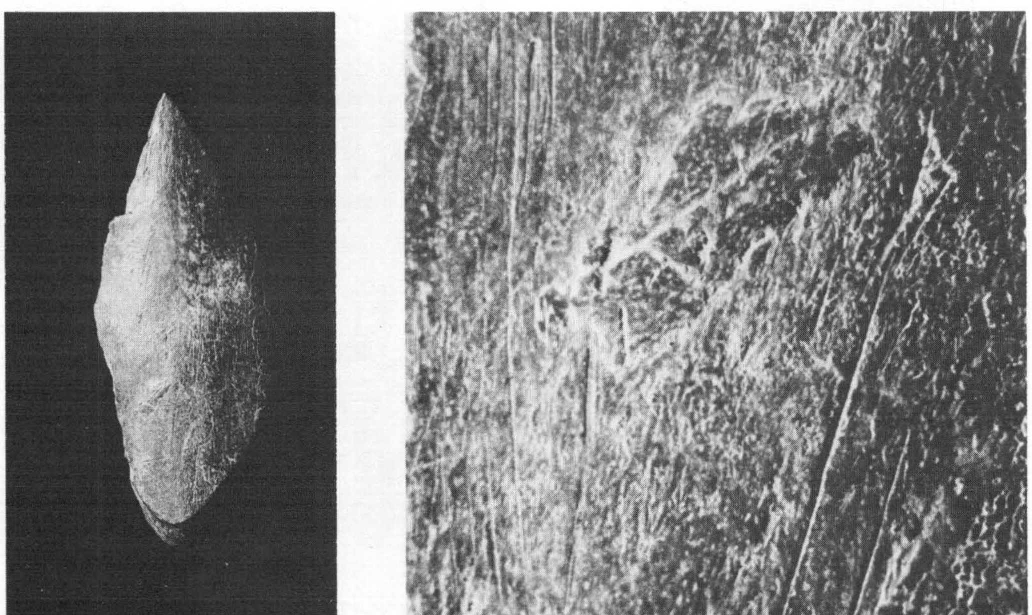
This is a high bluff on the left bank of the Porcupine River which was examined by C.R. Harington on 31 July 1967. He collected the intact humerus of a duck (MfVe-1:2) and 19 fragments of large mammal long bone which were glued together to form a large portion of a caribou femoral shaft (MfVe-1:1). These specimens occurred at the base of a peat layer eight feet (2.4 m) thick which forms the top of the exposure above the upper lake clays. Elsewhere on the exposure the thickness of the peat reached 15 feet (4.5 m). Basal dates on such peat exposures in the Old Crow region have ranged between 6430 ± 140 B.P. (GSC-372) at NaVl-1 to 10,740 ± 180 B.P. (GSC-121) at MlVl-1, suggesting that the specimens from MfVe-1 date to some time in that range. The interesting thing about the bones from MfVe-1 is that both of them are intensely burned and that the caribou femur was fractured when green and prior to burning (Pl. 7.10). It is possible that a forest fire burned these bones after a carnivore had fractured the caribou femur in which case the alterations are natural, but the association of a waterfowl and a caribou in the fire suggests that artificial fracture and burning of the bones should not be ruled out. J.V. Matthews, N.W. Rutter, and C.E. Schweger attempted in 1977 to recover more information from this locality, but they were unable to examine the units in question because of a large draped peat layer which concealed the face of the exposure.

Summary

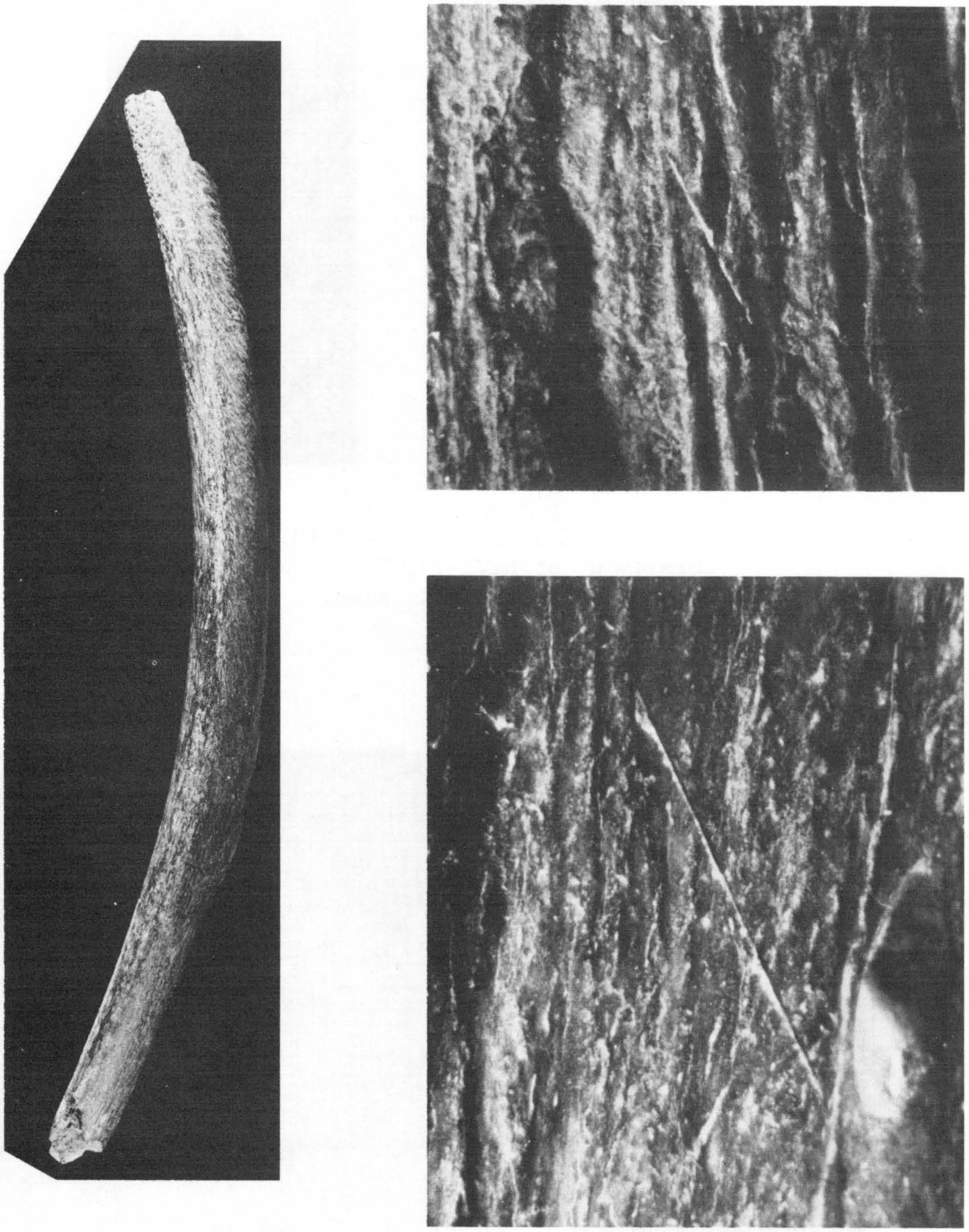
Taken together with MlVl-2 (Chapter 6), the six localities described in this chapter show that the Old Crow basin offers prospects for undisturbed archaeological sites beginning with Disconformity A and extending through Units 4 and 5 of our composite profile (Fig. 2.2). The upper glacio-lacustrine clays (Unit 6) may represent a significant hiatus in the regional archaeological record (see Chapter 9), but more attention should be devoted to the silts (Unit 7b) which can be exposed between the lake clays and the peat in all three basins of the northern Yukon and which may contain important early Holocene archaeological materials.



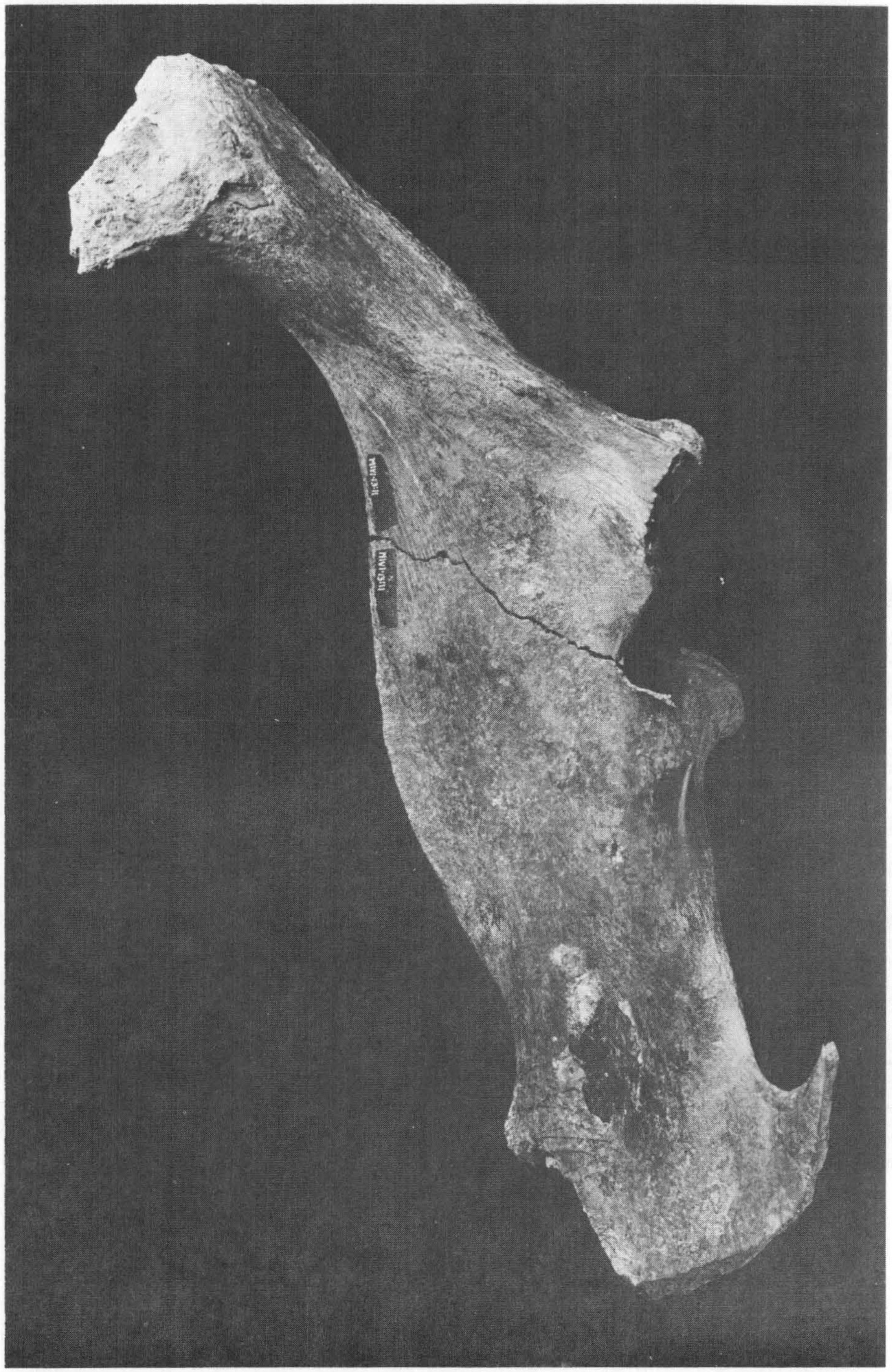
Pl. 7.1. Shaped mammoth(?) (cf. *Mammuthus* sp.?) long bone fragment (MlVl-13:10) from "Disconformity B" at MlVl-13, Old Crow River, northern Yukon Territory. Nat. size.



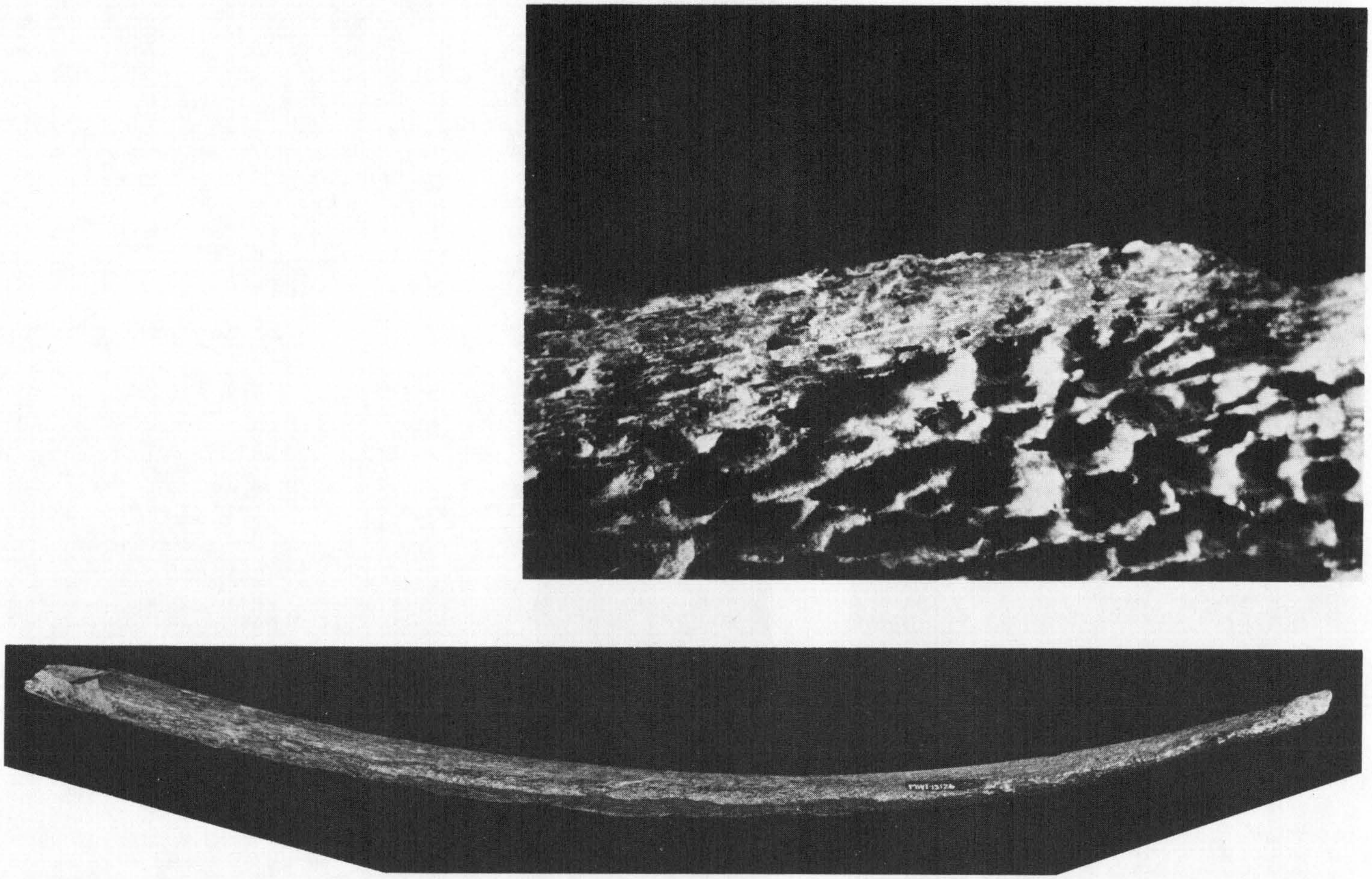
Pl. 7.2. Scraped long bone fragment of an unidentified large mammal (MlVl-13:20.1) from Disconformity A, MlVl-13, Old Crow River, northern Yukon Territory. Nat. size on left, enlargement on right, 7X.



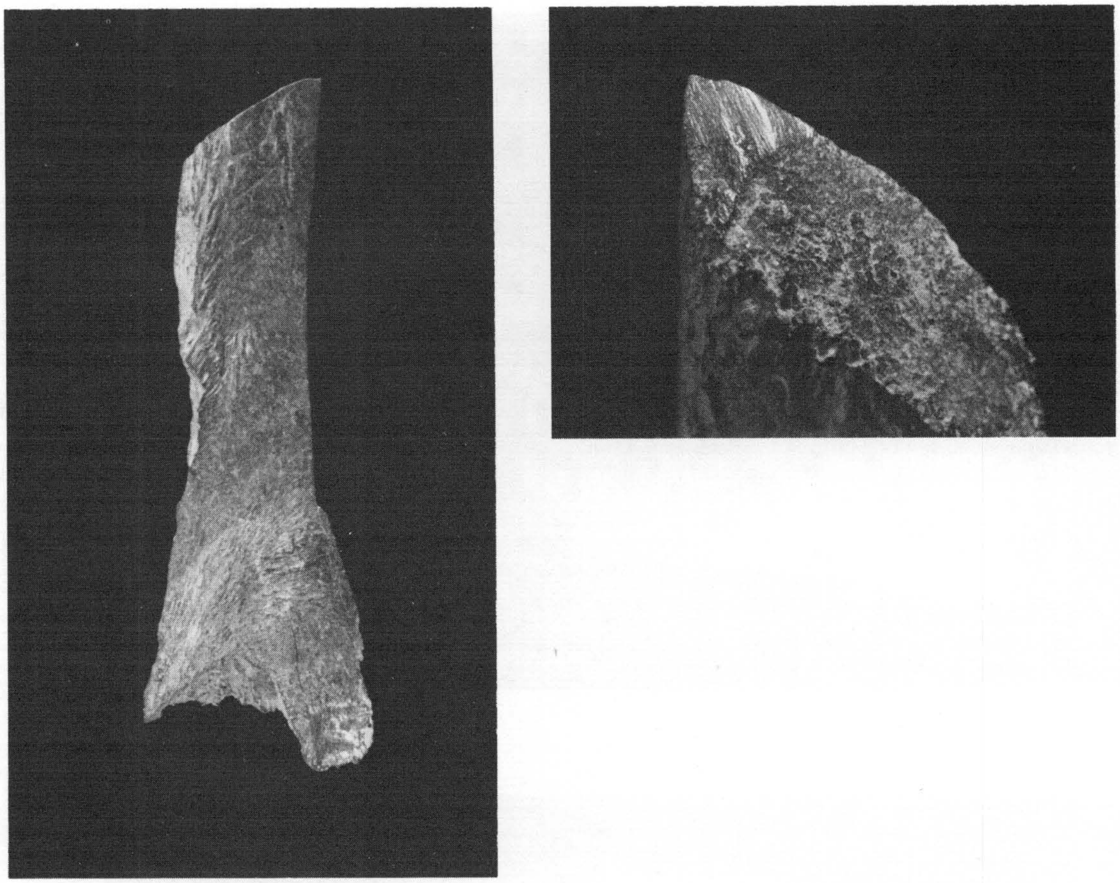
Pl. 7.3. Cuts made by stone tools on a large mammal (bison?) rib fragment (MlVl-13:21) from Disconformity A, MlVl-13, Old Crow River, northern Yukon Territory. Overview, ½ Nat. size; enlarged views, ca. 14X.



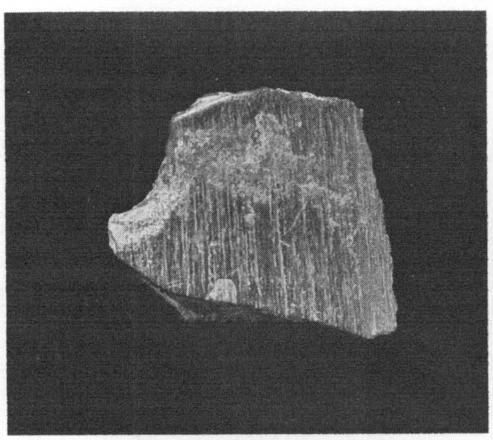
Pl. 7.4. Bison (*Bison* sp.) innominate (MlVl-13: 11) with cuts made by stone tools on the medial side of the ischium, from Disconformity A, MlVl-13, Old Crow River, northern Yukon Territory. Overview, ½ Nat. size; enlargement, ca. 8X.



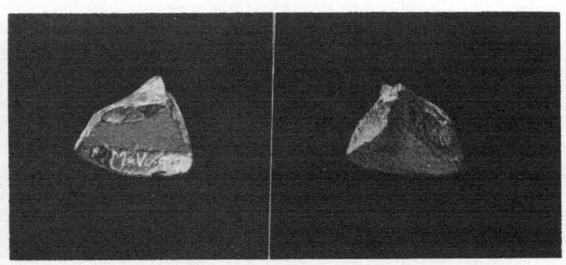
Pl. 7.5. Longitudinally split large mammal (bison?) rib (MlVl-13:26) from Disconformity A, MlVl-13, Old Crow River, northern Yukon Territory. Overview, ½ Nat. size; enlarged view of cut edge, ca. 14X.



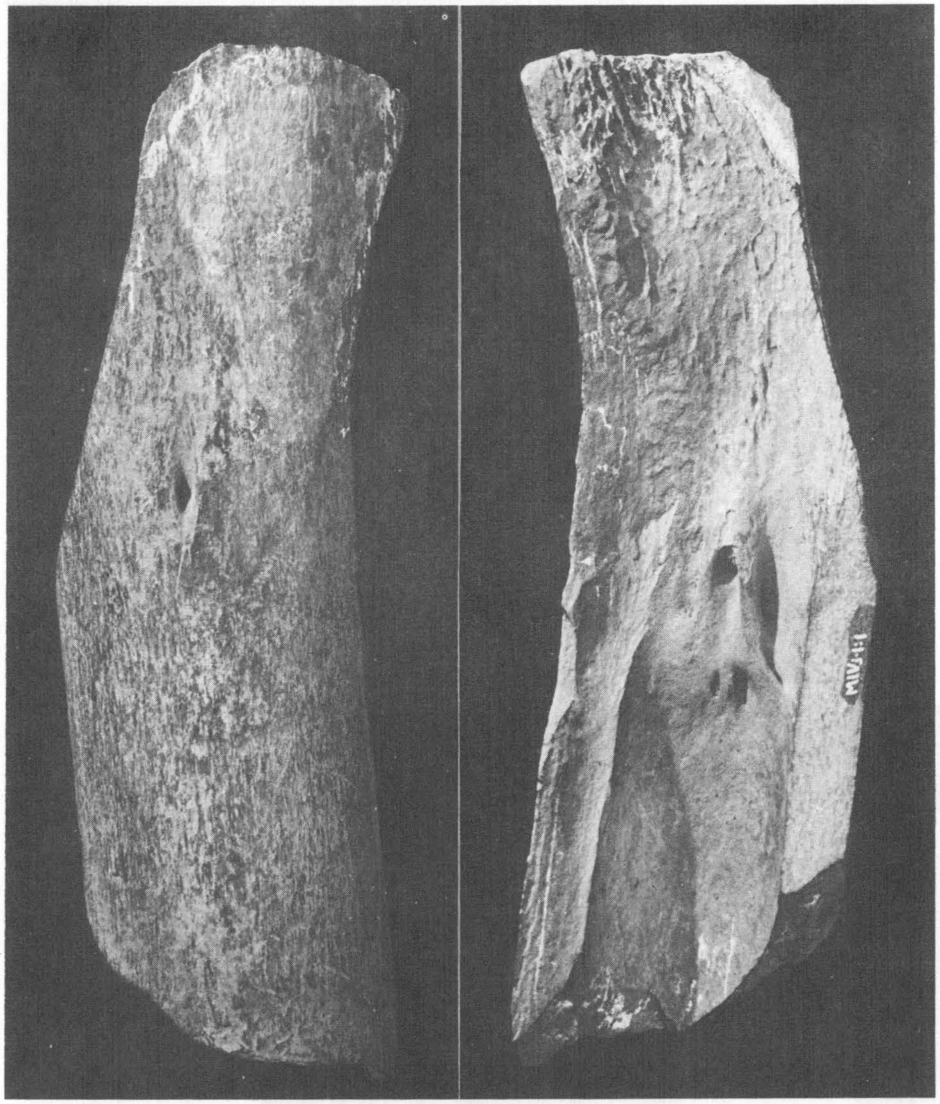
Pl. 7.6. Unidentified large mammal rib (MkVl-10:16) with polished facet on tip, from Disconformity A, MkVl-10, Old Crow River, northern Yukon Territory. Overview, Nat. size; enlargement, 3X.



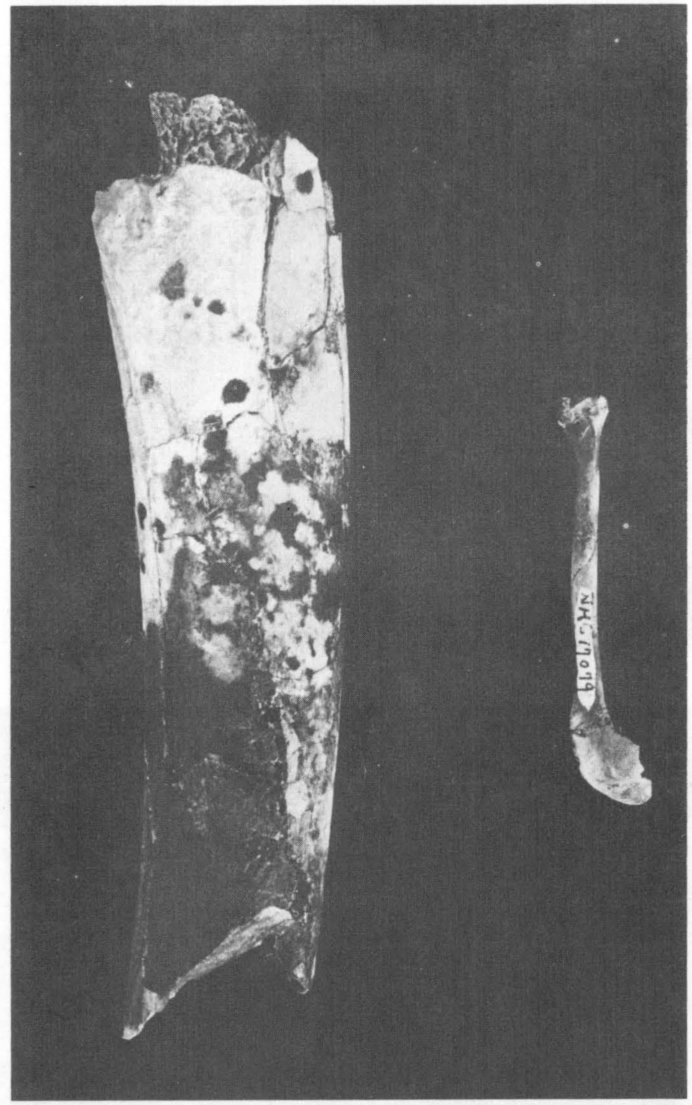
Pl. 7.7. Mammoth (cf. *Mammuthus* sp.) tusk fragment with polished edge, from Disconformity A, MkVl-10, Old Crow River. Nat. size.



Pl. 7.8. Small bone flake from mid-section point bar deposits at MkVl-9, Old Crow River, northern Yukon Territory. Nat. size.



Pl. 7.9. Moose (*Alces alces*) metacarpal fractured when green (MlVj-1:1) from early Holocene silts at MlVj-1, Johnson Creek, Old Crow basin, northern Yukon Territory. Nat. size.



Pl. 7.10. Burned caribou (*Rangifer tarandus*) femur and duck (Anatidae) humerus (MfVe-1: 1, 2) from basal Holocene peats at MfVe-1, Porcupine River, northern Yukon Territory. Nat. size.

CHAPTER 8. STONE ARTIFACTS IN THE OLD CROW VALLEY

Introduction

A large number of archaeological sites on the slopes and upland surfaces surrounding the Old Crow basin have been investigated in recent years (Irving and Cinq-Mars 1974; Morlan and Cinq-Mars 1980) and have yielded through both surface collecting and excavation an impressive collection of stone artifacts but very little in the way of bone preservation. Excavations during 1978 and 1979 at the Bluefish Caves just south of the Bluefish basin have produced a small lithic industry in association with well preserved faunal remains (Cinq-Mars 1979), and continued work along the Porcupine River, primarily by Cinq-Mars and Raymond LeBlanc, has greatly enlarged the middle to late Holocene prehistoric record.

Despite the many months of searching along the Old Crow River, during which one of the richest Upper Pleistocene vertebrate fossil concentrations in the world has been intensively collected, very few stone artifacts have been discovered, and no undisturbed Holocene archaeological sites have been encountered in the numerous terrace deposits which line most of the valley walls. With the exception of a few specimens to be reported here (and an unknown number of surface finds at the University of Toronto), the only signs of human occupation seen in the Old Crow valley are the modified bones and antlers, most of which are thought to date to the Upper Pleistocene, and the remains of historic cabins and other kinds of historic camps.

This plethora of bones and paucity of stones is one of the most peculiar characteristics of the redeposited collections from the Old Crow valley, but it should certainly not be construed as an indication that the Pleistocene artisans of the region lived by bone alone! I have argued elsewhere that we should expect vertebrate fossils and stone artifacts to be differentially sorted during redeposition in the Old Crow valley (Morlan 1979a:142). The morphology of objects transported in fluvial systems is critical in determining the manner and extent to which they are influenced by alluvial processes. Large bones, with relatively large cross-sectional areas, present large surfaces to moving ice and water whereas smaller cross-sections, especially in flat objects, present small surfaces and could more likely remain stationary on the bottom of the channel (cf. Voorhies 1969:Tables 11-12; Behrensmeyer 1975b:488). Even if downstream movement occurred by underwater saltation and scouring, these flat pieces, such as most stone artifacts, could remain in the bed load and become reburied rather than being left exposed on sand bars and silt banks. Recently we have discovered that many of our rich collecting localities are found in the truncated cross-sections of drained ox-bow lakes which are now perched as much as 15 m above the modern valley floor (Morlan 1978b). This observation demonstrates the occurrence of bone concentrations in the bed loads of former meander loops and implies that such concentrations are present in the modern bed of the Old Crow River. The ox-bow channel deposits could provide prospecting sites for the recovery of lithic artifacts which might belong with the fossil bone

Table 8.1. Attributes of lithic bifaces and flakes from the Old Crow valley, northern Yukon Territory.

Cat. No.	Raw material	Length	Width	Thick.	Weight	Other
NaVl-9:1	Black basalt biface	112.5	32.7	11.2	46.7	Coll. 1975 by C.R. Harington
MkVl-12:1	Black chalcedony biface	83.4	42.8	10.8	38.6	Coll. 1973 by C.R. Harington Bonnichsen 1979:97, Pl. VIII-1
NaVk-5:35	Black andesite biface	99.5	43.7	13.1	66.3	Coll. 1975 by G.R. Fitzgerald
*NaVk-6:1	Black obsidian biface	49.0	30.1	6.6	10.1	Coll. 1971 by C.R. Harington Bonnichsen 1979:97, Pl. VIII-1
MkVl-12:2	Black chalcedony flake	20.2	22.9	5.5	2.6	Coll. 1973 by C.R. Harington Bonnichsen 1979:98, Pl. VIII-1
*NbVl-2:5	Black chalcedony flake	26.4	12.0	2.7	0.9	Coll. 1971 by C.R. Harington Bonnichsen 1979:98, Pl. VIII-1
NbVl-4:1	Gray chalcedony microblade	32.0	4.9	1.4	0.4	Coll. 1973 by C.R. Harington Bonnichsen 1979:99, Pl. VIII-1
NaVl-5:1	Gray chalcedony flake	47.4	17.6	4.2	3.6	Coll. 1975 by C.R. Harington
NaVl-2:4	Brown quartzite flake	51.8	48.4	10.3	21.7	Coll. 1967 by W.N. Irving Bonnichsen 1979:98
MkVl-5:17	Black andesite flake	51.1	100.6	16.0	97.0	Coll. 1976 by C.R. Harington

* with catalogue number marks specimens found in association with the *Anodonta* phase

specimens, but such materials would still be difficult to date.

Stone Artifacts

Ten stone artifacts in the National Museum of Man collections have been recovered from reworked deposits in the Old Crow valley (Table 8.1, Pl.8.1). Nearly all of them were found by C.R. Harington during his extensive travels along the Old Crow River, and two of them were recovered during excavation of the very early Holocene or late Pleistocene terrace deposits in which the valves of *Anodonta beringiana* occur in growth position. Four of these were not discovered until 1975 and 1976, but the other six were reported by Bonnichsen (1979).

NaVl-9

A well made biface of black basalt (NaVl-9:1) was made on a large tablet which had been fractured naturally, and a small remnant of the ancient fracture surface is still visible on the distal half of the reverse face of the specimen. The flaking of the two faces differs somewhat with broad thinning flakes having been detached from the obverse face primarily from the left edge while the reverse face is broadly flaked from both edges with the scars terminating in a low mid-line ridge. Final shaping and thinning of the biface also reveals variations of some importance. The left edge on the obverse face and the right reverse edge exhibit rather irregularly spaced and sized flake scars, some of which terminate in abrupt hinges. The right obverse and left reverse edges, however, are characterized by evenly spaced uniformly sized flake scars of generally equal length. I suspect that the former represent finely controlled percussion flaking while the latter were produced by pressure. Pressure flaking is particularly suggested by the tip and base of the specimen where the forces were directed into the mass of the piece so as to avoid damage to the final form. The hinge fractures near the left obverse and right reverse edges may have discouraged efforts to finish their flaking by means of pressure.

The biface is very symmetrical in plan but slightly asymmetrical in section. Neither edge is precisely centered or straight, and the distal two-fifths of the cross-section exhibits a 10° clockwise twist when viewed from the tip. The sides of the specimen diverge gradually from a straight base which is 14.1 mm wide, and maximum width is reached approximately two-thirds of the way from the base to the tip. The cross-section is biconvex in most areas. Edge grinding is clearly apparent on both sides from the base to the maximum breadth, but no such grinding can be seen or felt on the base itself.

The symmetry of this piece and the grinding of its edges suggest that it was hafted for use as a projectile, and a small scar at the tip may indicate damage upon impact.

C.R. Harington (memo dated 11 March 1976) reported that this biface was found on the surface of the lower lake clay which was exposed 1.4 feet

(0.4 m) above the river level and approximately nine feet (2.7 m) from the water's edge. "Normally it would have been underwater. *Anodonta* shells and Pleistocene mammal bones were found with it. I am inclined to think it was washed out of the '*Anodonta* phase' stream bed exposed at the site..." Regardless of whether this specimen was actually deposited when the *Anodonta* were living there (more than 10,000 years ago?) its occurrence illustrates the need to search the valley floor at lowest stages of the river level.

MkV1-12

A black chalcedony biface (MkV1-12:1) was probably made on a large flake detached from a core with numerous interior flaws. More than 50% of the reverse face appears to represent the original ventral surface of the flake. The right edge of the specimen is irregularly thinned on both the reverse and obverse faces with broad expanding flake scars extending beyond the mid-line on the obverse side. The left edge is very delicately retouched on both faces with evenly spaced parallel-sided flake scars approximately 10 mm long. This finishing work was probably done by means of pressure with the flaker working first from the base to the tip on the reverse side but then using a less regular approach on the obverse side.

A slightly asymmetrical biface with an ovate form resulted from these procedures, and the cross-section of the piece is quite irregular but roughly biconvex. Truncations of the pressure flake scars on the left edge suggest that the base snapped off in use or at some later time, and there is no evidence that the break occurred during manufacture.

The asymmetry and differential flaking on this biface suggest that it was designed as a knife, but general rounding of high spots on both the edges and the faces, probably as a result of fluvial transport, prevent an assessment of use wear. Harington found this piece one foot (0.3 m) below the surface of a modern gravel bar (memo to G.F. MacDonald dated 13 December 1973).

A small flake from the same gravel bar (MkV1-12:2) appears to have been struck from raw material very similar to that of the biface. It appears to have terminated distally in a hinge induced by a flaw in the core. All edges of the specimen are irregularly nicked, probably by damage during fluvial transport. The platform remnant is plain but could represent a broadly flaked surface.

NaVk-5

A very asymmetrical biface (NaVk-5:35) is made on a weathered black andesite tablet, and 80% of the reverse face is characterized by intense weathering. The right edge of the specimen exhibits weathered fracture surfaces at near right angles to the reverse face in the middle third of its length. The right edge is barely flaked at all on the reverse face but is broadly thinned along the basal two-thirds of the obverse face with the flake scars extending just beyond the mid-line. The distal third of the right edge is more steeply flaked to a slightly concave bevelled area with more delicate (cautious?) retouch at the tip.

The left edge is more completely flaked on both faces with somewhat irregularly spaced and sized scars appearing first on the reverse face and then on the obverse face. This bifacial retouch carries around the base for a short distance along the right edge.

The result is a parallel-ovate biface with a nearly symmetrical plan but a strongly asymmetrical plano-convex cross-section. I suggest that the nearly unmodified section of the right edge formed a back on a bifacial knife for which the working edge is on the left. The specimen may not have been hafted, and it would probably be effective as a hand-held knife. A crushed area near the tip may represent damage during use, and the remainder of this edge is in a very fresh condition. In contrast the right edge is ground on most high spots as if to reduce its sharpness so as to prevent injury to the hand. High spots on the faces of the biface are not noticably polished, so the specimen exhibits no evidence of fluvial transport.

This biface was found by G.R. Fitzgerald, Harington's colleague in the Paleobiology Division, National Museum of Natural Sciences, on the lower lake clay which outcrops to form the modern bank at the downstream end of the Holocene terrace designated NaVk-5 (Loc. 22).

NaVk-6

An obsidian biface was made on a struck flake, a ventral remnant of which occupies 25% of the reverse face extending from the center to the right margin of the biface. This remnant is more heavily scratched and worn than the adjacent flake scars but does not appear to have been abraded by stream action. Since obsidian is not native to the Old Crow basin, we might attribute the wear on this remnant to damage incurred during relatively long-range transport of a flake of obsidian which was retouched to form a biface after it had reached the Old Crow region.

All the retouch on this piece may have been done by pressure. The largest scars are of equal width and spacing, are 14-20 mm long, and are directed into the mass of the specimen rather than being oriented perpendicular to the edges. On the reverse face, it is clear that the flaker began work near the base on the right edge and proceeded clockwise around the specimen but did not complete the entire border and therefore left the ventral face remnant. The retouch on the obverse face is not quite as systematic but clearly was developed in a clockwise direction along the right edge. Smaller, more delicate flake scars are concentrated near the tip and base, particularly on the reverse face, but final symmetry was not achieved and may not have been desired.

The final asymmetrical parallel-ovate outline places the tip closer to the left edge. The tip is not sharply pointed, the base has a generally rounded outline but it is somewhat irregular, and the cross-section is plano-convex. The basal half of the biface could have been incorporated in a haft with the diagonally oriented distal half of the right edge serving as the cutting edge of a knife. High spots on the basal half have been blunted by grinding, but such blunting is not seen on the distal half and therefore is probably not due to fluvial transport.

This biface was recovered from some of the earliest Holocene or latest Wisconsinan terrace deposits in the Old Crow valley. It was "found in coarse sand above the lowest layer of organic detritus and above a basal clay layer which outcrops along that part of the Old Crow River. It was 28 feet (8.5 m) below the surface and well into the bank. ...I collected all bone from the artifact horizon and also shell (*Anodonta*), conifer cones, and part of a tree trunk which lay on the same level as the artifact. ... A tentative list of species so far collected from the artifact horizon include: beaver (*Castor canadensis*), moose (*Alces* sp.), woolly mammoth (*Mammuthus primigenius*), caribou (*Rangifer tarandus*), bison (*Bison* sp. -- probably *B. crassicornis*), horse (*Equus* -- probably a large species), ?hare (*Lepus* sp.) and bird, fish and rodent remains." (C.R. Harington, letter to G.F. MacDonald, dated 27 July 1971). Although several extant forms of mammals appear in this list, there are three extinct species as well as the Arctic hare (*Lepus arcticus*) which has since been identified and which does not live in northern Yukon Territory today. Each of these taxa is known from Disconformity A, and some have been recovered from later Pleistocene levels below the upper lake clays. All the bones are darkly stained and similarly permineralized, and none of them indicates that final Pleistocene or early Holocene elements are included in the deposit with the exception of the *Anodonta* shells and some of the wood. Therefore the obsidian biface is coeval with either the shells and the wood or with the Pleistocene fauna which pre-dates the upper glacio-lacustrine unit.

NbVl-2

A small black chalcedony flake (NbVl-2:5) was excavated from a context very similar to that in which the obsidian biface was found at NaVk-6. The proximal and distal ends of the flake were lost to transverse snapping, and the dorsal face scars indicate previous flaking of the core in the same direction that produced the flake. Since the local stratigraphy is somewhat different from that observed at NaVk-6, it is worth describing in order to show the kinds of lateral facies changes which occur in the basal Holocene terrace deposits. The flake "was excavated ... from fine oxidized gravels... 5" to 8" (12.7-20.3 cm) thick [containing] lenses of clay, peat and sand. A fine brown sand unit (over 4' thick [1.2 m]) overlay the fossiliferous gravel, which in turn was underlain by an unknown thickness of basal blue gray clay. Many species of Pleistocene vertebrates are represented by bones from the fossiliferous gravel at this locality..." (C.R. Harington, letter to G.F. MacDonald, dated 8 November 1971). Wood and *Anodonta* shells were also found.

A caribou antler with a polished base (NbVl-2:6) was found in the same deposit on the following day, and the antler billet (NbVl-2:15) and a cut innominate (NbVl-2:12) were found there in 1975 (see Chapter 4). I propose to conduct a detailed taphonomic study of this deposit, but it is beyond the scope of this report. Certainly we should continue to excavate at this locality since it is subject to significant erosion whenever spring breakup is vigourous and accompanied by high water levels.

NbV1-4

A gray chalcedony microblade (NbV1-4:1) is complete and very well preserved although its edges have been nicked during redeposition. The distal end is markedly recurved, and the narrowness of the specimen and that of its dorsal facets (3/3) suggest that it was detached from a wedge-shaped core. It was found in "oxidized fine sandy gravels about 4 feet (1.2 m) above stream level with Pleistocene vertebrate bones" (C.R. Harington, memo to G.F. MacDonald, dated 13 December 1973).

NaV1-5

A gray chalcedony flake (NaV1-5:1) which is transluscent at its very thin left margin, is complete except for a small area of the distal right corner which has been snapped off. It exhibits a plain, unfacetted platform and the scar of one flake which was previously removed by flaking in the same direction on the core. The right edge of the flake is bordered by a narrow weathered surface which shows that cortex was present on the core. A small retouched notch on the left ventral edge might have been intentionally formed but could have resulted from fluvial transport which also nicked other edges of the specimen. It was found with Pleistocene mammal fossils on the surface 8 feet (2.4 m) above stream level (C.R. Harington, memo dated 11 March 1976).

NaV1-2

A brown quartzite cobble spall (NaV1-2:4) was surface collected in 1967. Its dorsal face and platform remnant are entirely covered with cortex.

MkV1-5

A very broad thick black andesite flake (MkV1-5:17) was surface collected in 1976. It appears to have been struck from a weathered andesite cobble which had already been naturally split in half. The platform remnant consists of such a weathered surface, and the dorsal face is covered with cortex. This flake is rather heavily rounded by fluvial transport. It may not have been struck artificially, although it is doubtful that such massive flaking occurs naturally today in the Old Crow River.

Summary

This small collection of stone artifacts accumulated very slowly during a decade of work along the Old Crow River and its tributaries. Certainly there is no great abundance of stone tools and debitage on the modern banks and sand bars as might be expected in a basin which has apparently been occupied by man throughout the Holocene (Irving and Cinq-Mars 1974). The settlement patterns and routes of travel in this basin seem to have attracted prehistoric peoples to the surrounding slopes and uplands rather than along the Old Crow valley itself. Two of the specimens described above (NaVk-6:1, NbVl-2:5) were excavated from deposits believed to date, on the basis of the large mollusc shells, to more than 10,000 years ago but less than 12,000 years ago when down-cutting of the Pleistocene sediments began. They were accompanied by abundant Pleistocene vertebrate fossils, many of which were redeposited during that 2000 year interval from primary burial sites below the upper glacio-lacustrine unit. Furthermore an additional five specimens (NaVl-9:1, MkVl-12:1, 2, NaVk-5:35, NbVl-4:1) were found in or on similar deposits which have recently been eroded by the Old Crow River, and these may likewise have been introduced to basal terrace deposits more than 10,000 years ago. Only three specimens (NaVl-5:1, NaVl-2:4, and MkVl-5:17) were found on the surfaces of point bars which are totally divorced from the earliest Holocene layers.

This is circumstantial but suggestive evidence that the stone artifacts found thusfar in the Old Crow valley are of considerable antiquity, and many of them may have been originally associated with the Pleistocene specimens described in earlier chapters.

A review of cuts on bones and antlers

It is surprising that only six of the mammoth long bones which were fractured and flaked when green exhibit longitudinal scraping which could have resulted from the removal of periosteum with a stone scraper. Since the removal of the periosteum is an essential prerequisite to the controlled flaking of bone, this process must have been accomplished with less vigourous uses of stone scrapers or with the use of other tools. Periosteum can be removed by burning, but only a few small bone fragments from MlVl-2 and two bones from MfVe-1 exhibit the kind of differential staining which might be interpreted as the result of exposure to a fire. During the Ginsberg elephant butchering experiment (Stanford, *et al.* 1980) we discovered that an antler wedge can be used to remove periosteum by driving the wedge beneath the membrane so as to roll it back along the shaft of the long bone. This technique can result in the ripping of tendons from the bone surface so as to leave distinctive scars on the bone, and such scars were noticed on one of the mammoth bone cores (NaVl-7:1, Pl. 4.11) from the reworked deposits. It may also be possible to remove the relatively thick periosteum from a mammoth bone by more careful cutting with a sharp flake, and such a procedure might leave little evidence on the bone.

Butchering marks are also surprisingly rare on the bones from the Old Crow basin. Two goose bones from the reworked deposits, two large mammal bone fragments from Disconformity A at MlVl-2, one hare radius from the mid-section deposits at MlVl-2, and two bison bones from MlVl-13 are the only specimens which exhibit cuts thought to have resulted from butchering. Of these, the goose bones were probably cut during disarticulation of joints, the hare and bison bones were likely cut during muscle stripping, and the other two specimens are not readily interpretable. Sharp knives were probably responsible for the cuts on the goose, hare, large mammal bones, and bison rib, and a stone scraper probably was used on the bison ischium from MlVl-13.

A partial explanation of the scarcity of butchering marks may be found in the existence of bone flaking techniques. The Ginsberg experiment demonstrated that large sharp-edged bone flakes are excellent butchering tools. They readily cut through lean meat and even through the myelin membranes which cover muscle bundles, but they will not leave evidence of their use in the form of butchering marks on the bones because they are deflected by the periosteum. Since bone cores and flakes comprise our most common categories of artificially modified specimens in these collections, it seems reasonable to suppose that they were made for the purpose of butchering carcasses and that their use accounts in part for the scarcity of butchering marks.

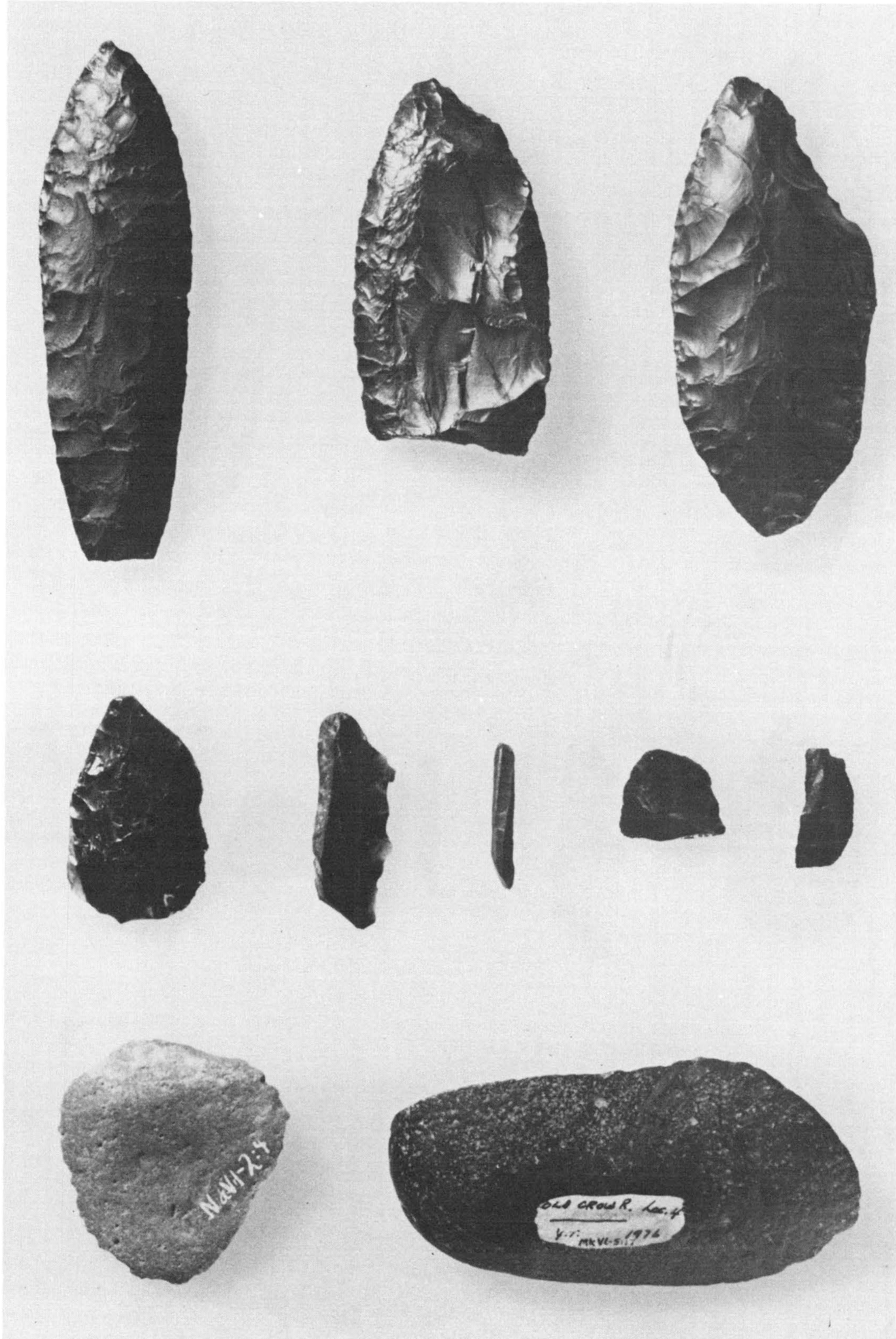
It is noteworthy that nearly all the bone and antler tool forms which are familiar from investigations in later archaeological sites were shaped in part by stone tools. The antler billet (NbVl-2:15) was not only shaped by stone tools but was probably also used to make them. The removal of the brow tine was accomplished by means of three major cuts which would have required a very stout cutting edge unless the antler had been softened by pre-soaking. A sharper more delicate edge may have been used to cut the bez tine, and I have no idea how the nicking on the bez tine was created.

Two of the antler wedges were probably made with stone tools which included a scraper to produce the tool marks on the example from MjVl-1 and a sharp but sturdy cutting edge to score the butt for the transverse division of the antler beam. The third wedge (MjVj-6:1) was shaped in part with a metal file, but the grooving and splintering of its face may have been accomplished with stone tools.

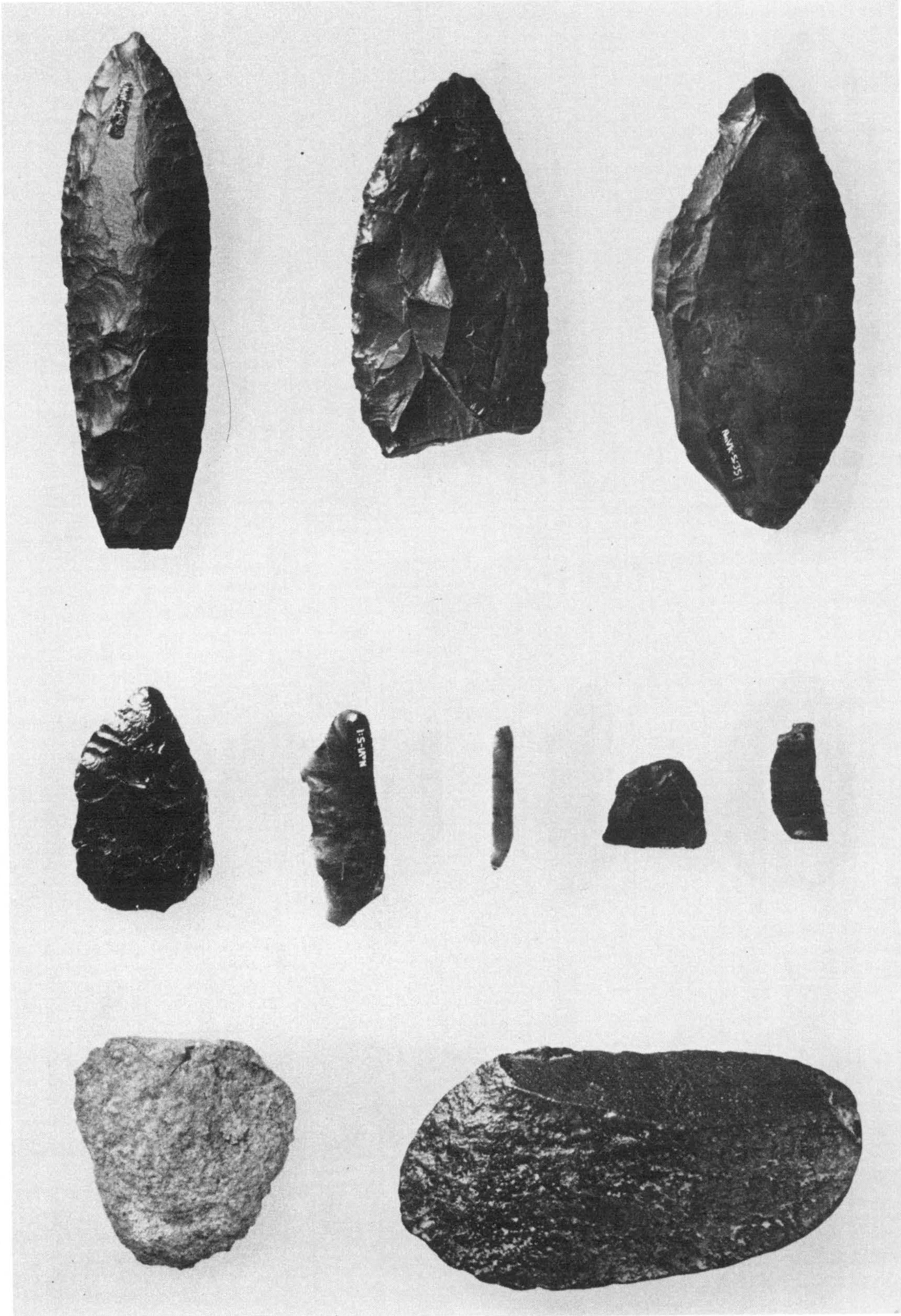
Stone tools were also employed in the fashioning of the flesher (MlVl-1:1c), in the finishing of the split large mammal rib (MlVl-13:26), and possibly in the shaping of two blunt bone points (MlVl-7:289, MlVl-13:10). A loon bone awl in the University of Toronto collections was fashioned by cutting a long bevel on one end of the bone and finishing the worked area by polishing, and there are probably many more examples of stone tool use in those collections (e.g., Harington, *et al.*1975:47).

The most interesting example of stone tool use in the collections reported here is the possible artistic expression on the ulna of a bison from Disconformity A at MlVl-2. Whether or not this piece actually represents art, the cutting of the bone appears not to have resulted simply from a butchering process.

The definition of a lithic tool kit, like that of a "bone technology," must await the discovery of undisturbed archaeological sites in the Old Crow valley, but I cannot emphasize too strongly the importance of painstaking observations on each bone and antler specimen in order to discover the minute traces of stone tool use on these Pleistocene fossils. The specimens must be carefully cleaned and examined with magnification under good light to ensure that small but informative cuts will not be missed, and we must remember that many examples of stone tool use have probably been discarded in the field. The few examples which I have reported, however, indicate clearly that lithic tools were in use as part of the human interaction with Upper Pleistocene fauna in the Old Crow basin. Among our rather "noisy" bones are the faint but visible traces of "silent" stones.



Pl. 8.1. Stone artifacts from the Old Crow valley, northern Yukon Territory (obverse, dorsal). Upper left to lower right: NaVl-9:1, MkVl-12:1, NaVk-5:35, NaVk-6:1, NaVl-5:1, NbVl-4:1, MkVl-12:2, NbVl-2:5, NaVl-2:4, MkVl-5:17. 3/4 Nat. size.



Pl. 8.2. Stone artifacts from the Old Crow valley, northern Yukon Territory (reverse, ventral). Upper left to lower right: NaVl-9:1, MkVl-12:1, NaVk-5:35, NaVk-6:1, NaVl-5:1, NbVl-4:1, MkVl-12:2, NbVl-2:5, NaVl-2:4, MkVl-5:17. 3/4 Nat. size.

CHAPTER 9. SUMMARY AND DISCUSSION

Old Crow Region: an Overview

The frequencies of all artificially modified bones presented in Chapters 4-7 have been recast in Table 9.1 along with corresponding frequencies for natural or artificial and probably artificial alterations. These and the stone artifacts have been summarized in relation to their stratigraphic and geomorphologic provenience. It is clear that our recovery of artifacts from the modern banks and bars is ten times greater than that from any excavated context. Probable artifacts are scattered throughout the series of units, and the dubious specimens of the natural or artificial status are abundant and widespread. If the green fractured bones of large mammals smaller than mammoths had been counted for the reworked deposits, their frequency would at least match that of Unit 3/4 (Disconformity A).

Nearly half of the artifacts consist merely of mammoth bones which were fractured when green (45%), and nearly one quarter (24%) were not only fractured when green but also were flaked. Flakes detached from such cores account for 11.4% of the artifacts, and the remainder includes flaked tusk ivory, flaked large mammal bones, and scratched, polished, and cut bones and antlers. Of 251 artificially modified bones, tusks, and antlers, only 23 have been recovered from Pleistocene stratigraphic contexts with 20 examples from Disconformity A at two locations and three from the mid-section deposit at M1V1-2.

Mammoth bone cores have not yet been found in Pleistocene contexts, and only one mammoth bone flake has been excavated from the bluffs. Seven of the 23 excavated specimens are cut, and it seems quite surprising that only a few of the 228 redeposited pieces exhibit cuts. I believe that the low frequency of cut bones from the reworked deposits is due to a strong observational bias brought about by the fact that minute cuts are so difficult to see under field conditions. Many examples may have been discarded in the field. During recent excavations at the late Pleistocene site of Bluefish Cave (Cinq-Mars 1979), cuts were observed on only one or two bones while in the field, but dozens of specimens have now been recognized as cut bones due to careful microscopic analysis in the laboratory (Cinq-Mars, pers. com. in 1980). Likewise all the cuts on bones from M1V1-2 and M1V1-13 were first recognized in the laboratory.

Regardless of these considerations, the excavated samples are so different from the overall distribution of artificial alterations in the reworked deposits that it is difficult to believe that Disconformity A is a significant source of the redeposited artifacts found on the valley floor. In view of the picture presented by available radiocarbon dates (see below), I believe that we have stumbled onto significantly older evidence of human occupation on Disconformity A than would have been predicted on the basis of the redeposited specimens. We already suspect that stratigraphic contexts above Disconformity A may produce artificially modified bones, but we have devoted too little attention to this part of the profile to be certain of where to look for more materials between Disconformity A and the upper lake clays. It is possible that we have been too enchanted with Disconformity A and that we should climb even higher in the exposures to look for larger numbers and larger sizes of fossil specimens which could stand as better

Table 9.1. Distribution of artifacts, probable artifacts, and possible artifacts (natural or artificial) in relation to the stratigraphic and geomorphologic units identified in Figs. 2.2 and 2.4, Old Crow region, northern Yukon Territory.

	Nat. or Artif.				Probably artificial					Artifacts			
Form of alteration — Unit:	3	3/4	7	9	3	3/4	5	7	9	3	3/4	8	9
Mammoth bones and tusks													
Green fracture only									1		11	8	87
Green fractured and scraped												1	4
Green fractured and ground													2
Green fractured and polished							1				2		1
Cores, flaked only												4	43
Cores, flaked and scraped													2
Cores, flaked and polished												2	3
Flakes (bone)									2	1			26
Ivory cores and flakes	3	2			1	1			1				7
Polished ivory										1			
Other bones, teeth, and antlers													
Large mammal bones, green fracture only	22	143		NC			1	1					
Large mammal cores, flaked only		2				1							16
Large mammal cores, flaked and polished		1											1
Large mammal flakes	1	2										1	1
Scratched bones		1		1		2					1		1
Scratched and grooved teeth		1		1									
Scraped bones		2				1			1				
Polished bones		7		8	1				3				8
Cut and polished antlers												2	3
Cut bones										1	6	1	4
Burned(?) bones		6	2										
Stones (Table 8.1)												2	8
Totals	26	167	2	10	2	5	2	1	8	3	20	21	217

Cross-references: Unit 3, Tables 6.20, 7.2; Unit 3/4 (Disconformity A), Tables 6.19, 7.1, 7.2; Unit 5 ("Disconformity B") Tables 7.1, 7.2; Unit 8 (*Anodonta* phase) Table 4.11; Unit 9 (modern reworked deposits) Table 4.11. (NC, not counted) candidates for the sources of much of the evidence in the reworked deposits.

Spatial Distribution in the Old Crow Valley

Bonnichsen (1979:70-76) proposed the hypothesis that the distribution of spirally fractured bones along the Old Crow valley may indicate the former areas of human activity in the Old Crow basin. He tested this hypothesis by plotting the total frequency of fossil bones against the frequency of spirally fractured bones ordered in clusters of ten collecting sites each with the clusters arranged in sequence from upstream to downstream along the valley floor. He found pronounced peaks (I-IV) in the overall bone distribution in addition to a somewhat different pattern of peaks (A-C) in the spirally fractured bone distribution (Bonnichsen 1979:Fig. 10). While admitting that these patterns were not clearly understood, he suggested that the differences in these frequency distributions might be explained in terms of the former presence of archaeological sites which had been eroded by the river during downcutting of the valley.

I am not able to make an identical test in this report, because my data do not include bone totals for every locality. Instead I have arranged the specimens described in Chapter 4 according to their distances from the mouth of Old Crow River (Table 9.2), and both the distribution along the valley floor and the co-occurrence of different forms of artificial alteration can be examined in this arrangement. Only seven localities have produced more than 10 artificially altered specimens, five localities have produced between five and nine specimens, and the remainder have yielded less than five apiece. There are fewer specimens than kilometers in the overall distribution! Nonetheless, interesting patterns are discernible in this rather sparse distribution.

As the sample size from a given locality increases, the diversity of alterations also tends to increase. This is not a linear relationship, but it is clear that the more collecting we do at a given productive locality, the more likely we are to find a greater variety of artificial alterations among the specimens from that locality. This might seem self-evident, but in fact we should probably expect to find less diversity with sample size increases if the alterations in question are due to natural causes. If natural agencies were responsible for these alterations we might expect to find concentrations in the valley where a single natural process had produced many examples of a given alteration. The maximum diversity observed in Table 9.2 occurs at MlVl-1 where 11 types of alteration were described on the basis of 25 specimens. Similarly, the 26 specimens from MlVl-5 were altered in 10 different ways. At MlVl-7, however, only eight kinds of alteration were observed among 33 artificially modified specimens, but I suspect that this drop in diversity in relationship to sample size is due to our not having been selective in our collecting from this locality (see Chapter 5).

A second important pattern is seen in Fig. 9.1 where the distribution of artificially modified specimens is plotted in relation to the distance from the mouth of the Old Crow River in five kilometer intervals. The graph on the left has been devised by converting Bonnichsen's (1979:Table 8, 27) data so that it will match the data reported here which is graphed on the right. A careful comparison of these two graphs reveals the influence of minor interpretive differences discussed above, but the general pattern is similar

Table 9.2. Distribution of redeposited bone, tooth, tusk, and antler specimens along the Old Crow valley and its tributaries and along the Porcupine River, northern Yukon Territory. All specimens from Units 8 and 9 (Table 9.1) are included.

		cf. *Mammuthus* sp.																	
Km from mouth	Site Number	Green Frac.	Cores 1	2	3	4	5	6	Flakes 1	2	Lg. Mammals 1	2	3	Cut and polished 1	2	3	4	5	Totals
298.0R	NbVn-1															1			1
284.5L	NbVn-3													1					1
264.8L	NbVm-5	1			1				1										3
220.8L	NbVm-2	1							2										3
217.4R	NbVm-6								1										1
214.6L	NbVm-4	1								1									2
206.5L	NbVl-9				1														1
205.9R	NbVl-11					1													1
204.4R	NbVm-1													1					1
201.6L	*NbVl-2	2					1		1				*1			1	*2	*1	9
199.8L	NbVl-1								3		1					1			5
Timb.Cr.	NbVl-5	1																	1
199.3L	NbVl-6											1							1
195.4L	NaVl-7				1														1
182.4L	NaVl-12		1													1			2
161.5R	NaVl-1								1										1
158.2L	NaVl-8	1	1													1			3
143.8R	NaVl-4	1									1								2
139.9R	NaVk-10								1										1
130.8L	NaVk-1	5	1			1	1		1										9
130.1L	NaVk-5	5[1]	1		2	1	1				2					3			15
124.1L	NaVk-9		1																1
121.5R	NaVk-6	6[2]	2			1			2		1					1			13
120.3L	NaVk-8								1										1
112.1R	MlVk-4	1																	1
95.5L	MlVk-1	2[3]																	2
90.6R	MlVl-14	1																	1
88.3R	MlVl-13	1[4]				1									1				3
84.4R	MlVl-16											1							1
75.1R	MlVl-5	11[5]	1	4		4			2	1	3							1	26

Table 9.2 (Continued).

Km from mouth	Site Number	cf. *Mammuthus* sp. Green Frac.	Cores 1	Cores 2	Cores 3	Cores 4	Cores 5	Cores 6	Flakes 1	Flakes 2	Lg. Mammals 1	Lg. Mammals 2	Lg. Mammals 3	Cut and polished 1	Cut and polished 2	Cut and polished 3	Cut and polished 4	Cut and polished 5	Totals
74.1R	*M1V1-12	*7	*2		*2														11
73.8R	M1V1-2	1	1																2
John.Cr.	M1Vj-2	3																	3
John.Cr.	XI-B-366	1																	1
John.Cr.	M1V1-10	1			1														2
John.Cr.	M1V1-7	20		1	1		1		3		3			1		3			33
John.Cr.	M1V1-3															1			1
70.5R	*M1V1-1	*7[6]	*2			*2	1		3	1	1	2				*4		2	25
68.5L	M1V1-11	1																	1
66.8R	MkV1-10			1		1													2
66.0R	MkV1-24				1				1										2
64.9L	MkV1-9	2			1											1			4
63.9L	MkV1-25							1											1
61.9L	MkV1-12							1	2				1					1	5
57.3R	MkV1-8	5[7]	2	2				2	3										14
54.8R	MkV1-26					1		1											2
49.2R	MkV1-23	2																	2
48.1R	MkV1-18										1								1
43.4R	MkV1-5	2[8]																	2
40.5L	MkV1-4	5			1		1												7
36.6L	MkV1-27	2																	2
36.4R	MkV1-3	2																	2
Porc. R.	MjVj-6																1		1
Porc. R.	MjVj-1	1[9]																	1
Porc. R.	MjV1-1																1		1
Porc. R.	MiV1-1	1[10]		1												1	1		4
Totals		103	15	9	12	12	6	5	28	3	13	4	2	3	1	19	5	5	246

Legend: Km from mouth given for left (L) and right (R) banks of Old Crow River; other streams are Timb. Cr. (Timber Creek), John.Cr. (Johnson Creek), and Porc. R. (Porcupine River).

Cores: 1, cores without platforms; 2, cores with unmodified platforms; 3, cores with retouched platforms; 4, cores flaked transversely; 5, core fragments and misc. "cores"; 6, ivory cores.

Flakes: 1, bone flakes; 2, ivory flakes.

Table 9.2 (Continued).

Legend:

Lg. Mammals: 1, longitudinal cores; 2, transverse cores; 3, flakes.

Cut and Polished: 1, scratched bone and tooth; 2, scraped bone; 3, polished bone; 4, cut and polished antler; 5, cut bones.

Green fracture column: [1]includes 2 scraped, 1 ground, and 1 polished bone; [2]includes 1 polished bone; [3]includes 1 polished bone; [4]includes 1 polished bone; [5]includes 1 scraped and 1 polished bone; [6]includes 1 scraped and 2 polished bones; [7]includes 1 ground bone; [8]includes 1 scraped bone; [9]includes 1 scraped bone; [10]includes 1 scraped bone.

* marks specimens excavated in association with the *Anodonta* phase.

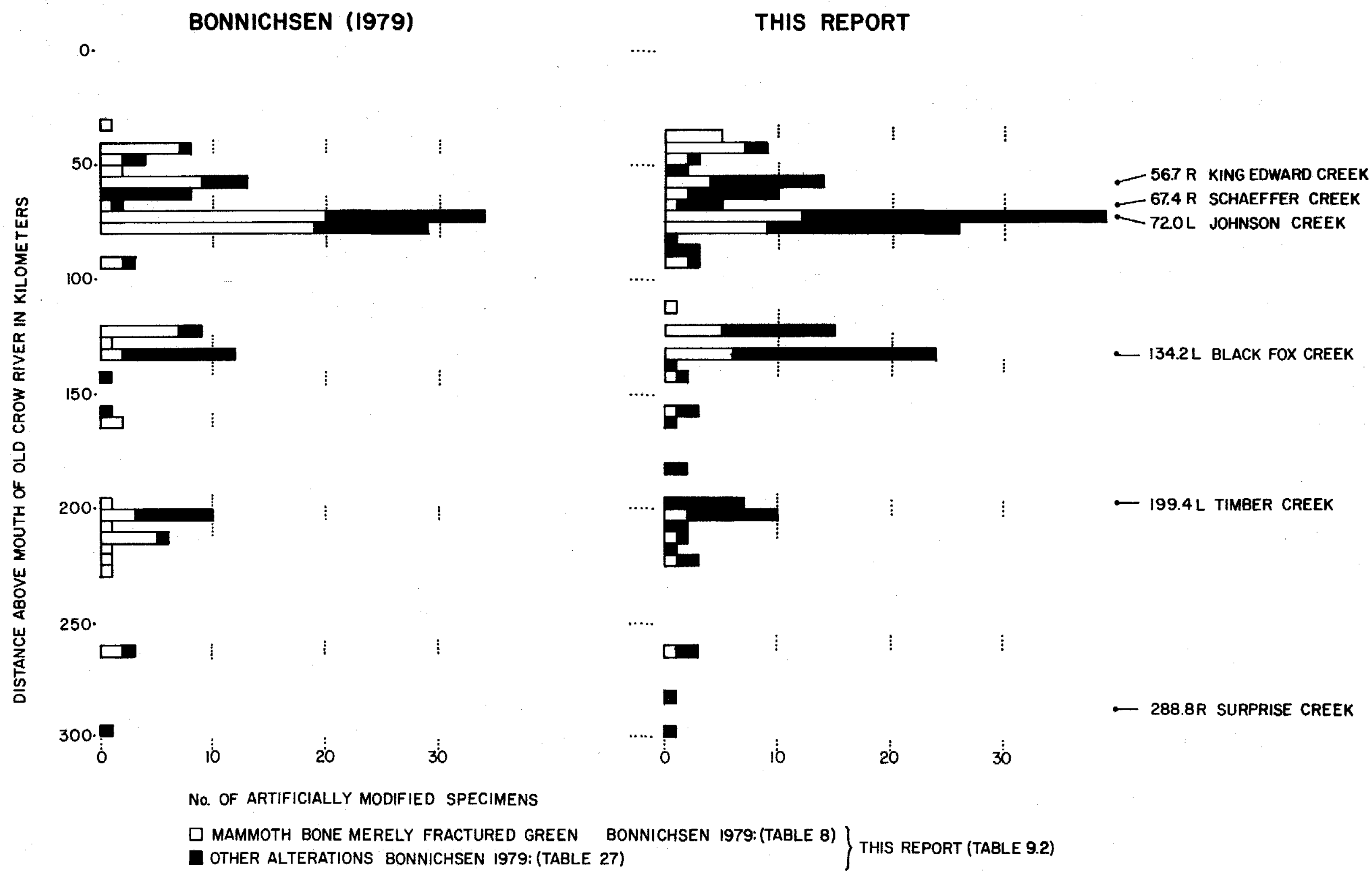


Fig. 9.1. Histograms showing the distribution of artifacts along the Old Crow River, northern Yukon Territory as measured in 5 km intervals above the river mouth. Note the close association between major peaks and stream mouths.

and shows that three major concentrations of artificially modified specimens continue to emerge from further collecting in the Old Crow valley. The major concentration is quite broad and encompasses all suitable exposures between 35 and 80 km from the mouth of the river. The three concentrations are situated very close to the mouths of the three major tributaries of the Old Crow River (Johnson, Black Fox, and Timber Creeks), and we must suppose that these streams are at least partially responsible for the accumulations of fossil specimens in the Old Crow valley. I have omitted from the graphs in Fig. 9.1 all the localities which occur in the creek valleys themselves with the exception of MlVl-3 which is a high bluff probably cut originally by the Old Crow River. This association between stream mouths and fossil concentrations is to be expectd and is the kind of pattern long utilized by placer miners in their prospecting for gold and other precious metals and minerals (cf. Péwé 1975: 98). Therefore I doubt that the distribution reflects former archaeological site locations with the possible exception of the peak near the mouth of Timber Creek. NbVl-2, which is responsible for more than half of this peak is located too far upstream to have been influenced by the Timber Creek discharge, and I believe that we can take this locality as an indication that an archaeological site formerly existed in the sediments eroded by the Old Crow River not much more than 200 km above the present river mouth. The long gap in the distribution between 225 and 260 km is not entirely a result of our having ignored the area. Fifteen collecting localities have been designated in this interval, and none of them has produced an artificially modified bone. Perhaps this enables us to narrow the search for the source of the Timber Creek concentration to a 25 km section of the river (between 200 and 225 km above the mouth), and this possibility will be field tested in the near future.

One other major omission from Fig. 9.1 is the incredibly large collection from Bonnichsen's Loc. 89 (Harington's Loc. 11A; MkVl-12, 61.9L) which is housed at the University of Toronto and which has been assembled by W.N. Irving and his field parties. Tens of thousands of fossil bones, teeth, tusks, and antlers have been collected and catalogued: great quantities have also been discarded in the field; and the number of artificially modified specimens probably runs at least into the hundreds and perhaps into the thousands. Thusfar only three specimens, an immature human mandible (Irving, *et al.* 1977), a Canid mandible thought to represent a domestic dog and a peccary (cf. *Platygonus* sp.) radio-ulna fragment (Beebe 1978), have been reported in the literature. Nowhere else in the Old Crow valley have we seen such a concentration of vertebrate fossils, and it is of some importance to account for this occurrence. Although we must await reports from Irving and his colleagues for details, it appears that both ancient and modern ongoing factors are responsible for this bone concentration. The ancient factor is traceable to the earliest period of significant final Wisconsinan downcutting in the Old Crow valley when a rapidly lowering base level and very rapidly retreating nick point must have formed a powerful sluice in which vertebrate fossils mined from all stratigraphic levels between the two glacio-lacustrine clay units were carried downstream to become redeposited along a relatively straight channel bottom. These new deposits were buried beneath Holocene alluvium but have been reexposed by the river as its meander loops have oscillated across the valley floor. Thus much of the material on this bar is being exhumed from a burial environment originally established in latest Pleistocene and earliest Holocene times (during the *Anodonta* phase).

An additional increment of bone may be added to the bar in major flood stages during spring breakup. Because of the unusually tight bend made by the Old Crow River at this spot, a huge whirlpool sometimes forms during high water stages and this process has scoured a deep hole in the river bed just beyond the point of the bar. Such fluvial or hydraulic activity may also be capable of replenishing the lag concentrate of vertebrate material which literally paves the bar at low stages of water.

I have mentioned this locality only for the purpose of indicating that the collections reported in this monograph are but a pale reflection of the potential yield of the Old Crow valley. As further work is done there, we can reasonably expect to redouble our understanding of these materials many times.

Bones as Sedimentary Particles

Since nearly all the vertebrate fossils reported in this study are believed to have been redeposited by fluvial processes, it is of some interest to consider the properties of bones as sedimentary particles in the fluvial environment. Elsewhere I have made the observation that the vertebrate fossils are frequently the largest and most conspicuous objects on the modern banks and bars of the Old Crow River and its tributaries, but their relative gross size may be misleading in terms of their responses to hydraulic forces. Behrensmeyer (1975b) has provided a lengthy discussion of bones as sedimentary particles and has compiled useful data on the critical aspects of size, density, shape, and settling velocities which are needed in a discussion of bone transport potential. She has shown that by plotting the wet weight against the density of skeletal elements the various groupings of elements observed in Voorhies' (1959) flume studies can be obtained, although there is some overlap between Voorhies Group I (which transports readily) and Group II (which is intermediate between transport and lag) (Behrensmeyer 1975b: Fig. 4). Size, density, and shape contribute to the settling velocity of a given bone, and some bones, such as the scapula appear to present special problems due to particular shape characteristics which influence the response to moving water (Behrensmeyer 1975b:492-493). Nonetheless, when these variables are taken into account, it is possible to calculate the approximate diameter of a quartz grain which would settle at the same rate as a given bone when placed in water, and therefore the characteristics of a bone assemblage can be examined in relation to the particle size distribution of the enclosing matrix to demonstrate whether the matrix and its contents reflect similar hydrological potentials.

Considerations of this sort are of special interest in the Old Crow valley because pebble- and cobble- size stones are so rare that the competence of the stremas may not be accurately reflected in the particle size distributions of their deposits. Unfortunately there are no hydrological data available for the Old Crow River and its tributaries, and we know very little about the bed form and cross-section of most reaches of these streams. Spring breakup is undoubtedly the time of greatest erosion and redeposition of all kinds of materials, but the level and energy of breakup varies considerably from year to year and depends on several complex variables such as amount of winter precipitation and rapidity of spring melting and runoff. During the past five years breakup has occurred late and low with relatively little

Table 9.3. Predicted quartz grain diameters equivalent to the largest mammoth long bone fragments recovered from various sedimentary and geomorphological contexts discussed in this report.

Specimen and Cat. No.	Reference	Dry Weight	Wet Weight	Volume	d_b	ρ	d_q
M1V1-2, Disconformity A							
M1V1-2:105-11, mammoth long bone	Table 6.16	130	150	71	5.14	2.10	3.43
M1V1-2:30, largest rock	none	64		24	3.59	2.65	3.59
M1V1-2, Mid-section							
M1V1-2:146, mammoth femur	Table 6.6	6265	7202	3429	18.71	2.10	12.47
M1V1-2:144-31, mammoth long bone	none	114	131	62	4.92	2.10	3.28
M1V1-2:143, largest rock	none	70		26	3.69	2.65	3.69
M1V1-2, basal							
M1V1-2:172-9, mammoth long bone	none	351	404	192	7.16	2.10	4.77
M1V1-2:21, largest rock	none	200		75	5.24	2.65	5.24
M1V1-7							
M1V1-7:281, mammoth long bone	Table B1	701	806	384	9.02	2.10	6.01
Other reworked deposits							
MkV1-5:13, mammoth femur	Table B1	2433	2798	1332	13.66	2.10	9.11
M1V1-5:25, mammoth long bone	Table B1	1102	1267	603	10.48	2.10	6.99

Legend

Weight in grams; volume in cubic centimeters

ρ = density = weight ÷ volume, in g/cc

d_b = nominal diameter of bone, in cm; $d_b = \sqrt[3]{1.91 \cdot \text{volume}}$

d_q = diameter of quartz grain equivalent to bone, in cm; $d_q = (\rho_b - 1)d_b \div 1.65$

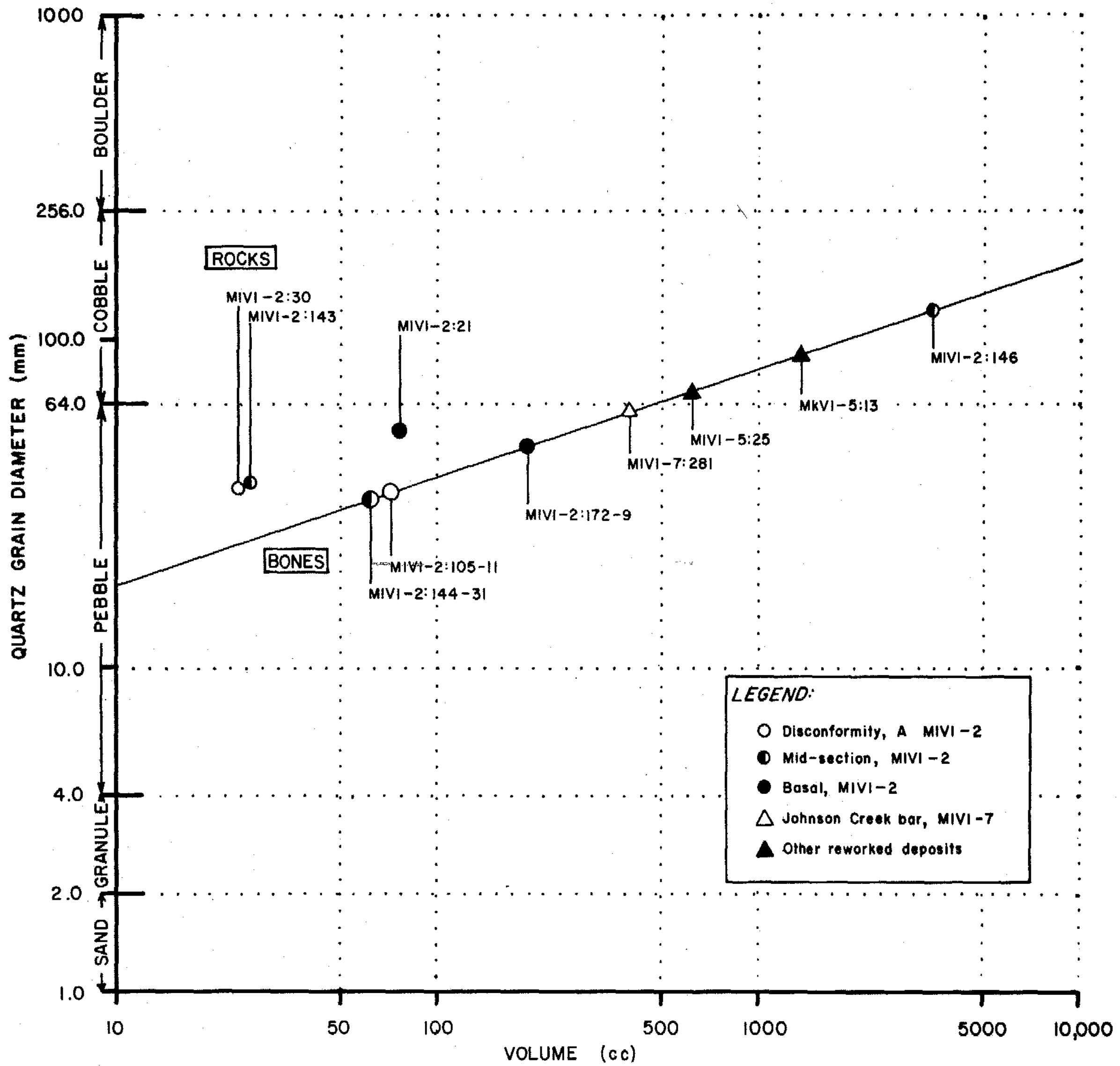


Fig. 9.2. Relationship between volume and calculated quartz grain diameters for the largest bones and rocks from several contexts in the Old Crow valley, northern Yukon Territory.

erosion of the high bluffs which have attracted our attention; in many cases it has been possible to relocate the previous year's data stakes and trowel marks. Surprisingly little downstream movement has occurred among the hundreds of horse bones experimentally placed in the valley in 1977 (Parama 1978), and on many of the point bars which we have visited annually during this period one must wonder whether large bones are newly arriving during breakup or being newly exposed by erosion of more ancient deposits.

Any effort to estimate quartz grain diameter equivalents for the Old Crow fossils is seriously hampered by the difficulty of measuring their volumes accurately. The bones are badly damaged by wet-dry cycling once they have been removed from the field, and my attempts to measure volume by weighing displacement of carefully sieved sand met with only partial success. A small series of fossils was sacrificed for wet weight and volume measurements, and the density of compact bone specimens was calculated to be 2.10 g/cc. This value is somewhat greater than the densities reported by Behrensmeyer (1975b:484), and the higher density of the Old Crow fossils probably results from permineralization and sediment entrapment in small foramina and other cavities. The compact bones also increased in weight by 10-20%, and I have assumed that weight changes due to water uptake will represent 15% of the dry weight of the fossils.

On the basis of these rather arbitrary numbers, I calculated the predicted wet weight and volume of the largest compact mammoth bones from each sedimentary context discussed in this report and used these predictions and the assumption of 2.10 g/cc density to calculate the diameters of quartz grains which would settle at an equivalent rate in water (Table 9.3). The resulting figures can be compared with the largest rocks obtained from each of the excavated deposits at MlVl-2, and the indicated particle sizes can be matched against the Wentworth scale of particle size classes (Fig. 9.2). The results of this exercise, even though based on several possibly shaky assumptions, indicate substantial agreement between the lithics and the bones in all three deposits at MlVl-2 with a single noteworthy exception. Most of the largest bones appear to be equivalent to pebble-size stones with respect to their predicted settling velocities, and pebbles of comparable size were found in each of these deposits. Only a few of the very largest bones from the reworked deposits appear to be equivalent to cobbles.

The one noteworthy exception is the large mammoth femur from the mid-section deposit at MlVl-2 which seems to be entirely out of place in relation to the other stones and bones which were found in association with it. It is difficult to imagine that this femur was transported by the same fluvial processes responsible for the other fossils in the mid-section deposit. Given its excellent state of preservation, it is hard to believe that this femur was transported by fluvial processes at all, but the possibility that it was ice-rafted to its position of discovery cannot be ruled out. It is interesting to note that the same deposit produced a number of large fragments from a single mammoth ulna as well as an enormous piece of mammoth tusk which would probably settle at a velocity like that of a boulder. These nearby specimens raise the possibility that a mammoth carcass once lay in the edge of the stream represented by the point bar deposits of the mid-section at MlVl-2 and that the bones and tusk represent the lag component of a fossil concentration which was winnowed by the fluvial activity associated with point bar growth. The inevitable seasonal fluctuations of the stream could have initially eroded the locality, carried away some of the associated elements, and progressively subsided to a summer low water stage during which the smaller bones which comprise the bulk of our sample could have been deposited and buried in close proximity to the mammoth remains. This line of argument also raises questions concerning the artifacts found in the mid-section deposit. Were the mammoth bone flake and the ivory flesher used on the spot by people who killed or scavenged the mammoth carcass, or were they brought into apparent association with the carcass by the gradually subsiding stream?

Throughout the discussion of the mid-section deposit I have often referred to it as a relatively high energy fluvial environment as compared with Disconformity A, and such a difference would not seem to be supported by the display in Fig. 9.2. The basal deposit, on the other hand, has yielded both larger bones and larger rocks with respect to settling velocity, and a higher energy fluvial environment may be more clearly indicated. The higher energy idea was proposed for the mid-section deposit partially because of the mammoth femur and other very large bones and partially to account for the frequencies of such variables as degree of rounding. In making such comparisons on the basis of Fig. 9.2, the fluvial systems themselves are vastly oversimplified. I have specified the density and nominal diameter of the particles (bones) in order to estimate the sizes of quartz grains with similar settling velocity, and I have assumed perfect sphericity and roundness for each particle. I have said nothing about the fluid in which the particles would travel and have assumed (probably incorrectly) that the fluid velocity, depth, specific weight, density, and dynamic viscosity will be the same in all situations (see Krumbein 1942:622 for a discussion of these variables and for a presentation of several non-dimensional parameters which relate settling velocity to the flume behaviour of non-spherical particles). Furthermore these considerations have centered primarily on laboratory studies of settling velocity in still water or hydrodynamic behaviour in flumes, and the complex relationships derived from variations in bed form, suspended load, packing, spacing, and orientation of different size particles, and seasonal fluctuations in flow have not entered into the picture to the extent that they should (e.g., Fahnestock and Haushild 1962; Baker and Ritter 1975; Bagnold 1977; Butler 1977; Shackley 1978). A detailed discussion of such relationships is beyond the scope of this report and will require further investigations both in the field and in the laboratory, but several observations on the major samples reported in Chapters 4-7 should point the way to specific research needs.

For the basal deposits at MlVl-2 we need a larger sample of fossils, and the outstanding sizes of the mammoth femur and tusk from the mid-section deposit have already been mentioned. A review of the weight measurements for specimens from Disconformity A at MlVl-2 reveals an interesting pattern. Ten specimens weigh more than 50 g, and seven of these were fractured when green. The other three are mammoth scapula fragments which may represent a single bone which was broken during redeposition at MlVl-2. Of the seven green-fractured specimens, four are mammoth long bone fragments which were interpreted as artificially fractured. One is a *Bison* sp. ilium which was chewed by carnivores and was reconstructed from five fragments found near one another on Disconformity A; this ilium exhibits a small remnant of a green fracture surface which could have been artificially induced. The sixth specimen is the bison humerus fragment on which the flaking (and perhaps the fracturing) is probably artificial, and the seventh piece is the large bison humerus from Station 15 which exhibits a green fracture most likely due to man (but possibly due to carnivores). Thus the majority of the largest specimens in the Disconformity A sample seem to have been associated with human activity when they were fresh, and these specimens account for nearly a third of the archaeological potential of the sample. Since Disconformity A is probably an erosional contact created during overbank flooding by a sizeable stream, we might expect that the largest pieces subsequently buried on the contact were already in place in deposits on the bank. Smaller pieces could be introduced to the top of the bank during the flood, and they could have originated in many different sedimentary and geomorphological settings. It seems likely that the largest pieces as well as many of the smaller ones which were artificially modified have simply been moved laterally across the floodplain, redeposited on the erosional surface, and buried during the recession of the flood waters.

An even more intriguing picture has emerged from the complex series of deposits which appear to be equivalent to Disconformity A at MlVl-13. The occurrence of a bison innominate in articulation with a sacrum in very fine silts and sands may be difficult to account for in terms of fluvial processes, and it is more likely that any movement of the specimens was accomplished by means of colluvial processes (e.g., downslope movement). The butchering marks on the innominate and on other bison bones in the same deposits suggest that an archaeological site was disturbed in the immediate vicinity of MlVl-13, and field work in 1980 will include a reevaluation of this locality.

The large bison radius on "Disconformity B" at MlVl-3 is likewise out of place in the fine grained organic matrix which enclosed the bone so that fluvial transport seems unlikely to account for its occurrence. In Chapter 7 I suggested that ice-rafting on a thaw lake might be responsible for this deposit, and we will return to the locality in future years to seek more evidence of an eroding archaeological site on the shore of such a lake.

The wide variety of reworked deposits near the floor of the valley are too complex to permit simple generalizations, but the deposits representing the *Anodonta* phase may be amenable to a taphonomic analysis in which the bones can be viewed as sedimentary particles which were deposited together under a set of definable circumstances. Such an analysis will be attempted with the enticing collection from NbVl-2 where stone, bone, and antler artifacts have been recovered.

Radiocarbon Dates

Problems surrounding radiocarbon dates from Old Crow Flats have been with us since the beginning of our paleontological and archaeological work in the region. O.L. Hughes (pers. com. in 1968) recognized the major difficulty early in the work, and Irving and Harington (1973:339) defined it in print:

> One problem that we have been unable to resolve thus far is why, so far, no organic materials other than bone from the basin-fill sediment have yielded dates between 11,000 and 31,000 years B.P. Only radiocarbon dates on bone fill this seeming gap at present. Clearly, more radiocarbon dates and more detailed stratigraphic work are needed...

In the years since these observations were made, a much larger series of dates and much more detailed stratigraphic work have been accomplished, but the picture presented by radiocarbon dating has remained precisely the same. Harington (1977:108, Table 5) has endeavoured to date various genera and species of vertebrates systematically, while geological work by Hughes, Matthews, Rutter and Schweger (Yukon Refugium Project) and Jopling and Westgate (Northern Yukon Research Programme) has greatly enlarged our understanding of the stratigraphy of the basin fill sediments (see Hughes, *et al.* 1980). Our youngest date on organics other than bone from below the upper glacio-lacustrine unit is still around 31,000 years ago, although eight collagen-based bone dates lie between 22,000 and 30,000 years ago.

Radiocarbon dates for the Old Crow basin are summarized in Tables 9.4 and 9.5 where they are arranged according to general stratigraphic context where known or simply in chronological order for bones from reworked deposits. All the bone dates in Table 9.4 are based upon the collagen fraction, and only one of the dates was obtained from an artificially broken bone (I-11,050). Three additional dates have been obtained on artifacts, but all three were based upon the apatite fraction (see Irving and Harington 1973:336). These dates were obtained at a time when apatite-based dates were thought to be more reliable than collagen-based dates on bone (Irving and Harington 1973: 339; Haynes 1968), but subsequent studies have shown that the apatite component of bone may be subject to alteration by ground-water contamination and other processes (Hassan and Ortner 1977; Hassan, *et al.* 1977). A series of ten Old Crow fossils has recently been radiocarbon dated on the basis of pair collagen and apatite samples (R. Stuckenrath, pers. com. in 1978), and the results show little agreement between the two fractions. The collagen-based assay from each pair is included in Table 9.4, but I shall leave full discussion of this interesting experiment to its promulgators, W.N. Irving and R. Stuckenrath.

Radiocarbon measurements on organic material other than bone from the sediments of Units 3, 4, and 5 reveal a generally coherent picture with relatively few gaps from 31,000 years ago to beyond the range of the method (Fig. 9.3). Dates on post-glacial peat begin around 11,000 years ago and extend to mid-Holocene times, and dates on Holocene terraces (except for two demonstrably mixed and redeposited samples) provide a similar picture. *Anodonta beringiana* shells from the earliest intact terrace deposits date between 10,000 and 11,000 years ago. Since several samples of the clays from the upper glacio-lacustrine unit have been found to be devoid of organic material other than wind-blown pollen (Hughes 1969), we might suppose that the apparent absence of organic material between 31,000 and 11,000 years ago represents the period during which the glacial meltwaters inundated the Old Crow basin during classical Wisconsinan times.

Radiocarbon dates based on the collagen fraction of redeposited bones from the Old Crow basin provide substantial support for a slightly modified version of this interpretation. These dates have been added together to form a single histogram by means of a technique developed by Jaguttis-Emden (1977), and they exhibit a pronounced peak centered on 28,000 B.P. in Fig. 9.3. Hence collagen-based dates suggest that large vertebrates in the Old Crow basin preserve a record of radiocarbon ingestion for a period of at least 3000 years after an apparent cessation of radiocarbon activity in the recoverable record of plants. At least two explanations of this seeming anomaly

Table 9.4. Radiocarbon dates on bone collagen from reworked deposits in the Old Crow Region, northern Yukon Territory. All dates given with two-sigma errors. Species and element identified when known to me.

Date (Yrs. B.P.)	Lab. No.	Locality	Species, element, reference
4,570 ± 200	I-4225	MkVl-1	*Cervus canadensis* humerus (Harington 1977:Table 5)
6.450 ± 270	I-4221	MlVl-5	*Rangifer tarandus* antler (Harington 1977:Table 5).
11,450 ± 400	Qu-780	MkVl-12	*Bison* sp. humerus (Cinq-Mars, pers. com. in 1980)
11,910 ± 360	I-7765	MkVl-9	*Bison crassicornis* scapula (Harington 1977:Table 5)
12,220 ± 1500	Qu-783	MkVl-9	*Bison* sp. humerus (Cinq-Mars, pers. com. in 1980)
12,275 ± 360	I-7764	MkVl-12	*Bison crassicornis* horncore (Harington 1977:Table 5)
12,460 ± 440	I-3574	MkVl-9	*Bison crassicornis* lumbar vertebra (Harington 1977:Table 5)
12,660 ± 560	Qu-782	MkVl-12	*Bison* sp. humerus (Cinq-Mars, pers. com. in 1980)
12,900 ± 100	GSC-2881	Bluefish Cave I	*Equus* sp. femur (Cinq-Mars 1979)
22,600 ± 1200	I-3573	MlVl-1	cf. *Mammuthus* sp. femur (Harington 1977:Table 5)
25,910 ± 1360	SI-2818	MkVl-12	(Stuckenrath, pers. com. in 1978)
26,460 ± 3760	Qu-784	MkVl-12	*Equus* sp. humerus (Cinq-Mars, pers. com. in 1980)
26,640 ± 2800	Qu-781	MiVl-1	*Bison* sp. humerus (Cinq-Mars, pers. com. in 1980)
27,700 ± 920	SI-2812	MkVl-12	(Stuckenrath, pers. com. in 1978)
28,050 ± 1000	SI-2825	MkVl-12	(Stuckenrath, pers. com. in 1978)
28,200 ± 1000	SI-2824	MkVl-12	(Stuckenrath, pers. com. in 1978)
29,300 ± 2400	I-11,050	MkVl-3:9	cf. *Mammuthus* sp. long bone fragment (Harington, pers. com. in 1980); artificially fractured (see Table Bl, Pl. 4.1)
32,800 ± 1600	SI-2820	MkVl-12	(Stuckenrath, pers. com. in 1978)
33,800 ± 4000	I-4227	MlVl-1	*Bison crassicornis* humerus (Harington 1977:Table 5)
33,800 ± 4000	I-4229	NaVk-5	*Alces latifrons* antler (Harington 1977:Table 5)
34,000 ± 5200	I-4222	NbVl-1	*Equus* sp. metatarsal (Harington 1977:Table 5)
34,000 ± 2000	SI-2822	MkVl-12	(Stuckenrath, pers. com. in 1978)
36,650 ± 2600	SI-2816	MkVl-12	(Stuckenrath, pers. com. in 1978)
>38,000	SI-2817	MkVl-12	(Stuckenrath, pers. com. in 1978)
>39,900	I-4228	NbVm-4*	cf. *Mammuthus* sp. thoracic vertebra (Harington 1977:Table 5)
>39,900	I-4223	NbVm-4*	*Equus* sp. innominate (Harington 1977:Table 5)
>42,000	SI-2823	MkVl-12	(Stuckenrath, pers. com. in 1978)
>42,000	SI-2814	MkVl-12	(Stuckenrath, pers. com. in 1978)

*I-4223 and I-4228 were excavated from the base of Unit 3 at NbVm-4 (see Chapter 2)

Table 9.5. Radiocarbon dates on organic materials other than bone from Upper Pleistocene and Holocene stratigraphic contexts in the Old Crow Region, northern Yukon Territory. See Fig. 2.2 for composite profile which identifies stratigraphic unit numbers. All localities are in the Old Crow basin except MiVl-1 (Bluefish basin) and HH72-98 (Bell Basin).

Date (Yrs. B.P.)	Lab. No.	Locality	Unit	Sample material, reference, remarks
Holocene terrace deposits:				
1,740 ± 200	I-2756	NaVk-5	8	Organic detritus (Harington 1977:Table 7)
2,420 ± 160	I-2755	NaVk-5	8	Wood (Harington 1977:Table 7)
9,190 ± 90	GSC-2461	HH72-98	8	*Salix* sp. wood (Matthews, pers. com. in 1977)
14,390 ± 160	GSC-730-2	MlVl-1	8	Wood (Harington 1977:Table 7); mixed
41,280 ± 1600	GSC-730	MlVl-1	8	Wood (Harington 1977:Table 7); reworked
10,200 ± 280	I-11,038	MkVl-24	8	*Anodonta beringiana* shell (Harington, pers. com. in 1980)
10,700 ± 160	GSC-1167	CRH 141	8	*Anodonta beringiana* shell (Harington 1977:Table 7)
10,850 ± 320	I-4224	MlVl-5	9	*Anodonta beringiana* shell (Harington 1977:Table 7)
Post-glacial peat profiles:				
6,430 ± 140	GSC-372	NaVl-1	7b	Peat? (Harington 1977:Table 7)
7,620 ± 160	GSC-1252	MlVl-2	7b	Organic detritus (Harington 1977:Table 7)
7,650 ± 150	GSC-1175	NaVl-1	7b	Peat (Harington 1977:Table 7)
8,100 ± 160	GSC-1243	NaVl-1	7b	Peat (Harington 1977:Table 7)
8,270 ± 140	GSC-1329	NbVm-4	7b	*Populus* sp. wood (Harington 1977:Table 7)
8,460 ± 120	GSC-2605	NbVm-4	7b	Wood (Matthews, pers. com. in 1978)
10,740 ± 180	GSC-121	MiVl-1	7b	Peat (Harington 1977:Table 7)
Alluvium below upper glacio-lacustrine unit:				
31,300 ± 640	GSC-1191	NaVl-1	4-5	Organic detritus (Harington 1977:Table 7)
31,400 ± 660	GSC-2739	MkVl-10	5	Autochthonous peat (Matthews, pers. com. in 1978)
32,400 ± 770	GSC-952	MiVl-1	5	*Pisidium idahoense* shells (Harington 1977:Table 7)
>37,000	GSC-958	MiVl-1	5	Wood (Harington 1977:Table 5); probably reworked, associated with GSC-952
35,500 ± 1050	GSC-2507	MkVl-10	5	Peat (Westgate, pers. com. in 1977)
>36,000	GSC-2775	MkVl-10	5	*Betula* sp. wood (Matthews, pers. com. in 1979); from same peat layer as GSC-2507
38,800 ± 2000	GSC-2756	MlVl-2	5	*Salix* sp. wood (Matthews, pers. com. in 1979)
41,100 ± 1650	GSC-2574	MlVl-2	5	*Salix* sp. wood (Matthews, pers. com. in 1978)

Table 9.5 (Continued).

Date (Yrs. B.P.)	Lab. No.	Locality	Unit	Sample material, reference, remarks
Alluvium below upper glacio-lacustrine unit:				
>37,000	GSC-2792	MlVl-3	4-5	Organic detritus (Matthews, pers. com. in 1979); associated with green fractured *Bison* sp. radius (Chapter 7)
>39,000	GSC-1189	MiVl-1	4-5	Wood (Matthews, pers. com. in 1978)
>42,000	GSC-1297	MkVl-9	4-5	*Salix* sp. wood (Harington 1977:Table 7)
>51,000	GSC-2559-2	MkVl-9	3/4	Autochthonous peat (Matthews, pers. com. in 1978); correlated with Disconformity A (see Chapter 6-7)
>41,300	GSC-199	MiVl-1	3	Wood (Harington 1977:Table 7); probably upper part of Unit 3
>53,000	GSC-2676	MiVl-1	3	*Salix* sp. wood (Matthews, pers. com. in 1978); upper part of Unit 3, just below volcanic ash
>39,900	I-3572	NbVm-4	3	Wood (Harington 1977:Table 7); base of Unit 3
>42,000	GSC-1589	CRH 88	3	*Picea* sp. wood (Harington 1977:Table 7); base of Unit 3
>44,000	GSC-1593	NbVm-4	3	*Picea* sp. wood (Harington 1977:Table 7); base of Unit 3
>54,000	GSC-2066	NbVm-4	3	*Picea* sp. wood (Harington 1977:Table 7); base of Unit 3

can be suggested:

1. that radiocarbon dates based on bone collagen are not precise and tend to err on the young side of the true age; or

2. that the vertebrate remains recovered from redeposited contexts in the Old Crow valley preserve a record of radiocarbon ingestion which has not been preserved in the form of plant fossils of the same age.

Early attempts to obtain radiocarbon dates from bones met with considerable controversy, partly because the whole bone had constituted the sample and therefore could have contained contaminants of many kinds (Krueger 1965). Collagen extraction was introduced in an effort to reduce the errors but even this refinement did not provide entirely satisfactory results (cf. Sellstadt, *et al.* 1966; Barker 1967). Tamers and Pearson (1965) found that radiocarbon dates on bone collagen tended to err on the young side when compared with associated dates on charcoal, but their pretreatment procedure did not include a sodium hydroxide leach which would remove humic acids by making them soluble. Further refinements in the pre-treatment of bone samples have added this essential step (Berger, *et al.* 1964, 1971; Longin 1971), but a recent tabular comparison of radiocarbon dates on bone collagen and other materials (Berger 1975:Table 9) still appears to indicate a tendency for the bone collagen dates to be slightly younger than those based on charcoal. In applying these considerations to the Old Crow fossils, we should note that they seem to have been preserved in ideal burial environments for the preservation of uncontaminated collagen, and the laboratory procedures which have been employed with these samples have included both hydrochloric acid and sodium hydroxide pre-treatments (Harington 1977:114-115). I do not know whether bone collagen pseudomorphs (see Berger 1975:175) have been observed during the pre-treatment process, and it would be useful to conduct further studies of the condition of collagen preservation in the Old Crow fossils to determine whether the collagen molecule exhibits general integrity or whether it has been partially hydrolized into its component amino acids. Hence I would suggest that we should not completely dismiss the possibility that the 3000 year gap between the 28,000 year collagen-based peak and the youngest date on other organics is due to errors of approximately 10% in the dates obtained from the bones.

The alternative arises from the observation that the broad floor of the Old Crow basin may have been a stable plant- and animal-supporting surface for several or even many thousand years before it was inundated by glacial meltwater as a result of the classical Wisconsinan advance of Laurentide ice. Thusfar our fossil evidence suggests that arboreal plants (particularly spruce) may have been eliminated from the basin prior to the inundation by the glacial meltwater (Hughes, *et al.* 1980) so that large pieces of wood which could have been preserved in the anaerobic lake bottom may not have been present on the basin floor. The more delicate plant tissues of herbs, grasses, and shrubs which were probably growing in the basin when inundation occurred would more likely have been destroyed and floated away from appropriate burial sites. We seem to have direct evidence of this process from three of the dates listed in Table 9.5. GSC-2507 (35,500 ± 1050 B.P.) and GSC-2756 (38,800 ± 2000 B.P.) were obtained on detrital organics which form a distinctive thin band at both MkVl-10 and MlVl-2 at the base of a series of silts and clays which probably represent the transgressive phase of the glacial lake. GSC-2739 (31,400 ± 660 B.P.) was obtained on an aquatic peat which appeared to have been disturbed

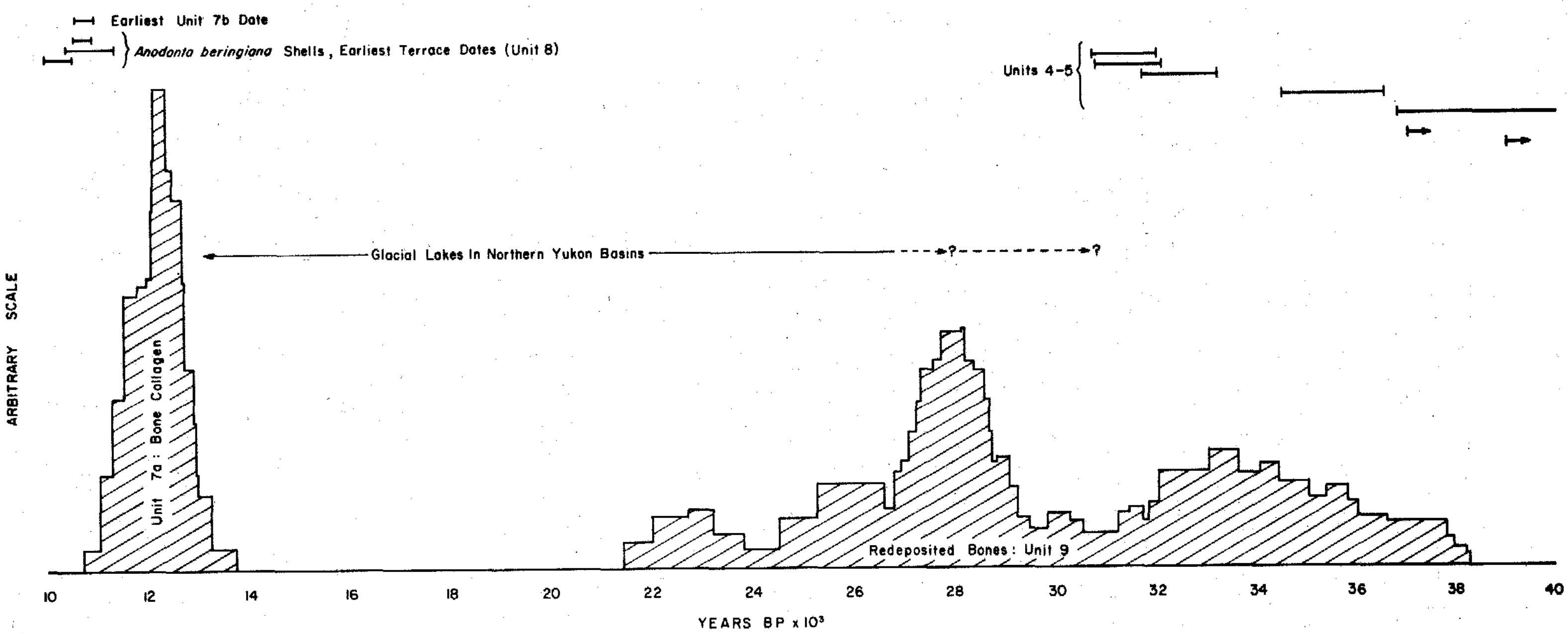


Fig. 9.3. Graphic comparison of bone collagen dates (histogram) and radiocarbon dates on other organic materials (bars) from the Upper Pleistocene of the Old Crow region, northern Yukon Territory. Note the long hiatus apparently attributable to the inundation of northern Yukon basins by glacial meltwater in classical Wisconsinan times.

by cryoturbation but not by the transgression of the lake, and this sample was recovered approximately 50 cm below GSC-2507 at MkVl-10. Hence the detrital organics at the base of the transgressive phase seem to contain older materials which have been brought into physical association with younger ones during the inundation of the basin, and there may be little possibility of finding datable organic materials other than bone which would date to the period immediately prior to the lake transgression. If so, the vertebrate remains would supply our best indication of the time of the transgression, and we might expect to obtain a relatively large number of dates attributable to the transgression in view of the likelihood that large mammal mortality was elevated by miring and drowning when the basin was flooded (cf. Child 1968). The bones of such animals would be deposited in ideal sedimentary environments to ensure their preservation, and they would be available for redeposition by the Old Crow River and its tributaries during final Wisconsinan downcutting of the basin.

Three of the collagen dates in Table 9.4 and Fig. 9.3 appear to indicate that some large mammals were still resident in the basin shortly after the 28,000 year old peak. Perhaps these dates represent animals which fell through the ice which must have formed at least seasonally on the glacial lake.

In general, however, it appears that the radiocarbon dates already provide the expected picture of a cessation of large mammal life in the Old Crow basin for a period of at least 10,000 years, and perhaps as much as 16,000 years, during which the glacial meltwater of the Laurentide advance continued to maintain a large lake in the basin. Therefore it may be very difficult to develop a coherent and continuous record of human occupation in the Old Crow region through the critical period of late Wisconsinan time. While it is possible and even likely that some of the lithic complexes recovered from sites on the slopes and uplands around the basin date to this interval (Irving and Cinq-Mars 1974; Cinq-Mars 1978), it will be very difficult to determine their ages or to define archaeological assemblages which belong specifically to this period.

The end of the lake high stand is rather clearly marked by six dates on *Bison crassicornis* bones which can be traced to a channel deposit related to the earliest stage of downcutting of the basin during the drainage of the glacial lake. These dates show that downcutting was underway by 12,000 years ago. Dates on *Anodonta beringiana* shells in the earliest terrace deposits of the Old Crow River show that the drainage had reached a new base level near the modern valley floor by 11,000 years ago so that the entire episode of rapid dissection through the fine sediments in the Old Crow basin was accomplished in a single millennium. The straight-line distance along the general valley floors of the Porcupine and Old Crow Rivers from the Alaskan border at the Ramparts of the Porcupine to the furthest upstream Pleistocene exposure on the Old Crow River is 175 km. The river appears to be graded to a bedrock threshold near the Alaskan border so that this distance can be used to calculate the approximate rate of retreat for the nick point which responded to the lowered base level in final Wisconsinan times. If downcutting occurred in only 1000 years, the nick point must have retreated at the rate of one kilometer every 5.7 years. Hence the drainage of the glacial lake and the dissection of the underlying sediment must have been accompanied by powerful (catastrophic?) fluvial activity, and such processes may be responsible in part for the abundant vertebrate fossils which are concentrated in the deposits associated with the *Anodonta* phase.

Finally, before leaving this discussion of dating, we can show reasonable expectations that amino acid racemization measurements will eventually contribute to the resolution of some of our chronological problems (Rutter, *et al.* 1977). Bone has not proved to be a reliable sample material for the use of this method in the Old Crow region, but freshwater molluscs and wood samples have provided useful results when partitioned first by genus (Hughes, *et al.* 1980). The amino acid measurements have been used for relative dating and correlation in our work thusfar, but chronometric dates may eventually be forthcoming.

Some Implications of the Glacial Lakes

It is already evident from available radiocarbon dates that the flooding of interior lowlands by glacial meltwater in classical Wisconsinan times is responsible for a significant discontinuity in the record of fossil vertebrates in the Old Crow basin. A similar discontinuity is likewise to be expected in the portion of the archaeological record which is recoverable from the valley walls of the Old Crow River, but we do not know how the existence of the lake may have affected large mammal (including human) life on the slopes and uplands which surround the basin. It is likely that such a large body of glacial meltwater had a profound influence on local climatic parameters, and this influence may have ramified through much of the neighbouring ecosystem. Even today the large lakes on the surface of Old Crow Flats significantly retard the onset of the growing season because the high albedo of the winter ice cover lowers the ambient temperatures of the immediate vicinity, and such an effect may have been vastly multiplied for a lake which covered the entire basin.

Other than the relatively narrow Arctic coastal plain, only four areas of Yukon Territory lie below 1000 feet (305 m) elevation (Energy, Mines, and Resources Map MCR 25, 1972). The largest of these areas is the Old Crow Flats, and the other three comprise portions of the relatively small Bluefish, Bell and Bonnet Plume basins. It has already been shown that the Old Crow, Bluefish, and Bell basins were inundated by glacial meltwater during classical Wisconsinan times (Fig. 2.1). The Bonnet Plume basin was also occupied by a glacial lake of some extent as inferred from our 1976 observations of glacio-lacustrine deposits both above and below a till at a section of Hungry Creek (see Hughes, *et al.* 1980). Therefore all interior habitats below an elevation of 1000 feet (305 m) were submerged by glacial lakes during classical Wisconsinan times in eastern-most Beringia. This fact must have had a profound effect on biological communities in the region, and the effect would have persisted for 10,000 years or more (Fig. 9.3).

Referring to both the Yukon and Alaska, Ritchie and Cwynar (1978) have provided a provocative assessment of Beringian lowlands in relation to island biogeographic theory and late Pleistocene extinctions. They note that

> the possibility remains strong that the period from about 18,000 B.P. to 14,000 B.P. was marked by a major diminution (X 0.1) of habitat suitable for large herbivorous vertebrates and that this

> restriction was aggravated by fragmentation into island habitats. ...We suggest, in conclusion, that habitat diminution and fragmentation should take its place along with the several other paleoecological factors proposed to account for the apparently major changes in fauna (at the end of the Pleistocene) (Ritchie and Cwynar 1978:3).

I suggest that the flooding of all interior lowlands in Yukon Territory during classical Wisconsinan times may have had similar effects. A major difference between the flooding event and the widespread shifts from herb or steppe tundra to shrub tundra in final Pleistocene times (see Ager 1975; Matthews 1976b, 1977; Hopkins 1979) is that mammal communities could have resorted to those lowland areas of eastern Beringia which were not affected by flooding. Enlarged coastal plains, the Kobuk, Koyukuk, Yukon Delta-Kuskokwim, Nushagak, Kantishna, and Fort Yukon lowlands (Ritchie and Cwynar 1978) would all have remained available for continued and in fact increased colonization by large herbivorous vertebrates. Presumably these alternatives prevented the extinction of many taxa as flooding occurred in the easternmost Beringian basins where local or regional extinctions of some lowland plants and animals may have been brought about as the basins filled with glacial meltwater.

The flooding of the Yukon basins may have been not only comprehensive but also catastrophic. Feasibility studies by the Water Resources Branch, Department of Northern Affairs and National Resources, in the 1960's, included a scheme in which the Ramparts of the Porcupine River would have been dammed near the Alaskan border, the headwaters of the Peel River would have been diverted through the Eagle meltwater channel, and the newly created outlet at McDougall Pass would have been dammed with a power generating station on the Rat River which flows to the east from McDougall Pass (see Fig. 2.1; DNANR 1965). Whether or not the planners were aware of it, they were contemplating the re-creation of the classical Wisconsinan glacial lakes, and their data concerning basin morphology and rates of flow are relevant to our understanding of late Pleistocene conditions in the northern Yukon Territory. These data permit the estimate that the basins could be filled in 10-15 years simply with the combined waters of the modern Porcupine drainage and those of the upper Peel. Presumably the augmented discharge provided by glacial meltwater from the Laurentide ice front would have accomplished this task even more rapidly in classical Wisconsinan times, so that it may not be unrealistic to imagine that the glacial lakes were raised in only a few years!

Judging from observations made during the flooding of the Kariba reservoir on the Zambezi River in Africa, such an inundation could have been truly catastrophic for the mammal communities resident in the area (see Child 1968). Operation Noah was launched on the Zambezi to study the behaviour and to accomplish the rescue of as many mammals as possible. At this stage in our study we must ask whether the Zambezi is a suitable analogue for the flooding of northern Yukon lowlands, but some of the general consequences, if not the exact behaviour of the affected vertebrates, are probably similar in the two situations. Vertebrate populations in the lowland areas probably could not simply seek higher ground over the long run since niches on the slopes and upland surfaces would already have been filled by other forms and individuals. Any appreciable topographic relief on the surfaces of the basins would have promoted the formation of islands, boggy areas, and enlarging coalescent lakes. Increased incidences of miring and drowning or of "entrapment" on islands and points of land could have improved the food procurement opportunities for predators and scavengers during a period of a few years or even a decade or more. We can only wonder whether human hunting societies resident in the Old Crow basin and surrounding areas could have taken advantage of such an opportunity to dispatch vulnerable prey.

Perhaps this combination of events is responsible for the 28,000 year old peak in the radiocarbon dates on bone collagen from the Old Crow region (Fig. 9.4). Increased mortality in the large mammal communities of the Old Crow and other basins of the northern Yukon is an expected result of the rapid inundation of these basins whether or not human hunters and scavengers were involved in the demise of the animals. The radiocarbon dates on other organic materials seem to provide the expected indication that the floor of the Old Crow basin was a stable habitable surface for at least several millennia immediately prior to inundation by glacial meltwater, and the area may have afforded an ideal habitat for human hunting societies.

Technology and Human Adaptation

As I have stated several times in this report, any definition of the "technology" represented by collections from the Old Crow basin is necessarily based upon the assumption that all (or many) of the specimens belong together. In fact it is obvious that the archaeological specimens from the reworked deposits may represent a minimum of 30,000 years, the period extending from Disconformity A to the basal sediments of the upper glacio-lacustrine unit. Fully half (or more) of the known and knowable prehistoric record of the region may be represented by these collections! In our summary papers concerning the Old Crow materials each of us has tended to gloss over this problem to various extents (e.g., Bonnichsen 1978, 1979, n.d.; Irving 1978b, 1978c; Morlan 1978a, 1979a, 1979b). The existing Old Crow data cannot provide a basis for writing history, but it can enable the identification of some major themes.

Bonnichsen (1979:185) has advanced the "theoretical position... that the peopling of the New World can be best understood as an adaptive process." He has organized the techniques observable among the Old Crow fossil specimens into a series of "adaptive strategies" and "repertoires" which form the basis for defining adaptive processes by means of which human societies developed the ability to cope with the environmental limitations and make use of the resources of the "Arctic-Steppe biome" (see Matthews 1976b, 1977; Hopkins 1976; Schweger and Habgood 1976). Irving and I have made similar but somewhat less specific statements along these lines (Irving 1978c; Morlan 1979b).

The salient points of this argument include the observation that an enlarged use of bone, ivory, and antler for a variety of subsistence tasks could free human hunters from constant reliance on suitable lithic resources which may have been somewhat difficult to procure, at least in some seasons of the year (Bonnichsen n.d.; Morlan 1979a). A broad intermontane basin such as Old Crow Flats is nearly devoid of lithic sources which are to be found only in the surrounding mountains where surface outcrops would be buried under snow and ice during nearly half of the year. The ability to derive a large part of the functional tool kit from the carcasses of animals being butchered for hide and meat would free hunting bands from the need to stockpile and transport supplies of lithic raw material. Many of the tools produced during butchering would simply be expedient tools which could be discarded as soon as the task had been performed. Resharpening of blunted bone flake knives might be possible with grinding techniques, but such uses of grinding have not been observed on the specimens from the Old Crow region. Marginal retouch of bone flakes seems to result in a loss of cutting efficiency since the edges become thicker and less regular than those of well-formed unmodified flakes. The disposability of bone cores and flakes may partially account for their apparent abundance in the Old Crow basin.

In order to lend weight to this functional interpretation of bone flaking techniques it was necessary to determine whether bone flakes were truly useful in butchering a large mammal, and it was important to establish the ease with which bone could be procured and made ready for flaking during a butchering operation on a large mammal. The Ginsberg experiment (Stanford, *et al.* 1980) provided an opportunity for such a study, and it is clear that many aspects of elephant dismemberment can be accomplished with such bone tools. It is also clear, however, that the hide and many of the tougher integuments of the carcass are not easily cut with bone tools so that the use of stone flakes and knives should always be considered a normal part of the tool kit.

Mammoth and mastodon long bones (like those of modern elephants) are especially well suited for the production of flaked bone tools because of the thickness of their walls and their ability to withstand the concentrated forces delivered during flake production. Bonnichsen (1979:191) has made the interesting point that such massive proboscidean materials require more modification than smaller bones in order to produce useful tools if only because the large pieces obtained from mammoth or mastodon long bones do "not fit nicely into the human hand." It should be expected, then, that primary archaeological assemblages of this kind of material will provide a basis for inferring core reduction strategies peculiar to this kind of raw material.

Many of the functionally interpretable artifacts from the Old Crow region can be understood in terms of the adaptive problems which would face human societies living in a cold climate. The caribou tibia flesher, the polished ivory specimen (flesher?) from the mid-section deposit at MlVl-2, the loon bone awl in the University of Toronto collections, and possibly many of the polished bones are related to hide-working techniques which would have been essential for the manufacture of clothing, house covers, and perhaps boat covers. Antler wedges, if they were truly part of the mid-Wisconsinan tool kits, may have been used in working hides as well as in other functions. It is not surprising that such an emphasis on hide-working should be apparent in our first glimpse of this northern technology.

An essential aspect of the technology which is not at all evident is the procurement of a carcass for butchering. Bonnichsen (1979; n.d.) has discussed at some length the alternatives of skilled hunting, scavenging, or a combination of these practices as that might have characterized societies in the Old Crow region, but primary archaeological sites will be needed to clarify this important question. It seems doubtful to me that a stable subsistence economy could have been based upon anything but the skilled hunting of many kinds of game, given our present understanding of the environmental conditions of the time; scavenging would often have been possible but surely could not be relied upon as a regular means of obtaining food.

Bonnichsen (n.d.) also argues that our view of the early technological products in Beringia should be framed in terms of cultural knowledge which may cross-cut the raw material categories so often used for the archaeological definition of past cultures. Irving (1978d:93) has made a similar observation in pointing out that archaeologists must learn to understand "technology" as "all those aspects of culture which have to do with getting and distributing food and shelter." Specifically, in the case of the Old Crow material, an essential feature of the technology is seen as a transfer of rules and procedures from one raw material form to another. Many of the rules for working stone can be transferred to bone, while many distinctive bone working techniques can be transferred to wood, etcetera and vice versa (Bonnichsen n.d.). It is the flexibility afforded by this kind of transfer technology that represents the heart of human adaptation to Arctic environments or indeed to many environments (cf. Hutterer 1976). "This flexible repertoire of technological procedures would have readily permitted new tool forms to be created when new problems were confronted and as preferences, needs and changing environmental contexts were encountered in the Arctic-Steppe" (Bonnichsen n.d.). It seems to me that these concepts are neither obscure nor profound, and it is unfortunate that an understanding of these principles seems not to be widespread in archaeological writing.

Paleoenvironmental Considerations

Bonnichsen (1979:193; n.d.) has elaborated the concept that the colonization of the New World represents an adaptive response to the hunting opportunities afforded by an enlarging steppe-like habitat which seems to have characterized large areas of Beringia in classical Wisconinan time. There can be little doubt that this habitat supported an enormous wealth and diversity of big game (e.g., Guthrie 1968; Harington 1977, 1980; Cinq-Mars 1979), and any hunting society equipped to exploit these resources could have colonized large areas of northeastern Asia and northwestern North America both readily and quickly.

The major difficulty with this concept is the link between the initial colonization of the New World and the spread of steppe-like habitat. Fossils on Disconformity A demonstrate that a forest of some kind occupied at least parts of the Old Crow basin approximately 60,000 years ago. Spruce cones and needles, and forest-dwelling mammals such as snowshoe hare (*Lepus americanus*), red-backed vole (*Clethrionomys rutilus*), heather vole (*Phenacomys intermedius*), and lynx (*Felis canadensis*) (Morlan 1978c) are, respectively, direct and indirect indicators that an open forest was present locally during the time period represented by Disconformity A. On the other hand, the disconformity has also produced a number of obligate tundra forms among both insects and mammals as well as many taxa which are adapted to both forest and tundra. These fossils, along with sedimentary structures, such as ice-wedge pseudomorphs and cryoturbation folds, suggest that the climate and biota of 60,000 years ago may have been somewhat similar to those of the present time in this area. If this was the time of initial human colonization, we cannot suppose that enlarging steppe-like conditions are part of the picture. Earlier evidence for human occupation would place the first colonists not in a steppe-like environment but in possibly warmer and more densely forested conditions which seem to have prevailed during portions of the Sangamon Interglacial (Matthews 1975). Even on Disconformity A the evidence that the ice wedges melted may indicate a climatic oscillation warmer than present conditions (Matthews 1980).

Irving (1978c:334; 1978d:94) has noted that the deep snows and generally low biological productivity of northern forests might have presented formidable barriers to human societies expanding northward from temperate latitudes. Certainly these are characteristics of modern boreal forest and taiga, and deep snows must always have presented a hazard in northern forests of any kind. On the other hand, an open forest or a mosaic of forest and treeless conditions may have characterized former Beringian landscapes and supported more diversity of biota at the local and regional levels than can be found today in the highly zonal distributions of major biomes. Less highly zoned environments could even offer the best of several possible worlds, viewed from today's perspective, in that both forest- and tundra-dwellers might be available to a given hunting band which could exploit a wide variety of resources. The potential for colonization of the New World might be enhanced in such a setting if the diversity of resources for food, shelter, and fuel required less specialization of technology and subsistence economy.

Fossil evidence above Disconformity A in the Old Crow basin supports the concept of gradually thinning forests and enlarging treeless landscapes as the climate grew cooler and drier early in classical Wisconsinan times. Human societies resident in the area might have found wood in decreasing supply but presumably could have adjusted their lodging and heating techniques as steppe-like conditions developed over larger areas. The use of bone and dung for fuel, and bone and ivory for building materials, seems to have been a widespread adaptation to such conditions in Eurasia so that the Beringian adaptation to the environments of classical Wisconsinan times could be seen as a secondary adjustment which took place in Alaska and the Yukon just as it seems to have occurred in other circumpolar areas which were already colonized. This model can still accomodate the concept of Beringian preadaptation for more southerly grasslands which Bonnichsen (n.d.) has proposed but which is difficult to perceive in the data available thusfar from such areas as the High Plains. Unfortunately we have so little real data concerning the temporal and spatial associations which originally prevailed among the fossil specimens from the Old Crow basin that these ideas concerning the peopling of the New World have the hollow ring of scarcely warranted speculation.

Other Beringian Localities

To whatever extent I have provided a satisfactory demonstration that the Old Crow region was occupied in early and mid-Wisconsinan times, I have also shown that the classical Wisconsinan glacial lakes which occupied the northern Yukon lowlands represent a significant interruption in the continuity of the potential archaeological record from these lowlands. Even if the slopes and uplands which surround the basins were continuously occupied by people during the classical Wisconsinan interval it will be very difficult to resolve the chronology of the surficial deposits which are preserved there (Irving and Cinq-Mars 1974). It has already been shown that final Wisconsinan occupation of the area begins no later than 13,000 years ago (Cinq-Mars 1979), but there may long be an apparent hiatus of as much as 15,000 years in the archaeological record of northern Yukon Territory.

Scattered finds from other areas of eastern Beringia already show promise for filling in this interval. Fossil bone, ivory, and antler artifacts have been recovered from a number of general localities in addition to the Old Crow region, and these can be summarized briefly to indicate the extent to which continuity can be expected to emerge from further work. Bonnichsen (1979:Chapter IX) has described materials from Whitestone River, Dawson, Lost Chicken, and Fairbanks. In addition, Stewart River in central Yukon and Jack Wade Creek in eastern Alaska can be mentioned.

Bonnichsen (1979:169) has reported an ivory core from the Whitestone River, a tributary of the upper Porcupine in the northern Yukon, but I am not entirely convinced that the specimen is an artificially produced core. Four flake scars seen at the smaller distal end of the tusk fragment could have been produced during life by the mammoth itself, and the cone-shaped fracture at the proximal end closely resembles broken tusks seen on living African elephants (Bonnichsen 1979:Pl. IX-1; Douglas-Hamilton and Douglas-Hamilton 1978: plates following pp. 64, 192).

A geological section on the Stewart River (HH65-25; KjVd-1) in central Yukon has yielded provocative but inconclusive evidence of possible human activity in close proximity to a volcanic ash thought to be >42,900 years old (GSC-524:Morlan 1977c:39). A caribou long bone fragment with two spiral fractures found in 1975 might be attributable to carnivore gnawing, but the 1977 field season yielded several bison long bones broken when green despite their very thick walls which are probably beyond the range of carnivore fracture capabilities. A large green fractured mammoth or mastodon long bone was recovered from deltaic deposits at the mouth of the gully in which the bison bones were found, and this small delta is believed to have received its fossils from the same deposit as the other bones.

In the Dawson area of west-central Yukon, continuing placer mining operations produce new paleontological and archaeological specimens annually (Bonnichsen 1979: 169-172). In addition to a previously reported antler "punch" (Harington 1975b; Bonnichsen 1979:171, Pl. IX-1), several green fractured mammoth and/or mastodon long bones and an extensively cut *Bison* sp. skull (Morlan 1977b) can be cited as secure evidence of human activity associated with Pleistocene fauna. The first mammoth bone core from this area was recovered in 1979 and will be described elsewhere. The age of these materials is not well known, and dates have ranged from quite recent Holocene times to beyond the range of radiocarbon dating (Harington 1977:Table 5). Most of the permineralized faunal specimens have produced ages approximating portions of the classical Wisconsinan interval. Harington (1978:58-60) has suggested that the major faunas of the region date to late Wisconsinan times.

The Lost Chicken locality in eastern Alaska has also produced late

Wisconsinan faunal material among which several artifacts have been reported (Bonnichsen 1979:172; Harington 1980:170). The most interesting pieces which have come to my attention include several cut antlers (Bonnichsen 1979: Pls. IX-2-IX-3), a *Bison crassicornis* tibia which exhibited a massive point of impact and was sacrificed for a radiocarbon date of 10,370 ± 160 B.P. (I-8582) (Harington 1980:170, Fig. 2), and a massive green fractured mammoth limb bone fragment (NMC-25876: Harington 1980:170). Collecting was begun at this locality in the early part of this century (Whitmore and Foster 1967; Foster 1969), and Lee Porter is carrying out ongoing studies and notes that most of the bones are thought to be older than 25,000 years ago (Porter 1978).

Among the thousands of Pleistocene fossils from the Fairbanks area mucks are an unknown number of artifacts of various kinds (e.g., Hibben 1943; Rainey 1939, 1940). A long chronological range, from Illinoian to Holocene, is thought to be represented with most of the finds dating to late Wisconsinan times (Péwé 1975:91-101; Harington 1978:75). The fossils have often been selectively collected and preserved with an eye toward paleontologically significant materials. This collecting procedure must have reduced the potential for archaeological recovery quite considerably, for Bonnichsen (1979) found among materials sent to the American Museum of Natural History in New York only tantalizing hints of the full range of technological procedures which must have been represented. A previously unpublished packing list of specimens, many of which have never been examined since removal from the field in the 1930's, suggests that carving of bone may have been important in the Fairbanks materials (Bonnichsen 1979:174, Table 30), but I have known some observers who were not familiar with flaking techniques to mistake flake scars as signs of "carving." Surely the Fairbanks mucks can be reexamined for their potential to add to the archaeological picture being developed in the Yukon Territory.

The Jack Wade fauna of eastern Alaska is also under study by Lee Porter who reports that the assemblage is unusual because it contains "60% sheep (no other Alaskan site has exceeded 5% sheep), it is stratified, and the bones may be the midden of a human kill-site" (Porter 1978:2). Detailed reports on this material will be eagerly awaited.

It should be clear from this brief review that several localities in eastern Beringia are beginning to produce evidence similar to some of the Old Crow region materials. Most of these finds seem to date to classical Wisconsinan times, although chronological control is nowhere as precise as would be desired. The existing finds are probably little more than the tip of the iceberg but it seems noteworthy that the most distinctive aspect of the Old Crow collections is conspicuous for its absence in most of these other areas: the bone cores and flakes which are so common in the Old Crow basin had not been found elsewhere in eastern Beringia until the single example from the Dawson area came to light in 1979. Many other satisfactory comparisons can be made between Old Crow and the rest of these areas -- polished facets on bones and antlers, shaping bone and antler tools and butchering animals with stone implements -- but the distinctive procedure of flaking bone seems to have a much more restricted distribution than might at first be anticipated. Perhaps a larger perspective can shed some light on the possible reasons for this pattern.

Old World Precursers and New World Descendents?

The data points needed to understand the Old World origins of the earliest Beringians are simply too few and too widely scattered to afford a satisfactory view of the problem. The earliest reported sites in Mongolia, the Soviet Far East, Siberia, and Japan are plagued with chronological problems and often by questionable artifact identifications (see summaries by Powers 1973; Chard 1974; Ikawa-Smith 1978a, 1978b). The Diuktai tradition is the earliest well documented archaeological entity in eastern Siberia, beginning approximately 30,000 years ago (Mochanov 1978) and apparently making a considerable contribution to the final stages of Pleistocene archaeology in eastern Beringia (Powers 1978; Anderson 1978, with references). Whether the Diuktai tradition or its predecessors can shed light on the earliest Beringian evidence remains to be seen, but reports of "bifacial" tools of proboscidean tusk at Diuktai Cave (Mochanov 1969:Fig. 4, no. 2) and "a worked mammoth bone of incomprehensible purpose" at Ust-Mil' II (Mochanov 1978:56) can do little more than whet our curiosity without detailed descriptive statements (see below).

A recent major reorientation of concepts surrounding ancient East Asian cultural traditions has been summarized in terms of "Early" and "Late Paleolithic" (Ikawa-Smith 1978c) as distinct from "Lower" and "Upper Paleolithic" dichotomies. Irving (1978d) has gone much further than I would dare in suggesting a link between this East Asian Early Paleolithic and our earliest New World evidence:

> I would like to suggest that the tool kits from Valsequillo, Old Crow, Lower Shukubai, and the two main site areas in the Phillippines, because they include a very small number of types of cutting and scraping implements and no projectile points or specialized scrapers or evidence of the blade and burin technique, could all be part of a single technological tradition. Now, of course, my problem, and I would like to make it everyone's problem, is to demonstrate that this is in fact true (Irving 1978d:93).

The link is made more than usually difficult to see because of differences in the preservation of bone in these various areas, and Irving's suggestion would seem to harken back to the idea that each of these sites or localities expresses one or more aspects of a flexible repertoire for generating tools from a variety of raw materials. Thusfar, however, there is nothing especially compelling about this circum-Pacific view, and I would caution that we must avoid cluttering up our view with marginally satisfactory sites which have produced too little evidence to interpret.

The circumpolar view which spans northern Eurasia provides no better solution to the problem, and it is further obscured by theoretical considerations surrounding the evolution of fully modern man in Europe. Whether earlier forms of man were able to colonize northern latitudes has been debated from several standpoints (compare Klein 1976b and Bryan 1978a). That glacial climates were successfully colonized during the Riss glacial complex and perhaps even earlier is already clear (Bordes and Thibault 1977), but there has been little careful consideration of the differences between glacial stades at 45° N. lat., say, and interglacial or interstadial conditions at 60° N. lat. with respect to human adaptation. If fully modern man did not emerge in Europe until 40,000 years ago (Klein 1976b), are we to suppose that our 60,000 year old evidence in eastern Beringia represents some earlier stage of human evolution? Neither the Old Crow mandible (Irving, *et al.* 1977) nor the human paleontological record from East Asia can clarify this problem at the present time. The Old Crow individual died too young and at an unknown time, and the East Asian record is still subject to a wide variety of interpretations including the separate evolution of fully modern man (Aigner 1978). Meanwhile the presence of *Homo sapiens neanderthalensis* in a kind of "tundra-steppe" environment 60,000 years ago at Salzgitter-Lebenstedt (Müller-Beck 1979) shows that people had by then adapted to truly "northern" kinds of environments and suggests that Europe may hold more potential for the discovery of New World origins than I have sometimes believed (Morlan 1976b, 1978a).

During recent travels in Czechoslovakia and Germany, with the kind assistance of Profs. Hansjürgen Müller-Beck, B. Klíma, and K. Valoch, I was able to examine the large collections from Kůlna Cave, Předmostí, Dolní Věstonice, Pavlov, and Vogelherd. Together these sites span a long Paleolithic sequence from Micoquien through Magdalenian, and mammoth bone cores and flakes were seen in each of the collections but were not present in the Magdalenian components. The earliest examples were in the Micoquien levels of Kůlna Cave (Valoch 1979) which date to 50-60,000 years ago, but the best development of bone flaking techniques was observed in the Gravettian kill site of Předmostí which is thought to be approximately 26,000 years old (Absolon and Klíma 1977; Jelínek 1975:Figs. 285-289). At Dolní Věstonice, a Gravettian habitation site dating to approximately 25,000 years ago (Klíma 1963), there were fewer bone tools in proportion to lithic specimens, and flaked bone tools were especially less common than at Předmostí. A similar pattern is seen at the nearby Pavlov site which is also a habitation site of similar age. Both Dolní Věstonice and Pavlov are located well up on the valley wall overlooking the broad floodplain of the Tyara River, but Předmostí is located on the floodplain where it is very deeply buried beneath alluvium (redeposited loess) and was found during quarrying for a brick yard.

The following speculative comments are taken from notes which I wrote during my stay in central Europe. Kůlna Cave shows that flaked bone techniques were being practiced in central Europe at least as early as Disconformity A in the Old Crow region. Well made facially flaked cores are clearly part of the Micoquien technology at Kůlna Cave, but such cores are less well represented in the Gravettian sites. Their presence in the Gravettian technology can be inferred from the flakes and from a few poor examples of facially flaked cores. Edge spall cores are present in all these sites, but are not always easy to recognize (this is also true in the northern Yukon). Transversely flaked pieces, some quite long, are present in Gravettian times and appear to represent primary shaping for the production of "spatulae." The bone spatula is well represented in the Gravettian and has several forms and possibly several functions. Very long, straight, massive examples were made on mammoth long bone fragments by flaking their lateral edges and then finishing them by whittling and polishing. Smaller, lighter, curved examples were made on mammoth ribs mainly by polishing and cutting, and they exhibit bevelled ends with use wear facets. These were probably used as fleshers and meat strippers during mammoth butchering. Their long, curved forms would be ideal for many of the problems encountered by mammoth butchers, and they could be especially good for stripping off massive "blocks" of meat where the hand or haft gets in the way with smaller tools (a problem noticed during the Ginsberg experiment). At least one spatula from Pavlov exhibits ragged convex scars on its lateral edges which might have resulted from heavy "hacking" at tendon or near bone.

All three Gravettian sites contain numerous segments of tusk approximately 10-20 cm long with one or both ends rounded to form a working surface. Their wear patterns suggest at least three possible functions: (1) a few are polished and could have served as pestles, and one of these from Pavlov was used to powder ochre and has hematite densely adhering to one end; (2) a few are heavily "pocked" as if used as flint knapping billets; and (3) many are neither polished nor pocked and may have been used to detach bone flakes. Two (and perhaps more) antlers have rounded pocked tines suggesting flint-knapping, and these have precisely the same design as the Old Crow billet. At least one antler wedge from Dolní Věstonice is inseparable from the Old Crow region wedges except that the former is stained with red ochre; it has a uni-bevelled working end and a heavily hammered transverse butt which was hollowed out as if to receive a shock absorber. At Pavlov are many bevelled antler pieces with the bevelling appearing on a tine which is still attached to the main antler beam so that the form of a hoe is achieved. The working end is always bevelled toward the antler base, and one example of resharpening by the removal of an exhausted edge was noted. Numerous bone awls are also seen in these Gravettian sites.

A general pattern in the Gravettian data is the relatively great abundance of flaked bone specimens at the kill site of Předmostí, on the floodplain of the Tyara River, as compared with the habitation sites of Dolní Věstonice and Pavlov, well above the valley floor. Is this difference related to the distance from suitable lithic raw material sources and to the scarcity of lithics in the floodplain alluvium near Předmostí? Does it reflect the relative ease of preparing butchering tools of bone as compared with transporting sufficient stone tools across the broad floodplain of the Tyara River? Is it due to chance alone? With a sample of only three related sites to consider, it is obviously impossible to come to a conclusion as to the significance, if any, of the ratios of bone and stone tools in these Gravettian occupations, but the pattern should be borne in mind in the search for primary archaeological sites in the Old Crow basin and in our patience concerning the paucity of lithic tools in the Old Crow valley. The apparent abundance of bone tools might have resulted from the presence of kill sites near the center of the basin. If habitation sites are located in mid-Wisconsinan sediments near the slopes surrounding the Old Crow basin they are either under the upper glacio-lacustrine unit where they will not likely be discovered or they are above the maximum lake level where bone preservation would not likely occur. Sites of the latter sort may already have been found during Cinq-Mars' surveys, but we do not know how to recognize them as mid-Wisconsinan occupations.

Unfortunately the central European Gravettian sites are simply too far from the northern Yukon Territory to permit speculation as to the meaning of either specific or general similarities between the two areas, and I have seen no comparable materials in the literature on sites in European Russia. Further to the east, however, in western Beringia, Mochanov (1977:Pl. 5, no. 15) has recently illustrated an antler billet from Diuktai Cave which appears to have been made in a manner very similar to the example from the Old Crow basin, and he has noted the transverse and longitudinal artificial flaking which appears on a long bone fragment from Ikhine I, Layer 3 (Mochanov 1977:44, Pl. 12, no. 3) which apparently dates at least to lower Sartan times (= early part of classical Wisconsinan; cf. Tseitlin 1979:Table 16). Additional evidence of this kind will undoubtedly come to light as work continues in Siberia.

If we have accomplished little by looking west to the Old World, I fear we may gain little more from the view to the south in the New World. We can barely glimpse threads of continuity which might indicate a continuous record of human occupation from our earliest dates in the Old Crow region through the remainder of the late Pleistocene in eastern Beringia. Presumably people did not abandon Beringia once they had settled the area, but we are a long way from demonstrating an historical development from 30-60,000 years ago in the northern Yukon through the late Wisconsinan to the 12-15,000 year old record which extends into Holocene times. In seeking such evidence we might find some "index fossils" useful, but very few of the Old Crow artifact types clearly qualify for that kind of treatment. The caribou tibia flesher can hardly be seen as a diagnostic of mid-Wisconsinan Beringia when a nearly identical tool is "diagnostic" of Late Prehistoric occupations on the northwestern Plains (Frison 1978:Fig. 2.24) and very similar specimens are common in late prehistoric Indian and Eskimo contexts in the north (Morlan 1972:Pls. 1d, 4f; Le Mouel 1976). Likewise the known records of caribou antler uni-bevelled wedges, antler billets, and bird bone awls extends throughout prehistoric times and into the ethnographic present (Poplin 1976; Bordes 1974; Deffarges, *et al.* 1974; Gifford 1940:182; Goddard 1903:15). The remarkable spatial and temporal distributions of these tool types are probably results of their elegantly simple designs and specific functional requirements, and careful stylistic studies would be needed to discriminate portions of the distributions which might have demonstrable historical integrity.

Perhaps a more satisfactory index fossil is the bone core and flake complex which is so well developed in the Old Crow basin. In this sense I am referring not to the shaping of bone artifacts by flaking techniques (which is common in several late prehistoric contexts, e.g. St Lawrence Iroquois:Wintemberg 1972) but to the production of flakes which are useful without further modification as cutting implements in butchering and other tasks. I have already noted that these procedures have seldom been identified in other Pleistocene Beringian deposits, and they seem to be rare in the known record of other areas as well. The abundant broken bone from Valsequillo, Mexico, does not seem to include cores and flakes (see Camacho 1978), and the broken mammoth bones in Owl Cave were not treated in this way (see Miller and Dort 1978). Thusfar only two unequivocal examples of mammoth or mastodon bone cores in central North America have come to my attention: an excellent specimen, as well as associated bone flakes, from the Dutton site in eastern Colorado which underlies a Clovis occupation (Stanford 1979b:Figs. 8, 12) and a core recently recovered in association with a Clovis point at the Kimmswick site in Missouri (see Early Man: magazine of modern archaeology, Summer 1979, pp. 1, 25; Stanford, pers. com. in 1979). Perhaps these are our first glimpses of a distribution which will be better defined in the years ahead, and the faunal remains from some of the large and well preserved Clovis sites should be reexamined to confirm the presence or absence of such specimens.

Recommendations and Expectations

From my point of view, the archaeological aspect of the Yukon Refugium Project has been caught up to date with the completion of this report, and a lengthy discussion of stratigraphy and paleoecology is also nearing completion (Hughes, *et al.* 1980). The multi-disciplinary framework of this project has paid handsome rewards and has provided specific guidance for the organization and conduct of a systematic survey of the Old Crow valley designed to search intensively for primary archaeological deposits. Such a survey will begin during the 1980 field season and will focus primarily on the approximately five meters of sediment just below the upper glaciolacustrine unit and designated here as Units 4 and 5. The silts which immediately overlie the lake clays (Unit 7b) will also be examined. The following search criteria will guide the field work: (1) each of the 60 high bluffs which have been identified on aerial photographs (Morlan 1978b) will be examined; (2) the exposures will be searched intensively for evidence of sub-aerial weathering features -- pedogenesis, ice-wedge formation, cryoturbation -- which would indicate stable habitable surfaces; and (3) large pieces of bone and ivory which appear not to match the hydrodynamic potential of the enclosing sediment will be eagerly sought.

Accompanying this search for primary deposits will be further attention to buried materials belonging to the *Anodonta* phase, and a taphonomic analysis of NbVl-2 will be conducted to investigate the possibility that archaeological specimens can be traced back to their original sources by reconstructing the hydrodynamic characteristics of these transported materials. Similar studies might also be warranted for some of the truncated ox-bow scars which are perched on the Holocene terrace remnants. Many other contexts, including the modern banks and bars, can be expected to enlarge our collections of redeposited artifacts and excellent paleontological specimens.

We must continue to improve our interpretive analogues and to develop new ones. We need more careful field observations of the precise circumstances in which polished bones are found, and we need experimental studies of both natural and artificial modes of scratching, scraping, grinding, and polishing bones. Abrasion is known to occur very rapidly in many streams (e.g., Schumm and Stevens 1973), but the Old Crow valley is producing a few highly abraded and polished pieces as well as many more examples which exhibit little or no alteration of this kind.

Likewise more work is needed on carnivore capabilities and on the effects of trampling on bones. Spiral fractures have been reported on late Pleistocene mastodon and sloth bones at Boney Springs, Missouri (Saunders 1977:105-108) and on mammoth bones from the Hot Springs site in South Dakota (Agenbroad, pers. com. in 1979). A careful reexamination of these specimens, incorporating the total suite of attributes which I have recommended, could pose a major challenge to one of the fundamental hypotheses in this report; alternatively it might disclose an archaeological record which has not previously been recognized. Similar reexaminations should be undertaken on the very ancient (e.g., Miocene) assemblages reported by Myers, *et al.* (n.d.) and on the faunal remains from Clovis and other early man sites. These fracture patterns are interesting precisely because they are not found in all bone assemblages, but in some cases such fractures and other subtle alterations may comprise the only remaining evidence of ancient human activity (e.g., Mehl 1966; Chmielewski and Kubiak 1962). What of the many mastodon finds in the Great Lakes region (see Dreimanis 1968 for a summary)? Have we overlooked evidence of human activity which was preserved only in the form of bone fractures and other alterations on bone?

In Beringia there are many avenues for study already given modest attention but susceptible to much more intensive work with little additional expense of either time or money. The colluvial deposits of the Dawson, Lost Chicken, and Fairbanks areas must be monitored with greater regularity as soaring gold prices encourage more active (even year-around) placer mining of the underlying gravels. The enormous collections from the Fairbanks area (Péwé 1975:92) have never been adequately described and in some cases have not even been unpacked! A series of caves overlooking the lower Porcupine River in Alaska has recently produced faunal assemblages, some of which date to the Pleistocene (Dixon, *et al.* 1979), and disappointment has been expressed over the absence of cultural material in some of these contexts. I am not disappointed; I am delighted, because these caves may provide invaluable opportunities to examine the taphonomic history of late Pleistocene natural bone accumulations which could be compared with the Old Crow basin materials and the large collection from the Bluefish Caves where archaeological materials have been dated to final Pleistocene times (Cinq-Mars 1979).

It seems to me that we are inhibited by the concept of the "archaeological site." Too often we turn away from datable, stratified deposits containing well preserved fossil materials because they are "paleontological" rather than "archaeological." Obviously there can be serious problems with funding agencies if we do not adhere closely to our chosen discipline, but our proposals for field work and our definition of problems to be investigated through field work should be framed less in terms of these disciplinary boundaries and more in terms of the ongoing natural (including artificial) processes which are responsible for the creation and preservation of a buried record of the past. Some workers have long understood that archaeological sites can make significant contributions to other fields of study (e.g., Wintemberg 1919; Gilmore 1949), but we have been rather slow to take advantage of those contributions, on the one hand, just as we have rarely realized the potential for non-archaeological deposits to contribute to archaeology, on the other hand. Through a more holistic view of the sedimentary matrix and its fossil contents we can hope to give more meaning to the record of the past, and we can hope to attribute no more meaning than the record can support.

These ideas have been given a somewhat different expression by Binford who has referred to localizations as opposed to sites (Binford 1977:494) and to geological deposits which include archaeological evidence as opposed to archaeological deposits *per se* (Binford n.d.). Binford (n.d.) argues that, with the possible exception of Terra Amata, the earliest true "archaeological sites" are Molodova I and V in the Ukraine. If so, what meaning can we give to the standards of evidence cited in Chapter 1? What are the requirements for our future discoveries in the early and mid- Wisconsinan deposits in the Old Crow basin? I dream of houses made of mammoth bones and tusks (cf. Pidiplichko 1976) and red-ochre burials with strings of shell and bone beads (cf. Bader 1967), but I awaken to the realization that the quality of our data from the Old Crow basin might not improve and that the sedimentary record below the glacial lake may never yield more than a glimpse of the peopling of the New World.

APPENDIX A. INTEGRATIVE LEVELS IN LONG BONE FRACTURE

Introduction

In this appendix I have assembled information from a variety of studies of bone in order to show that long bone spiral fracture is best explained at the macrostructural level of analysis. The concept of integrative levels has been borrowed from Feibleman (1954) to whom the reader is referred for a theoretical discussion, and the levels which have been considered in this study are as follows: (1) molecular and crystalline, including the elongate protein molecule, collagen, and the tiny crystal, apatite; (2) cellular, including various modes of the bone cell or osteocyte, viz., the osteoclast and the osteoblast; (3) histological, including the arrangement of such microstructural components as osteons and lamellae; and (4) macrostructural, including the principal visible structural components, such as the diaphysis or shaft, the epiphyses, and the medullary cavity.

I have considered the nature of bone as a material and then turned my attention to its biomechanical properties. The conclusion that the spiral fracture of long bones cannot be readily explained at the microstructural and lower integrative levels supports a discussion in Chapter 3 in which the macrostructural fracture of long bones is seen as analogous to the fracture of glass tubes and other cylinders.

Bone as a Material

Long bone fracture has received extensive study, primarily from the standpoint of clinical diagnosis and treatment. Bone as a material has been analyzed at the molecular, cellular, and histological levels, and whole bones as well as machined samples of bone have been repeatedly tested by means of standard engineering techniques. Most of these studies have contributed to a broadening understanding of ways in which bones, particularly long bones, represent the results of evolutionary adaptation to the forces which normally act upon a skeleton during life. Relatively few of the available analyses are directly helpful in understanding bone as a raw material for prehistoric fracturing and flaking techniques of artifact production. On the other hand, it is possible to assemble some basic concepts which are relevant to such archaeological problems by synthesizing a broad range of the available literature so as to eliminate those areas of consideration which do not seem to bear upon the deliberate fracture of bone.

The four major constituents of bone are water, the protein collagen, a ground substance consisting primarily of mucopolysaccharides, and an inorganic compound of the apatite family. Water constitutes 20% or more of the weight of a living bone (Robinson 1952:390). About 70% of dry, fat-free bone is inorganic hydroxyapatite which occurs in both crystalline and amorphous forms with the latter predominating in early bone and being gradually superceded by the former as the bone matures (Sweeney, *et al.* 1965:3; Posner 1969:778; Posner, *et al.* 1965). Of the remaining 30%, 90-96% is collagen with the other 4-10% being comprised of non-collagenous proteins and mucopolysaccharides (Sweeney, *et al.* 1965:3; Robinson 1960:69).

The embryological and ontological details of bone development are beyond the scope of this discussion (see McLean and Urist 1968) and in any case seem to be only vaguely understood. As with any living tissue, the constituents of bone are assembled under the metabolic control of living cells which in the case of bone are called osteocytes. These cells undergo modulation (as opposed to differentiation) from one form to another so that a given osteocyte may at one time be an osteoblast which constructs bone and at another time an osteoclast which resorbs bone (McLean and Urist 1968: 5ff; see also Sweeney, *et al.* 1965; Robinson, *et al.* 1973; Pritchard 1956; Hancox 1956). Apparently the organic constituents of bone are laid down as an extracellular matrix on or in which the apatite crystals are arranged. The precise steps involved in crystal seeding and growth are unknown, but the osteoblasts must synthesize the collagen matrix as well as the apatite either within the cell from which they are excreted or through construction outside the cell but under cellular control (Posner 1969:786-787). Since amorphous apatite seems to precede crystalline apatite, the solution and crystallization of this compound must also be under the control of the cell, but the mechanism is unknown; as much as 40% of the mineral in some mature bones remains in an amorphous, non-crystalline form (Posner 1969:778). The apatite crystals of mature bone either lie along or are embedded in the collagen fibers, and the C axis of the crystals is laid down parallel to the fiber axis (Currey 1964:8). Indeed there is some evidence that the size of the crystals is limited by the length of the tropocollagen period (Herrmann and Liebowitz 1972:773-775; Posner 1969:775-776; Carlström and Glas 1959:52).

The main structural component of bone is called the osteon, a roughly cylindrical structure in which successive lamellae surround a central Haversian canal in which blood vessels and nerves are carried (Fig. A1). The osteoblasts guide the formation of the lamellae in such a way as to alter the precise alignment of collagen fibers and apatite crystals from one lamella to the next. This gives the final osteon a layered appearance in spite of its integrity as a single structure (Ascenzi, *et al.* 1966, 1973). The Haversian canal of a given osteon remains in communication with neighbouring osteons through a network of Volkman's canals which extend radially through the osteons, and further commucication occurs through even smaller openings called canaliculi which lie in circumferential orientations within the osteons. By this means, the lacunae, which house the osteoblasts, are inter-connected with one another as well as with the central canal. The final osteon and its collagen and apatite components generally lie parallel to the axis of the long bone (Currey 1964:9; Herrmann and Liebowitz 1972:773; Sweeney, *et al.* 1965:3).

As the osteoblasts complete their construction work, they become osteocytes which maintain the bone as a tissue. The boundaries between osteons are lined with mucopolysaccharides which apparently have a cementing function. The deposition of the cement is probably related to the cessation of osteon enlargement. In order to accommodate growth and as a response to new stresses in the bone, osteons are frequently remodelled. For this purpose the osteocytes become large cells called osteoclasts which cause the mineral and protein contents of one or more osteons to be returned to solution so that new osteons can be built within the remaining cavity in the

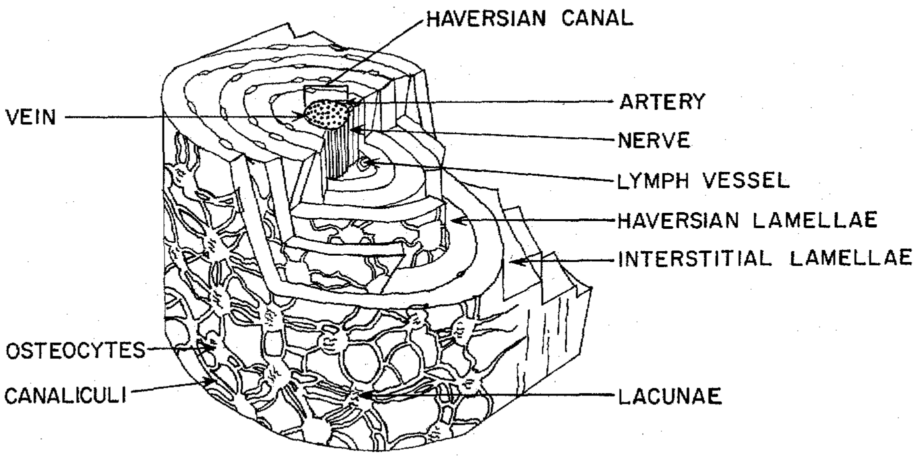


Fig. A1. Structures in the osteon of Haversian bone (after Bonnichsen 1979:Fig. 4).

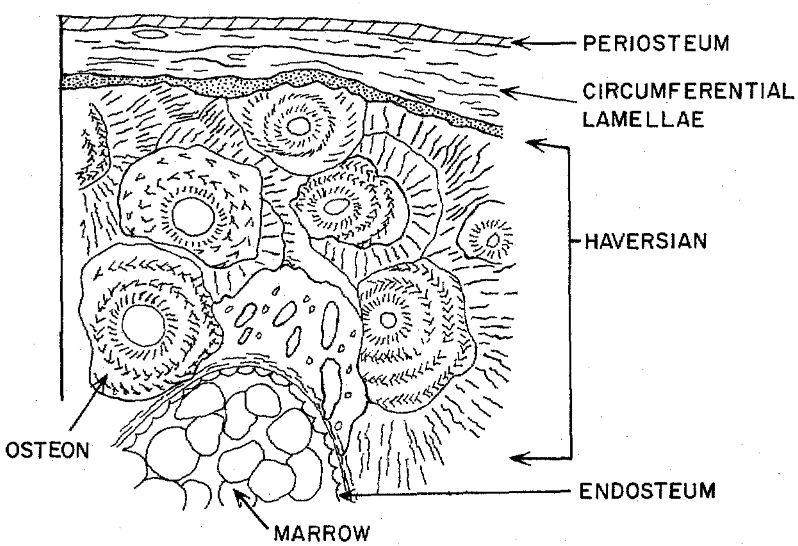


Fig. A2. Transverse section through Haversian bone showing arrangements of osteons at greatly exaggerated scale (modified after Bonnichsen 1979: Fig. 3).

bone wall. The remodelling crosses former cement lines and creates a tubular space in which osteon construction begins with the deposition of lamellae at the outer wall and continues inward until a critical remaining space has been created to form the Haversian canal. As each lamella is laid down, small lacunae are left within it to house the remaining osteocytes whose long fibrils are interconnected through the canaliculi. Once remodelling has been accomplished, there remains among the osteons portions of former osteons which are no longer under active maintainence and which comprise interstitial bone. Mature cortical bone consists of about 50% Haversian systems (osteons) with the remainder occupied by non-Haversian bone and osteon remnants that have been partially replaced (Currey 1962:122; Robeinson, *et al.* 1973; Sweeney, *et al.* 1965:3; McLean and Urist 1968:104 ff; Sissons 1956).

Near the outer limit of the long bone shaft, the Haversian system gives way to circumferential lamellae which encircle the entire shaft and give it a hard cortical outer layer (Fig. A2). This layer is covered by a membrane called periosteum which apparently participates in the construction and maintainence of the lamellae, serves for the attachment of tendons, and carries elements of the circulatory system (Sweeney, *et al.* 1965:3; McLean and Urist 1968:11-12). At the centre of the bone is the medullary or marrow cavity which is lined with a layer of cells together called the endosteum. Endosteum is also found in the lining of the Haversian canals and covering the trabeculae of cancellous bone. It participates in marrow and bone formation and maintainence and, like periosteum, takes an active part in healing fractures (McLean and Urist 1968:12).

These cellular and micro-structural components are combined to form several macro-structural components including the shaft or diaphysis, the ends or epiphyses, and cartilaginous plates at which growth by elongation occurs (Fig. A3). The diaphysis consists of compact bone surrounded by periosteum which encloses the marrow or medullary cavity in turn lined by endosteum. The epiphyses are formed by a relatively thin covering of compact bone which encloses spongy or cancellous bone. Lengthwise growth occurs at the cartilaginous plates between the diaphysis and epiphyses, and these plates eventually become ossified as an animal matures (McLean and Urist 1968:11-12).

Together the structural and cellular components outlined above make up a supportive and connective organ which is remarkable for its strength and its ability to resist stresses imposed during normal living activities. That the strength and tolerance of this organ can be exceeded is demonstrated daily in emergency wards all over the world, and much of the study of bone has been directed toward the prevention and treatment of fractures which are so debilitating to those who suffer from them. Our purpose here, however, is to understand the processes of chemical and mechanical alteration which act upon a bone once it has ceased to function as a living organ. Not the least of the considerations will be the manner in which the strength of bone can be systematically and deliberately overcome and employed so as to make it a useful raw material in artifact production and use.

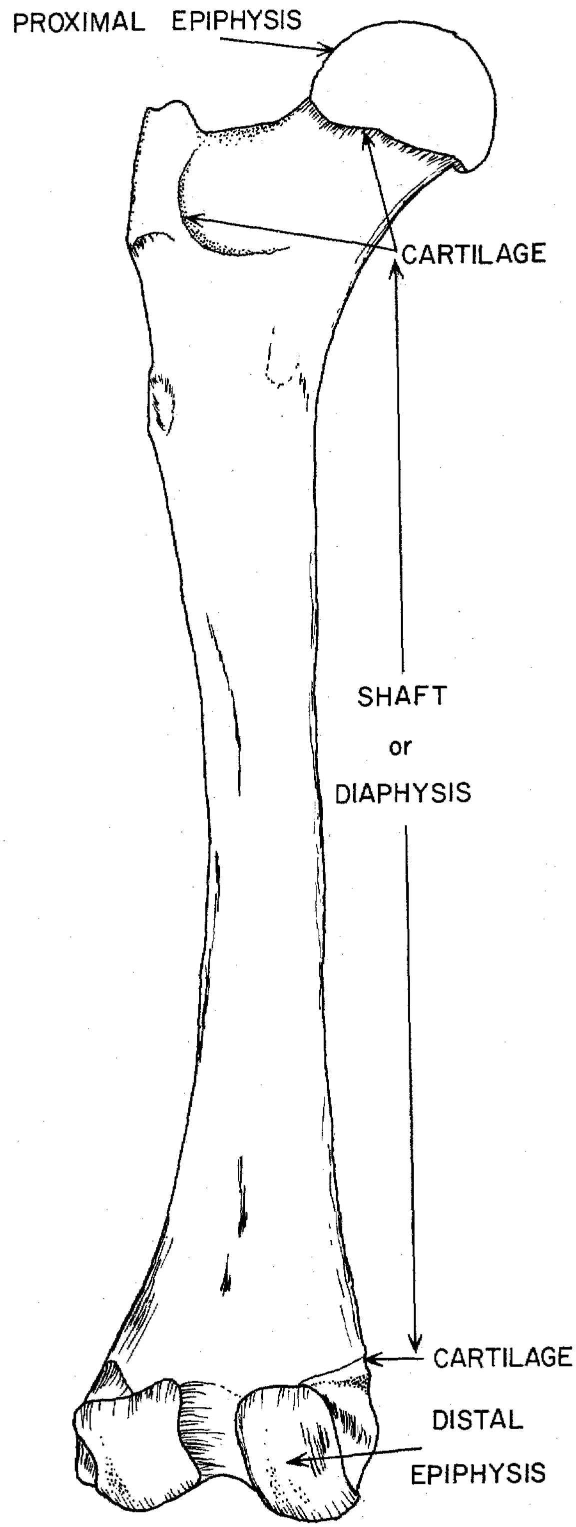


Fig. A3. Macrostructural elements of a long bone (modified after Bonnichsen 1979:Fig. 1).

Mechanical Properties of Bone

Several characteristics of bone are important for understanding its susceptibility to fracture: structural organization, ultimate strength, orientation of components, and mode of deformation. Several models have been proposed to account for the overall structural organization of lamellar bone. Currey (1964) argues quite effectively against models which depict bone as a compound bar (like reinforced concrete) or as a prestressed material as hypothesized by Knese (1958). Currey (1964:6-7) notes that such models assume that collagen and apatite in bone have properties similar to those which they might exhibit in bulk, and this assumption is quite unlikely. Instead the collagen and apatite components should be viewed as two phases of bone, each of which includes the other, and he advances a model of bone as a two-phase material analogous to fiberglass. An important feature of such materials is the great difference in elasticity between the two phases. Elasticity is the ability of a body to return to its original size and shape after removal of a force, and the "modulus of elasticity" is a measurement of the stiffness of a material (Evans 1957:239). "Bone, then, consists of a matrix with a low modulus of elasticity with, embedded in it, discrete crystals with a high modulus of elasticity" (Currey 1964:7). In non-engineering terms, this means that the collagen phase is a highly elastic matrix in which the very stiff (non-elastic) apatite crystals are embedded. The resulting two-phase material (bone) has an intermediate modulus of elasticity but much greater strength than either of the individual components when tested separately (Currey 1964:7-8).

That failure of such a material should occur at all implies that dangerous flaws must exist and that such flaws must be capable of enlarging when the material is stressed. It is difficult to determine precisely where such flaws might occur. The apatite crystals are so small as to preclude the frequent occurrence of Griffith cracks ("the original cracks present in all brittle materials made without special treatment") (Currey 1964:8), and even if failure began in the crystal the crack would soon spread to its borders where highly elastic collagen would be encountered and the crack would be arrested or turned. Ascenzi and Bonucci and their colleagues have shown that individual osteons of Haversian bone are variously organized with respect to collagen fiber orientation and that within an osteon "cracks run between, not across, collagen fibrils, separating them and indicating that the interfibrillar substance is considerably less resistant than the fibrils themselves" (Ascenzi, *et al.* 1973:232). Furthermore, some types of osteons have greatest ultimate compressive strength while other types have greatest ultimate tensile strength under a given loading orientation (Ascenzi, *et al.* 1973:234, with references).

It is possible that the numerous holes such as lacunae and canaliculi produce concentrations of stress which promote the propogation of cracks, but Currey (1962) has shown that such internal holes are so oriented as to reduce their effects as stress concentrators and to enhance their ability to prevent cracks from spreading. These findings are consistent with those of Dempster and Coleman (1961) and Evans and Bang (1966:Fig.4) who suggested that fractures tend to follow the cement lines around the Haversian systems although many other courses have also been observed (see Herrmann and Liebowitz 1972). In general there appears not to be an identifiable weak

Table A1. Summary of variables considered in selected bone deformation studies reported in the literature.

Sample	Loading	Force	Deformation	Other Variables	References
M	V	S	Te	Temperature	Bonfield and Li 1966
M	Tr	D	C	Temperature	Bonfield and Li 1966
M	V	S	Te	Wet and dry	Evans and Lebow 1951; Evans 1964
M	V	S	C		McElhaney and Byars 1965
M	V Tr Tw	S	B To	Decalcified	Sweeney, Kroon and Byers 1965
M	V Tr	S	B		Dempster and Coleman 1961
M	V Tr	S	B		Dempster and Liddicoat 1952
W	Tr	D	B		Evans, Hayes and Powers 1953
W	V	D	B		Pederson, Evans and Lissner 1949
W	Tw	S	To		Evans, Pederson and Lissner 1951
W	V	D	B		Evans, Lissner and Pederson 1948
W	V	S	B		Evans and Lissner 1948
W	V Tw	S	C To	Graft removal	Frankel and Burstein 1965
W	Tr	S	B	(Rat bones)	Bell, Cuthbertson and Orr 1941; Bell 1959
W	Tw	S	To	(Rat bones)	Bell and Cuthbertson 1943

Legend
Sample: W, whole bone; M, milled sample
Loading: V, vertical, Tr, transverse; Tw, twisting
Force: S, static; D, dynamic
Deformation: Te, tension; B, bending; C, compression; To, torsion

Major summaries
Evans 1952, 1953, 1957, 1961
Evans and Lebow 1952
Herrmann and Liebowitz 1972

anatomical unit which regularly accounts for bone fracture, and the fracture front simply follows the least common denominator of force resistance within a particular bone and for a particular orientation of force application.

The orientation of stress is clearly important in that long bones (as well as other skeletal elements) have evolved in response to the stresses which are routinely applied during the normal behaviour of animals. Thus it is not surprising that the strength of a limb bone loaded longitudinally is much greater than that of an identical bone loaded transversely (Dempster and Coleman 1961; Bonfield and Li 1966; Sweeney, *et al.* 1965; Evans and Bang 1966). This conclusion can be confidently derived from comparisons of the many bone deformation studies which have been published during the last 40 years (see Tables A1-A2). Paradoxically, the importance of orientation is clearly seen in the abortive experimental efforts described by Biberson and Aguirre (1965) in which they attempted to fracture a modern elephant femur by striking it with a hand axe on the proximal end. More recent experiments have shown that the enormous strength of an elephant femur may be systematically overcome by loading the bone in a transverse position (Stanford, *et al.* 1980).

The mode of deformation in bone has been a subject of discussion for many years. Early work suggested that bone undergoes elastic deformation up to its ultimate strength when fracture occurs (Bell, *et al.* 1941; Bell 1959), but more recent studies have clearly indicated the anelastic deformation of bone (Bonfield and Li 1966; Currey 1965). Anelasticity is recoverable strain appearing over a period of time (Currey 1965), and plastic flow appears to be a necessary component of bone deformation because of the different elastic moduli of apatite and collagen (Bonfield and Li 1966:873). It is less clear when plastic strain appears during the deformation of a bone: whereas Bonfield and Li (1966:874) report plastic strain at approximately 400 psi, Currey (1965:281) says that the plastic range begins at about 10,000 psi. Temperature effects have been shown to be important in that energy absorption was not influenced by deep freezing but was eliminated by burning (Bonfield and Li 1966:874).

An unusual characteristic of bone, when compared with other brittle materials, is its high tensile strength in relation to its compressive strength. Bone fails in tension at approximately 15,000 psi and in compression at about 25,000 psi (Currey 1964; Simkin and Robin 1973 Table 1; see also Table A2). Most brittle materials have much lower tensile strength. Nonetheless the difference between these two figures would foster the prediction that bone would fail first in tension and only later in compression, and the transverse loading studies cited in Table A1 seem to support that expectation (but see Bargren, *et al.* 1974; Reilly, *et al.* 1974, for opposing views). When human femora were supported as simple beams and loaded transversely, Evans and his colleagues found that the maximum tensile stress occurred on the side of the bone opposite the impact site (Evans, *et al.* 1953); supposedly the bones would have failed in this zone of maximum tensile stress had loading been increased beyond their ultimate strength in tension (Herrmann and Liebowitz 1972:811). Recent experiments by Bonnichsen, Stanford and me, with horse, beef, and elephant bones have been filmed at high speed (5000 frames/second) with the bones supported as simple beams and loaded dynamically with large hammerstones. In several of the films the first sign of failure has been

Table A2. Ultimate strength of various milled bone samples measured in pounds/square inch (psi). These figures are not precisely comparable due to variations in testing apparatus, skeletal element, and other factors.

	Ultimate strength (psi)	
	Longitudinal	Transverse
Bovine bone (wet)[1]		
Tension	18,660	8,135
Compression	31,781	22,184
Torsion	8,502	-
Bovine collagen[2]		
Tension	2,403	848
Bovine apatite[2]		
Tension	983	452
Compression	5,348	2,818
Human bone (wet)		
Tension[3]	13,818 ± 3910	1,432 ± 420
Compression[4]	19,007 ± 3100	16,988 ± 4600
Human bone (dry)		
Tension[3]	19,939 ± 3120	1,648 ± 472
Compression[4]	29,575 ± 2580	19,203 ± 3139

Sources

[1]Sweeney, *et al.* 1965: Table 2
[2]Sweeney, *et al.* 1965: Table 3
[3]Dempster and Coleman 1961: Table 1
[4]Dempster and Liddicoat 1952: Table 4

seen opposite the point of impact and has been most clearly recorded by placing a mirror beneath the bone. Local deformations due to tension at the impact site have also been observed and were reported in other experiments (Evans, *et al.* 1953:175).

Summary

There appear not to be anatomical features which generally help to explain bone fracture at the microscopic level. While fractures may follow cement lines and other features, they may also diverge from such features in unpredictable ways. "Bone is almost unique, among materials used to take heavy stresses, in being stiff, brittle, and filled with many tiny holes" (Currey 1962:131), and it seems clear that the two-phase structure of bone is responsible for its remarkable strength. This structure is highly anisotropic, however, and the tensile strength of bone which usually determines its failure is lower by an order of magnitude in transverse as opposed to longitudinal loading (Dempster and Coleman 1961: Table 1). "Cross-grain" tensile fractures are simple cleavages in which the failure occurs transverse to the direction of pull and parallel to the Haversian systems, while tension parallel to the "grain" causes ruptures which are oblique or transverse with the fracture lines generally being straight unless they are perturbed by local resistance (Dempster and Coleman 1961:359).

On the basis of the foregoing discussion I have argued in Chapter 3 that long bone fracture is best explained at the macrostructural level and that the fractures of long bone shafts are analogous to the fractures of glass tubes and other cylindrical materials.

APPENDIX B. DESCRIPTIVE MATERIAL FOR REDEPOSITED BONES FROM THE OLD CROW REGION

Introduction

In this appendix I have assembled verbal descriptions and tabular presentations of data pertaining to the redeposited specimens discussed in Chapter 4. The detailed descriptions have been isolated here to permit the reader to gain an overview of the record from the text while still having access to the details in this and other appendices.

This appendix is organized in terms of sections which parallel those of Chapter 4 except that classificatory procedures are not given further discussion here. Identical section headings have been used to facilitate cross-references, and all illustrations have been presented with the text discussion. Each section includes tabular data presentations and instructions for reading the tables as well as descriptions of individual specimens which exhibit unique or unusual features. These presentations are given here without comment, and the reader should consult the appropriate sections of Chapter 4 for discussion of the data.

Mammoth Bone Fracture

Metric and non-metric attributes are provided for 104 mammoth limb bones in Table B1. The specimens marked with an asterisk (*) next to the catalogue number of those found in association with the *Anodonta* phase (Fig. 2.4). These pieces are believed to be at least 10,000 years old on the basis of radiocarbon dates obtained on the molluscs at several localities, but it is suspected that most of the bone are much older than this date and that they were redeposited near the valley floor early in the downcutting history of the Old Crow River. All other specimens in Table B1 are surface finds.

The linear measurements in Table B1 are expressed in millimeters, and weight is given in grams. Two width measurements, chord and perimeter, are indicated for each bone. The chord is a straight line measurement of width as determined on an osteometric board, and the line of measurement is perpendicular to the axis of length and to the general split-line orientation of the bone. The perimeter was measured is the same place as the chord, but a flexible tape measure was used to determine the approximate amount of the cross-section of a bone which is included in a given specimen. The chord can be greater than the perimeter because of the obtuse angles formed between some fracture surfaces and outer bone surfaces. In such cases the perimeter measurement refers only to the portion of the perimeter which represents the outer surface of the bone. For bones preserved as cylinders rather than fragments (see below) this measurement is replaced by depth.

The occurrence of green and non-green fracture was recorded in the form of a fraction. The denominator of the fraction indicates the total number of margins which have been fractured at any time, and the numerator designates the number of margins which were fractured when the bone was green. Thus an intact one is designated as 0/0 since none of the margins

Table B1. Attributes of green-fractured mammoth bones from reworked deposits in the Old Crow region, northern Yukon Territory (see text for explanation).

						Wall	Loading Point			
Frac.	Cat. No.	Length	Chord	Perim.	Weight	Thickness	Form	Location	Diam.	Other
1/5	MkV1-4:5.1	(126)	(45)	(45)	87.5	21.4				
1/5	M1V1-5:5	(107)	(39)	(45)	80.6	13.2	Scar	End	>8.0	
1/4	MjVj-1:1.1	(286)	(111)	(205)	1792.0	46.1	Cone	End	14.3	Scraped; Pl. 4.3
1/4	MkV1-4:11.17	(31)	(18)	(18)	8.9	18.9				
1/4	MkV1-4:17.2	(410	(55)	(57)	637.9	18.4-36.7				
1/4	MkV1-5:11.5	(122)	(38)	(40)	66.1	17.8				
1/4	MkV1-9:16	(226)	(60)	(63)	363.1	22.8-27.6				
1/4	MkV1-27:1.1	(163)	(62)	(65)	183.4	18.7	Scar	End	31.0	Rebound scar
1/4	MkV1-27:1.2	(323)	(63)	(95)	698.7	34.9				
1/4	M1V1-1:72	(80)	(48)	(65)	76.2	9.8	Scar	End	>11.0	
1/4	M1V1-2:134	(304)	(80)	(136)	788.1	29.6-36.9				Broken when dry
1/4	M1V1-7:134	(68)	(82)	(82)	102.4	10.7-20.6				
1/4	M1V1-7:277	(273)	(106)	(93)	567.7	22.3				
1/4	M1V1-7:309	(66)	(41)	(41)	25.5	12.5-12.9				
1/4	*M1V1-12:8	(38)	(36)	(36)	20.9	>11.8				
1/4	*M1V1-12:10	(280)	(72)	(72)	376.7	27.7				
1/4	*M1V1-12:15	(107)	(52)	(53)	93.5	19.1				
1/4	NaVk-1:1.5	(130)	(77)	(69)	183.1	21.8				
1/4	NaVk-6:3	(132)	(76)	(81)	204.9	16.8-26.2				
1/4	NaVk-6:5	(211)	(92)	(99)	503.8	thinned	Scar	End	>11.0	Rebound scar
1/4	NbV1-5:1	(101)	(48)	(45)	90.3	13.6-13.8				
1/4	NbVm-5:1	(122)	(41)	(37)	130.1	>27.5				
1/3	M1V1-5:7	(132)	(46)	(46)	139.2	15.6-21.3				
1/3	M1V1-7:144	(81)	(27)	(27)	29.9	13.0-18.9				
1/3	M1V1-7:331	(91)	(19)	(19)	43.7	27.3-31.8				
1/3	M1V1-13:13.2	(105)	(51)	(43)	87.1	18.6				
1/3	NbVm-2:4.3	(89)	(34)	(37)	54.5	24.0				
2/6	M1V1-10:4	(129)	(51)	(55)	106.4	12.8-19.6	Scar	End	NM	

Table B1 (Continued).

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
2/5	MiV1-1:11	(230	(95)	(121)	562.4	23.6-37.2				
2/5	MkV1-8:9.1	(118)	(60)	(79)	147.0	12.0-25.7	Scar	End	>11.8	
2/5	M1V1-1:63	(188)	(76)	(114)	395.3	21.3-27.5	Cone	End	>12.7	
2/5	M1V1-5:1	(214)	(83)	(120)	359.9	14.2-28.8				
2/5	M1V1-5:19	(194)	95	128	656.3	21.8-31.8				Etched on fracture
2/5	M1V1-7:28	(146)	(48)	(54)	119.9	9.3-22.0				
2/5	M1V1-7:75	(176)	(107)	(140)	326.1	9.1-15.6				
2/5	NaV1-4:9	(138)	(71)	(107)	211.0	8.5-17.7				
2/4	MkV1-3:2.1	(94)	(61)	(56)	88.5	4.4-22.7				
2/4	MkV1-8:16	(148)	97	127	492.4	13.8-30.2				Ground
2/4	M1Vj-2:2	(186)	(59)	(69)	206.8	7.8-17.7				
2/4	M1Vk-1:1.1	(138)	(45)	(37)	75.6	20.1-21.7				Polished
2/4	M1Vk-1:1.4	111	(68)	(90)	149.4	13.0-24.5				
2/4	M1V1-1:67	(90)	(55)	(32)	90.0	thinned				Etched on fracture
2/4	M1V1-5:18	(170)	(91)	(95)	220.6	10.8-15.3				Scraped; etched on fracture
2/4	M1V1-5:24	161	(58)	(84)	264.8	19.3-20.4	Cone Cone	One end Other end	>15.7 >15.8	
2/4	M1V1-5:43	(108)	(62)	(69)	119.4	11.8-19.0				
2/4	M1V1-7:138	(89)	(62)	(62)	70.9	14.7-17.5	Scar	Corner	9.0	
2/4	M1V1-7:176	(195)	(59)	(50)	302.7	16.2-29.9				Etched on fracture
2/4	M1V1-7:301	(102)	(48)	(46)	60.9	11.0-12.5				
2/4	*M1V1-12:9	(372)	(83)	(90)	735.3	12.1-22.9				
2/4	*M1V1-12:36	124	(62)	(90)	159.3	13.5-25.0				
3/5	MkV1-9:22	(253)	66	126	438.9	5.8-19.1				
2/3	*M1V1-1:124	127	(59)	(84)	123.5	12.2-24.9				
2/3	*M1V1-1:144	203	(72)	(137)	464.9	17.0-25.6	Cone	End	8.3	Rebound scar; scraped
2/3	M1V1-7:284	(139)	(57)	(41)	155.3	16.2-17.6				
2/3	M1V1-7:329	(78)	(43)	(63)	38.0	6.3-18.2				
2/3	NaVk-1:9	(176)	(58)	(79)	236.6	12.0-22.5				
2/3	NaV1-8:3	(168)	75	79	262.9	15.0-20.3				Etched on fracture
2/3	NbV1-2:19	143	(44)	(36)	113.4	20.3-24.4				

Table B1 (Continued).

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
3/4	MkV1-8:12	156	(53)	(56)	131.3	15.8-22.6				
3/4	MkV1-23:1	248	(92)	(155)	832.5	8.0-22.1				
3/4	MkV1-23:2	(206)	130	174	818.7	27.2-38.1	Scar	Long edge	NM	
3/4	MlVj-2:1	(248)	82	125	622.1	9.9-29.5				
3/4	MlV1-5:11	66	(20)	(20)	24.5	9.1-18.1				
3/4	MlV1-5:23	113	(60)	(60)	144.0	12.8-26.0				
3/4	MlV1-7:5	83	(85)	(87)	170.9	19.6-25.0	Scar	Corner	12.0	
3/4	MlV1-7:58	47	(70)	(59)	58.6	13.3-22.7				
3/4	*MlV1-12:11	173	(67)	(87)	288.8	20.4-34.3				Pl. 4.4
3/4	MlV1-14:3	141	(115)	(140)	423.2	23.8-31.9	Scar	End	>19.3	Pl. 4.5
3/4	NaVk-1:15	20	(23)	(16)	10.2	22.5				
3/4	NaVk-5:38	204	(65)	(70)	221.7	17.0-21.4				
3/4	NaVk-6:16	100	(50)	(53)	104.4	14.8-22.7	Scar	Corner	NM	
4/5	MlV1-7:65	(148)	72	75	141.3	10.8-12.8				
4/5	MlV1-7:77	145	77	77	245.8	13.8				
4/5	NaVk-5:7	(92)	64	64	70.1	6.2-14.0	Scar	End	Large	Scraped
4/5	NaVk-6:6	(138)	68	74	156.9	8.5-16.5				
4/5	NbVm-4:14	(83)	48	65	72.9	13.0-18.6				
5/6	MkV1-8:24	216	(63)	(91)	359.2	10.6-22.6				
5/5	MlV1-5:25	(335)	77	145	1101.5	13.4-25.2	Scar	Long edge	NM	
3/3	MkV1-3:9	288	77	NM	682.6	14.5-32.0	Scar	End	NM	Pls. 4.1, 4.2
3/3	MkV1-4:11.4	95	51	51	114.8	18.6-32.3	Cone	Corner	Small	
3/3	MkV1-4:11.6	124	54	72	99.5	15.9-20.4				
3/3	MlV1-5:15	101	54	41	71.6	12.5-18.6				
3/3	MlV1-7:294	68	56	51	64.7	21.4-25.4				Etched on fracture
3/3	*MlV1-12:6	143	56	69	164.1	16.6-22.3				
3/3	NaVk-1:17	157	71	54	170.8	25.1-26.8				
3/3	NaVk-5:6	166	65	65	140.9	12.9-19.5	Scar	End	>11.3	Ground
3/3	NbV1-2:11	200	48	75	149.2	6.3-21.2				{Bonnichsen 1979: 103, Pl. VIII-2
4/4	MkV1-5:13	465	117	248	2433.0	9.9-25.1	Scar {Scar Scar	Corner Opp. Corner Long edge	>23.4 >7.2 Large	Scraped; Pl. 4.6

Table B1 (Continued).

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
4/4	MkV1-8:19	129	70	65	187.7	15.9-25.0				Etched on fracture
4/4	M1Vj-2:3	132	60	75	160.9	17.4-25.4				
4/4	M1Vk-4:1	118	74	74	126.3	>25.2				
4/4	M1V1-1:70	93	82	82	81.2	thinned				
4/4	M1V1-1:71	88	50	82	82.0	15.2-16.7				
4/4	M1V1-7:66	110	47	47	58.0	10.4-13.2				
4/4	M1V1-7:281	289	89	144	701.2	16.6-22.7	Scar	Long edge	NM	Rebound scar
4/4	M1V1-11:1	130	103	122	272.9	17.9-28.9				Etched on fracture
4/4	NaVk-5:26	94	71	105	126.1	11.3-23.4				Bonnichsen 1979: 118, Pl. VIII-12
4/4	NaVk-6:9	162	67	75	263.2	16.9-18.9				
5/5	M1V1-7:285	119	83	88	275.5	17.7-29.7				Chewed
5/5	NaVk-1:11	129	58	45	156.9	21.1-25.9				
5/5	NaVk-5:37	133	74	93	154.7	7.5-22.8				
5/5	NaVk-6:21	235	101	139	716.3	20.7-42.8				Etched on fracture
6/6	XI-B:366	312	78	200	1390.0	9.8-28.1				
	N	44	37	36	103	100 100			16	
	Mean	151.4	73.2	95.0	291.6	16.1 23.3			13.9	
	S.D.	79.0	19.3	46.0	362.6	6.6 6.8			6.3	

(measurements in parentheses not included in calculations)

Bone struck when green, not all margins fractured after permineralization:

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
0/4	MkV1-5:4.2	(295)	(153)	NM	1845.0		Ring crack	Outer surface	19.7 X 23.1	Right femur (distal)

Legend
* with catalogue number marks bones associated with *Anodonta* phase
NM means "not measureable" (Diam.) or "not measured" (Perim.)
See text for other explanations

is fractured. 0/y indicates that one or more margins is fractured but that none of the fractures was produced when the bone was green. x/y signifies that of "y" fractured margins, "x" of them were fractured when the bone was green. The distinction between green and non-green fractures is based upon the constellation of attributes in Tables 3.2-3.3.

The fractional format for fracture coding works well for fragments of bone which are often relatively flat, because a discrete number of margins can be specified for any given specimen. The smallest possible number is three which is the minimum requirement for defining a two dimensional plane, and the largest number which I have found it necessary to define is six. This approach is difficult to apply to specimens preserved as cylinders, but there are relatively few such pieces in the sample to be described here. Binford (n.d.) has recently called attention to the importance of distinguishing between fragments and cylinders in evaluating the frequency of carnivore induced alterations in bone assemblages, and some very complex procedures have been devised for quantifying the shapes and sizes of cranial material and long bone cylinders (Hills and Brothwell 1974; Tomenchuk 1976; Biddick and Tomenchuk 1975; Tomenchuk and Tomenchuk 1976). Since most long bone cylinders have been excluded from this sample on the basis of discrete variables (such as pitting and scoring by carnivores), it will not be necessary to introduce such procedures in this report.

In addition to the fracture coding, I noted whether the length or the width (or both) had been reduced by post-permineralization fractures. These observations are of some importance since they govern the interpretation of linear measurements. If all margins have been fractured when green, we can infer that the final shape and size of the specimen is that produced by human activity, but reduction of length and/or width by later fractures erases some of the patterning which might appear in the record. Measurements in parentheses in Table B1 (and in other tables) are those which have been reduced by relatively recent fractures, and these measurements have not been included in the calculations of mean and standard deviation which appear at the end of the table(s).

The measurements of thickness in Table B1 refer specifically to the bone wall adjoining green bone fractures. The range of bone wall thickness was measured adjacent to each green fracture, and the overall variation on all green-fractured margins of a given specimen is represented in Table B1. A few of the bones could not be measured for thickness since abruptly acute or obtuse fracture margins had the effect of thinning the specimen. In a few cases the lower limit of thickness is indicated due to removal of the outer surface by such processes as exfoliation. The thickness measurements have been recorded here for the purpose of a later discussion of the excavated samples.

Whenever a loading point could be observed on a specimen it was categorized as a cone or a scar. When an impact is delivered to a bone wall a cone of force is produced in a manner very similar to the cones observed on cryptocrystalline lithic materials (Crabtree 1972). The total cone is manifested on the outer surface of a bone as a ring crack (see discussion in Bonnichsen 1977:111 ff). If the bone does not completely fail, such a ring crack may be preserved in its entirety as in the last specimen listed in Table B1. Separation of fragments usually divides the ring crack into segments, and a portion of the affected area may be preserved as a cone (Pl. 4.4), if the ring crack was incomplete, or as a scar. The scar is a negative record of a cone segment which has been removed from the specimen. In Table B1 these loading point forms, their locations, and their diameters are indicated for those specimens on which loading points could be observed. In a few cases the diameter was not measurable because of poor preservation of the loading point at the outer surface of the bone, and in most cases the measurement is a minimum one since most cones and scars are only partially preserved. It is noteworthy that the measured loading points are quite large; it is my impression that they are larger than any carnivore tooth contact area, although I have not yet confirmed that with quantifiable data.

Three specimens deserve special mention. MkV1-3:9 was recently sacrificed for a radiocarbon date based on its collagen content: 29,300 ± 1200 B.P. (I-11,050: Harington, pers. com. in 1980). Before it was sent for dating I photographed (Pl.4.1) and described the specimen and then fractured and flaked it with a 900 g hammerstone. All the resulting fragments were typical of post-permineralization fractures with their rectilinear shapes, contrasting colours, rough surface textures, and right angles between the fracture surfaces and the outer surface of the bone (Pl. 4.2). This is the only collagen-based radiocarbon date currently available on an artificially modified bone from the Old Crow valley, but more examples will be submitted in the near future.

A very large femur shaft fragment (Pl. 4.6; MkV1-5:13) exhibits three loading points -- a poorly preserved one along one long edge, and two well defined ones on opposite sides of the shaft. The opposing points imply that this bone was loaded on a anvil and that one of the points represents the kind of anvil damage often observed on lithic materials. A smaller specimen (MlV1-5:24) exhibits a cone at each end. These cones resulted from loading in the same plane and the same direction, and they have been duplicated in recent fracture experiments.

It may seem strange that only three of the specimens with all margins fractured when green have preserved loading cones or scars. The absence of such features frequently results from the intersection of fracture fronts which travel in different directions and cause fragmentation of the bone shaft into many more pieces than might be expected from only one or two loading points. This is one reason that green fractures on bones smaller than those of mammoths and elephants are so difficult to interpret with confidence.

The column of other observations in Table B1 includes a variety of attributes which are important in different ways. References to scraping, grinding, and polishing mean that the specimens in question will be mentioned again in connection with those alterations. The term "rebound scar" identifies a particular kind of flake scar which occurs adjacent to the ring crack. Upon impact the wall of the bone is flexed inward, and it "rebounds" with such force that a small flake is often detached from the bone surface. Such detachments have recently been observed on high-speed film footage used to document experimental fractures of fresh elephant bones (Ginsberg experiment). The presence of such a scar is a good indication that the loading of the bone was dynamic. One specimen (M1V1-2:134) is believed to have been broken when dry because the fracture margin exhibits several off-set "jogs" which were formed wherever the running crack intersected developing split lines. All other attributes of the fracture surface and form indicate that the fracture occurred before significant staining and permineralization had taken place. The designation "etched on fracture" refers to the action of plant rootlets (see Chapter 3). Such etching has never been observed on a fracture surface believed on other grounds to have been produced following permineralization, and it is probable that the etching occurs only when the bone contains sufficient nutrients to attract the rootlets of plants to its surface. Although this phenomenon is poorly understood, it may be a secondary indication that a given fracture surface was formed when the bone was green.

One bone exhibits evidence of chewing by carnivores (M1V1-7:285), but the bone represents an adult mammoth and the chewing is not associated with the fractured margins. Despite the evidence of carnivore activity I am confident that this bone was fractured by man in view of the discussion presented in Chapter 3.

Mammoth Bone Cores and Flakes

In order to reduce the amount of individual description required in the presentation of the cores, they are treated first as green fractured bones with the same attributes which were used in Table B1. A second tabular presentation for each of the four major categories of cores summarizes the attributes related to the secondary flaking of the bones which has caused them to be classified as cores. Special features will be mentioned where appropriate.

Longitudinally Flaked Cores without Preserved Platforms

In Table B2 the green fracture attributes of all the cores lacking platforms are summarized, and in Table B3 the flaking attributes of these cores are presented. It is noteworthy that all but two of the cores are made on long bone fragments, and the exceptions are segments of mammoth or mastodon scapulae.

The column headings in Table B3 (like Tables B5, B7, B9) require some explanation. The locations of the flake scars have been identified with respect to the plan view (perimeter) and the cross-section (circumference). The designations of right and left margins have been based upon the same orientation rules used by Bonnichsen (1979:101): with the outer surface of the bone facing up, the platform area is placed nearest the analyst. The number of scars has been expressed as a fraction in some cases, and these fractions must not be confused with those which were used to designate fractured margins. In the case of flake scars, the numerator refers to the number of intact scars, and the denominator refers to the number of partial scars which have been truncated by the intact ones. When a numerator appears alone, it signifies that one or more scars is intact and that multiple scars are adjacent rather than partially or wholly nested within one another. The measurements of maximum length and width refer to

Table B2. Green fracture attributes of mammoth bone cores without preserved platforms from the reworked deposits in the Old Crow region, northern Yukon Territory (see text for explanations).

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
0/6	*MlVl-12:2	(198)	(62)	(63)	305.6					
1/4	NaVl-12:2	(147)	(31)	(32)	153.1	33.0				
4/6	MkVl-8:13	211	(97)	(122)	438.2	9.2-20.8	Scar Scar	Distal end	>15.7 31.1	
3/4	MlVl-1:102	(116)	50	54	112.9	13.9-18.7				
3/4	NaVk-1:12	170	(54)	(108)	351.6	17.1-17.8	Cone	End	>7.2	2 rebound scars; Pl. 4.7
4/5	MkVl-8:20	170	(68)	(69)	247.9	11.1-26.6				Scapula fragment
4/5	NaVl-8:2	186	97	125	408.2	20.5-27.9				
5/6	NaVk-6:12	227	49	90	251.3	13.7-16.2				Polished on end
3/3	MlVl-5:28	109	51	52	59.7	8.9-15.4				Etched on fracture
3/3	NaVk-5:2	186	52	84	279.6	16.3-20.0				
4/4	MlVl-2:189	100	70	74	121.3	18.5-33.3	Scar	Corner	21.0	
4/4	*MlVl-12:16	105	64	70	111.8	16.4-19.3				
5/5	*MlVl-1:143	171	77	80	330.9	17.0-25.0	Scar	Corner	>12.7	Polished; Pl. 4.8
5/5	NaVk-6:10	164	78	88	279.3	8.5-30.8				Bonnichsen 1979: 105, Pl. VIII-4
5/5	NaVk-9:1	164	45	71	119.7	11.3-13.5				
	N	12	10	10	15	14 14			5	
	Mean	163.6	63.6	78.8	238.1	15.4 22.7			17.5	
	S.D.	40.3	16.9	20.7	118.6	6.3 6.7			9.1	

Legend
* with catalogue number marks bones found in association with the *Anodonta* phase.

Table B3. Flaking attributes of longitudinally flaked cores without preserved platforms from the reworked deposits in the Old Crow region, northern Yukon Territory (see text for explanation).

Cat. No.	Scar Locations: Perim.	Scar Locations: Circumference	No. of Scars	Max. Length*	Max. Width	Distal Terminations	Platform Loss
MlVl-12:2	End	Outer	1	(42.3)	50.0	Deep hinge	Recent fracture
NaVl-12:2	End	Outer	1/4	57.3	26.0	1 F, 4 H	Facial flaking
MkVl-8:13	End	Outer	1/1	67.1	51.8	2 Feathered	Too deep a bite
MlVl-1:102	End	Left Right	1 1/1	52.0	16.9	1 F, 2 H	Too deep a bite
NaVk-1:12	End	Outer & Right	1/3	88.9	34.0	2 F, 2 H	Too deep a bite
MkVl-8:20	Corner	Medial (scapula)	1/1	38.4	32.0	1 F, 2 H	Too deep a bite
NaVl-8:2	End	Right	1	62.5	30.7	Hinge	Recent fracture
NaVk-6:12	End	Left	1/1	37.5	22.0	1 F, 1 H	Too deep a bite
MlVl-5:28	End	Outer	1/2	63.1	28.2	1 F, 2 H	Too deep a bite
NaVk-5:2	End	Outer	Many	19.8	23.6	All hinged	Facial flaking
MlVl-2:189	End	Outer	1	77.3	64.6	Hinge	Too deep a bite
MlVl-12:16	End	Outer	1/1	36.9	33.3	2 Feathered	Too deep a bite
MlVl-1:143	End	Outer Left	1/1 1	39.2	51.9	3 Hinged	Too deep a bite
NaVk-6:10	End	Outer	2	109.0	36.8	1 F, 1 H	Too deep a bite
NaVk-9:1	End	Outer	2	65.6	23.7	1 F, 1 H	Too deep a bite
	N			14	15		
	Mean			58.2	35.0		
	S.D.			23.6	13.6		

* By definition, all the lengths measured here have been reduced by platform loss.

Table B4. Green-fracture attributes of mammoth bone cores with unmodified fracture surface platforms from reworked deposits in the Old Crow region, northern Yukon Territory.

						Wall	Loading Point			
Frac.	Cat. No.	Length	Chord	Perim.	Weight	Thickness	Form	Location	Diam.	Other
2/5	MiV1-1:12	(228)	61	118	487.9	4.0-12.4				Scraped; Pl. 4.9
3/4	MlV1-7:157	125	(42)	(42)	54.0	5.5-10.3				Pl. 5.2
4/5	MkV1-8:17	(143)	(81)	(86)	257.4	21.6-29.4				Pl. 4.10
3/3	MkV1-8:18	114	119	128	312.3	24.8-31.0				Bonnichsen 1979: 109, Pl. VIII-10
3/3	MlV1-5:29	96	44	53	69.5	12.9-18.4				
3/3	MlV1-5:44	111	48	60	136.0	17.3-17.7				
4/4	MlV1-5:21	143	51	52	138.0	22.5-23.3				Bonnichsen 1979: 105, Pl. VIII-4
4/4	MlV1-5:45	122	47	50	106.8	15.8-21.0				
5/5	MkV1-10:5.1	205	101	166	495.1	14.4-17.8	Scar	Long edge	NM	Rebound scar
	N	7	7	7	9	9 9				
	Mean	130.9	67.3	89.6	228.6	15.4 20.1				
	S.D.	35.7	30.1	47.1	170.9	7.2 6.9				

Table B5. Flaking attributes of longitudinally flaked cores with unmodified fracture surface platforms from reworked deposits in the Old Crow region, northern Yukon Territory.

Cat. No.	Scar Locations: Perim.	Scar Locations: Circumference	No. of Scars	Max. Length	Max. Width	Distal Terminations	Approximate Platform Angles
MiV1-1:12	End	Outer & Left	1/1	95.7	36.9	2 Hinged	70°
MlV1-7:157	End	Left	1	83.2	18.5	Hinged	75°
MkV1-8:17	One end	Outer	2/1	37.8	39.7	3 Hinged	45°
	Other end	Outer	1	(53.5)	46.7	Hinged	Recent fracture
MkV1-8:18	End	Outer	2	65.0	41.5	1 F, 1 H	45°-70°
MlV1-5:29	End	Outer	2/1	12.2	22.5	1 F, 2 H	30°-55°
MlV1-5:44	End	Outer	2/1	72.4	31.1	2 F, 1 H	70°
MlV1-5:21	End	Right	1/2	77.8	23.5	1 S, 2 H	45°-60°
		Outer	1	22.0	23.2	Hinged	90°
MlV1-5:45	End	Right	1/2	83.2	20.1	1 F, 2 H	85°
MkV1-10:5.1	End	Left	1/1	110.2	25.0	2 Hinged	50°-75°
	N			10	11		
	Mean			66.0	30.0		
	S.D.			32.0	9.8		

Legend
Distal terminations: F, feathered; H, hinged; S, stepped
See text for other explanations.

the largest measureable flake scars, and the two dimensions may be taken from one scar or from different scars. The reason for including such measurements is to show the much greater sizes of most of these flake scars as compared with those which can be produced by carnivore gnawing and levering. Such carnivore-induced scars are always short (20 mm or less), and they usually lack the micro-relief features such as ribs which commonly characterize scars produced by dynamic loading as with a hammerstone or billet.

Several kinds of distal terminations are recognizable on the cores and flakes from the Old Crow valley, but those in Table B3 are either hinged (H) or feathered (F) as defined by Bonnichsen (1977:Fig.11). Three modes of platform removal have been listed in Table B3. Recent fracture is self-explanatory. Facial flaking refers to the repeated removal of flakes so as to move the platform edge back to the cancellous tissue which lines the medullary cavity of the bone. The phrase "too deep a bite" is a similar process to facial flaking but occurs as a result of a single flake detachment which exhausts the platform area by moving its edge to a cancellous border. This process results in the production of flakes which bear cancellous tissue on their ventral faces (see below).

Several of the cores without preserved platforms deserve special comment. MkVl-8:13 exhibits two scars at one end which were interpreted as loading points in Table B2 but which could represent platform preparation although no facial flaking is associated with them. The facial flaking identified in Table B3 is on the opposite end of the core.

NaVk-1:12 is flaked transversely as well as longitudinally (Pl. 4.7). The transverse flake removals are on the right edge, distal to the longitudinal flake scars, and they consist of numerous small stepped scars along an area 79.0 mm long. The unmodified outer surface of the bone was used as a platform, the angle of which is approximately 55-65°, and the flakes were detached from the adjacent green-fracture surface.

The single flake scar on NaVl-8:2 is coated with an unidentified substance which appears to be organic matter and which is not present elsewhere on the bone. The surface of this coating is cracked into small areas not unlike the appearance of blistered paint.

MlVl-1:143 has lost most of its platform due to too deep a bite, but a very small remnant at the left corner is slightly polished as if for strengthening of the platform edge (Pl. 4.8). An effort to rejuvenate the platform area may be represented by four major hinged flake scars which originated from the right proximal corner. The longest of these scars measures 36.8 mm in length and reaches to the midline of the original platform. This flaking procedure was probably meant to remove the entire end of the specimen, but it failed due to the accumulation of hinged distal terminations.

Longitudinally flaked cores with unmodified green-fracture surface platforms

Table B4 lists the green fracture attributes, and Table B5 displays the flaking attributes of nine cores assigned to this category. The column headings bear the same meaning described for Tables B2 and B3, but an additional distal termination form (S, stepped) is indicated for one specimen (see Bonnichsen 1977:Fig. 11). Approximate platform angles were measured with a bar protractor by placing the bar on the flake scar and the protractor base on the platform area.

Four of these cores require special comment. MlVl-1:12 exhibits transverse flaking (2/2 scars) near the proximal end of the last longitudinal flake scar. The maximum scar dimensions are 11.3 X 28.0 mm, and all the scars are hinged or stepped. The unmodified outer surface was utilized as a platform for this flaking in the transverse direction. The purpose of such flaking may have been to make the longitudinal platform angle more acute.

MlVl-7:157 is heavily rounded on all surfaces including its single flake scar (Pl. 5.2).

The flaking on the distal end of MkVl-8:17 could be the result of anvil shock, but that possibility is difficult to evaluate since the distal platform area has been removed by a recent fracture.

MlVl-5:21 is flaked both on the outer face and along the right margin, and the marginal flaking appears to truncate the single facial scar.

Longitudinally flaked cores with retouched platforms

In Tables B6 and B7 the attributes are displayed for 12 cores in this category, but the column headings in Table B7 have been altered to permit more detailed recording of the platform area. Scar location takes the place of the circumference designation of previous tables, and platform location has been substituted for perimeter. Number of scars, maximum length and width, and distal termination form are given separately for facial and platform scars. In most cases the location of a platform at the end of the bone is clearly identifiable by means of flake scars which extend from the outer surface of the bone across a fracture surface to the cancellous tissue which lines the medullary cavity. In such instances there is little confusion between the identification of a platform and the recognition of the facial scars detached by impacts on that platform. Two specimens in Table B7 (NaVk-5:28, NbVm-5:9) present a somewhat different format, however, and it is difficult to decide which surface is the platform and which is the surface to be flaked from the platform. This problem is analogous to the separation of a platform and flaked surface on a dihedral burin, and the distinction is based upon the truncations at the proximal ends of the scars. Those scars which are intact are designated as the facial flake scars, and truncated scars are taken to form the platform.

As might be expected, these more complex cores will demand slightly more individual description. MkVl-9:15 exhibits a slightly rougher surface texture on all its flake scars, and the core may have been flaked after dessication had advanced to some extent. On the other hand, all the flake scars are stained to the same degree as the outer surface of the bone.

NaVl-7:1 (Pl. 4.11) has an interesting platform formed partially by an unmodified green fracture surface and partially by a flaked area on which numerous small stepped scars had the effect of making the platform angle

Table B6. Green fracture attributes of mammoth bone cores with retouched platforms from reworked deposits in the Old Crow region, northern Yukon Territory.

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
1/4	MkV1-9:15	(120)	(98)	(122)	372.9	30.5				
1/4	NaV1-7:1	(145)	(81)	(119)	268.6	15.0-25.4				Pl. 4.11
2/5	NaVk-5:28	(170)	(57)	(87)	232.1	10.4				Bonnichsen 1979:104; Scraped
2/4	MkV1-4:11.8	153	(39)	(27)	76.1	9.4-15.1				Bonnichsen 1979: 129, Pl. VIII-17
2/3	*M1V1-12:4	(123)	57	66	271.0	23.5-30.0				Etched on fracture; Pl. 4.12
3/4	M1V1-10:1	(229)	96	128	977.4	26.1-34.0				
3/4	*M1V1-12:37	97	(73)	(73)	114.2	11.0-13.1				
3/3	M1V1-7:192	180	103	121	608.6	8.9-60.2	Scar	Anterior	>16.3	Scapula fragment; Pl. 5.3
3/3	NbV1-9:1	166	40	43	116.9	13.5-23.0				Pl. 4.13
4/4	NaVk-5:31	213	101	119	530.4	16.6-25.0				Bonnichsen 1979: 104, Pl. VIII-3
4/4	MkV1-24:1	157	101	118	452.6	14.9-43.5				Pl. 4.14
4/4	NbVm-5:9	177	71	68	238.6	8.8-27.2	Scar	End	>18.9	
	N	7	7	7	12	12 12			2	
	Mean	163.3	81.3	94.7	355.0	15.7 28.1			17.6	
	S.D.	35.3	25.4	34.5	257.3	7.3 13.7				

Legend
* with catalogue number marks bones found in association with the *Anodonta* phase.

Table B7. Flaking attributes of longitudinally flaked cores with retouched platforms from reworked deposits in the Old Crow region, northern Yukon Territory.

Cat. No.	Scar Location	No. of Scars	Max. Length	Max. Width	Dist. Term.	Platform Location	No. of Scars	Max. Length	Max. Width	Dist. Term.	Platform Angles
MkV1-9:15	Outer	2/1	41.1	33.3	1H, 2S	End	2	8.0	30.5	2H	65°
NaV1-7:1	Outer	5/1	35.6	29.1	All F	End	Many	(small)	(small)	Stepped	50°-85°
NaVk-5:29	Right/ Outer	1/1	96.6	43.1	2H	Left/ Outer	1	41.5	31.5	Hinged	35°
MkV1-4:11.8	Outer	1	21.3	20.5	Hinged	End	1/2	24.9	22.8	3H	60°
MlV1-12:4	Outer	3/1	37.7	38.1	1F, 3H	End	1	14.2	30.3	Hinged	45°
MlV1-10:1	Outer	2	58.4 35.5	33.6 60.2	Feather Hinge	End	2/1	38.6	52.2	3H	40°-60°
MlV1-12:37	Outer	1	48.8	33.3	Feather	End	2	7.6	18.8	2H	65°
MlV1-7:192	Ant/med.	1	(13.7)	83.9	Feather	(Lost by green fracture)					
	Post/med.	4	(32.9)	36.7	4H	(Lost to final flaking)					
	Dist/med.	1/1	57.9	33.8	1F, 1H	(Unmodified fracture surface, anterior)					40°
	Post. edge	1/1	142.3	22.4	2H	Anterior	3/1	18.7	13.0	4H	40°
NbV1-9:1	Outer	1	41.1	37.5	Hinge	End	1/2	24.5	7.8	1F, 2H	35°
NaVk-5:31	Outer	2/1	88.8	33.2	2F, 1H	End	1/2	37.2	25.0	1F, 2H	45°
MkV1-24:1	Outer	2	54.8 45.5	51.2 50.4	Feather Hinge	End	1	21.8	41.6	Feather	95°
NbVm-5:9	Left	1/1	18.0	17.9	2H	Right	1	77.3	28.8	Hinged	30°
	N		15	17				11	11		
	Mean		54.9	38.7				28.6	27.5		
	S.D.		32.3	16.0				19.9	12.4		

Legend
Distal terminations: F, feathered; H, hinged; S, stepped
See text for other explanations.

less acute. A large exfoliation scar formed recently on the outer face provides a good contrast with the fresh-bone conchoidal flake scars with respect to both colour and surface texture. The outer surface of the bone is also extensively roughened, and a similar effect has been observed when an antler wedge is used to remove the periosteum from a fresh elephant bone (in the Ginsberg experiment); the tendons are literally torn out by the "roots" and have small bits of bone adhering to them.

MkVl-4:11.8 has a platform which could be interpreted as a loading point scar and associated rebound flake were it not for the multiple flaking of the platform area.

Transverse flaking has occurred on the outer face of MlVl-12:37 along the right margin. Two adjacent flake scars, 14.9 X 50.2 (hinged) and 21.3 X 28.5 (feathered), were detached by impacts on a platform which was apparently removed by too deep a bite.

MlVl-7:192 is a fragment of the right scapula of a mammoth or mastodon which exhibits four discrete episodes of flake removal (Pl. 5.3). The flake scars appear on the medial face of the scapula in three cases and along the posterior border in the fourth and final flaking procedure. A single large flake was first removed from the medial face by means of an impact on the anterior border of the scapula. This border was then removed by means of a heavy impact which left a prominent loading scar at the intersection of two large green-fractured margins. At least four impacts along the posterior border removed a row of smaller flakes from the medial face, and their platform was removed by the final flaking sequence. The green-fracture surface which truncated the distal end of the scapula was used first as an unmodified platform for the detachment of two flakes from the medial face. An adjacent area of this surface was then trimmed to form a platform on which impacts caused the detachment of long flakes which removed the posterior border of the scapula and produced the truncation of the second series of flake scars. This complex treatment of a scapula has been compared with several examples of stream-rolled mammoth scapulae which have been recovered from the Old Crow valley, and it differs markedly from the naturally reduced specimens in exhibiting green fracture characteristics on all surfaces and in revealing complex reorientation to accomplish the flaking. The stream-rolled examples always show a single direction of rotation during which the anterior and posterior borders and the prominent spine are removed, and the fractures on such specimens always post-date permineralization of the bone. MlVl-7:192 can be summarized as follows: facial flake detachment from opposite directions, platform production by means of green fracture, flake detachment from the new platform, platform trimming or rejuvenation, and removal of the posterior border by means of impacts on the new platform.

The platform of NbVl-9:1 could be interpreted as a loading point with an associated very large rebound scar (Pl. 4.13).

NaVk-5:31 is a complex core exhibiting transverse flaking (1/1 scars) along the left margin so as to truncate the flake scars which formed the platform for longitudinal flake removal. The longest of the transverse scars is 58.9 mm long, and the widest measures 13.7 mm; one is feathered and one is hinged. Several small step flakes were also removed from the inner surface of the bone along the right margin. The platform area of this core has been reduced to a blunt point by longitudinal flake removal, and it is possible that platform formation was not a discrete step in the working of this core. Its current condition could have resulted from straight-on, rather than angled, impacts with the core base rested on a firm but yielding surface (there is no anvil shock apparent on the specimen). This procedure was followed during a recent experiment in which this core was replicated, and the "firm but yielding" surface involved in the replication was the flank of a frozen elephant (Stanford, *et al.* 1980).

MkV1-24:1 reveals an example of platform rejuvenation which, once again, was not successful (Pl. 4.14). The detachment of one large flake from the core face removed part of the platform, and a large flake was then detached by means of an impact on the inner wall of the bone. This flake truncated the previous facial scars but left a platform angle of 95° in relation to the outer face of the core. With such an angle it would be very difficult to overcome the massive hinges produced on the outer face by the original flaking of the core.

Transversely Flaked Cores

An additional attribute needed to characterize transversely flaked cores is the flaking direction (Table B9). A fractured limb bone can be impacted for flake removal on the inner or on the outer side of the bone wall, and these two directions will produce flake scars on the outer surface or on the fracture surface, respectively. Interestingly, all but one example of transverse flaking in Table B9 occurred by means of impacts on the inner side of the bone wall. Unless otherwise specified in the comments which follow, all the transversely flaked cores have platforms comprised of unmodified green-fracture surfaces. Retouched platforms seem to be rare among transversely flaked cores.

It is possible that MlV1-13:7 is not an artificial core although the primary fracture of the bone was artificially induced. The outer surface of the bone is heavily scored by apparent carnivore gnawing, and the small, scattered flake scars which occur along the right margin might have been produced by carnivores. None of the scars exhibits the ribs which would indicate dynamically applied force.

MlV1-5:46 exhibits flake scars of about the same size as those thought to have been produced by carnivores, but these scars are abruptly hinged and are characterized by ribs which indicate percussion flaking. The outer surface of this bone is extensively scratched and polished, and the polished facet is truncated by the transverse flake scars described in Table B9.

The platform on the right margin of MkV1-10:15 was produced by the detachment of numerous short stepped flakes which trimmed the cortical wall back to the cancellous tissue of the medullary cavity and created a platform area 11.4 mm wide and 3.7 mm deep. The flaking on the right margin is continuous with that on the distal diagonal margin where no clear platform preparation is evident since the flake scars extend to the edge of the cancellous tissue. The entire left margin of this specimen has been removed by a recent fracture, but it is possible that this piece was used as a chopper in butchering.

Table B8. Green fracture attributes of mammoth bone cores flaked transversely from reworked deposits in the Old Crow region, northern Yukon Territory.

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Loading Point Form	Loading Point Location	Loading Point Diam.	Other
2/4	MlVl-13:7	(283)	(79)	(84)	670.1	22.2-28.4				Gnawed, polished
3/4	MlVl-5:46	148	(52)	(52)	129.8	14.8-20.4				Bonnichsen 1979:137, Pl. VIII-24; polished
3/4	NaVk-6:11	127	45	45	122.3	16.5-21.5				
3/4	NbVl-11:1	(239)	101	122	738.4	15.2-36.9				
4/5	*MlVl-1:142	(130)	90	93	292.9	21.0-24.4	Scar	End	>12.3	Polished; Pl. 4.15
4/5	MkVl-10:15	287	(120)	(126)	868.9	10.8-37.3	Cone	End	12.2	Bonnichsen 1979: 125, Pl. VIII-17
4/5	NaVk-1:7	(144)	71	94	218.5	13.3-13.7	Scar	Long edge	>7.6	Etched on fracture; Bonnichsen 1979: 124, Pl. VIII-15
4/5	NaVk-5:4	(262)	93	163	789.2	18.2-23.9				Bonnichsen 1979: 124, Pl. VIII-16
5/6	MlVl-5:27	177	(82)	(107)	371.7	18.9-22.1				Bonnichsen 1979: 124, Pl. VIII-16
5/5	MlVl-1:2c	259	96	166	(cast)	16.3-34.6	Scar	End	18.1	Bonnichsen 1979: 105, Pl. VIII-5
5/5	MkVl-26:1	314	92	111	1035.2	27.7-38.8				Pl. 4.16
5/5	MlVl-5:55	128	69	69	226.5	18.4-29.3				
	N	7	8	8	11	12 12			4	
	Mean	205.7	82.1	107.9	496.7	17.8 27.6			12.6	
	S.D.	79.1	18.9	42.3	329.4	4.5 7.9				

* with catalogue number marks bones found in association with the *Anodonta* phase.

Table B9. Flaking attributes of transversely flaked cores from reworked deposits in the Old Crow region, northern Yukon Territory (see text for explanation).

Cat. No.	Scar Location	Flaking Direction	No. of Scars	Max. Length	Max. Width	Distal Termination	Platform Angle
MlVl-13:7	Right	Inner to outer	Scattered	13.0	22.5	All feathered	60°
MlVl-5:46	Right	Inner to outer	4	12.6	23.7	All hinged	90°
NaVk-6:11	Right	Inner to outer	Scattered	(too heavily rounded and pitted to measure)			
NbVl-11:1	Left	Inner to outer	1	19.2	55.4	Hinged	45°
MlVl-1:142	Left	Inner to outer	2	(44.0)	68.7	2 feathered	Recent fracture
MkVl-10:15	{Right	Inner to outer	4	19.8	37.4	All hinged	65°-70°
	{Distal	Inner to outer	5	9.8	24.1	All hinged	?
NaVk-1:7	{Left	Inner to outer	1	24.0	56.3	Hinged	30°
	{Right	Inner to outer	5/1	19.7	56.2	5F, 1H	55°-60°
NaVk-5:4	(See text)						
MlVl-5:27	Right	Inner to outer	1	20.5	101.3	Hinged	50°
MlVl-1:2c	{{Left dist.	Inner to outer	1	25.6	70.5	Hinged	75°
	{{Left prox.	Inner to outer	1	30.0	76.7	Hinged	55°
	{Right	Inner to outer	Many	9.3	38.6	All stepped	70°
MkVl-26:1	{Right	Outer to inner	1	48.9	95.2	Hinged	55°
	{Left	Inner to outer	1/1	40.3	106.0	2 hinged	60°
MlVl-5:55	Left	Inner to outer	Many	22.1	81.7	All hinged	55°
	N			14	15		
	Mean			22.5	61.0		
	S.D.			11.2	28.0		

Table B10. Green fracture attributes of mammoth bone core fragments and miscellaneous "cores" from reworked deposits in the Old Crow region, northern Yukon Territory.

							Loading Point			
Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Form	Location	Diam.	Other
3/4	MkV1-4:17.1	147	49	71	174.3	18.9-27.5				
3/4	NbV1-2:7	(124)	29	29	137.1	46.1	Cone	End	(Large)	Bonnichsen 1979:103
4/4	MlV1-7:282	85	36	34	53.3	25.7				Pl. 5.4
4/4	NaVk-1:10	113	40	40	79.5	21.3				
Miscellaneous "cores"										
	MlV1-1:3c	148	119		(cast)					Bonnichsen 1979: 106, Pl. VIII-5
	NaVk-5:25	128	89		218.7					

The transverse flake removed near the left margin of NaVk-1:7 could be interpreted as a large rebound flake scar associated with a loading point. The loading point is clearly defined, and it formed the platform for facial flake removal. On the right margin the platform is formed by an unmodified green-fracture surface, but the facial flaking is continuous along a zone 119.7 mm long.

NaVk-5:4 is so complexly flaked that its attributes cannot be presented in tabular form. The following sequence of events may have characterized its formation: (1) the right margin was flaked from inner to outer to remove the original fracture surface; (2) cancellous tissue on the inner wall was removed by flakes originating from the left margin; (3) the left margin was further thinned by flaking from outer to inner by impacts on the outer surface of the bone (platform angle, 55°). The result is that this end of the bone has been flaked to a point, entirely by means of transverse flaking.

MlVl-1:2c has been described on the basis of an epoxy cast. This is one of the specimens which was sacrificed for a radiocarbon date of 25,750 + 1800 - 1500 (GX-1568) on the basis of the apatite fraction of the bone (Irving and Harington 1973:Table 1).

MkVl-26:1 exhibits two small longitudinal flake scars on the right fracture surface. Both are hinged, the larger measures 27.5 X 10.7 mm, and their associated platform angle is 40°.

A single longitudinal flake scar on the outer surface of MlVl-5:55 measures 13.3 X 24.0 mm, is hinged, and is associated with a platform angle of 45°.

Core Fragments with Confusing Features, and Miscellaneous "Cores"

MkVl-4:17.1 (Table B10) is flaked on one end, but its platform is missing and I cannot decide how it should be oriented for description.

Although Bonnichsen (1979:103, Pl. VIII-2) classified NbVl-2:7 as a dorsally flaked core, he noted that it lacks "clear-cut fracture orientation features" and that "it is impossible to determine from which end of the core the flakes were removed." I believe that the confusion arises from the fact that this core is flaked not on the outer surface of the bone but on the very broad fracture surfaces of an unusually thick-walled bone. The left and right margins are primary fracture surfaces on a narrow but thick fragment which was further broken by a heavy blow from left to right, resulting in a distinctive flared cone at the loading point. The loading point area served as an unmodified platform for the detachment of one feathered flake from the left side near the inner wall of the bone (55.1 X 16.4 mm). On the right side, flakes (1/1) were detached from the opposite end by impacts on a platform since removed by a recent fracture. Both of these flakes terminated in hinges, and the longest is 41.2 mm long and the widest is 31.1 mm wide.

MlVl-7:282 is probably a thick flake removed from an extensively trimmed core (Pl. 5.4). The core may have had a **gabled platform** (see below) and may have been shaped in part by transverse flaking as suggested by one scar on the right margin of this fragment.

Table B11. Attributes of mammoth bone flakes from reworked deposits in the Old Crow region, northern Yukon Territory.

P.E.	D.E.	Length	Chord	Perim.	Thick.	Weight	P.A.	P.S.	V.C.	Cat. No.	Other
1	5	(123)	46	57	28.4	111.2	NM		30%	NbVm-2:18	Pl. 4.17
2a	4	44	54	58	12.1	20.6	NM			NbVl-1:24	Bonnichsen 1979:118
2a	4	161	66	75	34.0	285.9	NM		10%	NbVm-6:1	Edge spall
2a	3	49	45	46	7.0	12.5	NM	2		MlVl-1:87	Bonnichsen 1979:119, Pl. VIII-13
2b	4&5	191	100	108	16.2	270.7	NM		30%	MlVl-7:507	Pl. 4.18
2b	5	83	48	48	7.3	20.5	NM		50%	NaVk-1:1c	
2b	5	106	29	18	15.8	33.3	NM			NbVl-2:4	
2b	5	79	111	111	18.1	70.5	NM	2	25%	NaVk-6:20	Diagonal flake
2b	5	131	40	36	20.8	72.5	NM			NaVk-6:15	
3	5	90	40	40	9.8	26.1	NM		20%	MlVl-1:53	Bonnichsen 1979:119
3	6	87	65	84	21.0	68.6	NM	1/1		MlVl-1:154	Bonnichsen 1979:119
3	1	(107)	51	52	14.2	63.1	NM			MlVl-5:50	Bonnichsen 1979:119
3	6	151	52	59	32.2	178.2	NM	1	10%	NaVk-8:1	
3	4	19	38	27	9.4	5.0	NM	2/1		NbVl-1:17	Transverse flake
4	5	53	93	93	10.3	47.3	90°	1		MkVl-8:11.1	Bonnichsen 1979:120; diagonal flake struck from dry bone(?)
4	2	60	40	49	14.0	26.2	30°			MkVl-12:11	Bonnichsen 1979:120
4	5	248	116	147	36.8	810.6	60°		10%	MkVl-24:3	Pl. 4.19
4	3	49	24	24	10.2	10.6	85°			NbVl-1:6	Bonnichsen 1979:118
4	4&5	57	83	83	23.2	76.7	55°		10%	NbVm-2:11	
5	5	79	62	62	10.7	40.2	80°	3/2		MkVl-8:22	Bonnichsen 1979:121, Pl. VIII-15; Etched on ventral face
5	4	110	43	24	16.7	61.9	55°			MkVl-12:12	Bonnichsen 1979:120
5	4	95	52	52	15.8	56.1	30°	1/2		MlVl-5:49	Bonnichsen 1979:119, Pl. VIII-13
5	4	78	55	58	13.7	47.4	60°	2/1	10%	MlVl-7:79	Pl. 5.5
5	2	119	55	61	15.8	79.5	80°	3		NaVl-1:1	Struck from dry bone(?)
5	5	109	121	121	18.2	108.4	70°	1		NaVk-10:1	Diagonal flake

Table B11 (Continued).

P.E.	D.E.	Length	Chord	Perim.	Thick.	Weight	P.A.	P.S.	V.C.	Cat. No.	Other
6	5	84	112	112	22.0	131.3	110°	3	30%	MkV1-8:21	{ Bonnichsen 1979:121 Diagonal flake
6	1	(97)	31	35	8.5	26.4	90°		40%	MlV1-7:156	Pl. 5.5
6	5	131	56	71	31.2	174.3	90°	3		NbVm-5:8	{ Bonnichsen 1979:118, Pl. VIII-12 Etched on flake scars
N		25	28	28	28	28					
Mean		98.5	61.7	64.7	17.6	104.8					
S.D.		50.7	28.1	32.5	8.4	155.9					

Legend

P.E. (proximal end): 1, recent fracture; 2a, platform lost because flake snapped at time of detachment; 2b, platform lost because the proximal end shattered at time of detachment; 3, platform area is a sharp-edged remnant too small to interpret; 4, platform remnant is an unmodified green fracture surface; 5, platform remnant is a retouched surface; 6, platform remnant is a gabled surface (see discussion).

D.E. (distal end): 1, recent fracture; 2, jagged; 3, stepped; 4, hinged; 5, feathered; 6, bipolar (the distal end exhibits crushing and rebound flake removal).

Thick. (thickness) refers to the total flake rather than the bone wall.

P.A. (platform angle) is NM (not measureable) for proximal ends of Types 1-3.

P.S. (previous scars) are those exhibited on the dorsal face of the flake.

V.C. (ventral cancellous) is the percentage of the ventral face occupied by cancellous tissue.

* with catalogue number marks specimens found in association with the *Anodonta* phase.

See text for other explanations.

NaVk-1:10 is either a flake or a core fragment, but I cannot decide how it should be oriented.

Two other flaked specimens are very similar to one another as both are from the proximal end of mammoth or mastodon radii and both have been flaked to blunt points after the primary fracture of the bones. MlVl-1:3c is represented by an epoxy cast and was sacrificed for a radiocarbon date of 29,100 + 3000 - 2000 B.P. (GX-1567) on the basis of the apatite fraction of the bone (Irving and Harington 1973:Table 1). Flakes have been detached from opposite sides of this piece as if to sharpen the fractured end to a point, and the largest scar, which has a feathered termination, measures 76.7 X 29.6 mm. Bonnichsen (1979:106, Pl. VIII-5) included this specimen among his dorsally flaked cores.

NaVk-5:25 is nearly identical to MlVl-1:3c but is slightly smaller. It exhibits flake scars on opposite sides with the effect of being sharpened to a point on the fractured end. Its largest feathered scar measures 46.0 X 20.0 mm.

Flakes

The attributes of 28 mammoth bone flakes are displayed in Table B11. Since we are able to recognize cores which have lost their platforms through "too deep a bite" (Table B3), it is not surprising that variable amounts of cancellous tissue can occur on the ventral faces of flakes. Such specimens create a gray area, however, between flakes and green fractured bone fragments, and I have separated these two categories by the dual observation of distal terminations and a 50% cut-off for the amount of cancellous tissue which can occur on the ventral face of a flake. The one flake which has as much as 50% of its ventral face covered by cancellous tissue (NaVk-1:1c) is classified as a flake because of its long feathered distal end. In a preliminary study of these materials, I restricted the definition of flakes to those specimens which completely lacked cancellous tissue on their ventral faces (Morlan 1979b:25), but I have found this criterion too restrictive in dealing with a larger sample of flakes and cores.

One of the proximal end forms requires description since it has not been defined in the literature on lithic technology. This is the gabled form which is comprised of a series of parallel ridges which span the entire width of the platform remnant on three of the flakes in Table B11. I am grateful to Tomenchuk (1976) for the "gable" label, and I have seen gabled bone surfaces produced in three different ways. Probably the most common mode of gable formation is in primary bone fracture when a bone is overcome by so massive an impact that it fails transversely without the propogation of spiralling fracture fronts. A second way to form gables is by means of flaking across the end of a bone fragment so as to build one step fracture inside another, and a third means is through the accumulation of hinge fractures at the distal ends of longitudinally struck flakes. The flake catalogued as NbVm-5:8 has been replicated experimentally during recent work on modern elephant bone (Morlan 1979a:Fig.8; Stanford, *et al.* 1980), and the gables on the replica were formed by Bonnichsen during the Ginsberg experiment as he flaked across the end of a fragment to create a secure platform for flake detachment.

Several of the flakes in Table B11 deserve special comment. NaVk-8:1 exhibits secondary retouch at its right ventral corner. A single transverse scar, 9.5 X 33.5 mm, has terminated in a hinged fracture on the ventral face. The distal end of this specimen is interesting in that it exhibits both crushing and rebound flake scars which indicate a bipolar mode of positioning the core. This evidence is consistent with the form of the proximal end which is a shattered edge below which a bulb of force is well preserved. This sort of platform area has been reproduced experimentally only when bipolar flaking was accomplished by means of straight-on, rather than angled, impacts on the end of the core.

MkV1-24:3 is by far the largest bone flake I have ever seen (Pl. 4.19). It is much too large to have been used as a hand-held tool with one hand, but it would have been an excellent cutting implement if equipped with a stout handle. Its proximal end preserves a well formed cone at the loading point, and the cone measures 17.0 mm in diameter. The unmodified fracture surface associated with this cone served as a platform for detaching the flake.

MkV1-8:21 has a gabled platform remnant produced by secondary retouch on a green-fracture surface. The retouch caused a series of deep step scars to accumulate and produce a rough gabled form. The dorsal face of the flake bears the scars of three previous flake removals, each of which came from a different direction -- proximal, distal and right. This is a diagonal flake, and its outline reflects the pronounced influence of bone structure on flake shape as the greatest dimension lies in the long axis of the bone rather than in the plane of force delivery. These attributes combine to suggest that the core from which this flake was detached had been extensively shaped by flaking in several directions. Unfortunately we have not yet discovered a core of the sort which this flake would seem to indicate.

Fractured and Flaked Mammoth Tusk Ivory

Metric data have been summarized in Table B12 which also contains non-metric observations on the flakes. Each of the cores will be described individually since they vary considerably and are not readily amenable to tabular presentation.

MkV1-26:2 is merely a fragment which is included in this discussion only because both of its ends were fractured when fresh. In each case the fracture surface forms an obtuse angle with the outer ivory surface.

MkV1-8:26 is a core with numerous transverse flake scars on the inner face of the left edge. The largest of these scars measures 17.0 X 32.2 mm, and all are hinged or stepped. The associated platform is on the unmodified outer surface of the tusk with an angle of approximately 35°. Recent exfoliation and fracture has altered the overall form of the specimen. One end of the core is polished.

MkV1-8:27 is a core with one flake scar (20.4 X 36.0 mm, feathered) on the outer face. The associated platform was formed by two main scars of which the largest measures 7.5 X 10.6 mm. Both scars are feathered distally, and the platform angle is 45°. One major scar occurs on the inner

Table B12. Attributes of ivory cores and flakes from reworked deposits in the Old Crow region, northern Yukon Territory.

Cat. No.	Length	Width	Thick.	Weight	Category	Prox. end	Distal end	Ventral Lamellar	Other
MlVl-1:51	28	74	11.7	19.8	Flake	Recent fracture	Feathered		Bonnichsen 1979: 119, Pl. VIII-13
MlVl-5:48	89	43	17.5	30.7	Flake	Recent fracture	Feathered	30%	Bonnichsen 1979: 118, Pl. VIII-13
NbVm-4:13	62	42	11.1	21.1	Flake	Shattered	Hinged	25%	Bonnichsen 1979: 119
MkVl-26:2	109	40	11.2	36.9	Fragment	See text			
MkVl-8:26	121	39	16.0	47.5	Core	See text			
MkVl-8:27	93	65	16.9	77.6	Core	See text			
MkVl-12:15	62	40	23.8	44.1	Core	See text			Bonnichsen 1979: 109, Pl. VIII-10
MkVl-25:2	41	31	11.3	9.0	Core	See text			

face (22.3 X 43.1 mm, hinged) in association with an exfoliated platform area forming an angle of about 30°.

MkVl-12:15 is a beautiful and complex core. At one end (which I will call proximal) a platform has been formed by a single blow to produce an area 24.0 mm deep and 38.7 mm wide. An impact on the edge of this platform detached a flake (23.6 X 29.8 mm, hinged) to form an angle of 60°. At the distal end a second platform was created by two long flake scars on the opposite (ventral) face and running in the opposite direction from the dorsal flake scar. The larger of these two scars measures 54.1 X 18.9 mm. Impacts on the edge of this platform detached four flakes (3/1) from the dorsal face, and these run back toward the hinge area of the first flake mentioned above (largest, 26.4 X 13.0 mm, two feathered, two hinged, platform angle 35°). Bonnichsen (1979:109, Pl. VIII-10) suggested that the distal flaking may represent an unsuccessful effort to remove the deep hinge which was produced by the first flake. One transverse scar (8.0 X 13.0 mm) on the left edge of the core may represent an earlier attempt along these lines as its proximal end is truncated by the ventral platform scars.

MkVl-25:2 is a core with 2/2 flake scars on the inner face at one end (largest 19.3 X 12.5, one feathered, three hinged). The associated platform is on the unmodified outer surface of the tusk, and the platform angle is about 35°. At the other end of the core a single flake scar (8.8 X 12.1 mm, hinged) appears on the inner face, and its platform was removed by a later fracture.

Cores and Flakes Made on Smaller Large Mammal Bones

The green fracture attributes and flaking attributes of seventeen cores made on large mammal bones smaller than those of mammoths have been separately presented in Tables B13 and B14. Little additional comment is required except to note in general that such bones can be flaked with little or no platform preparation.

A number of large mammal long bone "cores" in the collection have been placed in limbo as possible artifacts due to signs of carnivore gnawing in association with their flake scars (Table 4.12).

Two flakes discovered in 1975 deserve mention. NbVl-2:13 is a struck flake which was recovered from deposits associated with the *Anodonta* phase, and it exhibits the following attributes: retouched platform, angle 90°; feathered distal end; length, 60 mm; chord, 24 mm; perimeter, 28 mm; thickness, 10.6 mm; weight, 12.4 g; previous scars, 1/2; ventral cancellous tissue, 25%. The previous flake scars represent edge spalls removed from the right margin, and it is possible that they were removed after this flake was detached from its core (Pl. 4.20).

The other flake, MkVl-12:13, is from a loading point and has an oblong conoid shape, 20.1 X 12.3 X 4.4 mm (0.8 g). This is the kind of flake which is detached from the inner side of a bone wall to produce a loading point scar during primary green bone fracture (Pl. 4.20).

Table B13. Green fracture attributes of longitudinal and transverse cores made on large mammal bones other than mammoths from reworked deposits in the Old Crow region, northern Yukon Territory.

Frac.	Cat. No.	Length	Chord	(Depth*) Perim.	Weight	Wall Thickness	Other
Longitudinally flaked cores:							
0/4	NaVk-5:39	(129)	(35)	(49)	81.6		Probably *Equus* sp. tibia
1/4	MlVl-7:32	(83)	(32)	(46)	31.3	8.3	Etched on outer surface only
3/5	MlVl-7:224-2	62	(24)	(24)	12.9	5.6-11.5	
4/6	MlVl-5:54	(54)	28	32	14.7	11.6-13.2	Probably *Equus* sp. metapodial
4/5	NbVl-1:27	91	27	32	35.0	10.1-14.2	Probably *Equus* sp. long bone; etched on frac. Bonnichsen 1979:113, Pl. VIII-11
4/5	MlVl-1:100	(89)	48	54	26.3	7.3-12.9	Probably *Equus* sp. long bone
4/4	MlVl-7:87	42	33	35	14.7	7.3-12.1	
4/4	NaVk-5:36	89	42	51	55.2	8.5-17.0	Probably *Equus* sp. humerus
5/5	MkVl-18:4	69	59	84	68.3	11.0-17.4	Probably *Bison* sp. long bone Bonnichsen 1979:109, Pl. VIII-10
5/5	MlVl-5:33	82	44	45	62.6	10.6-17.3	Probably *Equus* sp. long bone Bonnichsen 1979:105, Pl. VIII-4
5/5	MlVl-5:30	94	32	24	38.0	11.3-12.3	Probably *Equus* sp. long bone; etched scars; Bonnichsen 1979:114, Pl. VIII-11
Cyl.	NaVl-4:6	58	67	43*	97.3	7.5-9.9	*Equus* sp. phalange, proximal half Bonnichsen 1979:104
Cyl.	NaVk-6:8	236	50	36*	438.6	9.0-15.3	*Equus* sp. right radius, distal 2/3 Bonnichsen 1979:105, Pl. VIII-3
Transversely flaked cores:							
2/5	MlVl-16:4	(141)	(47)	(53)	64.7	8.0-12.1	
4/4	MlVl-1:86	45	37	43	17.6	7.1-9.3	Etched on fracture
4/4	NbVl-6:1	61	15	21	4.5	3.2-4.6	*Rangifer* size long bone; Pl. 4.20
4/4	MlVl-1:93	77	20	35	12.4	3.5-4.7	*Rangifer tarandus* metatarsal; polished; Bonnichsen 1979:137, Pl. VIII-24

Table B14. Flaking attributes of longitudinal and transverse cores made on large mammal bones other than mammoths from reworked deposits in the Old Crow region, northern Yukon Territory.

Longitudinally flaked cores:

Cat. No.	Scar Locations Perim.	Scar Locations Circumf.	No. of Scars	Max. Length	Max. Width	Distal Termin.	Platform	Plat. Angle
NaVk-5:39	End	Outer	0/3	>22.2	>12.8	Hinges	Recent fracture	NM
M1V1-7:32	End	Right	1	>21.2	12.2	Feather	Unmodified green fracture surface	85°
M1V1-7:224-2	End	Right	1	33.2	10.8	Hinge	Unmodified green fracture surface	90°
M1V1-5:54	End	Outer	0/2	25.2	17.6	Feather	Removed by green fracture	NM
NbV1-1:27	Right	Outer/ fracture	1/2	>46.6	11.4	1F, 2H	Recent fracture	NM
M1V1-1:100	End	Outer	2/2	49.1	18.3	2F, 2H	Recent fracture	NM
M1V1-7:87	End	Outer	2	>8.9	16.1	2H	Removed by green fracture	NM
NaVk-5:36	Left	Outer/ fracture	0/1	>60.2	23.1	Hinge	Removed by green fracture	NM
MkV1-18:4	End	Outer	2	>40.2	30.5	2H	Removed by green fracture	NM
M1V1-5:33	End	Outer	2/3	35.4	10.5	5H	Unmodified green fracture surface	90°
M1V1-5:30	Right	Fracture	0/2	>43.0	12.5	2H	Removed by green fracture	NM
NaV1-4:6	End	Left	1	27.3	21.6	Feather	Unmodified green fracture surface	65°
NaVk-6:8	End	Left	1	55.3	22.1	Feather	Removed by green fracture	NM

Transversely flaked cores:

Cat. No.	Scar Location	Force Direction	No. of Scars	Max. Length	Max. Width	Distal Termin.	Platform	Plat. Angle
M1V1-16:4	Right	In → Ou	1	10.0	35.9	Feather	Unmodified green fracture surface	60°
M1V1-1:86	Right	Ou → In	3	8.6	20.6	3F	Unmodified green fracture surface	45°
NbV1-6:1	Left	Ou → In	Many	8.3	16.8	All F	Unmodified green fracture surface	40°-45°
M1V1-1:93	Left	Ou → In	Many	3.6	11.6	H & S	Unmodified green fracture surface	35°
	Right	Ou → In	2	3.3 3.5	9.9 8.3	Hinge Hinge	Unmodified green fracture surface	35°

Legend: Ou, outer; In, inner; F, feather; H, hinge; S, step; NM, not measureable

Bones and Antlers with Reduced and Incised Surfaces

In this section we will examine two scratched bones, one scratched tooth, eight scraped bones, two ground bones, 26 polished bones, five cut and polished antlers, and five cut bones. The classification of the specimens is discussed in Chapter 4.

Scratched Bones

MlVl-7:326 is an unidentified large mammal rib fragment (Table B15) which exhibits numerous straight transverse scratches on its outer surface. All margins were fractured after permineralization, and these fractures truncate the scratches. The scratches range from 0.3 to 1.6 mm apart and span the entire surface of the fragment. All the scratches are approximately parallel to one another. These scratches might have resulted from transportation in a stream, but they might have been produced by some artificial use of the bone; the specimen is classified as natural or artificial.

NbVm-1:3 is the distal two-thirds of an *Equus* sp. left metatarsal III (Table B15; Pl. 4.21). A loading point is preserved on the medial side (diam., 5.9 mm), and the lateral side has a gabled fracture surface. A dynamic load is indicated by hackle marks on the fracture surface, by diagonal cracks which run toward the anterior and posterior faces, and by the gabled fracture surface. The bone was somewhat dessicated at the time of fracture since the fracture surface is perturbed by jogs at split lines on either side of the gabled area.

Thousands of scratches in hundreds of bundles occur on the anterior face of NbVm-1:3, covering the entire face except for the distal condyles. The scratches extend irregularly to but not beyond the medial and lateral sides and they do not occur on the posterior face of the bone. Nearly all the scratches are microscopic and they are associated with a heightened gloss and small local polished facets. They are oriented in every possible direction. Most are straight, but a few have pronounced curves.

The lateral, medial, and distal areas of this metatarsal are darkly stained, locally as dark as 2.5YR2/2. Much lighter stain appears on the anterior face on most but not all of the scratched area (2.5Y5/2), and the posterior face has an intermediate colour (5YR4/2). The scratches and dark stain overlap on the medial and lateral sides, but they are nearly exclusive near the distal end of the anterior face. This difference in staining does not resemble the truncated permineralization rinds seen on naturally polished and scratched bones. It is not abrupt, and the relationship between scratching and staining is not exclusive on most parts of the bone. It is possible that the process that produced the scratches altered the chemical and/or physical properties of the affected bone wall so as to change its response to staining processes.

Nine rough, irregular, shallow scrapes on the lateral side are probably the results of carnivore gnawing (scoring), and they truncate the scratches on the lateral side. Eight short rootlet etch marks on the anterior face also truncate the scratches. This bone is an artifact of unknown function. The scratching alterations are complex, and they are truncated by other

Table B15. Selected attributes of scratched, scraped, and ground bones and scratched tooth from reworked deposits in the Old Crow region, northern Yukon Territory.

Cat. No.	Frac.	Length	Chord	Depth/ Perim.	Thickness	Weight	Element	Status
Scratched bones								
MlVl-7:326	O/y	37	26	P 26	4.4	3.5	Large mammal rib frag.	N or A
NbVm-1:3	Cyl.	198	37.5	D 30.6	W9.3-13.1	287.4	*Equus* sp. L. metatarsal III	Artif.
Scratched tooth								
NbVn-3:1	?	30	17.6		5.8	3.3	*Castoroides* sp. incisor frag.	N or A
Scraped bones (see also Table B16)								
MlVl-13:13.1	Cyl.	113	24.9	D 35.5		82.8	*Panthera* R. humerus shaft	Prob. A
Ground bones								
NaVk-5:6	(see Table B1)						cf. *Mammuthus* sp. long bone	N or A
MkVl-8:16	(see Table B1)						cf. *Mammuthus* sp. long bone	Artif.

Legend
Fracture: Cyl., cylinder
Depth/Perim.: P, perimeter; D, depth (as appropriate)
Thickness: W, wall thickness; others, total thickness
Status: N or A, natural or artificial; Prob. A, probably artificial; Artif., artificial alteration
See text for detailed descriptions.

identifiable alterations (gnawing and rootlet etching) which are normally associated with fresh bone. The scratches are also truncated by the fracture at the proximal end which probably occurred when the bone was relatively fresh but slightly dessicated. Some of the scratches occur in broad bundles within which the individual incisions are straight and quite parallel, and these probably were produced when the bone was rubbed against another object. Other scratches have such changeable orientations that they probably result from rubbing other objects against the bone.

Scratched Tooth

NbVn-3:1 is probably a *Castoroides ohioensis* incisor fragment on which the dominant alterations are scratches and polish (Table B15). The fracture of the specimen is difficult to evaluate. One major (4.9 X 3.8 mm) and three minor flakes were detached from the lingual face with an unmodified fracture surface comprising a platform at the proximal end. The flake scars have reduced gloss relative to the unflaked surfaces, and they may have occurred during fluvial transport. The fractured distal end appears to have been partly rounded by polishing, but no striae are visible.

Twenty-four single scratches appear on the lingual surface, and most are oriented approximately in the transverse plane while all others more or less point toward the center of the fragment. Only two of the scratches are paired, and they exhibit a distinctive wavy ( ) component. Most of the scratches are very narrow and parallel-sided, but a few are more like scrapes with converging sides and "chattered" centres as if a cutting edge had lost purchase during their creation.

These features might all be <u>natural</u>, produced either during the life of the animal or during fluvial transport. On the other hand, the chattered and wavy scratches look like tool marks which might have been created in fashioning the tooth into an engraving tool, so the specimen may have been an <u>artifact</u>.

Scraped Bones

Of the eight bones in this category, one represents a large field (Table B15), and the other seven are mammoth bones (Table B16) which have already been described with respect to fracture patterns and flaking attributes.

MlVl-13:13.1 is the right humerus shaft of a large cat, probably *Panthera leo atrox*, which exhibits a green-bone fracture on a portion of its proximal end and a more recent fracture on its distal end. This bone is scraped over much of its outer surface, expecially on the anterior and posterior sides and less on the lateral and medial sides. Most of the scrapes are longitudinal, but a few are oblique. A small polished flat facet occurs on the posterior side near the proximal break; it measures 13.2 X 10.2 mm and exhibits oblique striae. These alterations are <u>probably artificial</u>.

Seven scraped mammoth bones are presented in Table B16. These have

Table B16. Attributes of scraped mammoth long bones from reworked deposits in the Old Crow region, northern Yukon Territory

Cat. No.	Cross-References	Orientation of scrapes	Extend of scrapes	Other attributes
MkVl-5:13	Table Bl Pl. 4.6	Oblique, transverse	Local bundles	5 broad "cuts" of unknown origin
NaVk-5:7	Table Bl	Longitudinal	¼ of surface	
MjVj-1:1.1	Table Bl Pl. 4.3	Longitudinal	½ of surface	
*MlVl-1:144	Table Bl	Longitudinal	2/3 of surface	Scrapes truncated by etching
MlVl-5:18	Table Bl	Longitudinal	2/3 of surface	Scrapes truncated by etching
MiVl-1:12	Table Bl Pl. 4.9	Longitudinal, oblique	2/3 of surface	Scrapes truncated by flake scars
NaVk-5:28	Tables B6-7	Longitudinal	1/3 of surface	Scrapes truncated by flake scars

* with catalogue number marks a bone found in association with the *Anodonta* phase.

already been put forth as artificially modified on the basis of their fracture patterns and flaking properties as outlined in the tables cross-referenced in Table B16. MkVl-5:13 differs from the others, and it could have acquired all its surface alterations during fluvial transportation; I do not know whether the alterations are natural or artificial. The longitudinal scraping seen on NaVk-5:7 and MjVj-1:1.1 is probably artificial on the basis of its extent and continuity across curved surfaces. The remainder I am prepared to declare as artificially modified because of the truncations of the scraping by etching and flake scars. The scraping seen on these bones has been replicated by using stone end scrapers to remove periosteum so as to improve the flaking properties of the material (Ginsberg experiment), and I suggest that such a procedure may have been followed with some of these specimens.

Ground Bones

The entire outer face of NaVk-5:6 has been ground down flat with oblique scratches at an angle to the long axis of approximately 15° (Table B15). Very little polish is seen on the ground surface, and it is not clear whether portions of the permineralization rind have been penetrated. The alteration is quite simple, and there is no truncation pattern to indicate when the alteration was made. The bone could have been altered naturally or artificially.

MkVl-8:16 is a much more complex example of bone grinding (Table B15, Pl. 4.22). The outer surface has been ground to a nearly flat facet measuring 148 X 29 mm along the midline of the fragment with striae oriented obliquely (ca. 50° to long axis) from distal right to proximal left. To the left of the midline, slightly oblique scratches (ca. 15°) appear on the outer surface on an area ca. 88 X 18 mm; these scratches do not form a facet, and their orientation is from distal left to proximal right. At the left distal corner is a third set of scratches which runs from distal right to proximal left (ca. 35°) and covers ca. 33 X 26 mm. Scattered transverse scratches also appear near the midline at the proximal end. None of these scratches is associated with polish, but each set of scratches is locally truncated by rootlet etching. The complexity of this arrangement of scratches with the major set accompanied by surface reduction suggests to me a history more complex than reasonably expected from natural processes. Although I cannot suggest a precise function for this piece, I have included it among the artificially altered specimens. The discrete groups of parallel scratches indicate that the bone was used to rub on some other object rather than the other way around.

Polished Bones

Of 26 bones with polished facets, 14 have been interpreted as artificially modified, four exhibit alterations which are probably artificial, and eight are as likely natural as artificial (Table B17). These will be described in four groupings based upon the association between polishing and green fracture.

Polished facets on bones not fractured when green

M1V1-7:321 is an unidentified large mammal long bone fragment which was fractured on all four margins after permineralization of the bone. A polished facet forms a small bevelled area, 13.6 X 1.7 mm, at one end of the specimen and forms an obtuse angle (145°) with the outer surface. The facet is very darkly stained and exhibits no striae. The facet has been truncated by the post-permineralization fracture and may originally have been much larger. I cannot determine whether the specimen was altered naturally (by stream abrasion) or artificially (perhaps during a hide rubbing process).

The right humerus of a duck (NaVk-6:22, possibly an oldsquaw, cf. *Clangula* sp.) has lost its proximal end to a recent fracture, but 3/4 of the bone is preserved. A polished facet on the anterior face of the shaft, 17 mm from the distal condyles, measures 5.9 X 2.6 mm, is obliquely oriented from proximal-medial to distal-lateral, and is concave. The facet floor exhibits parallel striae in the long axis of the facet. This alteration could be either natural or artificial. If natural, its cause might be the rubbing of bone on bone within a sedimentary matrix disturbed by frost action. If artificial, it could have resulted from butchering or from the use of the bone in a rubbing function.

M1V1-1:4 is a fragment of the posterior border of a *Bison* sp. right scapula blade (Table B17, Pl 4.23). A post-permineralization fracture of the proximal end has exposed dense cancellous tissue just inside the glenoid fossa. At the other end an oblique fracture was probably made when the bone was green, but the fracture attributes have been eliminated by polishing on a facet. One main facet, ca. 21.2 X 11.0 mm, at this end forms an angle of 140° with the lateral face of the scapula and 130° with the posterior border. The facet is flat and exhibits fine lineal striae in the lateral-medial plane of the scapula (perpendicular to the long axis of the facet). These striae are interrupted by two concave polished grooves which partially cross the facet at an angle of ca. 15° to the striae. The grooves are more than 3.1 mm wide and as much as 1.6 mm deep. At the inner edge of the facet a narrow bundle of striae are parallel to the long axis of the facet indicating that polish began with a radically different orientation from later polishing. One corner of the facet at the posterior border is rounded to a convex facet at an angle of ca. 140° to the main facet. The polish also extends ca. 38 mm down the lateral face toward the proximal end of the scapula and on the medial face polish occurs on all high spots among a complex series of flake scars probably associated with the primary fracture of the specimen. The complexity of this polished specimen prompts me to refer it to our artificially modified count, but I do not know what its function may have been.

M1V1-7:289 is a fragment of an unidentified large mammal rib which has been altered in shape and cross-section to form a blunt point (Table B17, Pl. 5.6). The base of the specimen may have been snapped transversely when green, possibly with the aid of transverse grooving, but all diagnostic tool marks have since been obliterated by polishing and stream rounding. The specimen has been so reduced in size that the cancellous core of the rib now appears on its outer surface along both edges, but most of the outer surface is made up of highly polished cortical bone. The outer surface is undergoing progressive delamination which has resulted in only spotty preservation of

Table B17. Selected attributes of polished bones from reworked deposits in the Old Crow region, northern Yukon Territory.

Cat. No.	Frac.	Length	Chord	Depth/ Perim.	Thickness	Weight	Element	Status
Polished bones not fractured when green:								
MlVl-7:321	0/y	37	19	P 24	13.9	9.2	Large mammal long bone	N or A
NaVk-6:22	0/y	49.8	5.5	D 5.3		1.3	*Clangula* sp. R. humerus	N or A
MiVl-1:4	0/y?	198	53	D 23		157.9	*Bison* sp. R. scapula blade	Artif.
MlVl-7:289	0/y?	53	22		14.7	15.1	Large mammal rib	Artif.
Polish and green fracture in different locations:								
NaVk-5:32	Cyl.	127	75	D 40		211.1	*Bison* sp. L. metacarpal III	Prob. A
MlVl-1:35	2/4	124	42	P 43		36.4	Large mammal rib	Artif.
NbVn-1:1	Cyl.	208	13.9	D 28.4		129.6	*Bison* sp. L. ulna	Artif.
Polish intersects green fracture:								
NbVl-2:9	Cyl.	94	14.3	D 17.3	W3.7-4.9	27.4	Artiodactyl L. humerus	N or A
MlVl-1:104	4/4	89	43	P 46		26.8	Large mammal long bone	Artif.
NaVk-5:1	Cyl.	126	43.0	D 38.2		171.3	*Equus* sp. mandible	Artif.
MlVl-5:46	(see Tables B8-9)						cf. *Mammuthus* sp. long bone	Artif.
MlVl-1:93	(see Tables B13-14)						Large mammal long bone	Artif.
Polish on green fracture:								
MlVl-3:1	5/5	166	41	P 69		156.5	*Bison* sp. R. radius	N or A
MlVl-7:288	2/3	49	31	P 42	W 14.0	10.2	Large mammal humerus shaft	N or A
NbVl-1:19	3/4	126	33	P 63	W6.8-10.3	83.8	*Equus* sp. L. radius(?)	N or A
MkVl-9:14	Cyl.	202	45.0	D 47.6	W6.6-16.7	422.1	*Equus* sp. L. tibia	Prob. A
MlVk-1:1.1	(see Table B1)						cf. *Mammuthus* sp. long bone	Prob. A
MlVl-13:7	(see Tables B8 and B9)						cf. *Mammuthus* sp. long bone	Artif.
MlVl-1:155	Cyl.	244	37.0	D 24.8	W5.6-11.9	338.7	*Equus* sp. L. radius	N or A
NaVk-5:33	Cyl.	214	40.6	D 27.9	W8.2-12.0	357.4	*Equus* sp. R. radius	N or A
NaVl-8:1	Cyl.	182	76.2	D 37.1	W9.7-12.7	216.0	*Bison* sp. R. metatarsal III	Artif.
NaVl-12:1	2/4	137	44	P 49	W7.2-12.3	88.3	Large mammal long bone	Artif.

Table B17 (Continued).

Cat. No.	Frac.	Length	Chord	Depth/ Perim.	Thickness	Weight	Element	Status
Polish on green fractures (cont.):								
*M1V1-1:125	6/6	222	60	P100	W7.1-12.2	169.0	*Equus* sp. R. tibia	Prob. A
NaVk-6:12	(see Tables B2 and B3)						cf. *Mammuthus* sp. long bone	Artif.
*M1V1-1:142	(see Tables B8 and B9)						cf. *Mammuthus* sp. long bone	Artif.
*M1V1-1:143	(see Tables B2 and B3)						cf. *Mammuthus* sp. long bone	Artif.

Legend
* with catalogue number marks bones found in association with the *Anodonta* phase.
Fracture: Cyl., cylinder
Depth/Perim.: D, depth; P, perimeter (as appropriate)
Thickness: W, wall thickness; others are total thickness
Status: N or A, natural or artificial; Prob. A, probably artificial; Artif., artificial alterations
See text for detailed descriptions.

faint longitudinal striae which might represent primary shaping by a stone tool or which might have accompanied the polishing process. The blunt tip of the specimen lies in the cortical wall of the bone as would be required for a functional piercing implement, but the tip has been too extensively damaged by stream abrasion to warrant any detailed conclusion as to its function. I have classified the piece as artificially altered.

Polished Facets and green fractures in different locations

NaVk-5:32 is the distal end of a *Bison* sp. left metacarpal III. A loading point cone, ca. 4.0 mm in diameter, is preserved adjacent to the anterior face, and green fracture margins extend on either side but are truncated distally by post-permineralization fractures. Well preserved hackle marks show that the load was dynamic. Three polished facets occur on the medial trochlea just posterior to the coronal plane. Two of these facets (20.8 X 5.3 mm and 9.0 X 3.4 mm) form one plane at an angle of 65° to the coronal plane and 70° to the sagittal plane. These facets exhibit transverse striae and are floored with compact bone. A third facet (17.4 X 4.7 mm) forms a second plane at angles of 55° to the coronal plane and 40° to the sagittal plane. Striae on this facet are poorly defined, because the facet penetrates cancellous tissue. In order to produce the polish on these facets, the bone had to be stabilized in two different positions. While it is not out of the question that a natural agency created the facets, the occurrence of two adjacent but discrete planes favours the probably artificial classification of this specimen. Perhaps the rather sharp-edged trochlea were seen as suitable scraping edges. This specimen was illustrated as a "hide-working tool" in Canby's (1979:336) discussion, but the polished facets were not mentioned and emphasis was placed on the green fracture (cf. Bonnichsen 1979:132, Pl. VIII-21).

MlVl-1:35 is a large mammal rib polished on one end. Radiating cracks extending from one corner of this specimen point to the location of a loading point, but the latter is not measurable. The long margins of the rib fragment have been broken since permineralization, but the end opposite the loading point was broken when green and is highly polished on both its edge and its fracture surface. The polished end has a convex outline but lacks visible striae. It could have made a useful scraping or rubbing tool and has been classified as artificially modified. The scars referred to as "shaping flake" scars by Bonnichsen (1979:127, Pl. VIII-18) appear to me to be normal irregularities in the fracture surface.

NbVn-1:1 is a left ulna of *Bison* sp. with a complex polished facet on its distal end. The posterior border at the proximal end was removed by green fracture with an impact on the medial face behind the semi-lunar notch. The anterior portion of the olecranon process was removed by a post- permineralization fracture. The distal end of the ulna is formed by a gabled fracture surface as a result of transverse bending when the bone was green. Polish occurs on all high spots of the gabled surface as well as on an approximately triangular darkly stained facet on the medial face and along the posterior border (26 X 21 mm). The main facet has a very complex form, convex with respect to a diagonal ridge and concave transversely, following the natural contour of the medial face. Polishing has sharpened the posterior border and caused it to turn toward the lateral face. No striae are visible, and all changes in shape on the facet are very smooth and gradual. Six pairs of small scratches on the lateral face resemble the tooth marks of small rodents. The very complex form of the polished facet suggests that it was artificially produced, possibly during hide working or fleshing (cf. Bonnichsen 1979:135, Pl. VIII-22).

Polish intersects green fractures

NbV1-2:9 is the distal half of a left humerus from a small Artiodactyl. The bone was fractured in mid-shaft when green, and a polished facet, 7.9 X 5.1 mm, appears on the posterior face where it truncates a portion of the green fracture surface. The facet is flat, and there are no visible striae. The facet could be natural or artificial.

An unidentified large mammal long bone fragment (M1V1-1:104) is polished on the inner surface. All four margins appear to have been fractured when green, but their wall thickness has been reduced by polishing. The entire inner surface has been polished, but no striae are visible. The facets do not form a flat surface but are slightly concave, reflecting the original curvature of the bone wall. The polishing must have been created against a malleable surface, and it seems doubtful that a natural agency could create such extensive polish without flattening the facet. I have classified this piece as artificially modified, and it might have been a hide-rubbing tool (cf. Bonnichsen 1979:137, Pl. VIII-24).

Very complex polishing has occurred on the anterior portion of an *Equus* sp. mandible (NaVk-5:1) in which both canines are preserved (Table B17, Pl. 4.24). Fractures on the left and right mandibular corpus were made when the bone was relatively fresh but possibly somewhat dry, and the polishing of the corpus was done after the fractures had been created. Three polished facets, all darkly stained, occur on this specimen:

1. Two adjacent facets appear on the superior surfaces of the corpus near the fractures at the posterior border.

1a. The anterior facet is comprised of two segments which together form a plane at an angle of 160^{o} to the superior border of the corpus. The two segments are on opposite sides of the midline and are separated by a deep sulcus at the mandibular symphysis. The segment of the left corpus measures 30.4 X 7.6 mm, and the right segment measures 29.0 X 8.3 mm. The two segments share faint transverse striae. A projection of the plane of this facet intersects the two canine teeth ca. 3 mm below their existing tips.

1b. The posterior facet consists of two segments on the right corpus separated by an area lost to later fracture (see below). These two segments form a second plane with an angle of 160^{o} to the anterior facet (1a, above). The anterior and posterior segments measure 11.1 X 7.1 mm and 12.9 X 7.3 mm, respectively. The orientation of their striae is diagonal to the midline of the mandible and runs from posterior right to anterior left. A projection of the plane of this facet would rise well above the canines of the mandible.

2. A completely separate facet was formed on the anterior border of the mandible after all the incisor teeth had been pulled or lost. The alveolar ridges between LI_1/LI_2, LI_1/RI_1, and RI_1/RI_2 were ground to a flat plane which lacks visible striae. More than 3.5 mm of bone on the LI_1/LI_2 ridge has been removed.

After the facets on the corpus had been created, the mandible was chewed near the break by carnivores, and this chewing removed a few small pieces of bone which truncated facet 1b and left some small scars on facet 1a.

In order to produce these three facets, the mandible had to be stabilized in three different positions. Facet 2 could not be produced until the incisor teeth had been removed, and facet 1a was formed in a plane which intersects the canine teeth although the latter were not damaged. The complexity of these factors supports the classification of this specimen as <u>artificially</u> modified. Presumably the facets were formed as a result of a scraping or rubbing function (cf. Harington 1975a:121; Bonnichsen 1979:132, Pl. VIII-21).

M1V1-5:46 is a green fractured, transversely flaked proboscidean long bone core which has already been described (see Tables B8 and B9). Nearly the entire outer surface has been polished, and most of the striae are slightly oblique (nearly transverse). The striae and polish are truncated by the transverse flake scars which supports the view that the bone was artificially polished (cf. Bonnichsen 1979:137, Pl. VIII-24).

M1V1-1:93 is a *Rangifer tarandus* metatarsal shaft fragment for which metrics and flaking attributes have already been provided (Tables B13 and B14). Two very long triangular polished facets occupy the entire outer (lateral) face. Both have transverse striae, and each extends to one end of the specimen. I cannot determine whether the fractures truncated pre-existing polished facets or whether the former occurred before the latter. The two facets form planes at an angle of 170° to one another. Two longitudinal cuts occur just outside the natural sulcus on the anterior surface of the metatarsal, but their detailed attributes have been obscured by secondary rounding of the specimen. The complex combination of flaking, polishing, and cutting processes on this fragment suggests that it was <u>artificially</u> modified, but it is of unknown function (cf. Bonnichsen 1979:137, Pl. VIII-24).

Polish on green fractures

M1V1-3:1 is a *Bison* sp. right radius shaft with two small polished facets. All five margins were fractured when green, and a loading point scar, 25.0 mm in diameter, is preserved on the right margin. Polish occurs on the left edge in two places: a convex area ca. 28.4 X 5.2 mm at the distal end, and on the edge itself, ca. 16.1 X 1.8 mm, at the proximal end. There are no visible striae, and both polished areas could have been produced simultaneously by rubbing on a malleable surface. I cannot determine whether the polish is <u>natural or artificial</u>.

M1V1-7:288 is an unidentified large mammal humerus shaft fragment on which at least two of three margins were fractured when green. One of the green fractured margins is differentially rounded and highly polished, but the polished area exhibits no striae. This alteration could be natural or artificial.

NbV1-1:19 is a left radius(?) shaft fragment of *Equus* sp. Three of the four margins were fractured when green. Polish occurs on a 17.0 X 7.5 mm area at the proximal end, and striae are nearly transverse with respect to the bone wall. The polish could be natural or artificial.

MkV1-9:14 is a left tibia shaft of *Equus* sp., fractured when green at both ends (Table B17, Pl. 4.25). Polished high spots with no visible striae occur on an area 13.0 X 8.6 mm on the medial side of the proximal fracture. Polished facets appear on the posterior (10.2 X 5.9 mm) and anterior (6.0 X 3.3 mm) fracture surfaces at the distal end, and these facets form a single plane at 55° to the long axis; striae are oblique. The occurrence of three facets restricted to green fracture surfaces suggests that the alterations are probably artificial.

M1Vk-1:1.1 is a green-fractured proboscidean long bone (see Tables B1 and B17) with a polished facet on the fracture surface at one end. The facet measures 19.1 X 8.5 mm and is slightly convex with longitudinal striae. In spite of its simple form the presence of a convex facet on a green fracture surface suggests that this modification is probably artificial (cf. Bonnichsen 1979:137, Pl. VIII-23).

M1V1-13:7 is a green-fractured proboscidean long bone (see Tables B8-9, B17) on which the green fracture surface at one end is rounded and polished on all edges. No facets or striae can be seen, and this sort of alteration could result from the use of a sharp edge as a chopper during butchering. I have classified it as an artificially modified bone.

M1V1-1:155 is the proximal 3/4 of an *Equus* sp. left radius. The green bone fracture which divided this bone exhibits short flake scars which nearly encircle its perimeter as if to make the end transverse. A highly polished facet, 12.2 X 14.6 mm, on the outer and fracture surfaces at the medial/posterior corner is highly convex with oblique striae. In addition, all high spots on the fractured end are slightly polished. Superficially, one is impressed by the artificial appearance of these alterations (cf. Bonnichsen 1979:139, Pl. VIII-25, "80-15450"), but the form and placement of the fracture surfaces at the distal end of the shaft are typical of carnivore gnawing. Only the highly polished facet suggests that artificial alterations may be involved in the history of this specimen, and we need to learn whether carnivores can create such polished surfaces through prolonged chewing (possibly with solution effects brought about by saliva). I have classified this polished specimen as either natural or artificial until such information becomes available.

NaVk-5:33 is the proximal half of a right *Equus* sp. radius on which a polished facet, 12.8 X 8.6 mm, occurs on the medial/posterior corner of the green fracture surface and exhibits oblique striae. A loading scar on the medial side of the anterior face is not measureable. The polish on the facet continues over a hinge on the fracture surface and appears on an adjacent high spot. The polish also appears on the outer surface at the loading point where it forms a small convex facet, 7.9 X 4.1 mm, without visible striae. This facet is continuous with the polish on the high spot.

The medial edge of the main facet is crushed only where polish occurs. This specimen is very similar to MlVl-1:155 (above) except for its more extensive flaking at the fractured end, and I find it equally difficult to interpret. All the features could be produced by using the bone as an ax-like chopper or cleaver during butchering (cf. Bonnichsen 1979:134, Pl. VIII-23), but its classification must remain in doubt (natural or artificial) until we learn more about carnivore capabilities.

NaVl-8:1 is the distal half of a *Bison* sp. right metatarsal III. A green fracture forms one long diagonal side,on which two polished facets occur in association with the green fracture surface. The distal one (ca. 22.4 X 13.3 mm) is on the outer bone wall just below the fracture surface and is slightly convex and has caused visible thinning of the bone wall. The proximal facet (ca. 33.0 X 10.4 mm) is on the inner wall of the bone which was exposed by virtue of the spiralling green fracture. These two facets are in slightly different parallel planes, and they could be simultaneously produced only by rubbing on a malleable surface such as a hide. In addition to miscellaneous scratches, the facets share longitudinal striae. Both are truncated posteriorly by a recent fracture surface. Both the outer and green fracture surfaces are etched by rootlets. I have classified this specimen as artificially modified (cf. Bonnichsen 1979:135, Pl. VIII-22).

NaVl-12:1 is an unidentified large mammal long bone fragment on which two of the four margins were formed by green fractures. The green fracture surface at one end is polished, especially on high spots, to a convex facet (ca. 55 X 10 mm) with scattered striae parallel to the long axis of the facet or oblique to both the facet and the bone wall. The facet forms an angle of 130° with the outer wall. Faint transverse scrapes could represent carnivore gnawing but are more regular than most such alterations and may represent artificial scraping. This specimen is unusual for its very light stain (7.5YR5/6). I have classified it as artificially modified because of the convex form and different striae orientations on the facet.

MlVl-1:125 is a right tibia shaft fragment of *Equus* sp. (Table B17, Pl. 4.26). All six margins were fractured when green, and the bone was polished on the outer and fracture surfaces at the distal end with transverse striae on the outer surface. Scattered polish also occurs on other green fracture surfaces, and general polish appears on the outer surface of the proximal third of the specimen and exhibits longitudinal striae. Polish in both the proximal and distal areas is truncated by carnivore gnawing and by rootlet etching. In view of the clear truncation of polish by the carnivore gnawing marks and the longitudinal orientation of the proximal striae, I believe that the polish is probably artificial; after the polishing was created, carnivores gnawed this bone, and rootlets etched it.

NaVk-6:12 is a green-fractured proboscidean long bone (see Tables B2-3, B17) on which fractures and the outer surface converge to a blunt point which is polished on all sides. General polish appears on about 50 mm of the specimen nearest the tip, but no definition of facets or striae is possible due to rootlet etching which has truncated the polished features. I have classified the specimen as artificially modified.

MlVl-1:142 is a green-fractured proboscidean long bone (see Tables B8-9, B17) on which the proximal-right margin is heavily polished on the fracture surface adjacent to a loading point. Both inner and outer edges of the fracture surface are also polished in this area. The polished area measures 40.5 X 20.0 mm and is truncated by a green fracture on the right margin. There are no visible striae, and the polish could have resulted from use of the steep edge for scraping. I have classified it as artificially modified.

MlVl-1:143 is a green-fractured proboscidean bone (see Tables B2-3, B17, Pl. 4.8) with a polished facet on a small (11.6 X 11.0 mm) remnant of the core platform. There are no visible striae, and it was suggested above that this polishing may have been used to strengthen the platform edge. On the right margin, a second platform edge is polished, especially on high spots, where an effort at platform rejuvenation was made. I believe that this polish, as well as the green fractures, is artificial.

Cut and Polished Antler

Antler "Pestle"

NbVl-2:6 is a *Rangifer tarandus* left antler base. Metrics: length, 197, medial-lateral diameter, 27.4; anterior-posterior diameter, 39.9; weight, 228.5 g. The fracture of the beam is probably recent, and breaks at the bases of the brow and bez tines are too poorly preserved to evaluate. Most of the surface of the antler has been lost to recent exfoliation except on the polished base. Five darkly stained polished facets are clearly preserved on the base which measures 35.3 X 32.2 mm overall:

(1) the anterior-most facet, 27.5 X 8.5 mm, is adjacent to the base of the brow tine, lacks visible striae, and forms and angle of 160^{o} with...; (2) a large central facet, 29.5 X 15.3 mm, which occupies half of the basal area with striae oriented diagonally from anterio-medial to posterior-lateral and forms an angle of 165^{o} with...; (3) a posterior-medial facet, 20.3 X 8.0 mm, with nearly transverse (slightly diagonal) striae, forming an angle of 175^{o} with...; (4) a posterior-lateral facet, 11.1 X 16.7 mm, with frankly transverse striae, forming an angle of 170^{o} with the central facet; (5) a lateral convex facet, 27.1 X 6.1 mm, rounds the lateral edge and lacks visible striae.

Antler billet

NbVl-2:15 is a right antler base of *Rangifer tarandus* with a section of the beam and a large portion of the bez tine preserved (Pl. 4.27; Morlan 1978a:Fig. 6). Metrics: Length of beam, 182; medial-lateral width, 24.0; anterior-posterior depth, 36.2; length of bez tine ca. 185; weight, 199.8 g. The distal end of the beam may have been fractured when fresh, but it is too poorly preserved to be certain. The bez tine terminates in a relatively recent break. Cuts occur in four locations:

(1) the brow tine was cut off by means of three major chop-like cuts; (2) the burr was trimmed off with many discrete cuts which have since been obscured by pocking of the base; (3) the bez tine is cut and polished on two

Table B18. Attributes of *Rangifer tarandus* antler wedges found on the banks of the Porcupine River, northern Yukon Territory.

Cat. No.	Length	Width	Depth	Weight	Length of Bevel	Angle of Bevel	Longest Flake Scar	Polish
MiVl-1:1	203	28.2	38.4	130.8	88.0	25^{o}	19.6	Obscured by pitting
MjVj-6:1	248	29.0	36.7	156.7	66.8	25^{o}	19.1	Obscured by exfoliation
MjVl-1:26c	190	32.1	39.5	140.1	121.6	30^{o}	76.4	Well preserved

Table B19. Attributes of cut bones found in reworked deposits in the Old Crow valley, northern Yukon Territory.

Cat. No.	Frac.	Length	Width	Depth	Thickness	Weight	Element	Status
MkVl-12:16	O/y	137	9.6	10.5		11.6	*Anser albifrons* L. humerus	Artif.
MlVl-5:56	O/y	107	7.6	6.5		4.4	*Anser albifrons* R. tibiotarsus	Artif.
MlVl-1:64	Cyl.	141	29.5	22.2	W4.9-6.9	65.5	*Rangifer tarandus* R. tibia	Artif.
*NbVl-2:12	O/y	55	60		17.1	37.2	Large mammal innominate frag.	Artif.
MlVl-1:1c	Cyl.	247	20.4	18.7	W2.8-4.1	(cast)	*Rangifer tarandus* L. tibia	Artif.

Legend
Fracture: Cyl., cylinder
Thickness: W, wall thickness; other, overall thickness
Status: Artif., artificial alteration
* with catalogue number means bone was found in association with the *Anodonta* phase.

See text for detailed descriptions.

darkly stained glossy facets on the medial-inferior border ca. 65 mm from the beam. Longitudinal striae are visible on these facets, and each facet measures ca. 41 X 6 mm. These facets may have resulted from the removal of a supernumery tine; (4) most of the superior edge and the distal 54 mm of the inferior edge of the bez tine are roughened by nicking and polishing.

Antler wedges (Table B18)

MiVl-1:1 is modified by pitting on its entire outer surface, so that the slight amount of polish now visible must be regarded as secondary although it is concentrated mainly at the ends. It is impossible to say how the bevel was formed, but it was not ground flat. Most of the bevel forms a plane which would have positioned the working edge at the edge of the cancellous tissue in the center of the beam, so the plane was altered to create the working edge within the compact wall. At the butt, the outer wall is locally bevelled, possibly as a result of the original groove which was made to snap the beam. The inner walls of the butt are regularly bevelled toward the center of the cancellous tissue, and the cancellous tissue is gouged out through the entire length of the specimen. This wedge may have been fitted with a shock absorbing plug of wood or bone in order to preclude serious damage to the butt. One major and several minor incipient flake scars are visible on the butt which also exhibits a heavily crushed area.

MjVj-6:1 has lost much of its outer surface to exfoliation, but local areas with tool marks and polish are preserved, especially at each end. Much of the antler face above the bevel was removed by a groove-and-splinter technique, and remnants of the grooves are visible on both sides. The splinter was apparently levered out with some sort of punch which left two flake scars on each groove wall. The resulting opening measures approximately 123 X 19 mm. Apparently the bevel was cut after the splinter was removed, and the bevelling tool was operated obliquely across the end of the antler beam with the result that the bevel is 13 mm longer on one side than on the other. The antler is locally bevelled outward to place the cutting edge of the wedge within the compact wall. The butt preserves a bevel on the outer wall which resulted from circumscribing the antler so as to snap the beam. A very slight inward bevel is locally evident, and cancellous tissue in the center has been hollowed out to a depth of 35.5 mm. Two major and several minor flake scars are present around the butt, and one which terminated in a sharp hinge may have fractured within a collar designed to hold a shock absorber in place. Tool marks in several local areas on the outer surface show that the cutting teeth on the shaping tool were evenly spaced, perfectly parallel, and 0.5 mm apart. These marks suggest that a metal file was used to shape this wedge.

MjVl-1:26c has a well preserved outer surface on which polish is restricted to the working edge, the bevel, and the outer surface opposite the bevel but near the working edge. This polish is so intensive that tool marks have been locally obliterated. The two compact walls which converge to form the bevel were separately scraped to their final form. These walls and the outer surface near the tip exhibit numerous tool marks as if the antler were shaped by a stone scraper. Chatter marks indicating the loss of purchase during cutting are abundant on this wedge. Tool marks are also preserved locally around a portion of the butt and show that the antler was grooved for transverse snapping, but most such marks are obscured by subsequent crushing of the butt. Half of the butt has been removed by heavy pounding which detached five flakes from the side on which the bevel occurs. The roughening of the outer surface seen near the butt may be scarfing for the positioning of a collar which held a shock absorber in place, but there is no well defined inward bevel for the insertion of a plug. The tip of the working edge is crushed as if by heavy use, and rootlet etching is visible on a portion of the outer surface, on cut surfaces, and on the flake scars near the butt. This wedge was found on the gravel beach below the late prehistoric Klo-kut site (MjVl-1; Morlan 1973), but the antler is better preserved than any found in place in the site excavations.

Cut Bones

Selected attributes of five cut bones are presented in Table B19, and more detailed descriptions will be given for each piece. All of them are <u>artificially</u> modified. Measurements of cut width, depth, and wall angle were made with the aid of an eyepiece reticule and goniometer on the microscope.

MkVl-12:16 is the left humerus of a white-fronted goose on which cuts occur in two major locations (Table B19, Pl. 4.28). Two separate strokes of a cutting tool converged to make a single cut 3.1 mm long and 0.62 mm wide on the anterior edge 4.8 mm above the distal end of the bone. The cut walls form an angle of 46° where they converge. The main cut has a U-shaped cross-section and is approximately 0.31 mm deep. In addition there are four oblique cuts on the posterior/medial corner of the shaft approximately 19.5 mm from the distal end. These are very shallow, have U-shaped cross-sections, are about 2.5 mm long, and measure <0.16 mm in width and depth. This bone is very darkly stained (2.5YR2/2). All these cuts are typical of those seen on bird bones in recent archaeological sites where they are supposed to have resulted from butchering.

MlVl-5:56 is a right tibiotarsus, probably from a white-fronted goose, and its distal condyles are cut transversely (Table B19, Pl. 4.28). These cuts are not precisely aligned with one another but could have resulted from a single slice intended to separate the tarsometatarsus from the "drumstick." The cuts appear on the distal-posterior corners of the condyles, are 3.6 mm long on the medial condyle and 2.0 mm long on the lateral one. Width and depth measure 0.62 mm and 0.31 mm on the medial condyle and 0.78 mm and 0.16 mm on the lateral condyle, respectively. In both cases the cross-section is a broad V-shape, and the cut walls form angles of 27°. This bone has a relatively light red-brown stain (5YR3/4). These cuts are undoubtedly related to butchering with a very sharp tool such as an unmodified stone flake.

MlVl-1:64 is the right tibia shaft of a caribou and is so lightly stained (5YR4/6) that one must suspect a Holocene age for the specimen. Four transverse cuts are present of the anterior face, and one is truncated by a green bone fracture at the proximal end of the specimen. The cuts range from 8.0 to 10.5 mm in length, up to 0.31 mm in width, and up to 0.16 mm in depth with V-shaped cross-sections and wall angles of 45^{o}-55^{o}. The cuts are sufficiently narrow in relation to their depth that they might have been made with a metal blade, but the possibility cannot be eliminated that they were made with stone.

NbV1-2:12 is an unidentified large mammal innominate fragment on which five subparallel cuts appear on the outer surface, oriented generally parallel to the long axis of the ilium (Table B19, Pl. 4.29). All the cuts are truncated by post-permineralization fractures, and their visible lengths range from 9.3 to 31.0 mm. The two longest cuts converge on the specimen, but the others remain independent of one another. The cuts are 0.16-0.62 mm wide and up to 0.31 mm deep. They have U-shaped cross-sections and wall angles of 30^{o}-40^{o}. I do not know of a specific butchering task which might be represented by these cuts, but they could be produced either during butchering or in connection with the preparation of a bone for tool manufacture. This bone fragment is darkly stained (5YR3/2) and was found in association with the *Anodonta* phase.

MlV1-1:1c is the famous flesher (Irving and Harington 1973) which was made on the left tibia of a caribou (Table B19, Pl. 4.30). The manufacture of this specimen was initiated by fracturing the proximal end of the bone, probably with an impact on the anterior crest of the tibia. This fracture created a bevelled area approximately 47 mm long which was smoothed and shaped on both the anterior and posterior bone walls by whittling with a stone tool. At least four discrete cut facets were left on the anterior wall and at least two facets appear on the posterior walls, and these are 0.8-2.7 mm wide with gently undulating surfaces. There are no transverse chatter marks which would indicate a loss of purchase by the cutting edge, and it is possible that the bone was softened in order to accomplish such expert cutting. The working edge was shaped to a convex outline and finally equipped with a series of delicate denticulations. The denticulations range from 1.4 mm apart at the edges of the row to 2.0 mm apart in the center, and they were formed by cutting 1.5 mm deep V-shaped notches in the end of the bone. Such notches might have been cut into a softened bone by means of a sharp stone flake or a saw made of twisted sinew. Eight denticulations are preserved on the specimen, and a broken area of the edge may have accommodated an additional four or five. The resulting serrated cutting edge was 26 mm wide.

APPENDIX C. DESCRIPTIVE MATERIAL FOR EXCAVATED BONES FROM M1V1-2

Introduction

In this appendix I have assembled descriptions and discussions of excavated specimens from M1V1-2 to support the more general discussion in Chapter 6. The same section headings which appear in Chapter 6 have been used here to show the relationship between these two bodies of text, but only those sections which require individual specimen description are included in this appendix.

Bone Flaking: "Cores"

These chipped and flaked pieces are presented with respect to green fracture attributes in Table C1 with their flaking attributes appearing in Table C2.

M1V1-2:88-1 could be regarded as a "bifacially" flaked bone fragment since the flaked edge is crushed on one face and flaked on the opposie face (Pl. 6.3). This specimen could be either natural or artificial.

M1V1-2:97-4 is a "burinated" rib fragment with two transverse "cuts" just below the distal termination of the longest flake scar (Pl. 6.3). The "cuts" are not clearly the result of stone tool work, nor were they clearly produced by carnivore gnawing. Four very faint darkly stained lines are visible on the outer face of the bone, and these probably resulted from differential staining of "bruised" areas on the bone surface where carnivore teeth raked across the bone without leaving the usual scrape marks clearly defined. Since the "cuts" may also have been produced by carnivore chewing and since the flake scars could have been made by the chipping back of the bone often seen on chewed specimens, this piece was probably naturally modified.

M1V1-2:4-1 exhibits a single flake scar which could easily be produced by carnivore gnawing, and it is probably naturally modified (Pl. 6.4). The same is true of M1V1-2:49-1 on which differential staining also occurs (Pl. 6.5).

M1V1-2:66-5 is distinctive in that its entire remaining outer surface is highly polished with small bundles of lineal striae lying in transverse and oblique orientations. This polished area is truncated at both ends by longitudinal flake scars, and I do not know how to explain this combination of features (Pl. 6.5). Whereas I am sure that carnivores could have produced the flake scars, I am less certain that they could be responsible for the polish, so I have classified these modifications as either natural or artificial.

M1V1-2:15 is modified in several ways and is the largest of the "cores" from Disconformity A at M1V1-2 (Pl. 6.4). One end of the specimen exhibits two adjacent loading points. One of these points preserves a small cone in the bone wall and resulted from a load with a contact area of about

7.8 mm diameter. The adjacent point is a scar with a diameter of 7 mm, and the fracture surfaces at this end of the bone were propogated from this scar. The centres of these two loading points are 7.3 mm apart. At the opposite end of the bone is a third loading point which is preserved as a scar and which resulted from a contact area of >8.3 mm. Fractures were propogated in both directions from this point, and they intersect the fracture surfaces produced by loading the other end of the bone. Prior to the loading of the third point, a large flake was detached in a transverse direction from the outer surface of the bone, and the resulting scar was truncated by the final fracture so that a remnant 10.0 X 30.7 mm now remains on the specimen and reveals a feathered distal termination. The last modification occurred along the opposite edge of the specimen where a longitudinal flake was detached as indicated in Table C2. This flake may have been detached after the bone had become somewhat dessicated, because the scar exhibits a slightly darker stain than the outer surface of the bone and a series of small side-wise steps along the edge of the scar may have resulted from displacements of the fracture front by split line features which had already formed in the bone wall. While it is not entirely out of the question that a large carnivore could produce these modifications, the apparently massive impacts required to produce the fractures on this specimen (probably a large *Bison* sp. humerus) suggest that the fracturing and the flaking of this bone was done by man. I have classified the piece as a probable artifact. This was the first indication of a possible archaeological record seen on Disconformity A, and the specimen has been illustrated elsewhere (Morlan 1978a:Fig 7; 1979a:Figs. 4-5).

The transverse flaking on all three remaining pieces (MlVl-2:47-2, 61-2, and 75-6) could readily be accomplished by carnivores while the small sizes of the specimens would seem to make them quite difficult to manipulate in the human hand (Pl. 6.5). They have been classified as probably natural.

Bones with Reduced and Incised Surfaces

Metric and non-metric data are presented for three scratched, three scraped, and 15 polished bones from MlVl-2 in Table C3.

Scratched Bones

Disconformity A

MlVl-2:4-9 exhibits hundreds of very fine scratches, most of which cannot be seen without magnification and many of which are truncated by post-permineralization fractures (Pl. 6.9). The scratches tend to occur in groups with highly variable orientations most of which are at angles from 10° to 45° with respect to the long axis of the rib fragment. Most of the scratches are straight and approximately 10-15 mm long, but a few of the longer scratches are gently curved. The scratches cross-cut one another in myriad ways, and I have not been able to decipher a pattern in their sequence of production. There are also many longitudinal scrapes which resemble those which can be readily produced on bone with a stone tool. Both the scrapes and the scratches appear to have been made before the bone was permineralized since their floors are evenly stained in comparison with

Table C1. Green fracture attributes for large mammal bone "cores" from MlVl-2, Disconformity A, Old Crow River, northern Yukon Territory.

Frac.	Cat. No.	Length	Chord	Perim.	Weight	Wall Thickness	Other
Longitudinally flaked "cores":							
1/5	MlVl-2:88-1	(31)	(27)	(27)	5.2	6.1-6.3	Probably proboscidean long bone fragment
2/4	97-4	(33)	(25)	(28)	5.9	2.8-6.3	"Cut"; large mammal rib fragment
4/4	4-1	35	21	21	4.8	7.4-7.9	Etched on fracture; long bone fragment
4/4	49-1	43	28	35	8.7	4.7-7.2	Differential staining; long bone fragment
4/4	66-5	20	11	11	0.8	5.3	Polished; long bone fragment
6/6	15	76	63	88	60.6	4.9-14.0	cf. *Bison* sp. humerus fragment; 3 loading points (see text)
Transversely flaked "cores":							
1/4	MlVl-2:47-2	(24)	(9)	(9)	1.4	5.7-6.8	Long bone fragment
2/4	61-2	28	(10)	(10)	1.5	3.3-3.7	Etched on fracture; long bone fragment
4/4	75-6	15	7	9	0.2	1.5-2.8	Rib fragment

Table C2. Flaking attributes of large mammal bone "cores" from M1V1-2, Disconformity A, Old Crow River, northern Yukon Territory.

Longitudinally flaked "cores":

Cat. No.	Scar Location: Perim.	Scar Location: Circumf.	No. of Scars	Max. Length	Max. Width	Dist. Termin.	Platform	Plat. Angle
M1V1-2:88-1	End	Outer	2	8.4 3.1	16.5 6.0	Hinge Hinge	Crushed area on inner surface	75°
97-4	Right	Outer	1/3	11.0	4.7	4 Hinges	Unmodified green frac. surface	90°
4-1	Left	Fracture	1	15.9	4.8	Hinge	Removed by green fracture	NM
49-1	Left	Outer/ Fracture	1	11.4	10.0	Hinge	Unmodified green frac. surface	90°
66-5	Prox.	Outer	1/1	5.0	3.1	Feather	Unmodified green frac. surface	60°
	Dist.	Outer	1	6.0	7.4	Hinge	Removed by green fracture	NM
15	Left	Outer/ Fracture	1	55.2	18.1	Feather	Removed by green fracture	NM

Transversely flaked "cores":

Cat. No.	Scar Location	Force Direction	No. of Scars	Max. Length	Max. Width	Dist. Termin.	Platform	Plat. Angle
M1V1-2:47-2	End	Rt. to Lf.	1	7.3	6.2	Hinge	Removed by recent fracture	NM
61-2	Left	In. to Ou.	2	4.6 3.8	10.5 7.3	Feather Feather	Unmodified inner wall	55°-60°
75-6	Right	In. to Ou.	1	3.0	5.8	Feather	Unmodified green frac. surface	75°

the rest of the bone. A low gloss associated with the slight rounding of the specimen has not been heightened even locally by the scratching and scraping, and the gloss was probably acquired by the specimen during fluvial redeposition. I have classified this specimen as a probable artifact because of the complexity of these features, and it is quite similar in the form and distribution of its alterations to a horse metatarsal found in redeposited sediments at NbVm-1 (see Appendix B; Pl. 4.21).

MlVl-2:75-9 exhibits scratches nearly identical to those seen on MlVl-2:4-9, but the scratching is less intensive on the former than on the latter (Pl. 6.9). The scratches lie in many orientations, are truncated by post-permineralization fractures on all sides of the bone, and they cross-cut the joints formed by the reconstruction of this specimen from three pieces found separately on Disconformity A. There is a very slight tendency for polished patches to appear in association with some of the bundles of scratches, but the bone is generally not polished except for the low gloss which accompanies slight rounding. No longitudinal scrapes have been seen on this long bone fragment, but the scratches were probably produced in the same manner as those on MlVl-2:4-9; therefore I have classified the specimen as a probable artifact.

MlVl-2:115-17 is less heavily scratched than the two specimens described above. Two main bundles of scratches are oriented transversely and obliquely with respect to the long axis of the bone. None of the three green-fractured margins of the specimen clearly truncates the scratches. Since this specimen would seem to require stabilization in only two orientations in order to produce the scratches, it does not stretch the imagination greatly to imagine that fluvial processes might have produced these features. On the other hand, the scratches might have resulted from an artificial use of the specimen as suspected for the bones described above. Hence I have classified the piece as either natural or artificial.

Scraped Bones

Disconformity A

MlVl-2:17-7 is intensively scraped and polished on its outer surfaces (Pl. 6.10). One side of this rib fragment is much less deeply stained than the other side (10YR5/3 vs. 7.5YR3/2), and one might suppose that the difference reflects the orientation of the bone in its primary burial environment. The light-stained side, however, exhibits two small areas of scraping and polishing, and these areas are as darkly stained as the other side of the rib. The dark-stained side of the rib is covered with scrape marks and prominent polishing so that the staining appears to be related to these alterations of the bone. The scrape marks vary from straight to wavy and lie in many different orientations although most of them are generally sub-parallel to the long axis of the rib. Another noteworthy feature of this specimen is the intensive polishing of one edge of the rib in marked contrast to the other edge which is not polished at all. This combination of attributes might have resulted from use of the rib as a cutting and rubbing implement, and I can think of no natural agency which would produce such differential modification of the bone. Therefore I have classified the alterations as

Table C3. Attributes of scratched, scraped, and polished bones from MlVl-2, Old Crow River, northern Yukon Territory. Thickness was measures at the edges of green-fractured bone walls and through the total cross-section of other specimens. All specimens are from Disconformity A except 144-21. 144-22, and 167-8 which were recovered from the mid-section deposit.

Cat. No.	Length	Chord	Perim.	Thickness	Weight	Frac.	Element	Location of Alteration	Status
Scratched bones									
MlVl-2:4-9	(109)	(24)	(30)	4.3	17.8	0/y	Rib	Outer	Prob. Artificial
75-9	(109)	(22)	(34)	5.4	22.0	0/y	Long bone	Outer	Prob. artificial
115-17	29	(14)	(14)	4.6-5.1	2.7	3/4	Long bone	Outer	Nat. or artif.
Scraped bones									
17-7	(93)	32	NA	7.1	11.8	0/y	Rib	Outer	Prob. artificial
71-14	48	(15)	(15)	8.4-11.6	7.1	2/4	Long bone	Outer	Nat. or artif.
107-9	23	12	12	1.5-2.5	0.6	5/5	Long bone	Outer	Nat. or artif.
Polished bones not fractured when green									
16-3	(16)	(11)	(11)	3.3	0.5	0/y	Long bone	Outer & Frac.	Prob. natural
27-6	(27)	(15)	(15)	15.4	5.7	0/y	Long bone	Outer	Nat. or artif.
61-45	(16)	(11)	(11)	4.9	0.7	0/y	Long bone	Outer	Nat. or artif.
83-2	(19)	(7)	(7)	7.3	0.6	0/y?	Long bone	Fracture	Prob. natural
91-1	(50)	(15)	(25)	9.7	6.1	0/y	Rib	Inner	Nat. or artif.
Polish intersecting green fracture									
9-3	(26)	(19)	(19)	9.8	3.6	1/4	Long bone	Outer	Prob. natural
39-21	(9)	(4)	(4)	4.1	0.1	1/4	Long bone	Outer	Nat. or artif.
66-5	(see Tables C1-C2)							Outer	Nat. or artif.
105-12	(35)	(23)	(23)	3.7-4.5	3.5	1/5	Rib	Outer	Nat. or artif.
Polish separated from green fracture									
167-8	(78)	(25)	(30)	7.6-9.5	26.2	1/4	Long bone	Outer & Frac.	Prob. natural
Polish on green fracture									
35-10	(18)	(8)	(8)	3.5-3.9	0.7	2/4	Rib	Fracture	Nat. or artif.
105-9	(see Table 6.16)							Fracture	Artificial
105-11	(see Table 6.16)							Fracture	Artificial
144-21	(80)	(20)	(50)	6.3-8.3	19.9	2/4	Rib	Fracture	Prob. artificial
144-22	(56)	35	40	6.9-8.3	19.2	3/4	Long bone	Fracture	Prob. natural

probably artificial.

M1V1-2:71-14 has been scraped diagonally and polished in association with the green fracture margin at one end, and the scrape marks appear to have been truncated by the adjacent post-permineralization fracture of the side (Pl.6.11). The polishing forms a contrast with the general low gloss produced by slight rounding of the bone. Such a scraped and polished corner could have resulted from use of the bone as a rubbing tool but these alterations might also result from intensive carnivore gnawing on an exposed end. The scrape marks are not closely parallel to one another and appear to have resulted from a process which could alter the orientation of the bone during the production of the features. Either man or carnivore could accomplish this, and I have classified the specimen as either natural or artificial.

The outer surface of M1V1-2:107-9 is heavily scraped and polished with the scrape marks lying in a diagonal orientation to the long axis of the original bone. The scrape and polish features are truncated on all sides by the green bone fractures, implying that a large piece of bone was employed by man in some kind of rubbing function or that a carnivore gnawed and fractured a larger piece of bone. I have classified this specimen as either natural or artificial.

Polished Bones Not Fractured When Green

Disconformity A

The alterations on M1V1-2:16-3 are probably natural. Darkly stained polish on the outer surface of the fragment extends around the broken edge onto a post-permineralization fracture, showing that some natural agency must be capable of producing this kind of polish. Perhaps partial burial and differential exposure to fluvial processes could explain these features. Another possibility is that a carnivore gnawed this bone after dessication was sufficiently advanced to produce the non-green fracture attributes on which the polish occurs.

M1V1-2:27-6 is highly polished on all remaining portions of its original outer surface (Pl. 6.11). The polished facet is truncated on all sides by post-permineralization fractures, but the polish does not extend onto the fracture surfaces. The thickness of this specimen suggests that it was derived from a proboscidean long bone. I have classified it as either natural or artificial.

M1V1-2:61-45 is intensively scraped and polished with the scrapes being oriented parallel to the long axis of the original bone. Along one edge of the piece is a second set of striations, much finer than the scrape marks and more difficult to see without magnification, and these are oriented perpendicular to the long axis of the bone and are associated with a higher degree of polishing than the rest of the outer surface. The fragment is too small to identify a function or cause of alteration, but the altering agency had to be capable of securing the bone in two orientations which were perpendicular to one another. Either man or carnivore could readily accomplish this, and I have classified the piece as either natural or artificial (Pl. 6.12).

M1V1-2:83-2 is highly polished on a fracture surface which forms one long margin of the specimen. The other margins were fractured after permineraliation, but the polished facet obscures the fracture attributes of the altered surface (hence the question mark adjacent to "O/y" in Table C3). The alterations could be natural or artificial.

M1V1-2:91-1 exhibits a peculiar scratched and polished concavity near one end, and this concavity is located on the inner (cancellous) surface of the rib fragment (Pl. 6.11). It forms a groove 7 mm wide and 1 mm deep with a long axis about 30° to the long axis of the rib. This groove is highly polished, and numerous scratches parallel to the axis of the groove are visible under magnification. The ends and one side of the groove are truncated by post-permineralization fractures. Perhaps carnivore gnawing and an artificial rubbing function on hides or on wood are valid candidates for the origin of these features. I have classified the alterations as either natural or artificial.

Polish Intersecting Green Fractures

Disconformity A

M1V1-2:9-3 is polished on the outer surface to form a facet which has a higher gloss than that conferred by the slight rounding which generally characterizes the specimen. Associated with the polish are both transverse and oblique scratches and the facet is interrupted by a deeply scraped area which resembles carnivore gnawing damage. These alterations are probably natural, although I have not seen a demonstration of this kind of polish and fine scratching on bones gnawed by carnivores.

The tiny fragment labelled M1V1-2:39-21 is very highly polished on all remaining portions of its outer surface. The polish is truncated by green bone fractures at both ends and by post-permineralization fractures on the two sides. It is too small to interpret and could be either natural or artificial.

M1V1-2:66-5 is both flaked and polished and was described as a "core" (Tables C1-C2) on which the flaking, if not the polishing, could have been done by carnivores. The polishing might be either natural or artificial.

M1V1-2:105-12 exhibits a highly polished facet ca. 2 mm wide adjacent to the only margin of the specimen which was fractured when green (Pl. 6.11). The facet is truncated by the adjoining post-permineralization fractures. The polishing has been intensive enough to flatten the natural contour of the outer surface, and very faint lineal striae are visible under high magnification with an orientation oblique to the long axis of the rib fragment. There is no sign of carnivore gnawing, but either fluvial processes or artificial use of the rib could have produced this polished facet when the bone was fresh; hence it is either natural or artificial.

Polish Separated from Green Fracture Surface

Mid-section

One end of M1V1-2:167-8 exhibits scattered polish on the edge between the outer surface and a post-permineralization fracture. Short, faint, oblique lineal striae extend from the polished facets onto the outer surface of the bone. Such features might be produced in a fluvial environment if the bone were stabilized in one appropriate position and were subjected to moving sand and silt particles or pieces of ice; the alterations are probably natural.

Polish on Green Fracture Surfaces

Disconformity A

M1V1-2:35-10 was fractured when green on one end and one side, and at the intersection of these green fractures is a highly polished facet which occurs on the fracture surface but does not extend onto the outer surface of the bone. Fluvial action, carnivore gnawing, or human use might explain this feature, but in any case the dark stain on the facet suggests that the polish was acquired either naturally or artificially when the bone was fresh.

Two of the green-fractured proboscidean bones from Disconformity A (105-9 and 105-11) each exhibits a differentially polished edge at the intersection of the outer and green fracture surfaces (Pl. 6.2). Although there might be a natural means of producing such polish, I suspect (partly on the basis of comparison with experimentally induced polish) that these edges were used by man in some sort of cutting or scraping function; they have been classified as artificially modified.

Mid-section

M1V1-2:144-21 is even more intensively polished on its edges where two green fractured margins converge to form a blunt point. The polish has advanced enough to alter the shape of the point so that the fractured margin is evenly rounded with the polish ext ding onto the outer surface of the bone. The extent of polish decreases away from this point suggesting that it was the shape of the end of the specimen which was significant in some sort of polishing process. This polishing process must have brought the bone into contact with a malleable surface such as a hide in order to create the complex convex facet seen on the bone. I have classified the alteration as probably artificial.

M1V1-2:144-22 exhibits a slight amount of polish on high spots which occur on a ragged green fracture surface. A deep short scrape on the outer surface of the bone suggests carnivore gnawing in direct association with the green fracture surface, and such gnawing might have produced the local polish as well as the fracture on which it occurs. I have classified the piece as probably natural.

Cut Bones

Disconformity A

MlVl-2:25-3 is a triangular large mammal rib fragment which was fractured when green on one margin. A straight cut 10.0 mm long penetrates the outer lamellae of the bone and appears to have influenced the position and form of the green fracture. It is truncated at both ends by post-permineralization fractures. Two tiny discontinuous grooves form the surviving wall of the cut, and such grooving is typical of cuts made with stone tools. I suspect that the cut was an accidental butchering scar rather than a deliberate groove designed to guide the fracture of the bone, but in either case it is artificial.

MlVl-2:27-1 is the anterior half of a *Bison* sp. olecranon process from the left ulna. It exhibits a complex cut pattern on its anterior border (Pl. 6.13). This pattern is clearly formed by cutting in that bone material has been removed along the grooves. The variable groove width seen in rootlet etching is not characteristic of this alteration, and the removal of bone shows that the grooves were not formed by cracking. Local discontinuities and changes in the cross-section of the grooves are typical of cuts made with a stone tool, and both are seen on this specimen. Stone tool cutting also yields a slight deepening of the groove at convex areas and a slight shallowing at concave areas of the surface being cut, and both effects are visible on this specimen. Dr. George Swinton, Professor of Art History, Carleton Univerisy, believes that this sort of cutting on bone is typical of prehistoric artistic expression; I believe that at the very least the cutting is artificial.

MlVl-2:61-3 is a metatarsal shaft fragment of an unidentified large mammal on which a portion of the anterior sulcus has been preserved. In this sulcus are two separate cuts which together form a nearly straight line ca. 20 mm long (Pl. 6.14). The cuts are truncated by a post-permineralization fracture at one end but do not extend as far as the other end of the specimen. One cut is locally truncated in the middle of the specimen by small exfoliation features, indicating that weathering of the bone continued after the cut was made. I suggest that these alterations are butchering marks made with a stone tool, and they are classified as artificial.

Mid-section

MlVl-2:132-8, from the mid-section deposit, is a left radius shaft fragment of *Lepus arcticus* which exhibits an oblique cut on its posterior-lateral border (Pl. 6.15). This cut removed an area of bone ca. 1.5 X 1.0 mm. It is probably a butchering scar made by a stone tool, and the alteration has been classified as artificial.

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Postscript

Only a few days after this monograph was completed, I received a copy of the oft-cited and long-awaited *Fossils in the Making: Vertebrate Taphonomy and Paleoecology*, edited by Anna K. Behrensmeyer and Andrew P. Hill (University of Chicago Press, 1980). The paper by Klein (cited above as 1976a) had been available to me in the form of a preprint and is now published as a chapter of this volume, but many other papers in this important book should also be consulted by readers who are interest in the many aspects of taphonomic analysis.

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Each component of the National Museum of Man, (the History and Communications Divisions, the Canadian Ethnology Service, the Archaeological Survey of Canada, the Canadian Centre for Folk Culture Studies and the Canadian War Museum), provides papers for publication in the Mercury Series. These are available from the following address on receipt of a cheque made payable to the Receiver General of Canada.

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No. 1 "An Archaeological Survey between Cape Parry and Cambridge Bay, NWT, Canada in 1963" by William E. Taylor, Jr., 106 p., 15 plates, 24 figures. $2.00

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No. 2 "The Aberdeen Site, Keewatin District, NWT" by J.V. Wright. 98 p., 7 plates, 3 figures, 7 tables. $1.75

Examination of multi-component caribou crossing site on the Thelon River Keewatin District.

No. 3 "The Cadzow Lake Site, (MjVi-1): A Multi-Component Historic Kutchin Camp" by Richard E. Morlan. 91 p., 5 plates, 17 figures. $1.50

Description and analysis of artifacts and fauna in three historic components of a stratified site on the Porcupine River, Yukon Territory.

No. 4 "The Knetchel I Site, Bruce County, Ontario" by J.V. Wright. 70 p., 6 plates. 6 figures, 10 tables. $1.00

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Description and analysis of artifacts, fauna and features in a smaller summer season occupation.

1973

No. 6 "Archaeology of the Lake Harbour District, Baffin Island" by Moreau S. Maxwell. 362 p., 72 figures, 36 tables. $4.00

Examination of a number of Pre-Dorset and Dorset sites ranging from 2500 B.C. to A.D. 480. Little cultural change is seen within the transition from Pre-Dorset to Dorset.

No. 7 "A Technological Approach to Lithic Artifacts from Yukon Territory" by Richard E. Morlan. 44 p., 21 figures, 1 table. $1.00

A list of 26 categories for the descriptive presentation of the morphological and technological attributes of stone artifacts from Yukon Territory.

No. 8 "The Roebuck Prehistoric Village Site Rim Sherds An Attribute Analysis" by James F. Pendergast. 59 p., 6 figures, 14 tables. $1.00

An attribute analysis of the rim sherds from the Roebuck St. Lawrence Irquois site in south-eastern Ontario.

No. 9 "Haida Burial Practices: Three Archaeological Examples: The Gust Island Burial Shelter, The Skungo Cave North Island, Mass Burials from Tanu" by George F. MacDonald and "The Gust Island Burial Shelter: Physical Anthropology" by Jerome S. Cybulski. 113 p., 32 plates, 2 figures, 10 tables. $2.00

Part I is an analysis of Haida mortuary practices using data from historical sources and from three excavated burial locations. Part II is the osteological analysis of one of these sites - The Gust Island Burial Shelter, Queen Charlotte Islands, B.C.

No. 10 "Archaeological Survey of Canada: Annual Review 1972" edited by George F. MacDonald. 46 p. on request.

No. 11 "The Later Prehistory of the Middle Porcupine Drainage, Northern Yukon Territory" by Richard E. Morlan. 583 p., 24 plates, 46 figures, 81 tables. $5.50

Description and analysis of artifacts and faunal remains from the Klo-kut site. Other sites in the middle porcupine drainage, northern Yukon Territory, are also mentioned in an attempt to reconstruct the subsistence economy, annual cycle, and settlement patterns of the late prehistoric Kutchin Indians.

No. 12 "Cow Point: An Archaic Cemetery in New Brunswick" by David Sanger. 214 p., 20 plates, 6 figures, 29 tables, 11 histograms. $2.75

A detailed description and analysis of an Archaic cemetery near Grand Lake, New Brunswick.

No. 13 "Archaeological Investigations in the Hecate Strait - Milbanke Sound area of British Columbia" by Bjorn O. Simonsen. 117 p., 23 figures, 1 table. $1.75

Results of archaeological investigations in 1969 in the Hecate Strait - Milbanke Sound area of British Columbia including the excavation report for FcTe-4, a site occupied continuously for 3500 years.

No. 14 "The Archaeology and Prehistory of Southern Alberta as Reflected by Ceramics" by William J. Byrne. Three volumes, 729 p., 27 plates, 42 figures, 28 tables. $8.50

This three volume monograph contains a detailed review of the aboriginal ceramics of southern Alberta, as well as an interpretation of late prehistoric, protohistoric and ethnohistoric developments on the Canadian plains as reflected by an analysis of these ceramics.

<u>1974</u>

No. 15 "Archaeological Salvage Projects 1972" compiled by W.J. Byrne. 174 p. $2.25

This report contains brief summaries of the archaeological salvage projects undertaken by the Salvage Section, Archaeological Survey of Canada, in the summer of 1972.

No. 16 "Faunal Remains from the Nodwell Site (BcHi-3) and from Four Other Sites in Bruce County, Ontario" by Frances L. Stewart. 149 p., 7 figures. $2.00

A study of five sites from Bruce County, Ontario revealed changes in the use of the fauna through time. Emphasis was given to the animal remains from the Nodwell Site (BcHi-3) and to the methods of faunal analysis.

No. 17 "Les schèmes d'établissement à la fin de la préhistoire et au début de la période historique: le sud du Québec par Roger J.M. Marois. 433 p., 37 figures, 88 tableaux. $5.25

Distribution géographique par bande, voisinage et par langue des Amérindiens du 17e siècle au sud du Québec; rapprochements entre les schèmes d'établissement de la période historique et ceux de la préhistoire.

No. 18 "Archaeological Collections from Norutak Lake on the Kobuk-Alatna River Portage, Northwestern Alaska" by Donald W. Clark. 67 p., 2 figures, 4 tables, 9 plates. $1.25

Material from small-scale excavations near the Eskimo-Indian interface relates to several periods of Eskimo prehistory but shows also interior or non-Eskimo influence.

No. 19 "Crowsnest Pass Archaeological Project 1972 Salvage Excavations and Survey Paper No. 1 Preliminary Report" by B.O.K. Reeves. 67 p., 6 figures, 5 tables, 9 plates. $1.50

The monograph constitutes a progress report on an extensive examination of occupations dating back some 8,000 years along the eastern shores of Crowsnest Lake in southwestern Alberta.

No. 20 "Contributions to the Later Prehistory of Kodiak Island, Alaska" by Donald W. Clark and Frederick A. Milan. 183 p., 17 figures, 8 tables, 30 plates. $2.75

Minor excavations and surface collections are described. This report focusses on material of the second millennium A.D. and the concurrent question of local variation.

No. 21 "Archaeological Survey of Canada: Annual Review 1973" edited by George F. MacDonald. 51 p., on request.

No. 22 "The Nodwell Site" by J.V. Wright. 335 p., 51 tables, 21 figures, 9 charts, 22 plates. $4.00

The Nodwell Site is a mid 14th century ancestral Huron-Petun village site that was almost completely excavated in 1971 by a joint National Museum of Man and Royal Ontario Museum expedition.

No. 23 "The Belly River: Prehistoric Population Dynamics in a Northwestern Plains Transitional Zone" by J. Michael Quigg. 165 p., 26 photographs. $2.00

This report summarizes the archaeological salvage investigations undertaken along the Belly River in southwestern Alberta. In the course of the project numerous archaeological sites were located eroding into the river, and some of the more important localities were excavated.

No. 24 "Crowsnest Pass Archaeological Project 1973 Salvage Excavations and Survey paper No. 2 Preliminary Report" by B.O.K. Reeves. 95 p., 6 plates, 8 photographs. $1.25

This report constitutes a statement on the progress of archaeological salvage operations at a number of important archaeological sites situated in the vicinity of Crowsnest Lake in southwestern Alberta. These sites, endangered by highway construction, have provided important information about the 8000 year occupation history of this region.

No. 25 "The McCluskey Site" by K.C.A. Dawson 116 p., 5 figures, 20 tables, 4 plates. $2.00

A detailed description of a Blackduck tradition site which also contained Laurel tradition and transitional materials. The major occupation is assigned to the Western Area Algonkian culture of northwestern Ontario.

No. 26 "Archaeological Salvage Projects 1973" complied by W.J. Byrne. 182 p., 2 plates, 14 maps, 24 photographs. $2.50

In 1973 the Salvage Section, Archaeological Survey of Canada, National Museum of Man, instituted 31 archaeological salvage projects across the country. This report contains summary articles dealing with 29 of the 31 projects.

1975

No. 27 "Archaeological Reconnaissance in Northern Interior District of Mackenzie: 1969, 1970 and 1972" by Donald W. Clark. 397 p., 16 plates, 13 tables, 20 figures. $4.25

Approximately 75 prehistoric sites and nearly 50 historic or recent camps are reported for the areas north and west of Great Bear Lake, Collections are small and in most cases superficial, but groupings and periodization are attempted.

No. 28 "Of Men and Herds in Barrenland Prehistory" by Bryan H.C. Gordon. 541 p., 1 map, 20 figures, 48 tables, 38 plates. $5.75

This study attempts to elucidate the temporal and spatial interrelationships between the barrenland Pre-Dorset peoples, climates and caribou herds in the period 1500 - 700 B.C. Items such as discreteness of herds and human bands, band movements and communication and differing cultural patterns as evidenced in artifacts, are discussed. All are used in the formulation of the discrete band/discrete herd relationship.

No. 29 "The Prehistory of Lake Athabasca: An Initial Statement" by J.V. Wright. 189 p., 22 tables, 6 figures, 19 plates. $2.50

The position of Lake Athabasca relative to the Plains, Boreal Forest, and Arctic physiographic zones, which have changed through time in response to climatic fluctuations, has resulted in cultures adapted to these three zones occupying areas of the lake during certain periods. During the later prehistory the western half of the lake was exploited by a Plains-derived, bison hunting culture whereas the eastern half of the lake was exploited by a Boreal Forest-derived, caribou hunting culture.

No. 30 "Skeletal Variability in British Columbia Coastal Populations. A Descriptive and Comparative Assessment of Cranial Morphology" by Jerome S. Cybulski. 319 p., 68 tables, 13 figures. $3.75

Metric and non-metric techniques of analysis are used to study the interrelationships of the Haida, Kwakiutl, Nootka, and Coast Salish ethnic divisions of British Columbia. Both between and within group variation is considered based on crania in museum collections.

No. 31 "Archaeological Survey of Canada: Annual Review 1974" edited by George F. MacDonald. 64 p., 16 photographs; on request.

No. 32 "Prehistory of Saglek Bay, Labrador: Archaic and Palaeo-Eskimo Occupations" by J.A. Tuck. 272 p., 8 figures, 27 plates. $2.75

Description of Maritime Archaic, early Palaeo-Eskimo, and Dorset Eskimo occupations of Saglek Bay in northern Labrador with comment on settlement - subsistence, culture history, and possible prehistoric Indian and Eskimo contacts.

No. 33 "Salvage Contributions: Prairie Provinces" edited by R. Wilmeth. 206 p., 12 figures, 17 plates. $3.00

The six archaeological reports in this issue pertain to salvage operations carried out under contract with the Archaeological Survey of Canada, National Museum of Man. Three of the projects were located in southern Alberta, one each in northern and southern Saskatchewan, and one in southern Manitoba.

No. 34 "An Archaic Sequence from the Strait of Belle Isle, Labrador" by Robert McGhee and James A. Tuck. 254 p., 6 tables, 3 figures, 28 plates, 2 appendices. $3.25

The evidence is presented for man's continuous occupation of the Strait of Belle Isle region of Labrador from approximately 8,000 - 9,000 years ago until 3,000 - 2,000 years ago when the local Maritime Archaic tradition was interrupted by a possible environmental change and the appearance of Dorset Eskimos.

No. 35 "Koniag-Pacific Eskimo Bibliography" by Donald W. Clark. 97 p. $1.50

This anthropological bibliography of the Pacific Eskimo area of Alaska also features an extended historical coverage for Kodiak and adjacent Islands. Many of the nearly 500 entries are annotated.

No. 36 "Archaeologocial Salvage Projects 1974" compiled by Roscoe Wilmeth. 92 p., 29 figures, 3 tables. $1.25

In 1974, the Salvage Section, Archaeological Survey of Canada, National Museum of Man, instituted nine archaeological salvage projects across the country. These ranged from a brief survey of one portion of the Mackenzie Highway to the extensive survey and excavations on the Suffield Military Reserve in southeastern Alberta. This volume contains summary articles describing these projects

No. 37 "An introduction to the Ecology of Early Historic Communal Bison Hunting Among the Northern Plains Indians" by George W. Arthur. 144 p., 1 figure. $1.50

This study uses archaeological, ethnohistorical and ecological data in an effort to understand the nature of early historic communal bison hunting among the northern Plains Indians.

No. 38 "Thule Eskimo Prehistory of Cumberland Sound, Baffin Island, Canada" by Peter Schledermann. 297 p., 4 tables, 48 figures, 50 plates. $2.50

A study of prehistoric cultural development of the Thule Eskimo tradition in southern Baffin Island and its relationship to the present inhabitants of the region.

No. 39 "The Beaches: A Multi-Component Habitation Site in Bonavista Bay" by Paul Carignan. 233 p., 13 tables, 6 figures, 38 plates. $3.00

The stratified Beaches site, Newfoundland, was occupied over the past 5,000 years by Maritime Archaic, Dorset and Boethuck populations.

No. 40 "Quelques techniques de décoration de la céramique impressionée: correspondance des termes français et anglais" par Roger J.M. Marois. 113 p., 32 figures, 8 planches. $1.25

Suite à l'examen de quelques ouvrages en anglais et en francais, cette étude dégage les différents sens que revêtent les termes reliés aux techniques de décoration, particulièrement de la céramique impressionée, et indique à quel niveau ces termes ont une correspondance dans les deux langues.

No. 41 "Indices de manifestations culturelles de l'archaïque: la région de Trois-Rivières" par Roger J.M. Marois et René Ribes. 107 p., 36 figures, 12 planches $1.75

Cette étude permet de croire que les peuplades de l'Archaïque dans la région de Trois-Rivières one été soumises à différentes influences culturelles, particulièrement de la Tradition laurentienne et de l'Archaïque des maritimes.

No. 42 "The Boys Site and the Early Ontario Iroquois Tradition" by C.S. Reid. 129 p., 43 tables, 32 figures. $2.25

A report on the 10th century Pickering branch village (early Ontario Iroquois tradition) that provides data on settlement trade, subsistence and artifact patterns.

No. 43 "A Paleoecological Model for Northwest Coast Prehistory" by Knut R. Fladmark. 328p., 15 figures. $4.25

The evolution of the Northwest Coast cultural pattern from two different archaeological traditions, one in the north and one to the south, is discussed in terms of environmental and subsistence factors.

No. 44 "L'Archéologie des provinces de Québec et d'Ontario" par Roger J.M. Marois. 117 p., 20 figures. $2.00

Cet ouvrage comprend l'historique et le bilan des recherches archéologiques dans les provinces d'Ontario et de Québec jusqu'en 1968.

No. 45 "Origins and Development of Early Northwest Coast Culture to about 3000 B.C." by Charles E. Borden. 137 p., 6 figures, 3 tables. $1.75

Based on a synthesis of current archaeological evidence from 8000 B.C. to 3000 B.C. a hypothesis on the origins of early Northwest Coast culture is developed, and is seen as an integration of Early Boreal and Protowestern cultures occurring in the central coast area of British Columbia.

No. 46 "The Cactus Flower Site in Southeastern Alberta: 1972-1974 Excavations" by John H. Brumley. 244 p., 17 tables, 16 figures, 36 plates. $3.25

A report on three years of intensive excavation of a deeply stratified site on the South Saskatchewan River. The major occupation belongs to the McKean complex and is dated between 3000 and 1500 B.C. Late spring to early autumn hunting activity is represented.

1976

No. 47 "The Grant Lake Site, Keewatin District, N.W.T." by J.V. Wright. 122 p., 10 figures, 2 maps, 10 plates. $1.75

The Grant Lake site, located on the Dubawnt River in west-central Keewatin District, consists of a number of horizontally discrete living floors that pertain to the Agate Basin complex of the Palaeo-Indian period. It is proposed that the environment during the occupation between 6000 and 7000 B.C. was similar to present conditions.

The following papers are being distributed gratis by the Chief, Archaeological Survey of Canada, National Museum of Man:

Les dossiers suivants sont distribués gratuitement par le Chef de la Commission archéologique du Canada, Musée national de l'Homme:

* No. 48 "Algonkians of Lake Nipigon: An Archaeological Survey" by K.C.A. Dawson. 151 p., 10 figures, 19 tables, 4 plates.

Archaeological survey and excavation at Lake Nipigon has revealed the presence of Shield, Laurel and Algonkian cultures with the most intensive occupation during the Terminal Woodland period. Evidence is also presented for the interaction of the Western Algonkians of the area with Northern, Southern and Eastern Algonkian groups.

* No. 49 "Contributions to Anthropology: The Interior Peoples of Northern Alaska" edited by Edwin S. Hall Jr. 391 p., 29 figures, 37 tables.

This volume consists of a series of papers that examine various aspects, archaeological and ethnographic, of the interior Eskimos and their neighbours of northern Alaska.

* No. 50 "The Excavation of Water-Saturated Archaeological Sites (Wet Sites) on the Northwest Coast of North America" edited by Dale R. Croes. 351 p., 139 figures, 16 plates, 1 map.

A compilation of thirteen papers dealing with the techniques of excavation, kinds of artifacts recovered, and methods of preservation of perishable materials from water-saturated sites on the Northwest Coast, originally presented at the 29th Annual Northwest Anthropologcal Conference in 1974.

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* These publications are not available.
Ces publications ne sont pas disponibles.

* No. 51 "The Potato Island Site, District of Kenora, Ontario" by Polly Koezur and J.V. Wright. 51 p., 4 tables, 2 figures, 5 plates.

"Albany River Survey, Patricia District, Ontario" by K.C.A. Dawson. 54 p., 6 tables, 1 figure, 3 plates.

A number of aspects of the prehistory of Northern Ontario are considered in these reports. Of central concern are the spatial variations of the Terminal Woodland ceramics and the evidence for the transition from the Laurel assemblage into Blackduck assemblage.

No. 52 "The Glenrose Cannery Site" by R.G. Matson. 329 p., 82 figures, 37 tables.

A report on the Glenrose Cannery Site (DgRr6) which spans over 6000 years of Fraser Delta prehistory from circa 8000 B.P. - 2000 B.P. The analysis concentrates on the reconstruction of prehistoric subsistence patterns evidenced from the site.

* No. 53 "The Prehistoric Occupations of Black Lake, Northern Saskatchewan" by Sheila J. Minni. 182 p., 6 tables, 19 figures, 5 plates.

Black Lake was occupied on a discontinuous basis from approximately 6,000 B.C. to the historic period by cultures originating from a number of different physiographic zones. An economical model outlines the historic and late prehistoric dependance of the Chipewyan on the barren ground caribou herds.

* No. 54 "The Culture History of Kirkland Lake District, Northeastern Ontario" by John William Pollock. 249 p., 52 tables, 64 figures.

The thesis attempts to delineate a cultural-chronological sequence from northeastern Ontario extending from the historic period to approximately 5,000 B.C. Four phases representing three cultural traditions are defined.

* No. 55 "Ramillies: A Late Prehistoric Bison Kill and Campsite located in southeastern Alberta, Canada" by John H. Brumley. 137 p., 18 plates, 9 figures, 6 tables.

Description of a unique style of bison pound, involving enlargement and modification of a natural depression near the edge of a deep coulee. The pound and a nearby campsite were used during the Avonlea and Old Women's phases.

* No. 56 "Migod - 8,000 years of Barrenland Prehistory" by Bryan H.C. Gordon. 310 p., 22 illustrations, 35 tables, 49 plates.

The discrete band/discrete herd association is used to explore 8,000 years of barrenland prehistory at the Migod site, west-central Keewatin District, N.W.T. The association appears applicable in the Four traditions represented - Agate Basin, Shield Archaic, Pre-Dorset and Taltheilei.

1977

* No. 57 "Pre-Dorset Settlements at the Seahorse Gully Site" by David A. Meyer. 293 p., 31 figures, 21 tables, 21 maps.

A study of technology, subsistence and settlement patterns of the late Pre-Dorset people who occupied a large coastal site near Churchill Manitoba around 3000 years ago.

* No. 58 "The Princess Point Complex" by David Marvyn Stothers. 503 p., 43 plates, 12 figures, 8 maps.

This study defines an early Late Woodland manifestation in south-western Ontario, the Princess Point Complex. This complex is seen as an early developmental stage of the Ontario Iroquois Tradition. Evidence is presented for changing subsistence and settlement patterns in response to the introduction of maize horticulture.

* No. 59 "The Development of Caribou Eskimo Culture" by Brenda L. Clark. 169 p., 9 figures, 9 plates, 2 tables.

The origin and development of historic Caribou Eskimo culture from prehistoric classic Thule is explained using archaeological and ethnohistorical evidence.

* No. 60 "Models for Deriving Cultural Information From Stone Tools" by Robson Bonnichsen. 262 p. 18 plates, 12 figures, 4 tables.

A model relating human cognition to decisions made in tool manufacture is advanced as a substitute for those approaches to artifact classification which rely only on morphology. The model is related to experiments designed to link specific input conditions (in stone fracture) with particular output features (flake and core attributes) and is used to resolve processual questions concerning projectile points from four Palaeoindian localities.

* No. 61 "The Saugeen Culture: A Middle Woodland Manifestation in Southwestern Ontario" by William David Finlayson. 701 p., 50 plates, 35 figures, 123 tables.

The Saugeen culture of southwestern Southern Ontario (circa 700 B.C. to 800 A.D.) is examined at intrasite and intersite levels of comparisons. It is suggested that the Saugeen, Point Peninsula and North Bay cultures should be considered as Middle Tier cultures which interacted to varying degrees with the Southern Tier Hopewellian cultures and the Northern Tier Laurel culture.

No. 62 "The Majorville Cairn and Medicine Wheel site, Alberta" by James M. Calder. 310 p., 27 tables, 57 figures.

Majorville is a large cairn situated in the centre of a medicine wheel. Stratigraphic excavation indicates initial construction in Oxbow times, with additional accretions ending in the Historic Period. Cultural continuity in ritual practice in the Plains over a period of 5,000 years is thus established.

* No. 63 " Refinement of Some Aspects of Huron Ceramic Analysis" by Peter George Ramsden. 305 p., 29 tables, 114 figures.

Using selected ceramic attributes from twenty-eight prehistoric and historic Iroquoian sites in Ontario an attempt is made to demonstrate the existence of clusterings of historically related sites. These data are then used to outline the economic and political processes which produced the mid-17th century Huron-Petun populations.

* No. 64 "The Skeletal Biology of Archaic Populations of the Great Lakes Region" by Susan Pfeiffer. 370 p., 3 figures, 108 tables.

Ten skeletal samples are described and examined with regard to cremation techniques, pathological conditions, dental characteristics and population affinities. A Number of similar activity patterns are found. Apparent breeding isolates as well as population similarities covering great distances complicate the pattern of populution interrelationships.

* No. 65. "Archaeology and Ethnohistory in the Arrow Lakes" by Christopher J. Turnbull. 307 p., 57 figures, 23 plates.

Archaeological and ethnohistoric evidence is presented to conclude that the Arrow Lakes region of southeastern B.C. has been an integrated part of the Columbia Plateau for at least 3,300 years.

No. 66 "Archaeological Survey of Canada: Annual Review 1975 and 1976" edited by George F. MacDonald. 113 p.,

* No. 67 "The Harder Site, A Middle Period Bison Hunters' Campsite in the Northern Great Plains" by Ian G. Dyck. 325 p., 34 plates, 18 tables, 32 figures.

An analysis and functional interpretation of the culural remains from a Middle Period (Oxbow complex) bison hunters' campsite situated in the parklands of central Saskatchewan.

No. 68 "The Estuary Bison Pound Site in Southwestern Saskatchewan" by Gary F. Adams. 204 p., 5 tables, 34 figures.

The Estuary Pound Site, located on the South Saskatchewan River just below its confluence with the Red Deer River, contains two major levels. The upper level relates to the Old Women's phase while the lower level contains elements of both the Old Women's phase and the Avonlea phase leading to the suggestion that the former developed out of the latter.

No. 69 "Beothuck Archaeology in Bonavista Bay" by Paul Carignan. 273 p., 8 tables, 45 figures, 32 plates.

Data are presented on four sites in Bonavista Bay ranging from A.D. 210 to A.D. 905 in age. It is suggested that the historic Beothucks were derived from preceding Maritime Archaic tradition and that they also cohabitated the region with Dorset Eskimos.

No. 70 "Thule Eskimo Prehistory along Northwestern Hudson Bay" by Allen P. McCartney. 485 p. 7 tables, 108 figures, 105 plates.

Thule house ruins were excavated at Silumiut and two other major winter settlements along Roes Welcome Sound and northwestern Hudson Bay. Radiocarbon dating places the occupation of these sites at about the end of the 12th century A.D. This work expands Mathiassen's original investigation of Thule culture southward from Repulse Bay.

No. 71 "Hahanudan Lake: An Ipiutak-Related Occupation of Western Interior Alaska" by Donald W. Clark. 153 p., 9 tables, 32 figures, 14 plates.

Five small house pits excavated near Huslia in the Koyukuk River drainage of western interior Alaska have produced lithic assemblages with Norton and Ipiutak culture characteristics. Radiocarbon dating indicates that cross ties are with the latter. This work extends the previously known inland range of Ipiutak culture which is known primarily from coastal sites in northwestern Alaska.

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No. 72 "L'Archéologie des Kitselas d'après le site stratifié de Gituas (GdTc:2) sur la rivière Skeena en Colombie Britannique" par Louis Allaire. 364 p., 12 figures, 30 tableaux, 23 planches.

Cette monographie est la reproduction d'une thèse de maîtrise présentée au département d'anthropologie de l'université de Montréal en 1970. L'ouvrage constitue le rapport de fouilles exécutees durant l'été de 1968 sur le gisement de Gitaus (GdTc:2) dans le canyon des Kitselas de la rivière Skeena (Colombie-Brittanique) par George F. MacDonald du Musée National de l'Homme, auxquelles l'auteur participait.

* No. 73 "Reports of the Lillooet Archaeological Project. No. I. Introduction and Setting" edited by Arnoud H. Stryd and Stephen Lawhead. 125 p., 25 figures, 4 tables.

Introduction to the 1969-1976 Lillooet Project and research area in British Columbia. Four papers pertain to the present-day ecology, geologic history, and ethnography of the area and recount the objectives and history of the Project.

No. 74 "Prehistory of the Aishihik-Kluane Area, Southwest Yukon Territory" by William B. Workman. 592 p., 48 plates, 62 figures, 30 table.

A detailed survey of the archaeology of Southwest Yukon Territory, based upon excavations in 1966 and 1968 as well as laboratory analysis of all sizeable collections obtained earlier. Archaeological, ethnographic, and paleoenvironmental data are integrated into a synthetic view of prehistory in northwestern North America.

No. 75 "Le Gisement Beaumier: Essai sur l'évolution des décors de la céramique" par Roger Marois. 299 p., 120 figures, 28 planches.

L'analyse de la céramique du gisement Beaumier constitue un effort pour développer une méthode de travail susceptible de favoriser la comparaison des données fournies dans les ouvrages pertinents. Les caractères morphologiques et décoratifs ont servi à établir une séquence culturelle des Iroquois du Saint-Laurent pour la région de Trois-Rivières. Le lecteur en désaccord avec l'interprétation de l'auteur aura la liberté de regrouper les caractères à sa façon afin de justifier ses affirmations.

No. 76 "Etude archéologique de sites eskimo aux îles Belcher, T.N.O." par Joseph Benmouyal. 260 p., 15 planches, 4 cartes, 4 plans, 14 tableaux.

A partir du matériel excavé de plusieurs habitations Eskimo par feu Claude Desgoffe, ce mémoire, montre que la culture Manitunik n'a probablement pas existé et qu'il s'agit plutôt d'un mélange artificiel d'outils provenent de sites de cultures et d'époques diverses.

No. 77 "Canadian Archaeological Radiocarbon Dates (Revised Version)" compiled by Roscoe Wilmeth. 218 p.

An expanded version of the 1969 publication, including all dates published in Radiocarbon and unpublished dates from National Museum of Man files. Sites are arranged alphabetically by province or territory. An index of Borden Site Designation System numbers is provided.

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* These publications are not available.
Ces publications ne sont pas disponibles.

No. 78 "Archaeological Investigations at the Antigun Site, Central Brooks Range, Alaska" by Ian R. Wilson. 244 p., 36 tables, 35 figures.

The Antigun site is marginal to both Indian and Eskimo territory, thus the primary concern of this analysis is the cultural affiliation of its occupants. Conclusions point to late summer occupation of the site by Athapaskans between A.D. 1400 and A.D. 1800. This period is defined as the Kavik phase.

* No. 79 "The Saamis Site: A Late Prehistoric-Protohistoric Campsite in Medicine Hat, Alberta" by Laurie Milne Brumley, with appendix by Babs Congram. 278 p., 48 plates, 32 figures, 33 tables.

Excavations at the Stampede Camp and the Saamis sites, located in Medicine Hat, Alberta, are described, and especial attention is given to features. Together, the two sites were occupied during the Middle Prehistoric, Late Prehistoric and Protohistoric periods.

No. 80 "Late Prehistory of Point Pelee, Ontario, and Environs" by David L. Keenlyside. 374 p., 71 plates, 37 figures, 14 tables.

Research at Point Pelee in extreme southern Ontario has revealed a unique sequence of prehistoric occupation at three major multicomponent sites. This sequence has been divided into four periods, commencing in the 6th century A.D. and terminating about the 15th century A.D.

No. 81 "The Development and Distribution of Discontinuous Morphological Variation of the Human Infracranial Skeleton" by Shelley Rae Saunders. 549 p., 48 plates, 20 figures, 40 tables.

Over 1400 skeletons from three major populations are examined for approximately 50 infracranial non-metric traits. Trait frequencies are studied for side, sex and age differences, trait intercorrelations, and association with bone robusticity. Skeletal population studies are performed using various combinations of the traits and two distance statistics.

* No. 82 "Anahim Lake Archaeology and the Early Historic Chilcotin Indians" by Roscoe Wilmeth. 252 p., 35 plates, 2 maps, 22 tables, 46 figures.

Excavation of a number of pit house sites at Anahim Lake in the central Plateau of British Columbia has resulted in the definition of five components, the last two attributed to the Chilcotin Indians. There are significant resemblances between these two components and Athabaskan complexes recorded elsewhere in North America.

"Vertebrate Faunal Remains from the Potlatch Site (FcSi-2) in South Central British Columbia" by Frances L. Stewart, 103 p., 4 appendices, 13 maps, 5 plates, 10 tables.

Analysis of the vertebrate remains from Potlatch site reveal much about the subsistence of the Chilcotin Indians through time. Significant changes occurred in the percentage of vertebrate remains through time. Evidence for butchering and artifactual modification are discussed. Range changes of several species are of zoological interest.

* No. 83 "An Experimental Study of Microwear Formation on End-scrapers" by John W. Brink. 238 p., 54 plates, 1 figure, 2 tables.

This experimental lithic study tests the hypothesis that wear patterns which form on stone tools are diagnostic of the material on which the tool was used. The results of the experiments indicate that the hypothesis is substantiated, or not refuted.

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No. 84 "Of Men and Herds in Canadian Plains Prehistory" by Bryan C. Gordon. 117 p., 7 figures, 2 tables.

This is a preliminary study of temporal and spatial relationships between Canadian Plains peoples, climates and bison populations over the past 10,000 years. Discreteness of two bison populations, hunting band movements and communication are discussed together with the probable role of grassland faciation as a control on bison migration.

No. 85 "Archaeological Material from Creswell Bay, N.W.T., Canada" by William E. Taylor, Jr. and Robert McGhee. 171 p., 32 figures, 18 plates, 2 tables.

Description and analysis of Thule and Dorset culture material, including house structures, excavated at three archaeological sites.

No. 86 "Ocean Bay: An Early North Pacific Maritime Culture" by Donald W. Clark, with Appendix "...Prehistory and Contact History at Afognak Bay" by William B. Workman and Donald W. Clark. 404 p., 47 figures, 40 plates, 53 tables.

Investigation of three 4000 to 6000-year-old sites of the North Pacific maritime Ocean Bay culture, located on the Gulf of Alaska, is described. The development of ground slate technology is discussed. An appendix documents subsequent occupations at one locality.

No. 87 "Skeena River Prehistory" co-edited by Richard Inglis and George F. MacDonald. 260 pages, 85 plates, 16 figures, 5 tables.

Survey and excavation along the Skeena River, northwestern British Columbia, has revealed a 4000-year occupation of this area which has direct ties to cultural events on the coast.

No. 88 "Thule Eskimo Culture: An Anthropological Retrospective" edited by Allen P. McCartney. 586 pages.

This volume is the proceedings of a symposium devoted to the prehistoric Thule culture and related northern studies, held at the 10th annual meeting of the Canadian Archaeological Association in Ottawa during May, 1977. It contains 31 papers.

No. 89 "Pleistocene Bone Technology in the Beringian Refugium" by R. Bonnichsen. 296 pages, 40 plates, 13 figures, 30 tables.

Examination of vertebrate faunal remains held in museum collections is reported. To understand or identify human modification of bone and antler, the analysis emphasizes post-mortem processes including geological, biological and cultural ones that have led to the alteration and distribution of bone elements. In addition, to provide analogs for this analysis, bone breaking experiments were conducted.

No. 90 "Patrimonio Cultural" by Daniel Rubín de la Borbolla and Roger J.M. Marois. 138 pages.

This publication presents in Spanish, French, English and Portuguese the proceedings of the Interamerican Seminar on Conservation and Restoration of Cultural Heritage and of the Technical Meeting on Rescue Archaeology, held jointly in the Panamanian Museum of Man in February 1978.

No. 91 "Dakah De'nin's Village and the Dixthada Site: A Contribution to Northern Athapaskan Prehistory" by Anne D. Shinkwin. 197 pages, 38 figures, 32 tables.

Archaeological remains from two late prehistoric/early historic Athapaskan sites in east central Alaska are presented. These data and those from the late prehistoric to historic Kutchin Athapaskan Klokut site in the Yukon Territory (ASC MERCURY No. 11) are examined for the comparative perspective that they offer on Northern Athapaskan prehistoric and very early historic culture.

No. 92 "The Palaeoeskimo Occupations at Port Refuge, High Arctic Canada" by Robert McGhee. 176 pages, 33 figures, 12 plates.

Archaeological work at six Arctic Small Tool tradition components is reported. Five of these are ascribed to the Independence I, and one to the Pre-Dorset variants of the ASTt. An attempt is made to interpret the social and economic patterns of early Palaeoeskimo occupants of the area.

No. 93 "A Report on the Banting and Hussey Sites: Two Paleo-Indian Campsites in Simcoe County, Southern Ontario" by P.L. Storck. 123 pages, 13 figures, 33 plates, 26 tables.

These sites were briefly occupied on several occasions by Paleo-Indian peoples between 11,500 and 10,500 years ago. In addition, the Hussey site was visited by later peoples. At both sites diagnostic areas or individual campsites are identified by the presence of discrete concentrations of material.

No. 94 "Taphonomy and Archaeology in the Upper Pleistocene of the Northern Yukon Territory: a Glimpse of the Peopling of the New World" by Richard E. Morlan. 407 pages, 79 tables, 19 figures, 77 plates.

The concept of taphonomy has been borrowed from paleontology and applied to the analysis of vertebrate fossils from the Old Crow region of the northern Yukon Territory. By means of this approach, archaeologically significant specimens have been isolated from the larger suite of materials which can be explained entirely in terms of natural processes. The analysis indicates that human occupation began in eastern Beringia more than 50,000 years ago and probably was continuous from that time onward, but primary archaeological deposits will be needed to clarify the historical and paleo-environmental significance of these finds.